System Installation & User Manual

VERSION 4.0.0

Cellwatch Frontier

Intended Use

Cellwatch Frontier is a battery monitoring system that monitors the state of health of batteries used to power UPS systems by measuring the battery voltage, current, temperature, and ohmic value.

There are features planned for future releases that are currently not available in this version. Future software updates will be available for download. If there are any questions on these features, please contact NDSL.

Regulatory Compliances

The Frontier and Data Collection Modules are fully compliant with CE regulations for EMC and safety to the following standards:

Emissions and Immunity

EN 61326:1:2013

Safety

EN 61010-1:2010 (3rd edition)
EN 61010-2-030:2010 (1st edition)
UL 61010-1:2012
UL 61010-2-03:2012
CAN/CSA-C22 No. 61010-1-12
CAN/CSA-C22 No. 61010-2-030-12
cTUVus

CE

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Section I – Installation Guide

Introduction

This guide will walk through the installation of the Cellwatch Frontier unit, the Data Collection Modules (DCM), Temperature Probes (TP), Current Transducers (CT) and Frontier Electrolyte Detectors (FEDs). Instructions on accessing and configuring the Frontier unit can be found in the User Guide and Battery Configuration Guide.

Trademarks

All brand and product names are the trademarks of their respective owners. Cellwatch™ is the registered trademark of NDSL Group Limited in the UK and the USA and a trademark of NDSL Group Ltd. in the rest of the world.

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Life Support

NDSL products cannot ensure performance for life-support devices or systems since the end user is responsible for monitoring and management of the system.

Liability

Neither NDSL nor any of its employees shall be liable for any direct, indirect, incidental or consequential damages arising from the failure of the battery monitoring system due to the failure of a proprietary part of the battery monitoring system, even if NDSL had been advised in advance except for as provided by law.

Specification

NDSL makes every effort to ensure that the specifications and details in this manual are accurate and complete. NDSL reserve the right to alter or improve the specification, design or manufacturing process at any time, without notice.

Warranty

Please contact your Cellwatch installer/provider for warranty issues.

Limitation of Warranty

This warranty does not apply to defects arising from system modification performed without NDSL's written approval, or misuse of the system or any part of the system. The warranty excludes defects or malfunctions resulting from failure by the customer, or his designated personnel, to maintain and upkeep the batteries to which the system is fitted.

This warranty does not apply to any part of the system supplied by the customer or problems arising from normal wear and tear or failure to follow instructions.

Important Safety Information

READ THE FOLLOWING INFORMATION CAREFULLY. SAVE ALL INSTRUCTIONS FOR FUTURE REFERENCE!

- Read these instructions.
- Keep these instructions.
- Heed all warnings.
- Follow all instructions.
- Clean only with a dry cloth.
- Do not expose this apparatus to rain, liquids, or moisture of any type.
- Do not block any ventilation openings.
- Never push objects of any kind into ventilation slots on the equipment casing.
- Install in accordance with the manufacturer's instructions.
- Do not install near any heat sources such as radiators, heat registers, stoves, or other apparatus that produces heat.
- Ensure the unit is Installed so that it is easy to operate and disconnect power by removing the power cord.
- This equipment should be connected to an electrical outlet with a protective ground connection.
- Use only the supplied power cord. Contact NDSL for a replacement if required. Do not use inadequately rated cords.
- Power supply cords should always be handled carefully and should be replaced if damaged in any way.
- Do not defeat the safety purpose of the polarized or grounding-type plug.
- Never break off the earth (ground) pin on the power supply cord.
- Protect the power cord from being walked on or pinched particularly at plugs, convenience receptacles, and the point where they exit from the apparatus.
- Only use attachments and accessories specified by NDSL.
- Servicing is required when the apparatus has been damaged in any way, such as power-supply cord or plug is damaged, liquid has been spilled or objects have fallen into the apparatus, the apparatus has been exposed to rain or moisture, does not operate normally, or has been dropped. Do not open the equipment case. There are no user serviceable parts in this equipment. Refer all servicing to qualified service personnel.
- Operation of the product outside of the recommendations in this manual can cause the protection provided by the equipment to be impaired.
- Unauthorized modification of this equipment is expressly forbidden by NDSL.
- Always replace damaged fuses with the correct rating and type.
- Follow all warnings and instructions marked on the product!

To completely disconnect this apparatus from the AC mains, disconnect the power supply cord from the AC receptacle.

WARNING: To reduce the risk of fire or electric shock, do not expose this apparatus to rain or moisture.

Beware!

Check the manual for important operation and maintenance instructions.

Danger Live Electrical Equipment

Danger Du Matériel Électrique

Cellwatch™ Service and Support

If during the use of the NDSL product any cracks, breaks, or defects are found in any of the units then please contact NDSL. You will be advised on the necessary action to be taken.

Visit http://www.cellwatch.com for the latest contact information and locations.

Installation Safety

The following safety precautions should be observed before any work is performed on the system containing the NDSL product.

- ✓ This system is intended for installation by personnel who are trained and qualified to recognize the hazards associated working with such systems and are familiar with the safety precautions required to avoid possible injury.
- ✓ Never work on any system that threatens life or injury through hazardous voltages. Even when safety precautions have been taken.
- ✓ NEVER WORK ALONE. Always ensure that two properly trained personnel are on site.
- ✓ NDSL recommends that when performing any work concerned with batteries, that the safety procedures and safe working practices as described in the appropriate battery manufacturers documentation should be followed at all times.

- ✓ Never make unauthorized changes or modifications to equipment. This may create unsafe or even hazardous situations.
- ✓ Where the battery documentation recommends that links are removed for safe working, it is **important** to totally remove any Cellwatch unit which is connected across any link to be broken prior to separation and subsequent removal of the link. **FAILURE TO DO SO WILL RESULT IN THE STRING NOT BEING TOTALLY ISOLATED**.

- ✓ After servicing of the battery, any removed links must be fitted and reconnected **before** the Cellwatch™ modules are reconnected.
- ✓ **Safety glasses should be worn at all times**.
- ✓ Ensure all equipment and tools are safe and in good working order.
- ✓ Ensure electrical tools have been tested for proper insulation and grounding.
- ✓ Do not wear loose clothing, jewelry, long hair when working near rotating machinery.
- ✓ Appropriate PPE should be utilized depending upon the application and hazards present.
- ✓ Observe all **CAUTIONS**, **WARNINGS** and **DANGER** notices on equipment, tools, and buildings whether internally or externally displayed.

Frontier Hardware Specifications

Power Supply	
AC Input	100-240 VAC @ 50-60Hz, 10W
(Alternative) DC Input	Option 1: 20-70 VDC, 10W Option 2: 70-150 VDC, 20W Option 3: 100-240 VDC, 20W
Permitted Mains Supply Variations	10%
Transient Overvoltage	Category 2
Fuse Rating	250V 1A Slow-Blow
Environmental (Indoor use only)	
Operating Temperature	0-65°C
Relative Humidity	5-90% non-condensing
Maximum Altitude	3,000 m (~10,000 ft.)
Pollution	Degree 2
Dimensions	
Wall Mount Model	9.75 in. x 5 in. x 2.5 in.
Rack Mount Model (1U)	1.75 in. x 19 in. x 6 in.
Weight	
Wall Mount Model	1.6 lbs. / 0.73 kg
Rack Mount Model	2.2 lbs. / 1.00 kg
Fiber Optics	
Optical Cable	Acrylic
Outside Diameter	2.2 mm
Wavelength	400-700 nm
Range	150 mm – 50 m (6 in. – 150 ft.)
Digital Inputs	
Isolated Digital Inputs	4
Relay Outputs	
Quantity	4
Type	Dry Contact (NO/NC) 30VDC 5A
Relays	Battery Alarm (programmable) System Alive String 1 Disconnect (Thermal Runaway only) String 2 Disconnect (Thermal Runaway only)
Capacity	
Max. Number of Measurement Points	256
Max. Number of DCMs	64
Temperature Probe	
Quantity	4

Temperature Sensor Range	2-80˚C +/- 1˚C
Current Transducer	
Quantity	2 (Wall Mount) 4 (Rack Mount)
Float Only Range	5A
Supported Directional / Bi-Directional Ranges (+/-)	50A, 100A, 300A, 600A, 1000A
Ethernet Ports	
Quantity	1 on Wall Mount or Rack Mount units Option: 2 ports on Rack Mount only
Rate	10/100 Mbps

DCM Specifications

DCM 5

DCM 5 Specifications			
Description	DCM 5		
Environment			
Operating Temperature	0-60°C		
Relative Humidity	5-95% non-condensing		
Maximum Altitude	3,000 m (10,000 ft.)		
Power Supply (full functionality)	4.5-80 VDC		
Power Supply (voltage, temperature & ripple)	4.0-80 VDC		
Protection			
Transient Suppression	600W		
Short Circuit Protection	Internal 3A fuse		
Reverse Polarity Protection	Any combination		
Insulation Resistance	1000 MΩs >1Kv		
Operating Current			
Quiescent Current	22mA		
Sleep Current	< 2mA		
During Ohmic Testing	0.5A or 2A		
Standard Measurement Characteristics	**Range**	**Resolution**	**Accuracy**
Voltage	0 to 60V	15mV	0.1% +/- 15mV
Ohmic Value	0 to 25.9mΩ	6.3µΩ	2% +/- 12 µΩ

Enhanced Measurement Characteristics (Requires Activation)	Range	Resolution	Accuracy
Voltage	0 to 80V	2mV	0.1% +/- 5mV
Ohmic Value	0 to 1mΩ	1μΩ	2% +/- 8μΩ
	1 to 65mΩ	1μΩ	1.5%
Cell Temperature (requires DCM5T)	2 to 80°C	0.01°C	+/- 1°C
Ripple Voltage across 4 channels (40Hz – 1KHz)	0 to $4V_{rms}$	$2mV_{rms}$	2% +/- $5mV_{rms}$
Fiber Optic Specification			
Optic Cable	Acrylic		
Sheathing	Fluorine containing polymer		
Core Diameter	1.0 mm		
Outside Diameter	2.2 mm		
Wavelength	400-700 nm		
Communication Rate	9600 baud		
Fiber Optic Range	Min: 150 mm (6 in.) to Max: 50 m (150 ft.)		
Mechanical			
Dimensions	4.2 in. x 3.1 in. x 0.9 in. (107 mm x 80 mm x 23 mm)		
Mounting Pads	3M™ Dual Lock™		
Base Plate with Mounting Holes	Optional		
Base Plate with DIN Rail Mount	Optional		
Enclosure Material	ABS		
Lead Length	36-72 in.		

DCM6-L

The DCM6-L is designed for use with 2-volt jars. It can operate up to a maximum power supply voltage of 12 volts between the white and brown wires. Unlike previous DCMs, the white and blue must be at the same DC voltage (connected to the same cell terminal post). Note the DCM6-L will not power up, flash the LEDs and play its startup song until the white, blue and brown wires are connected.

The DCM6-L cannot measure Ripple Voltage. A DCM6-R will be required to measure Ripple Voltage on a system utilizing DCM6-L units.

The DCM6-L has a lower quiescent current than previous DCMs and so must not be mixed on the same string of cells, it can however operate on the same fiber optic loop as previous DCM models.

DCM6-L Specifications			
Description	**DCM6-L**		
Environment			
Operating temperature	0 to 60ºC		
Relative Humidity	5 - 85% non-condensing		
Maximum Altitude	3,000 meters (10,000ft)		
Power supply full functionality	4 - 12 Volts DC		
Power supply voltage & temperature	3 - 12 Volts DC		
Protection			
Transient suppression	600W		
Short circuit protection	Internal 4-amp fuse		
Reverse polarity protection	Any combination		
Insulation resistance	1000 MΩs >1Kv		
Operating current			
Quiescent current	12mA		
Sleep current after 25 hours	<2ma		
During ohmic testing	1.5 amps		
Standard Measurement Characteristics	**Range**	**Resolution**	**Accuracy**
Voltage	0 to 12 volts	15 mV	0.1% +/-15mv
Ohmic Value	0 to 5mΩ	6.3µΩ	2% +/- 15 µΩ
Enhanced Measurement Characteristics Requires Activation			
Voltage	0 to 12 volts	2mV	0.1% +/-5mv
Ohmic Value	0 - 5mΩ	1µΩ	2% +/- 8 µΩ
Temperature -ve post (optional)	2 to 80ºC	0.01ºC	+/- 1ºC
Mechanical			
Fiber optic range	Min: 150mm (6”) to Max: 50meters (150 ft)		
Dimensions	4.2" x 3.1" x 0.9" 107mm x 80mm x 23mm		
Mounting pads	3M Dual Lock™		
Base plate with mounting holes	Optional		
Base plate with DIN rail mount	Optional		
Enclosure Material	ABS		
Wire lead length	40 - 72 inches		

DCM6-H

The DCM6-H is designed to work from 12- 80 volts. It will work on 4, 6, 8, 12, 16-volt containers provided the total voltage between the white and brown wires is >12 volts. Use the DCM6-L on 2-volt cells. The container voltage restriction is the only installation difference between the DCM6-H and the DCM5.

Please note that the DCM6-H has a lower quiescent current than other DCM models and so must not be mixed on the same string of containers. It can however operate on the same fiber optic loop as previous DCM models.

DCM6-H Specifications			
Description	**DCM6-H**		
Environment			
Operating temperature	0 to 60ºC		
Relative Humidity	5 - 85% non-condensing		
Maximum Altitude	3,000 meters (10,000ft)		
Power supply full functionality	12-80 Volts DC		
Protection			
Transient suppression	600W		
Short circuit protection	Internal 1-amp fuse		
Reverse polarity protection	Any combination		
Insulation resistance	1000 MΩs >1Kv		
Operating current			
Quiescent current	12mA		
Sleep current after 25 hours	<2ma		
During ohmic testing	0.5 amps		
Standard Measurement Characteristics	**Range**	**Resolution**	**Accuracy**
Voltage	0 to 80 volts	15 mV	0.1% +/-15mv
Ohmic Value	1 to 25.9mΩ	6.3µΩ	1.5%
Enhanced Measurement Characteristics Requires Activation			
Voltage	0 to 80 volts	2mV	0.1% +/-5mv
Ohmic Value	1 to 50mΩ	1µΩ	1.5%
Ripple Voltage	0 - 400 mVAC rms	1 mv	2% +/-5mv
Temperature -ve post (optional)	2 to 80ºC	0.01ºC	+/- 1ºC
Fiber Optic Specification			
Optic cable	Acrylic		
Sheathing	Fluorine containing polymer		
Fiber optic range	Min: 150mm (6”) to Max: 50meters (150 ft)		
Mechanical			
Dimensions	4.2" x 3.1" x 0.9"	107mm x 80mm x 23mm	
Mounting pads	3M Dual Lock™		
Base plate with mounting holes	Optional		
Base plate with DIN rail mount	Optional		
Enclosure Material	ABS		
Wire lead length	40 - 72 inches		

DCM6-R

The DCM6-R is designed to measure string ripple voltage on 2 volts cells up to a maximum string voltage of 300 volts. The white wire should be connected to the negative side of the Frontier cabinet fuse and the brown wire to the positive side. The DCM6-R is usually configured to be the last DCM on the fiber loop. You should null all the DCM6-R channels so that Frontier does not try to read voltage or Ohmic value.

DCM6-R Specifications			
Description	**DCM6-R**		
Environment			
Operating temperature	0 to 60ºC		
Relative Humidity	5 - 85% non-condensing		
Maximum Altitude	3,000 meters (10,000ft)		
Power supply full functionality	24 - 300 Volts DC		
Protection			
Transient suppression	600W		
Short circuit protection	Internal 4-amp fuse		
Reverse polarity protection	Any combination		
Insulation resistance	1000 MΩs >1Kv		
Operating current			
Quiescent current	12mA		
Sleep current after 25 hours	<2ma		
Standard Measurement Characteristics	**Range**	**Resolution**	**Accuracy**
Ripple voltage	0 - 5 VAC rms	1 mv	2% +/- 5 mv
String voltage	24 - 300 VDC	10 mv	0.5% +/- 100 mv
Mechanical			
Fiber optic range	Min: 150mm (6”) to Max: 50meters (150 ft)		
Dimensions	4.2" x 3.1" x 0.9"	107mm x 80mm x 23mm	
Mounting pads	3M Dual Lock™		
Base plate with mounting holes	Optional		
Base plate with DIN rail mount	Optional		
Enclosure Material	ABS		
Wire lead length	72 inches		

DCM6-L-CC

The DCM6-L-CC is designed to monitor charger cable connections. It is built using DCM6-L technology with a special cable harness that supports two power supply feeds to the device. It has built-in over-

voltage protection with an external fuse in the harness. The DCM6-L-CC uses 3-amp current to get the most accurate ohmic value measurement.

DCM6-L-CC Specifications			
Description	**DCM6-L-CC**		
Environment			
Operating temperature	0 to 60ºC		
Relative Humidity	5 - 85% non-condensing		
Maximum Altitude	3,000 meters (10,000ft)		
Power supply full functionality	4 - 9 Volts DC		
Protection			
Transient suppression	600W		
Short circuit protection	Internal 4-amp fuse		
Reverse polarity protection	Any combination		
Insulation resistance	1000 MΩs >1Kv		
Operating current			
Quiescent current	12mA		
Sleep current after 25 hours	<2ma		
During ohmic testing	1.5 amps		
Standard Measurement Characteristics	**Range**	**Resolution**	**Accuracy**
Ohmic Value	0 to 5mΩ	6.3µΩ	2% +/- 15 µΩ
Enhanced Measurement Characteristics Requires Activation			
Ohmic Value	0 - 5mΩ	1µΩ	2% +/- 8 µΩ
Mechanical			
Fiber optic range	Min: 150mm (6”) to Max: 50meters (150 ft)		
Dimensions	4.2" x 3.1" x 0.9" 107mm x 80mm x 23mm		
Mounting pads	3M Dual Lock™		
Base plate with mounting holes	Optional		
Base plate with DIN rail mount	Optional		
Enclosure Material	ABS		
Wire lead length	40 - 72 inches		

DCM5-DS

The DCM5-DS is designed for use in applications with short strings of two, three or four test points. These applications include 48-volt telecom sites, generator start batteries and any string with four or less containers. Previously, these installations utilized two DCM units to ensure the resistance of the charger or parallel strings did not impact Ohmic value readings. The DS stands for dual current sink which is the technology that allows it to replace two conventional DCMs.

The DCM5-DS looks similar to the DCM5T, but it has an extra black wire that is connected to the same post as the yellow sense wire at the center of the 48-volt string. This wire allows the DCM to have two independent Ohmic current sources each operating over half of the string.

The DCM5-DS should be wired to the jars in the same way as a conventional DCM but with the black wire on the same post as the yellow.

Warning: To prevent damage to the DCM5-DS the black wire must NOT be connected to either the white or brown DCM power wires

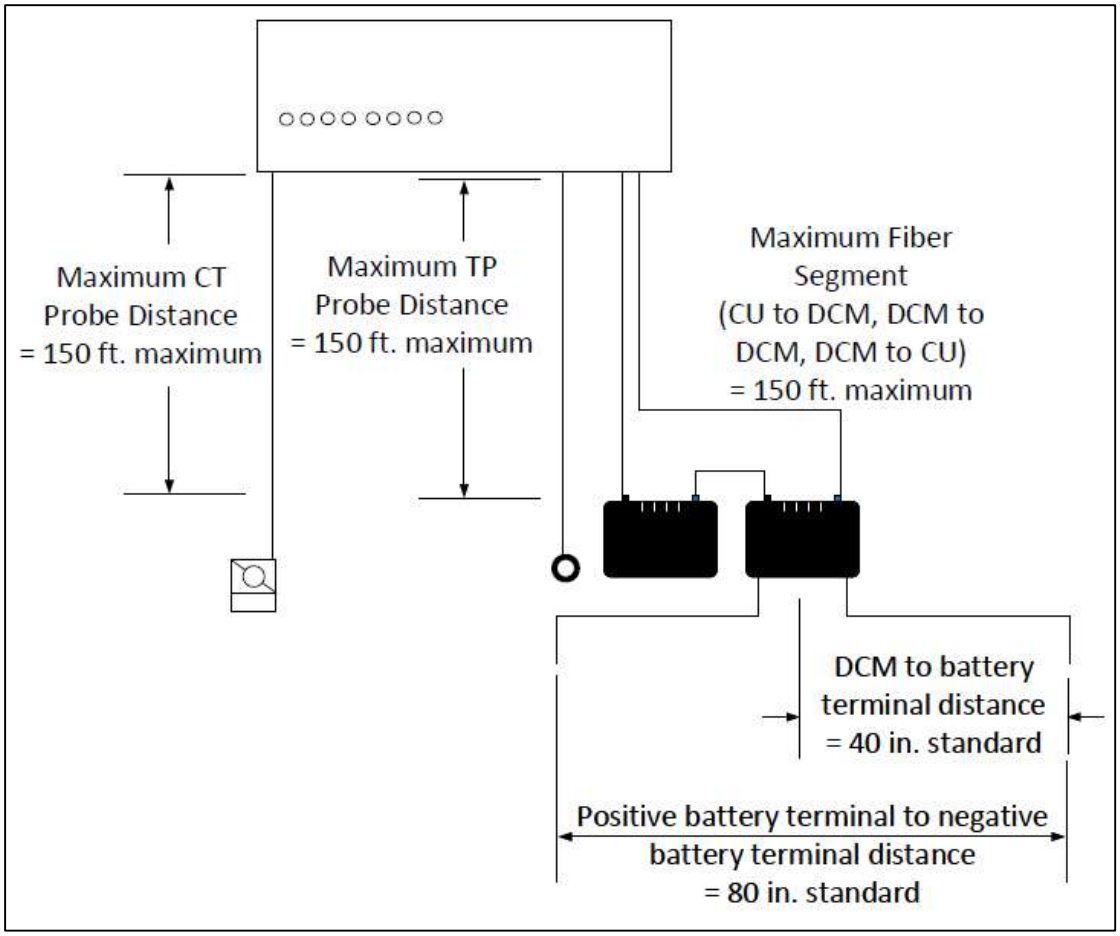
Note: The maximum operating voltage for the DCM5-DS is 60 volts so it cannot be used with four 16-volt jars.

DCM5-DS Specifications			
Description	**DCM5-DS**		
Environment			
Operating temperature	0 to 60ºC		
Relative Humidity	5 - 95% non-condensing		
Maximum Altitude	3,000 meters (10,000ft)		
Power supply	10 - 60 Volts DC		
Maximum voltage between black/white or black/brown	30 volts		
6 – 12 volt containers	2, 3 or 4 containers		
4-volt container	4 containers		
Protection			
Transient suppression	600W		
Short circuit protection	Internal 3-amp fuse		
Insulation resistance	1000 MΩs >1Kv		
Operating current			
Quiescent current	25ma		
Sleep current after 25 hours	<2ma		
During Ohmic testing	0.5 amp		
Measurement Characteristics	**Range**	**Resolution**	**Accuracy**
Voltage	0 to 60 volts	2mV	0.1% +/-5mv
Ohmic Value	1 to 65mΩ	1μΩ	1.5%
Temperature -ve post (optional)	2 to 80ºC	0.01ºC	+/- 1ºC
Ripple Voltage across 4 jars 40Hz - 1 KHz	0 to 4 volts rms	2mv rms	2% +/-5mv rms
Fiber Optic Specification			
Optic cable	Acrylic		
Sheathing	Fluorine containing polymer		
Core diameter	1.0 mm		

Outside diameter	2.2 mm
Wavelength	400-700 nm
Communication rate	9600 baud
Fiber optic range	Min: 150mm (6”) to Max: 50meters (150 ft)
Mechanical	
Dimensions	4.2" x 3.1" x 0.9" 107mm x 80mm x 23mm
Mounting pads	3M Dual Lock™
Optional base plate with mounting holes	
Optional base plate with DIN rail mount	
Enclosure Material	ABS
Wire lead length	36 inches

Critical Distances

The following are critical distances for a Frontier system. Current transducers and temperature probes have a maximum cable distance of 150 feet. Fiber segments, which run between the Frontier device and DCM units, cannot exceed distances of 150 feet. The leads of a standard DCM 6 (L or H) can be factory purchased at 40 inches or 80 inches long. Non-temperature capable DCM units may be extended an additional 40 inches in the field by ordering lead extension kits from NDSL.



Module to Module	Maximum Distance
Frontier to CT	150 ft. (45.7 m)
Frontier to TP	150 ft. (45.7 m)
Frontier to DCM	150 ft. (45.7 m)
DCM to DCM	150 ft. (45.7 m)
DCM to Battery (i.e. sense wires)	40 in. Standard DCM6 (36 inches for DCM5) 80 in. Optional DCM6 (72 inches for DCM5)

Mounting Options

The Frontier system is available in two different models. A wall mount model comes equipped with two side wings that allow the unit to be mounted to a hard non-conductive or grounded surface using a No. 6 Standard screw (0.138 in. or 3.505 mm). The wall mount unit can be mounted in an external box with minimum dimensions of 12 inches x 12 inches x 4 inches. The rack mount model is designed to be installed in a compatible 19-inch rack with 1U of available space. Note that due to the depth of the unit, connections may need to be terminated on the module prior to mounting on the rack.

The wall mount model weighs 1.6 lbs. and the mounting arrangement should be capable of supporting this weight, plus any user installed equipment and cables. If necessary, when mounting to drywall a backing plate should be used. The installer should use at least a ½" thick plywood sheet (covered with fire-retardant paint), or a 1/16" steel, or a 1/8" aluminum plate, for mounting. The plate should be at least 12" x 12" and large enough to be firmly secured by screws that go through the plate and dry wall, and then directly into at least two or more supporting studs. The wall mount unit should never be directly mounted to the drywall itself. A Frontier Wall Mount Cabinet Kit is also available.

Note: Strain reliefs should be used to prevent wires from being pulled out of the connectors unintentionally. This is especially important for the power cable. P-Clips are recommended but not supplied due to the variations in the installation of the cabling. It is very important that the placement of a strain relief for the power cable, or even the mounting location of the Frontier system itself, does not in any way restrict access to, or inhibit the action of disconnecting the power cable from the unit. The power cable is considered the disconnecting device for the Frontier system.

Exposed Installations

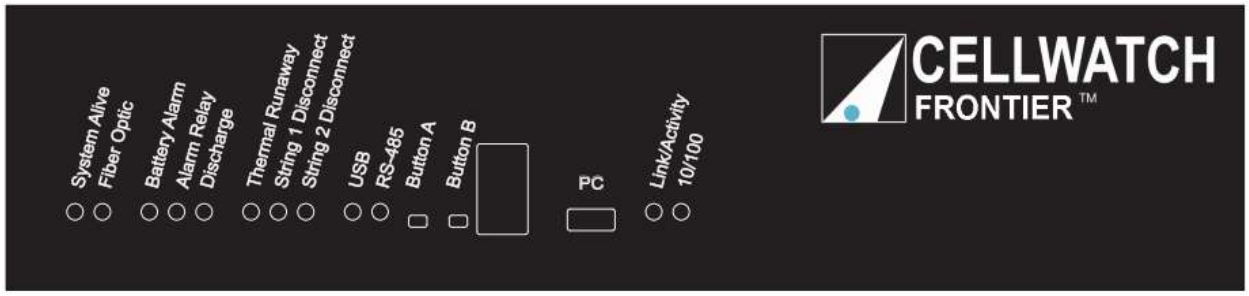
Frontier is designed for internal use only and should not be deployed outside or directly exposed to harsh weather environments. Installations that have the possibility of exposing the Frontier system directly to external elements, either through active fans or passively through vents, must be avoided. The Frontier unit could be protected from external moisture and debris by mounting the Frontier into a weather-proof enclosure or by deploying environmentally protected hardware.

Environmentally protected equipment will have a part number indicating the circuitry is protected. The part number will end in a –EP. The Frontier unit, Temp Probes, Current Transducers, FED units and FED adapters are available in EP. Contact NDSL prior to purchasing equipment for exposed installations to review available options.

DCM5-DS and FED Adapter part numbers indicating EP

Frontier Front Panel

The front panel of the Frontier wall mount model is shown below. The rack mount Frontier unit features a similar layout. For an explanation of the various status indicators located on the front of the Frontier unit, see the table below.



Status Indicator	LED	Description
System Alive	Slow flash	Powered on
Fiber Optic	Rapid flash	Flashes when FO communications are transmitted
Battery Alarm	Solid	Indicates an active battery alarm and relay activated if enabled
Alarm Relay	Solid	Indicates the alarm relay is active
Discharge	Solid	Indicates a discharge event is taking place
Thermal Runaway	Solid	Indicates thermal runaway conditions are present
String 1 Disconnect	Solid	Frontier has attempted to isolate a string from operation
String 2 Disconnect	Solid	Frontier has attempted to isolate a string from operation
USB	Flashing	Indicates USB service port activity
RS-485	Flashing	Indicates RS-485 activity
Link/Activity	Flashing	Indicates the Frontier system has been accessed via the network port
10/100	Flashing	Indicates network activity, not specific to the Frontier
Button	**Depress Time**	**Description**
A	Short (1-5 seconds)	Reload alarm limits
A	Long (10-15 seconds)	Reset the webpage password to default **admin**
B	Short (1-5 seconds)	Clear alarm relays

The USB ‘A’ port allows for the connection of a thumb drive to copy or remove files from the Frontier system. This function is not supported at this time.

The mini-USB (2021+) port allows a PC to be connected directly to the Frontier system and access the GUI via a USB to Ethernet bridge connection.

Note: Upon connecting the Frontier device to a Windows PC for the first time, the operating system will attempt to download drivers to access the Frontier. A USB to Ethernet/RNDIS Gadget Port driver will be downloaded and installed. It is highly recommended that the computer has a network connection with internet access to allow the operating system to download the proper drivers to

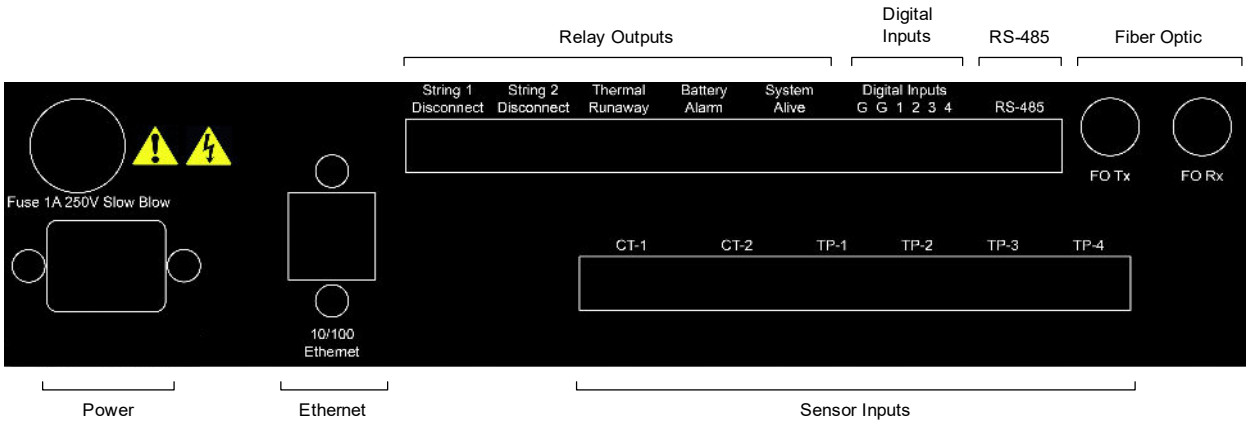
establish the connection. If needed an offline driver for Windows 7 and Windows 10 is available on the USB drive provided with the Frontier Unit.

Frontier Back Panel

The back panel of the Frontier system is explained in the following section.

Input Connections

The Frontier unit has various input connections as shown below. This section addresses the pin-out and wiring recommendations for each connection.

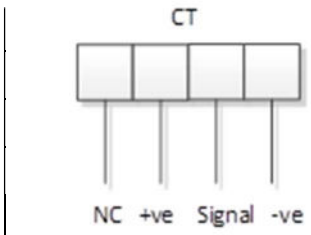


The back panel of the Frontier wall mount model. The rack mount Frontier (not pictured) features a similar layout.

Current Transducer (CT)

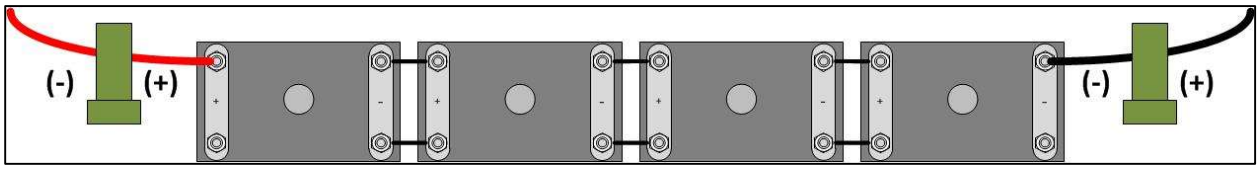
Current transducers can be connected to the Frontier system to monitor for discharge and charge events. Only use current transducers that are approved by NDSL. Below is the wiring diagram for connecting a CT to the Frontier unit.

Beginning from left to right:



Pin #	CT Connector	Wire Colors		
		50A, 100A, 300A		600A, 1000A
1	No Connection	White	White	No Connection
2	+Ve	Red	Red	Red
3	Signal	Green	Yellow	Green
4	-Ve	Black + Screen	Blue + Screen	Black + Screen

It is important that the current transducer face the proper direction to correctly identify a discharge event. The (+) of the transducer should face the containers if installed on the positive bus of the battery. The (-) of the transducer should face the containers if installed on the negative bus of the battery. **T**owards **I**f **N**egative, **A**way if **P**ositive is an acronym often used for remembering the direction of current flow in the current transducer. The T.I.N.A.P. method still applies for the directional arrow. The arrow should face towards the battery if positioned on the negative bus and away from the battery if on the positive bus.



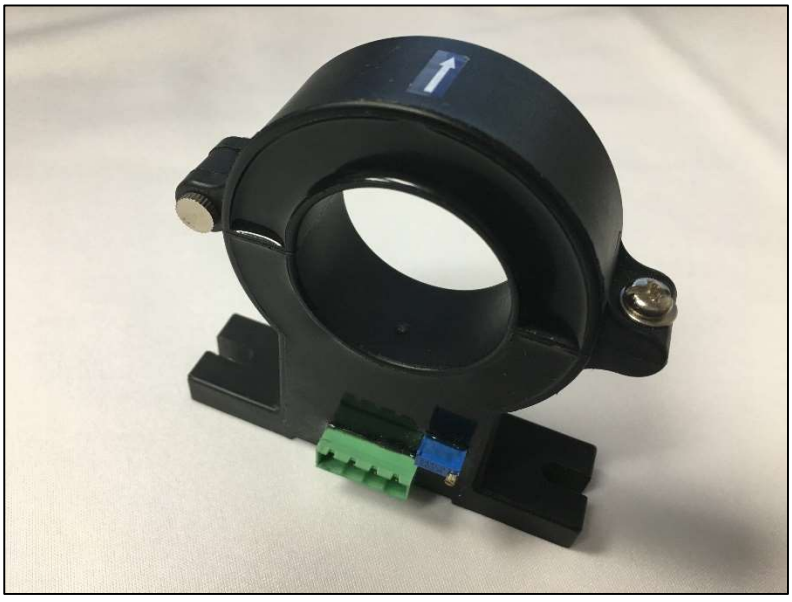
Direction of current transducer on positive or negative bus cable

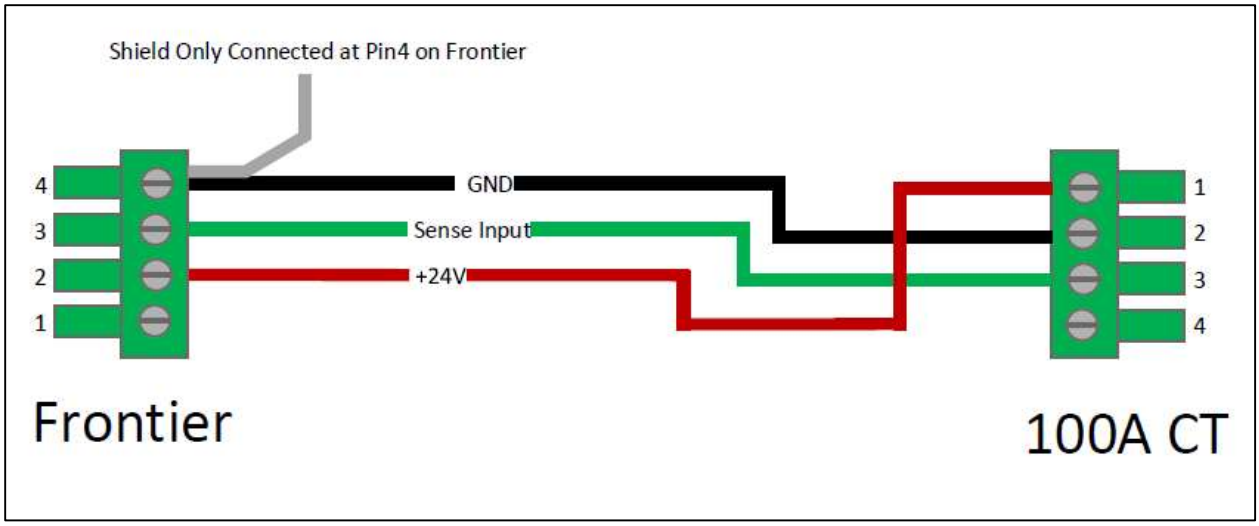
The standard current transducer used in a Frontier system has a 100A range to monitor for discharges. Current transducers with different ranges have been approved for use with the Frontier and can be found in the table below.

NDSL approved current transducers:

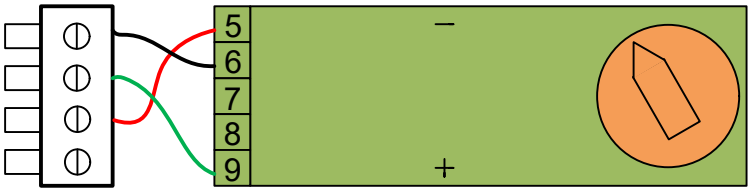
Function	Range(s)
Charge CT	5A
Discharge CT	50A, 100A, 300A, 600A, 1000A

The various types of discharge current transducers are shown below along with the wiring specific to each unit.

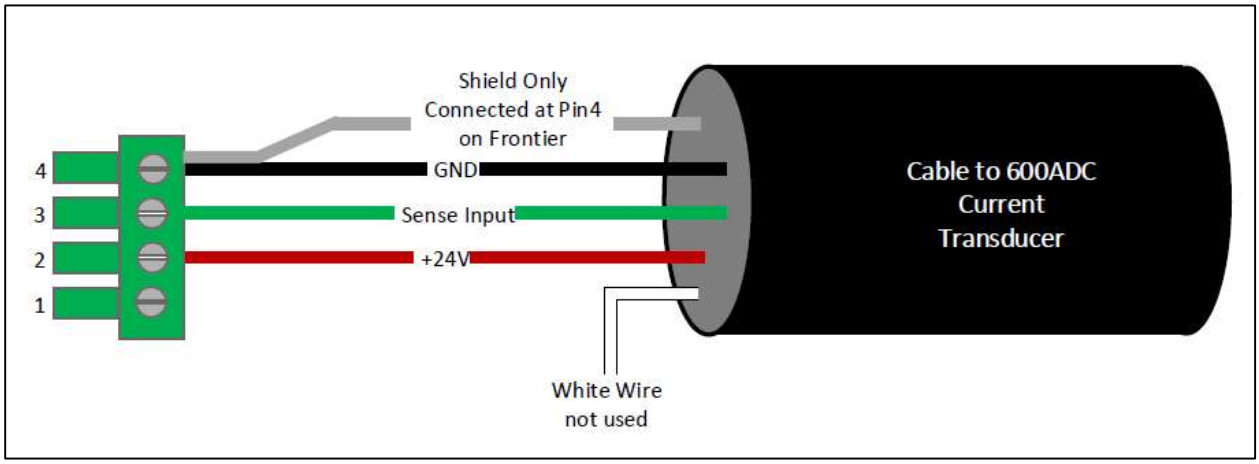




100A and 600A black low noise current transducer wiring



50A, 100A, 300A green current transducer wiring



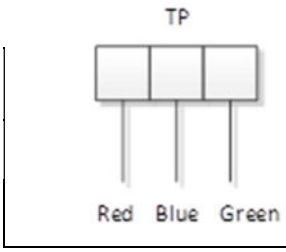
600A and 1000A larger black current transducer wiring

Note: Only current transducers provided through NDSL are tested and approved to work with the Frontier unit.

Temperature Probe (TP)

At least one temperature probe, per Frontier unit, should be used as an ambient temperature sensor. The wiring for temperature probes can be found below.

Beginning from left to right:

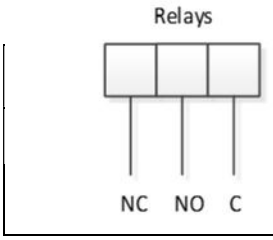


Pin #	Color	
1	Red	Red
2	Blue	White
3	Green + Screen	Black + Screen

Relays

There are four relays provided by the Frontier unit. Below are their predefined functions and connections:

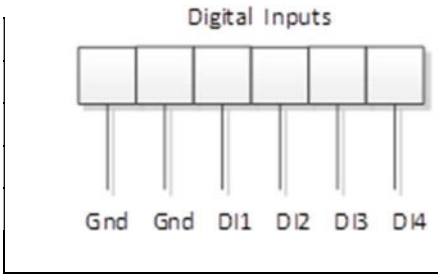
- **System Alive:** Relay will indicate if the Frontier system has stopped functioning.
- **Battery Alarm:** Relay is programmable by the user for any combination of alarm events, including voltage, Ohmic value, temperature, discharge current, low electrolyte, or hardware failures.
- **String 1 and 2 Disconnect:** Available if Thermal Runaway monitoring is enabled. The relay will disconnect the string from operation by going active for 15 seconds if all thermal runaway conditions are met. See the Thermal Runaway section of the manual for more details.



Pin #	Description
1	Normally Closed
2	Normally Open
3	Common

Digital Inputs

Four digital inputs are provided. Each input shares a common ground that is optically isolated from the Frontier device and the power supply. Digital inputs can be used to incorporate third party systems and notifications into the Frontier module. This may include devices such as ground fault monitors, electrolyte level detectors, hydrogen sensors, liquid/electrolyte leak detection systems. Connect the digital input to a volt-free, form C dry contact and return the signal to pins 1 or 2, ground.



Pin #	Description
1	Ground (common)
2	Ground (common)
3	Digital Input 1
4	Digital Input 2
5	Digital Input 3
6	Digital Input 4

Power (AC)

Frontier is powered from the AC mains at 100-240 VAC.

When using AC power, use the supplied power adaptor cable to connect to an acceptable AC outlet. It is recommended to power the Frontier from a UPS to ensure the Frontier module can properly detect and capture discharge events. If AC mains is used without a UPS, then the Frontier unit will power off in the event of power loss and will remain off until AC power is restored.

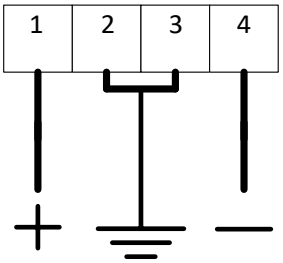
Use only the AC power cable that was supplied with the Frontier system. Contact NDSL if a replacement cable is needed.

Power (DC)

Frontier has two DC power options that allow it to be powered directly from the battery.

Option 1. 20-70 VDC allows connection to a 24V or 48V battery.
Option 2. 70-150 VDC allows connection to higher voltage batteries (e.g. 120V)

Internally, the Frontier uses an isolated DC-DC converter to prevent its ground from grounding the battery that powers it. For safety, please ensure that you connect the power input ground to a suitable ground point. It is recommended that you use 16-gauge 300V wire to connect DC power to the Frontier.



DC power connection. Pin 2 or 3 can be used for ground.

Fuse

Frontier uses a 1A, 250VAC, slow-blow fuse. The fuse is replaced by first removing power from the Frontier unit. The fuse cap is then turned counterclockwise and removed. The fuse is captured in the cap. The blown fuse is pulled out of the cap and the fuse is discarded. A replacement fuse of the

correct rating is inserted into the cap and then the cap is screwed back onto the fuse holder base on the back of the Frontier.

Warning: Remove power from the Frontier unit before replacing fuse! Use rated fuse only!

Fiber Optics

The Frontier device connects via fiber optics to Data Collection Modules (DCM) that read cell voltages, ohmic values, AC ripple voltage, and cell temperature (DCM 5T only). Frontier can communicate with up to 64 DCMs, which allows it to monitor up to 256 channels.

All fiber optic connections connect from blue to black. The blue fiber optic connector is the transmit port. The black fiber optic connector is the receive port.

Blue = Transmit

Black = Receive

Fiber optic communications are continuous unless a break in the fiber loop is detected. If a break is detected, Frontier will generate a battery alarm and a **DCM Failure** error will appear in the user interface. The **Battery Alarm** relay will trip if it is configured to do so. Frontier will attempt to reestablish communications every hour for 48 hours. After 48 hours have passed, communications will not be reestablished until all hardware issues are resolved and the user manually resumes scanning in Diagnostics. This is done so that the DCM units can enter a low current draw state (i.e. Sleep mode) in order to protect the batteries from continual current draw.

Connection Strain Relief

Strain relief should be used to ensure connections do not come loose during normal scheduled maintenance. It is recommended to use a P connector or alternate form of strain relief to reduce the stress on the wires connected to Frontier. Fiber optic cables do not require strain relief.

As an extra precaution, ensure a drip point is provided in the wires to prevent water or other liquids from traveling down a wire and into the Frontier device.

Installation: Data Collection Modules (DCM)

This section of the manual will walk the installer through mounting, placement, and installation of the tab washers and DCM units. Use the following simple rules to aid in placement of DCM hardware.

Rules for Placing DCMs

1. Whenever possible, a DCM should be installed on the container(s) it is monitoring or mounted on DIN rail.

2. Avoid fixing the DCM onto metalwork. Electrical noise can be radiated from the metalwork even if the frame is grounded and this can cause reading variations within the DCM.
3. Always place the DCM tab washers next to the battery post or strap. Never place any stainless-steel material between the battery post and the tab washer. Stainless steel is very resistive and may offset ohmic value readings.
4. Beware if a DCM is installed across a battery breaker or an open jumper between two cells. If the battery voltage is greater than 80V, opening the breaker could potentially damage the DCM. Always keep in mind the minimum operating specs for the type of DCM you are working with. Non-activated DCM 5 units operate at 4.5-60V while activated DCM 5 and DCM 5T units operate at 4.5-80V. DCM6-L units operate at 4-12V and DCM6-H units operate at 12-80V.
5. Always dress excess DCM wire in 'sticks' and not coils. Carefully fold the wires back on themselves and avoid creating loops. Loops create inductors that can cause variability in readings at low ohmic values.
6. Avoid grouping brown and white power leads with sense leads. Keeping power and sense leads separated reduces the risk of cross talk between the power and sense leads.

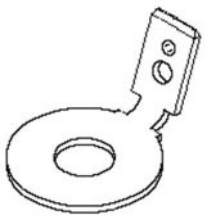
Preparing the Battery

There are a few basic steps that should be taken into consideration when preparing to tab the battery and install the DCMs. While the 3M™ Dual Lock™ fasteners on the DCM will not harm the battery, some users prefer that DCMs are mounted to another surface, often Panduit or Plexiglas covers. NDSL also offers a DCM with DIN rail mounting capabilities as an alternative way to mount DCMs. Dual Lock™ fasteners provided can be used on other surfaces such as Plexiglas or fiberglass suspended above or close to the batteries. DCMs should not be installed on the metalwork of the cabinet, rack, or stack.

The best placement for a DCM is often on the cells or container(s) it is connected to.

Tabbing the Battery

Several ring tab washer sizes are available to match the majority of termination bolt sizes. These are 3/16" (5 mm.), 1/4" (6.3 mm.), 5/16" (8 mm.), 3/8" (10 mm.), and ½" (12 mm.). Tab washers are provided as they are less likely to fall away from the battery and can be torqued to manufacturer specifications. Make sure you have the correct size for the cells you are monitoring by checking battery manufacturer specifications for bolt sizing.



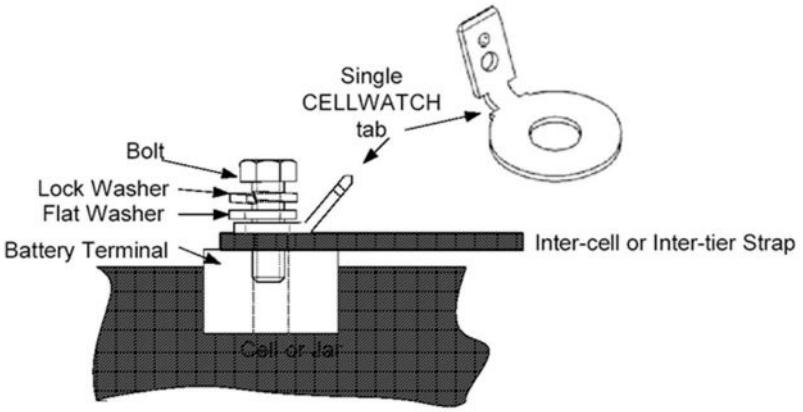
For accurate readings, particularly on low ohmic value cells or containers, connect the DCMs to the tin plated (lead-free) copper and brass tab washers provided by NDSL.

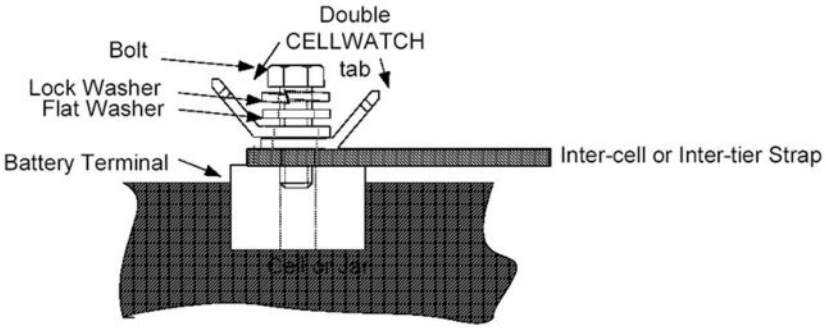
Note: Stainless steel tab washers or dual tab washers should not be used unless by prior agreement with NDSL. Stainless steel and dual tab washers may generate higher ohmic readings due to the higher resistance of the metals and/or common resistances.

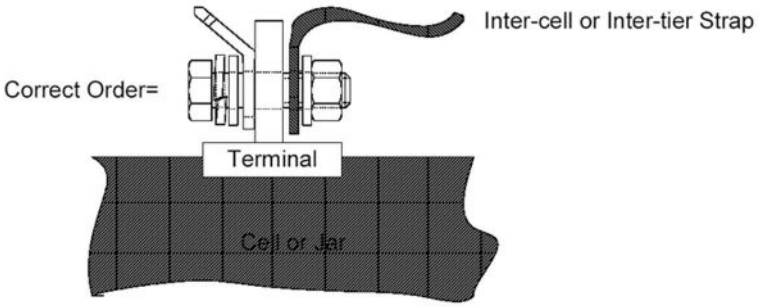
Ensure that the tab washers are fitted as close to the post of the cell or container being monitored. Make sure that the tab washers are either against the battery post or against the inter-cell strap.

Other methods such as clip-on connectors can be used if approved by NDSL in advance. Use caution with any connector as all exposed metal should be considered live. Clipped or C-Style connectors are discouraged as they could become unsecured and create a short by touching grounded metal or the battery.

Note: Do not place stainless steel washers, nuts, or any other hardware between the tab washers and the battery post.







As shown above, there should never be any other material between the straps or post and the tab. Ensure that the tab is directly against the lead post of the cell or on top of the load carrying cables. Where double tabs are needed, never place any material between the two tabs and the post or strap. In particular, never place a stainless-steel object between the post, strap, and tab such as a washer or nut. Stainless steel is 50x more resistive compared to copper and will affect the measurements.

Note: When installing multiple tabs on the same post, orient the tabs so that they are not overlapping to allow for easier DCM connections.

When possible, containers should be tabbed during battery installation. Otherwise, to fit the tab washer onto the cell the link must be broken, the tab installed, and the link torqued to manufacturer specification. For safety purposes, always take the battery offline when installing tab washers. DCMs will connect directly to these tab washers.

See the section titled *Battery Configurations* for installation practices on various battery configurations.

Two power wires are used to operate a DCM. The brown and white leads supply power to the DCM. These power leads are often paired with the blue and red sense leads. Therefore, on connections where the red and blue sense wires connect, there will be additional tab washers for the brown and white wires. On cells where two DCMs will be connected to the same post there may be a requirement of 4 or more tabs.

DCM Channel	DCM		Cell	
	1st Sense Wire	2nd Sense Wire	# Tabs on Positive Post	# Tabs on Negative Post
1	Red	Orange	2 (Brown, Red)	1 (Orange)
2	Orange	Yellow		1 (Yellow)
3	Yellow	Green		1 (Green)
4	Green	Blue		2 (Blue, White)

Standard tabbing diagram for a DCM monitoring 4 measuring points (or Channels)

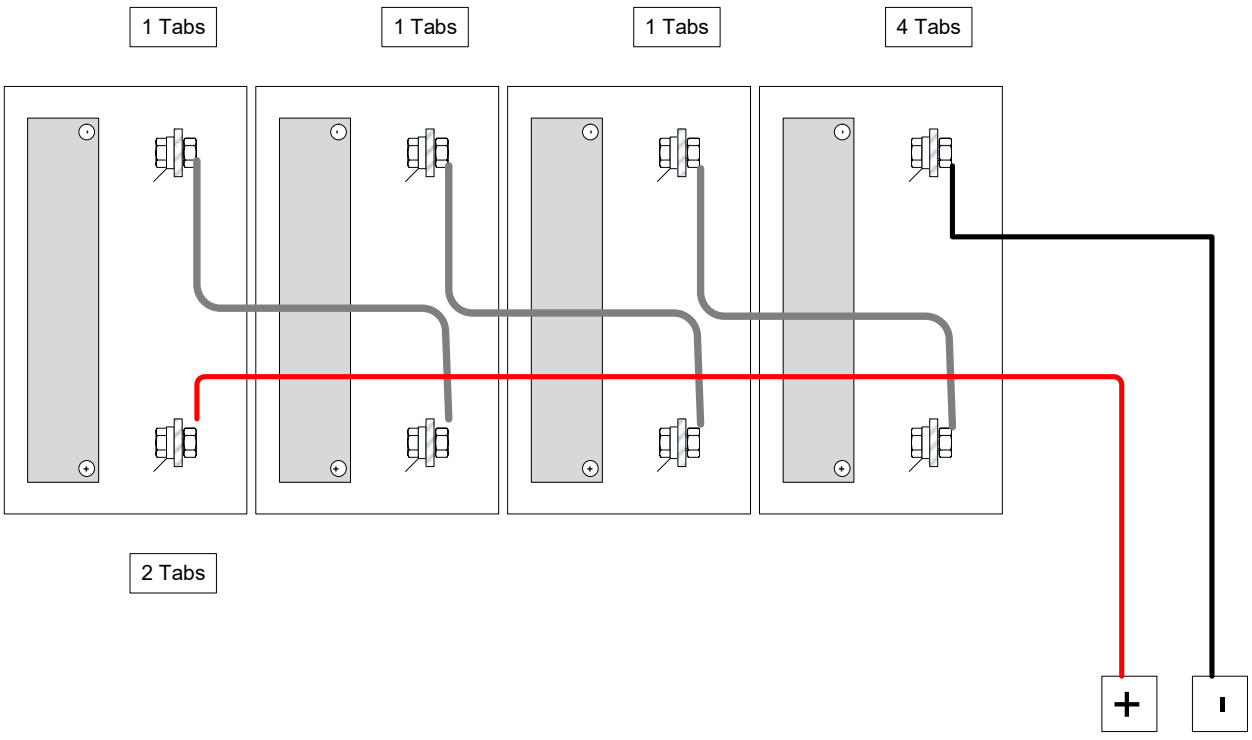
For systems where the number of measuring points is not divisible by four, one or more DCMs will have 'null' channels. To null channels, all sense wires for that channel are terminated on the same post or

unused posts; the unused channel must then be nulled in the Frontier web interface. Channel 4 should always be considered the first channel to be nulled, followed by 3, then 2. This is covered in further detail in the next few sections.

Every Negative Post method (systems divisible by four)

There are a number of ways the battery can be connected to the DCMs depending on the space available. The ideal method is the “Every Negative Post” method. Using a DCM equipped with temperature sensors, the Every Negative Post method allows the DCM to monitor for changes in temperature at the negative post of the cell. The steps for this method can be found below along with accompanying illustration.

1. Tab the most positive terminal of the first cell or container of the string with two tab washers. This is the only positive terminal that will be tabbed.
2. Tab the next three negative terminals with a single tab washer.
3. Tab the next negative terminal with four washers. This is the connection for the termination of the first DCM and the first connection of the second DCM.
4. Repeat steps 2 and 3 until the last negative post of the battery is reached. Place two tab washers on this post.



Tabbing for Every Negative Post method

Battery Configurations

There are several battery installations which require an alternate approach. By understanding these, an unusual installation can be accommodated.

- VRLA installation on shelves or small cabinets
- VRLA installation on open racks
- VRLA stacks with front access
- VLA (flooded) cells on open racks

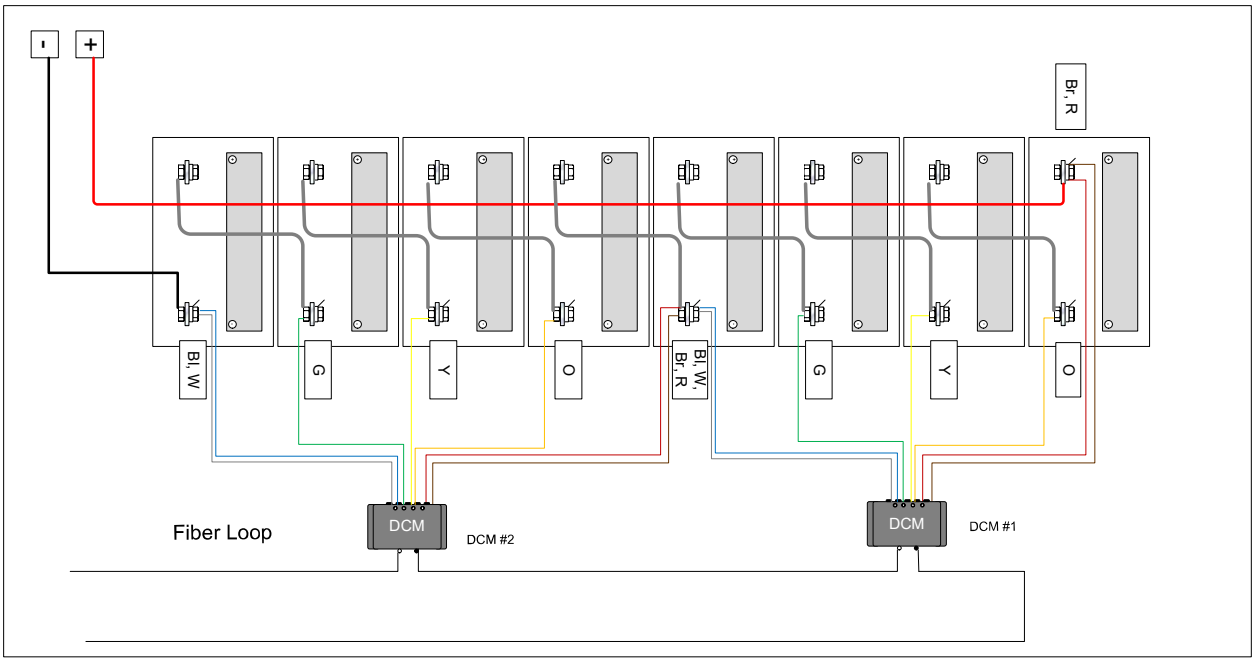
The DCM 5T is necessary for thermal runaway protection on open rack systems due to the temperature variances across the string. Small cabinet or contained systems are often small enough that a single ambient probe will suffice in monitoring overall temperature and can adequately detect thermal runaway conditions.

It is important to identify the type of installation using the outline above. Typically VLA or high amp-hour VRLA systems will have ohmic values below the 0.5mΩ range. Readings in this range can be impacted by both tab location and DCM wire dressing. It is always important to properly torque the battery, never to have stainless steel between the tab washer and the terminal post, and to consider DCM wire lengths and wire dressing.

The smallest capacity rated container that can be monitored and still meet our DCM specification is 28Ah (ampere hour) per DCM test point.

VRLA shelves in a cabinet, stack, or open racks and VLA in open racks

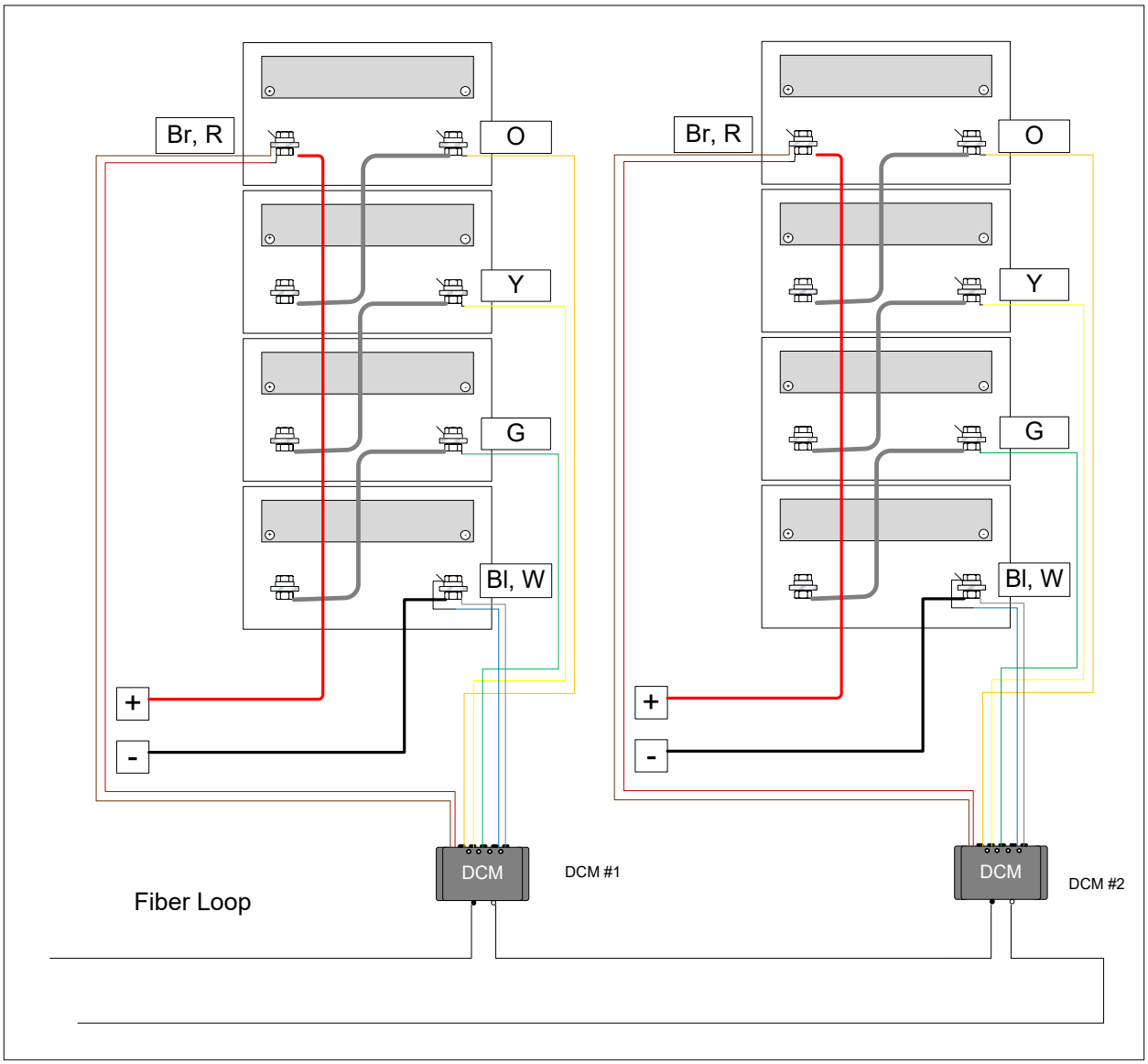
VRLA batteries can be stored in multiple configurations depending on the make and additives to the cells. Strings on open racks can be configured in a variety of ways with multiple inter-tier configurations. Regardless of the physical layout, it is important to identify the number of cells that will be monitored in this system. Configurations that are easily divisible by four (4 monitoring points) can quickly be tabbed for DCMs. The tabbing and installation process is replicated for every four cells as shown below. For systems that are not divisible by four, see the section titled *Short strings*. For systems where battery trays are used for easy removal of the cells, see the section titled *VRLA installation on four-jar trays*.



Standard DCM wiring to a string that is divisible by four

VRLA installation on four-jar trays

In a four-jar (or mono-bloc) per tray configuration, one DCM per tray should be used. If possible, disconnect battery trays to a safe voltage. Identify the most positive and most negative ends of the tray and ensure that they are double-tabbed. The remaining three negative posts should have a single tab washer fitted.



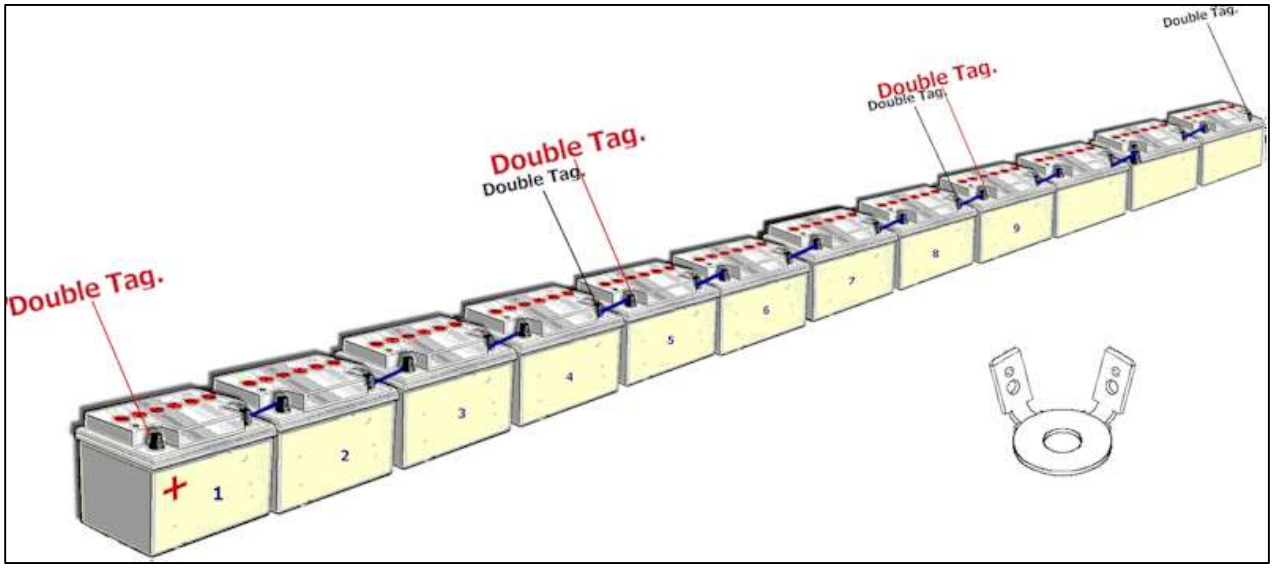
If a tray is equipped with isolation quick disconnects, it is important not to install the DCM across a quick disconnect. If a connection is opened, the DCM could be subject to high voltages and the battery may not be completely isolated as a result.

Systems with two tabs maximum per post

If bolt length does not permit four tab washers on a post where two DCMs meet, as shown above, the following method can be used.

1. Tab the most positive terminal of the first cell or container of the string with two tab washers. This is the only positive terminal that will be tabbed.
2. Tab the next three negative terminals with a single tab washer.
3. Tab the next negative terminal with two washers. This is the connection for the blue wire of DCM *n* and the red wire of DCM *n+1*.

4. Place two tab washers on the next positive post connected on the opposite side of the strap connected to the dual tabbed negative post. This is the connection for the white wire of DCM *n* and the brown wire of DCM *n+1*.
5. Repeat steps 2 through 4 until the last negative post of the battery is reached. Place two tab washers on this post.



Double tabbing the battery

Short strings

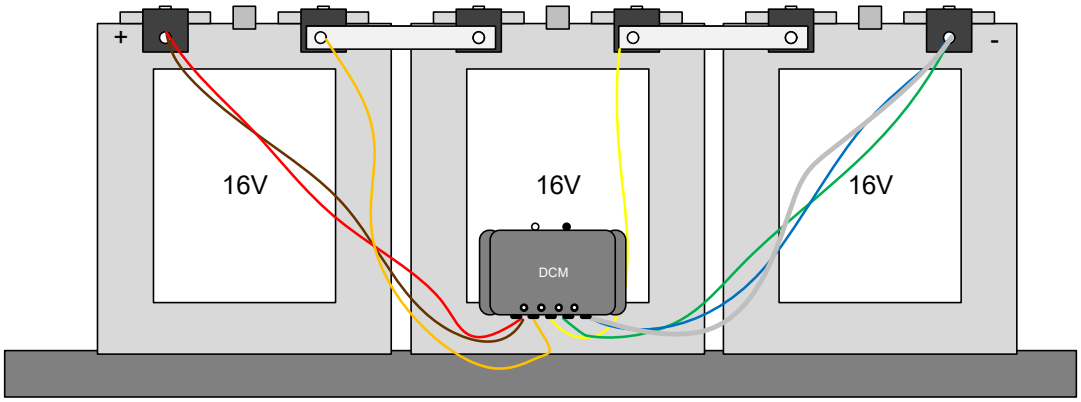
A battery configuration where the number of cells or monitoring points is not divisible by four will require special consideration for the connection of DCMs. To monitor these strings, a DCM will likely have null channels. The DCM can be fitted on a wide range of voltage and can monitor as little as 4 (qty.) Ni-Cd cells and as many as 4 (qty.) 16V VRLA containers.

Channel	1st Sense Wire	2nd Sense Wire
1	Red	Orange
2	Orange	Yellow
3	Yellow	Green
4	Green	Blue

Note: The Red and Blue sense wires are often paired with their respective Brown and White load wires for the DCM.

Should null channels be required, then the channel sense wires on one of the DCMs on the string will be tied together beginning with channel 4. For instance, a string of 30 measuring points would have 2

nulled channels on one of the DCMs, or a single channel on two DCMs. In the example below, channel 4 is nulled, meaning that the Green, Blue, and White wires would terminate on the same post.



Three-jar tray example nulling 4th channel

Note: Always start nulling from channel 4 first, then channel 3, and finally channel 2.

Considerations for high ampere-hour, low ohmic value VLA and VRLA

Any errors or variances introduced in ohmic value measurements can easily mislead the user in these configurations. In particular, it is recommended to:

1. Ensure tab washers are as close to the terminal post as possible (as described previously).
2. Ensure that there is no material between the tab washer and the terminal.
3. Do not install the DCM to the metal frame of the rack/stack.
4. Use a small amount of non-corrosive battery grease on the tab washers to reduce the possibility of corrosion. Conductive silver-loaded silicon grease can also be used.
5. Consider eliminating the inter-tier straps if they are not monitored individually.
6. Landing both power and sense leads on the same ring tab contact point will increase resistance readings. Best practice is to keep sense leads on a separate ring tab than the power leads.

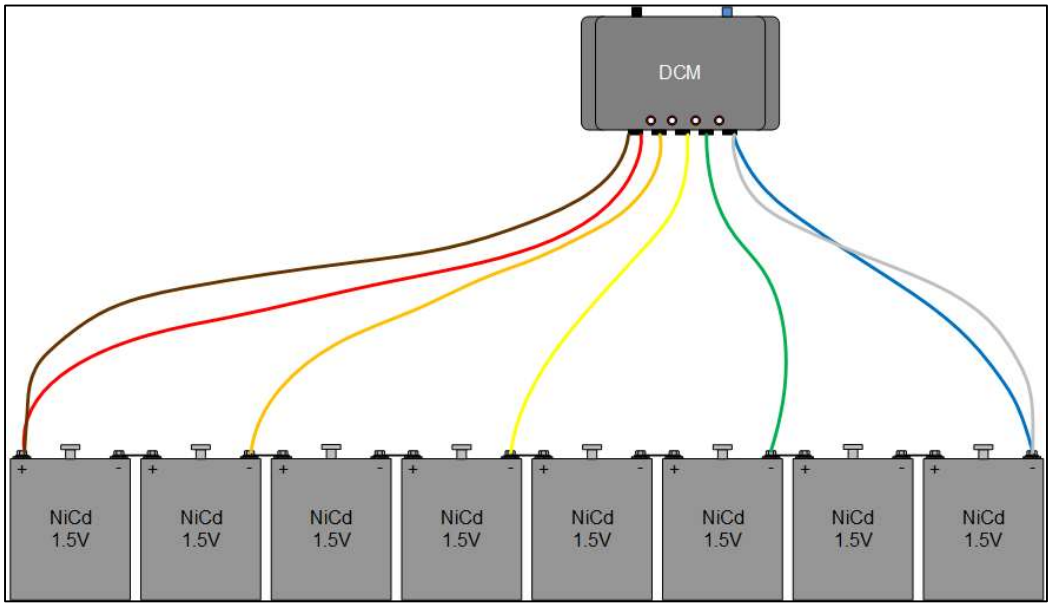
If measuring stacked, front terminated, bussed batteries, take great care to balance the channel measurements through tab washer location. This can be done by keeping all sense tabs on the same side of the cell.

Considerations for cells with four or more posts

Some installations, typically in open rack or stack configurations, may have more than one positive and negative post per cell. If there is more than one positive post, it is recommended to terminate the brown and white wires on the same post and the red and blue wires on the same post. This removes offsets that could be caused by current flowing through a tab washer providing a more accurate reading.

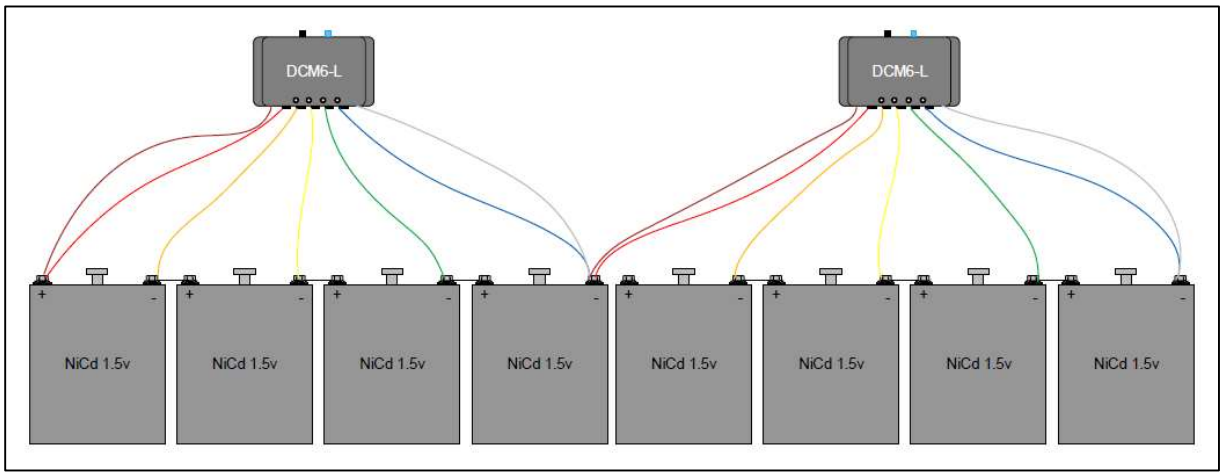
Considerations for low voltage jars

The operational voltage of the DCM must be considered when monitoring a string. The DCM must be wired so that at least 4.5V (DCM5) or 4V (DCM6) is supplied between the power leads (brown and white). If the cells monitored cannot supply enough voltage to power the DCM, then the DCM must be wired across more cells than typically connected. When wired this way, each channel in Frontier will measure across two jars. This will affect ohmic and voltage readings but will still allow the user to monitor the health of their battery.



Connecting the DCM5 across 2 NiCd jars per channel ensures that if one or more jars drops below its recommended charging voltage, the DCM will continue to operate.

The DCM6-L allows the system to monitor each cell. The DCM6-L can operate at voltages as low as 4V so it can be wired across as few as three NiCd cells. Normal wiring would have a single DCM6-L monitoring across four cells.

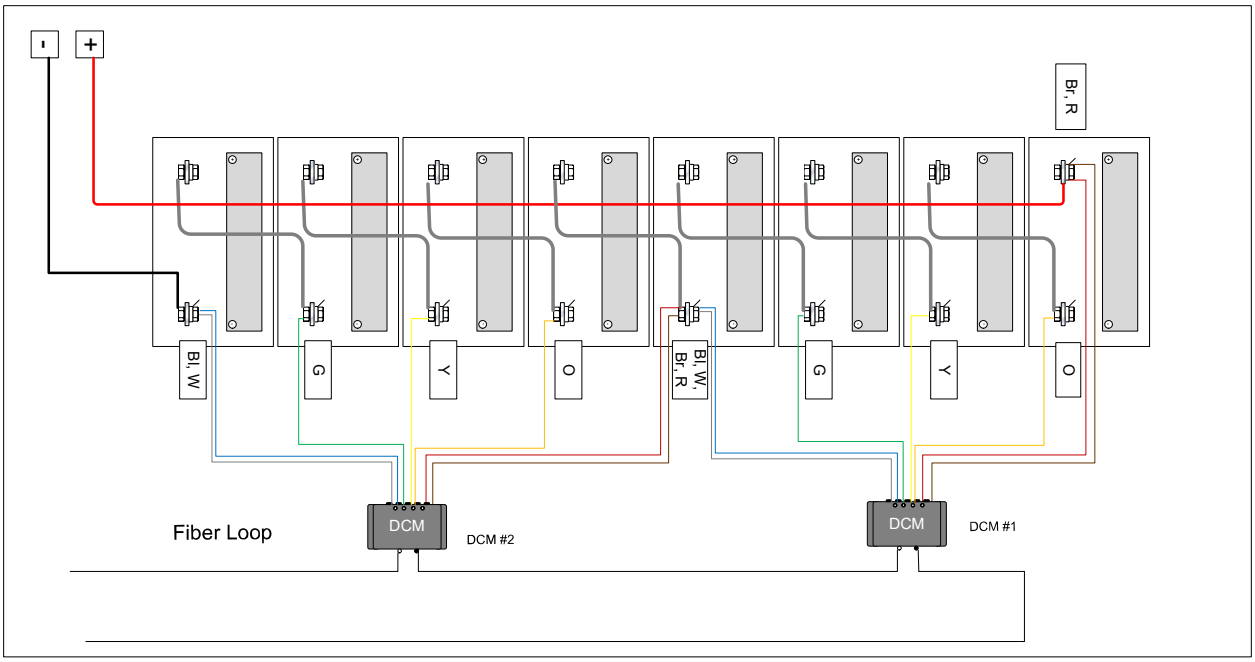


DCM6-L wiring for NiCd jars

If the number of cells in the string is not divisible by four, ensure each DCM6-L is wired across at least three cells. Most of the DCM units on the string will monitor four cells with the last one, two, or three (depending on the remainder) monitoring three cells.

Connecting a DCM

The DCM wire order of connection is not important when powering on the DCM, but placement of the wires to the cells is very important. Built-in circuit protection allows the DCM to be connected across the cells in any configuration and not damage the battery. Follow the connection diagram to ensure the DCM is connected properly; it is replicated here for easy reference:



When powered on, the DCM will emit an audible “beep” and flash the LEDs. Once powered on, the DCM is active and will remain active drawing current from the battery regardless of the open or closed state of the battery. The DCM is equipped with a deep sleep mode that will drop the DCM current draw to below 3 mA after 25 hours of inactivity, allowing the battery to survive a longer duration with a parasitic load connected.

- Do not connect the DCM to the cells such that any potential between any leads exceeds the operational voltage of the DCM. Connecting the DCM to excessive voltages beyond the functional range may damage the unit. The DCM is designed to withstand temporary high over-voltage conditions or reverse wiring conditions but will not withstand excessive voltages long term.
- Always secure the DCM wires by connecting to a tab washer. Do not allow loose DCM wires to hang in the cabinet. Excess wire should be dressed in a clean manner by zip tying the wires to themselves in “sticks.” Cables can and should be routed between cells to provide a clean appearance.

Standard maintenance around the DCM (i.e. replacing a cell)

When replacing a cell, the DCM connected to or across the cell that is being replaced should be removed entirely. Document the location of the wires and the directional path of the fiber optics. Using colored tape can help ensure that the fiber optics are connected properly.

There is always a risk of circuit completion (i.e. a short) on a battery that can result in the whole battery voltage or partial battery voltage being placed across a single DCM if a battery or inter-tier link is removed.

Damaged DCM units should not be reconnected to the battery for any reason. Always replace a DCM with same model or compatible DCM.

Note: DCM specifications may change with each generation and may not be compatible replacements for older models on the same string due to differences in current draw.

DCM location

The grounded chassis of battery cabinets or steel battery racks can radiate large amounts of high frequency electrical noise. The DCM is carefully "hardened" against EMC radiation but cannot withstand all radiation. In 1% of cases or less, fixing the DCM directly to a grounded steel cabinet or rack may cause a degradation in data measurements, variability in ohmic readings, or in rare cases data corruption. It is for this reason that NDSL recommends that the DCM be affixed to the battery (or Panduit/DIN rail) with the 3M™ Dual Lock™ strips provided. Stick the DCM to the front of the front most block or container, ensuring no safety or other labels are being covered. Dress all DCM cables using the cable ties provided, making sticks and not loops with excess cable.

Note: We always recommend fixing the DCMs to the insulated battery cases that are being monitored as opposed to the steel cabinets or racks. This is to avoid electrical interference from "Ground", as the noise radiated from the metal work is unknown.

Other considerations when placing DCMs

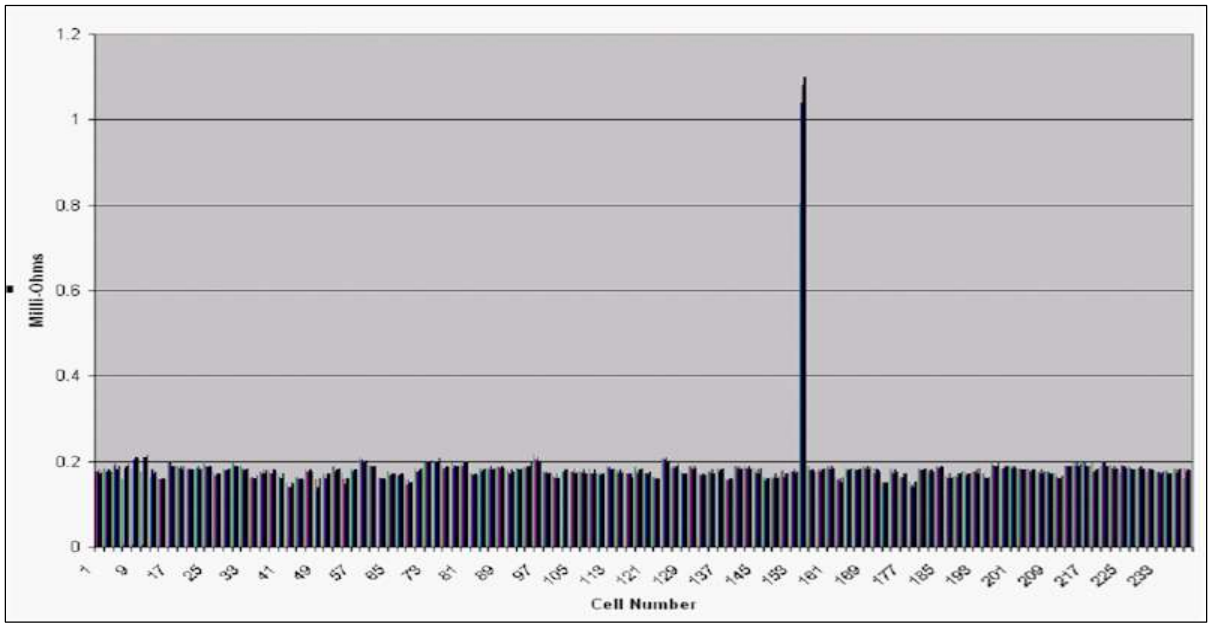
Other considerations should be evaluated when installing the DCMs on the battery system. These include but are not limited to:

- Monitoring inter-tier links
- Monitoring all inter-cell straps
- Monitoring DC bus cables
- Monitoring cell temperatures
- Strings not divisible by four
- VLA cells with dry cells
- 16V VRLA configurations

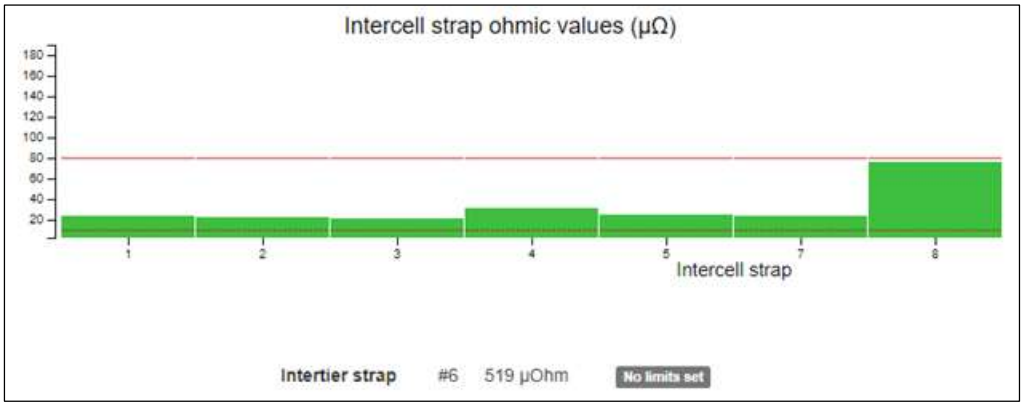
Each consideration will be addressed. For additional information or questions, contact NDSL Technical Support.

Long inter-tier links

If you have a battery installation that is broken up by long inter-tier or even inter-aisle cables, you will need to consider if you want to keep these in the measurement data set or omit them.



Shown is a graph of a 200µΩ per container (4V wet cells) battery system whose installer kept a single inter-aisle conductor in the measurement circuit. The ohmic-value of that inter-aisle link is clearly visible on the graph and will skew the averages for the entire string. However, Frontier can automatically adjust for this in setting ohmic value alarms. Altering the installation to remove the inter-tier connector can remove readings like this from the graphs. However, the ohmic value of the inter-tier connector would no longer be monitored.



Inter-tier links are separated from Inter-cell links for better scaling.

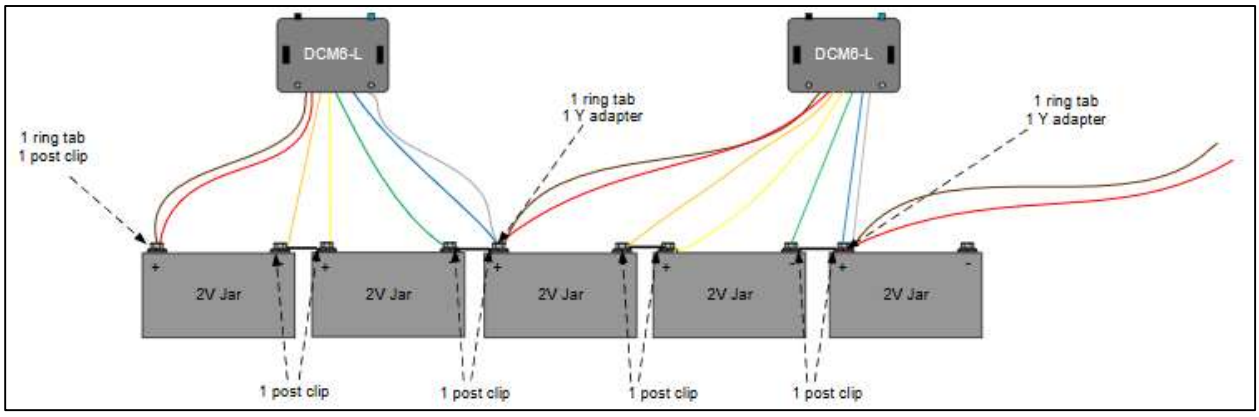
In Frontier, one or more channels can be specified as an inter-cell link, an inter-tier link, or a charger cable. Frontier will separate these channel readings from cell readings in order to provide better scaling with graphs while still allowing the link(s) to be monitored. A DCM unit equipped with Extended Leads can be used to monitor long inter-tier links.

Inter-cell and Inter-tier straps

Inter-cell straps and links can be monitored by modifying the DCM wiring. This allows the user to monitor for changes in torque or degradation of the connection between posts.

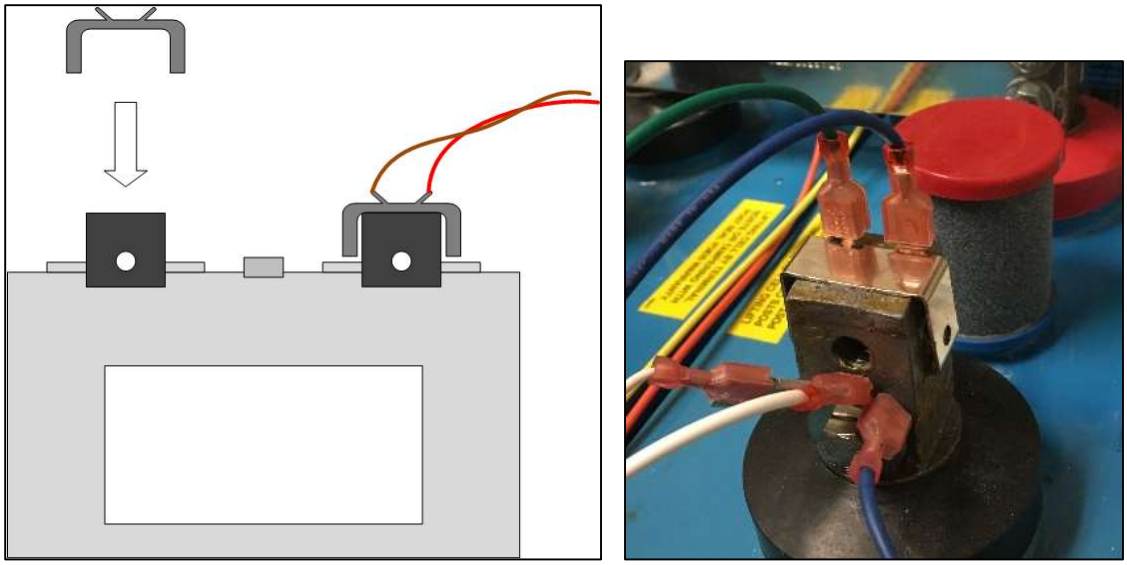
Additional hardware is needed to monitor straps separate from cells. NDSL provides terminal (post) clips that must be installed onto each container terminal to obtain accurate ohmic value readings for each link. See the next section for additional post clip information.

In this configuration, power leads are connected to ring tabs while sense leads are connected to terminal clips. Ring tabs are placed on the bolt of every other (odd numbered) terminal post, starting with the positive post of the first container in the string.



Example DCM 6 wiring for measuring straps and cells separate.

The power leads (brown and white, shown above) are extended across two 2V containers for each DCM to provide enough voltage to power the DCM. A Y-tab connector may be used to get additional sense leads onto one connection point.



Sense leads are connected to the terminal clips to obtain accurate ohmic readings for each strap.

Terminal (Post) Clips

The post clip that ships with your Frontier system is shown in the photo below. These clips are available in ¾ and 1-inch sizes. DCM sense leads will be connected to the post clips via the tabs on the top of the clip. The clip features two tabs which allow multiple DCM leads to connect and measure the post.

Post Clip with Two Tabs for DCM Connections

The post clip is held on to the battery terminal by spring tension. This tension allows the clip to stay attached to the terminal post under normal use. When fitting the clips to the post, landing DCM leads to the tabs, or removing the clips, ensure that necessary safety precautions are taken. The use of safety glasses is highly recommended when working with these clips.

When installing the post clip, take care to not push off any battery grease that might be on the side of the posts. The no-ox or battery grease creates an effective barrier against corrosion of the post. The best way to achieve this is to 'hook' one side of the post clip and then use an insulated flathead screwdriver in the available slot to 'pull' the other side of the clip over the post. While holding slight pressure to hold the clip open, move the clip down to rest on the top of the post. Use any size screwdriver that fits into the slot (example, ¼ inch).

Installing a Post Clip using Screwdrivers

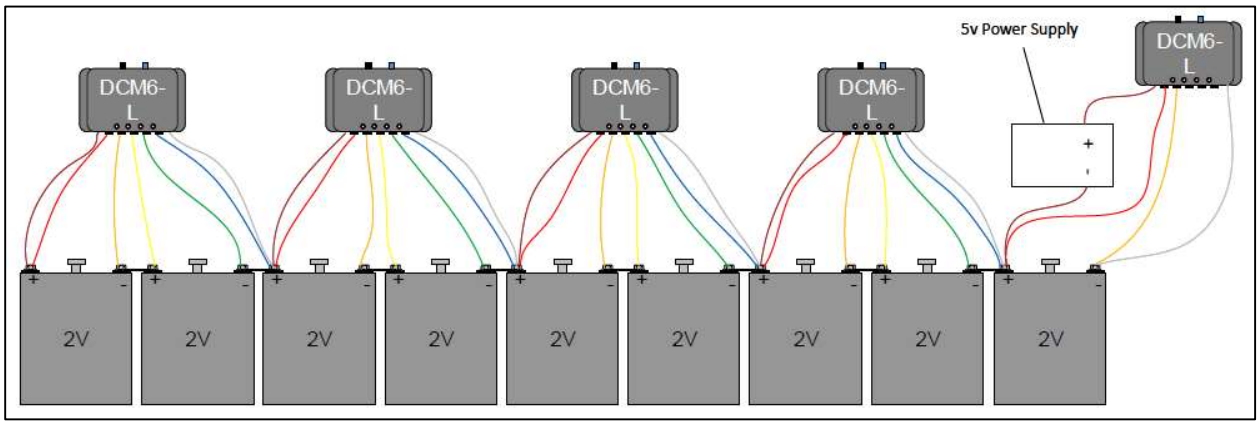
Front View of Installed Post Clip

Once the top section of the clip comes into contact with the top of the post, release the tension and pull the screwdriver(s) away.

To remove a clip, use a similar process but in reverse. Hook one side with a screwdriver and carefully pry and lift removing as little battery grease from the terminal as possible. Once the clip has cleared the top of the battery post, it is then OK to grab the clip by the tabs or continue lifting the clip away from the terminal with the screwdriver.

DCM 6-L with an Odd Numbered String

The DCM6-L is capable of being powered off two 2-volt jars. When monitoring straps separate from cells using these units, the need to extend power leads across four 2-volt jars is eliminated. When measuring a string with an odd number of cells using the DCM6-L, special consideration is needed for the one remaining cell. The DCM6-L measuring the single cell should be powered by an external 5v power supply (rather than being powered off the cell). The cell would be monitored using channel one (between red and orange leads) with the brown and white power leads wired back to the external power supply.



Example DCM6-L wiring for measuring straps and cells separately

DCM6-R

The DCM6-R measures string ripple and string voltage. It is usually connected as the last DCM on the fiber optic loop. Mount the DCM6-R on a jar or DIN-rail near the Frontier cabinet. Ensure the cabinet fuse is open so no power is supplied to the system. Then connect the brown lead to the positive side of the cabinet fuse and the white lead to the negative side of the cabinet fuse. Close the fuse to power the system back up.

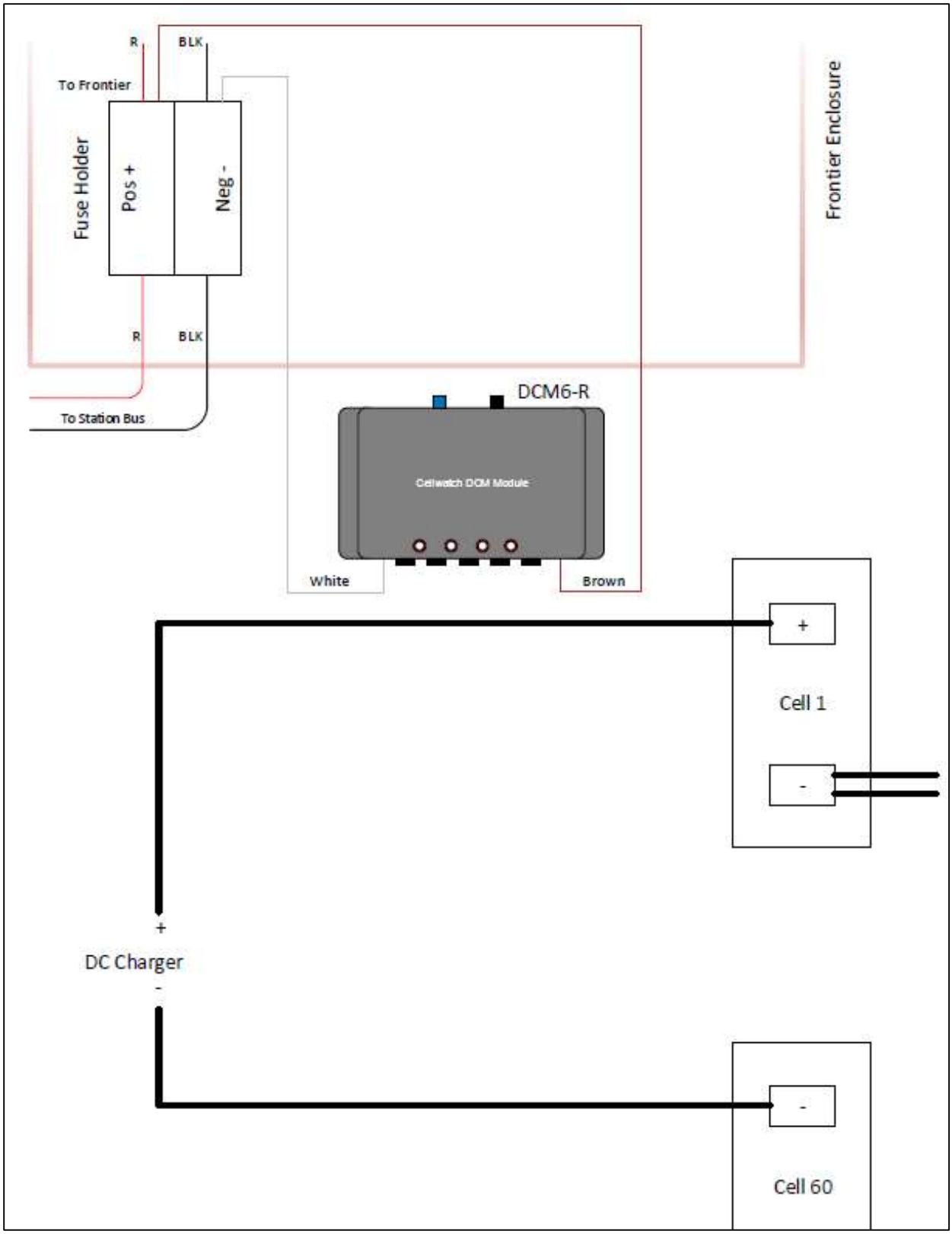
The DCM5 & DCM6-H measure ripple voltage across the DCM power supply between the white and brown wires. The ripple voltage measured by each DCM is then summed to give the string ripple voltage. The DCM6-L was designed specifically for 2-volts cells and does not measure ripple. In systems using 2-volt cells we supply the DCM6-R to measure string ripple by connecting directly across the entire string.

The DCM6-R is certified to work up to 300 volts. For systems with a string voltage less than 300 volts, use one DCM6-R connected directly across the string. When the string voltage is greater than 300 volts, we supply two DCM6-R's and then wire each DCM across half the string. The ripple measurement is then summed from each DCM. Connecting this way ensures we a balanced load on the whole string. The DCM6-R-600 is certified to work up to 600 volts and is another option for string voltages of greater than 300 volts.

When connecting or disconnecting to any systems greater than 100 volts DC there are significant safety risks & precautions should be taken when attaching this device.

As the DCM6-R is intended to be connected cross the string, it is important to be aware of the string potential.

- Use appropriate Hazard Risk Category PPE (level 2-4) as recommended by NFPA 70E when installing the DCM6-R on any voltage battery string.
- Some sites may require higher level PPE than what is recommended here, so check with the site safety officer when planning the work.
- **Remember: When disconnecting the DCM6-R from the wiring harness, be sure to open the fuse to power down the system. If the fuse is closed, the wires still carry the full string potential, even if the DCM is not attached!**



Wiring for a system less than 300v. For over 300v, use a DCM6-R-600 across the entire string.

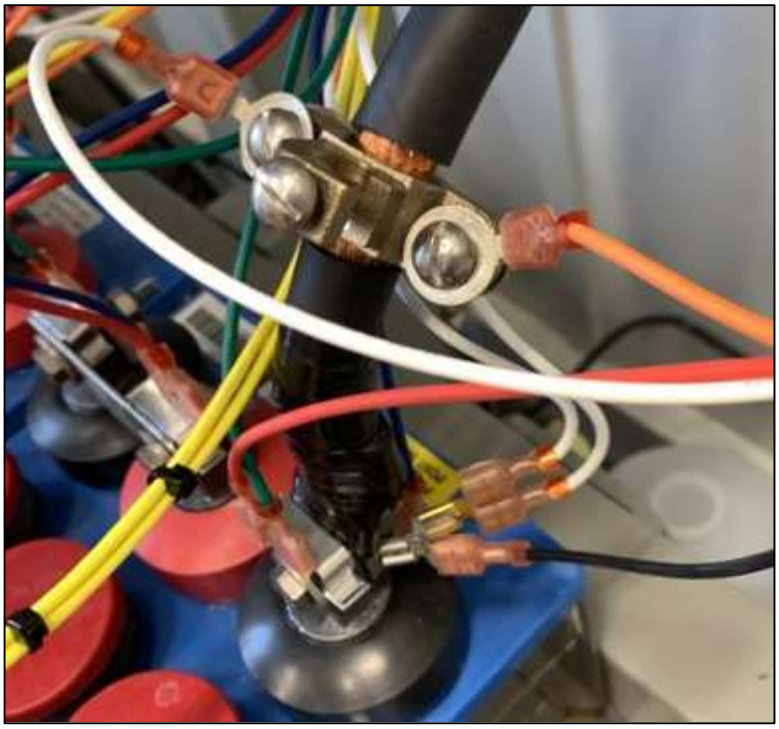
DC bus cables

DC bus cables can be monitored for continuity and variance. This requires two DCM6-L-CC units that connect from the positive of the DC power supply to the positive of the battery and the negative of the DC power supply to the negative of the battery. Channel one of each CC unit is used for the measurement (between the red and orange leads).

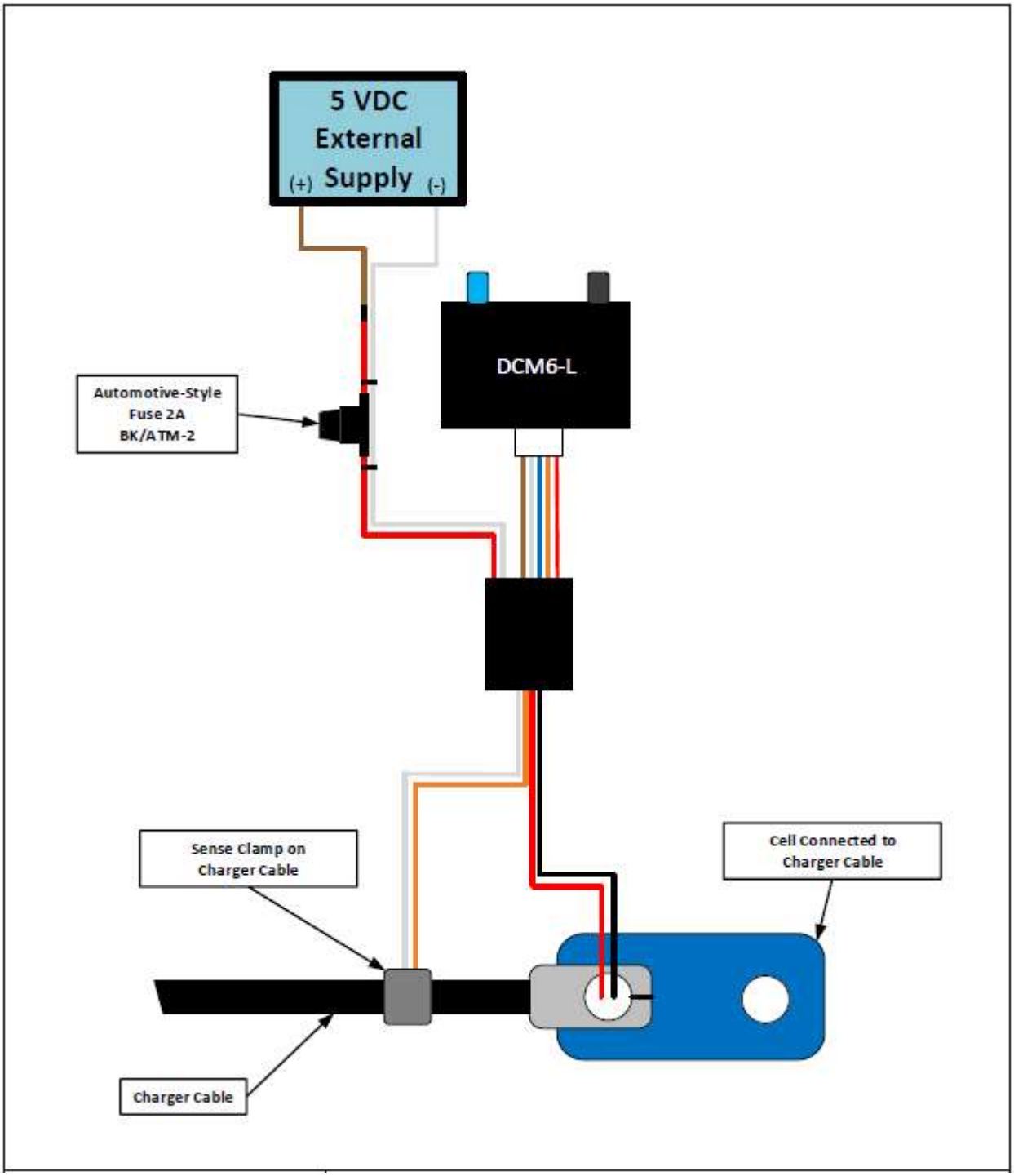
DC power supply units used to power the DCM6-L-CC mounted inside Frontier enclosure.

Incorporate the DCM6-L-CC into the fiber loop with the DCM6-L or DCM5 string. Standard designs are to locate the DCM6-L-CC as the last two DCMs or as the first and last DCM units in the loop. Connect the power leads to the 5 VDC External Supply.

Orange and white leads will connect to ring tabs on a clamp or other connection point along the charger cable. Ensure the orange and white leads are connected to separate ring tabs (Do not use a single ring tab and Y adapter for these connections).



Connect the red lead to a post clip on the most positive/most negative posts of the battery. Black should connect to a ring tab on the most positive/most negative posts of the battery. See the wiring diagram below.



Example wiring to monitor DCM6-L-CC connections to Charger Cable.

Monitoring cell/post temperatures

Individual cell or negative post temperatures can be monitored with the use of the DCM 5T or DCM 6T. The temperature probe is integrated into the wiring leads of the DCM. The Frontier interface will recognize that the DCM connected is equipped with this feature automatically and will display the readings on the homepage.

Strings or sub-strings not divisible by four

DCM units measure four channels of data at a time. If the battery is designed such that the measuring channels are NOT DIVISIBLE by four then special techniques must be used that require planning. In these situations, data channels must be nulled and special consideration should be taken into account with regards to the operational voltage of the DCM. Examples are described below.

58 VLA containing two dry cells

In some configurations, there may be dry cells contained within the battery string to provide the proper DC voltage for the plant. In these configurations if a DCM is monitoring on the individual cell level, then two DCM channels will be joined together (i.e. readings will be zeroed and nulled). The Frontier automatically accounts for these channels based on the voltage and the ohmic value readings.

16V VRLA jars

Due to space requirements, sometimes 16V VRLA jars may be used instead of larger 12V or 2V configurations. The DCM6-H has the ability to connect directly across 4 jars. Always remember to never connect the DCM in parallel with the DC charger as this will provide less accurate measurements.

Sub-strings of 2-volt wet cells not divisible by four

The DCM5 and DCM6-L are both capable of working on a string powered by three 2V cells. Any configuration requiring nulled channels on a 2V VLA/VRLA system must null only channel 4. Thus, if three channels are required to be nulled then three DCM modules will each have one null channel.

Because this is a highly unusual configuration, it is recommended that you contact NDSL to ensure that the tabbing and DCM wiring is done correctly.

DCM Connection Order

The order in which the wires are initially installed does not matter to the DCM. Two suggested methods are displayed below, either is acceptable.

Method 1

Connection order	Cable Colors		Typical Voltage (2V system)	Typical Voltage (12V system)
1st	White	Most Negative	0 volts	0 volts
2nd	Blue	Most Negative	0 volts	0 volts
3rd	Green		2 volts	12 volts
4th	Yellow		4 volts	24 volts
5th	Orange		6 volts	36 volts
6th	Red	Most Positive	8 volts	48 volts
7th	Brown	Most Positive	8 volts	48 volts

Method 2

Connection order	Cable Colors		Typical Voltage (2V system)	Typical Voltage (12V system)
1st	White	Most Negative	0 volts	0 volts
2nd	Blue	Most Negative	0 volts	0 volts
3rd	Brown	Most Positive	8 volts	48 volts
4th	Red	Most Positive	8 volts	48 volts
5th	Green		2 volts	12 volts
6th	Yellow		4 volts	24 volts
7th	Orange		6 volts	36 volts

Once the DCMs are installed, fiber optics run, current transducers, temperature probes, digital inputs, and relays have been connected, the system can be configured using the Frontier web interface. Instructions on connecting to the Frontier interface can be found in *Section II – User Guide*. Battery configuration information can be found in the section titled *Battery Design*.

Installation: Frontier Electrolyte Level Detectors

This section will provide an overview of the installation and functionality of the Frontier Electrolyte Level Detector (FED) devices.

Specifications

FED Specifications		
Description	Frontier Electrolyte Level Detector (FED)	
Power Supply	12 VDC (through Interface Module)	
Cable provided with each FED unit	1 ft. CAT5	
Cable provided for inter-tier connections	3 ft. CAT5	
Dimensions	2.17" x 1.59" x 0.79"	55.02 mm. x 40.4 mm. x 20 mm.
Max. number of FED units per Frontier system	250	
Interface Module		
Power Supply	AC (100-240V) or DC (24V)	

How it Works

The Frontier Electrolyte Level Detector (FED) contains a set of emitters and detectors that, when calibrated, detect the internal fluid levels of a container. As the electrolyte level drops below the fill

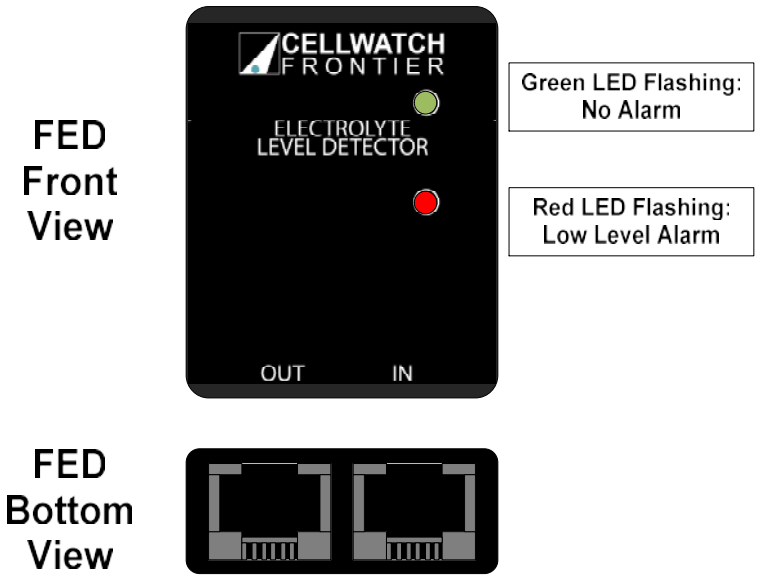
level line, the Frontier unit will trigger an alarm and the red LED on the level detecting device will indicate that fluid level is low. The status of the level alarm state is updated every 60 minutes in the Frontier user interface.

The FED contains two LEDs located on the front of the device. Each FED indicates if it is in alarm, not in alarm, or returns a communication error to the Frontier.

Green LED	Red LED	Interpretation
Fast flash	Off	Unit is working, but needs site calibration
Slow flash	Off	Has been calibrated, electrolyte level is normal
Off	Slow flash	Electrolyte level is low, in alarm
On (constant)	Off	Device error

Wiring

The FED units are connected in series using the provided CAT5 cable. Both power and communication to each FED is provided through this cable. Each cable will connect from the OUT of the first FED unit into the IN of the next FED unit, until the last FED unit in the system is reached. The last FED unit in the series is known as the "End of Line" (EOL) and reports the end of the string to Frontier. The OUT port will not be used on the EOL unit.

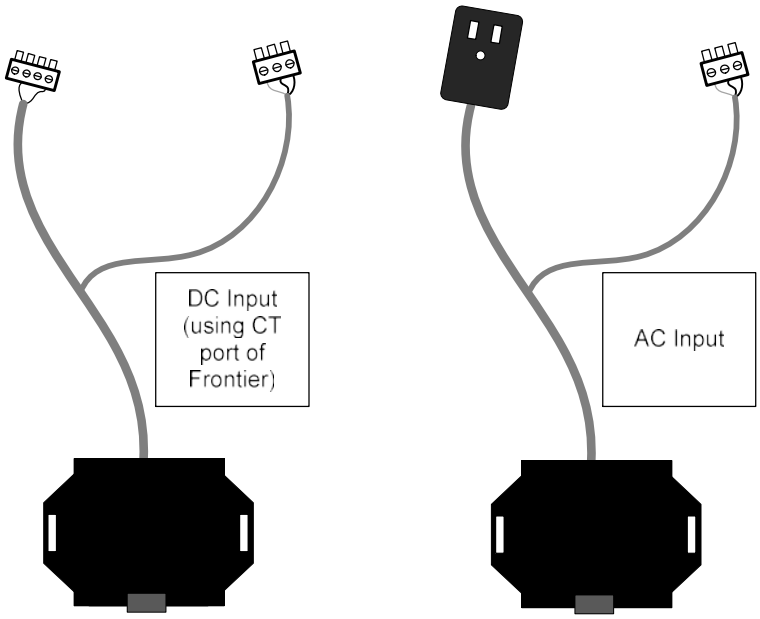


Note: The provided cables to connect FED units in series are 1 foot, straight-through CAT5. Use only cables provided by NDSL when installing FED devices. Using cable other than what is provided could

introduce errors in communication. Always use parts that are included in the kit to ensure the system operates properly.

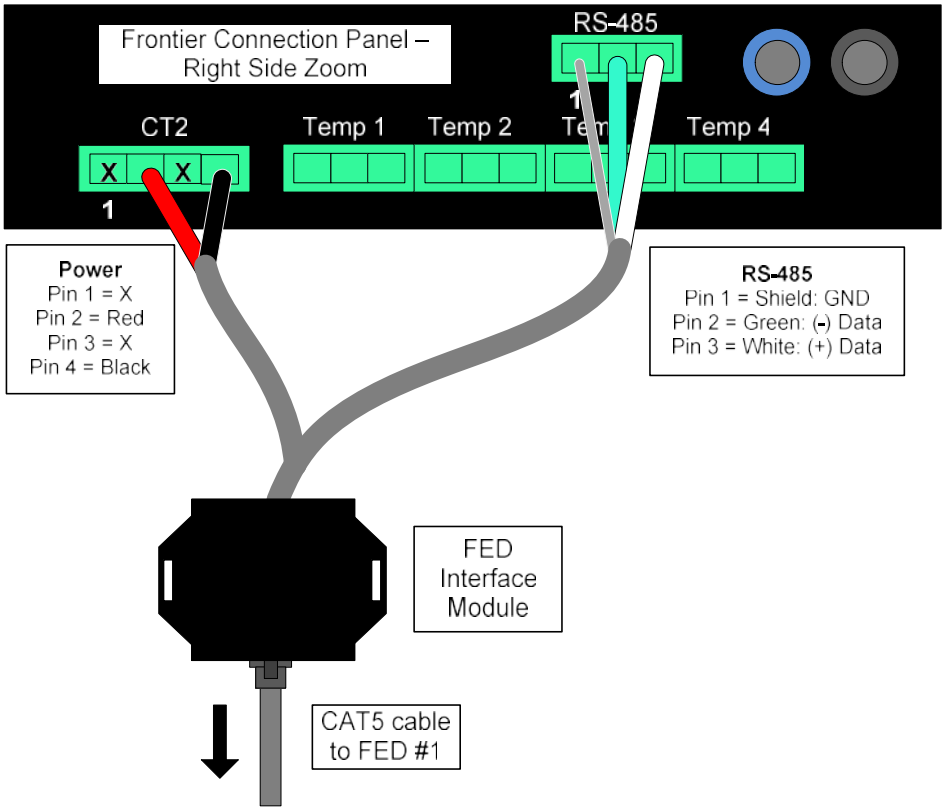
FED Interface Module

Communication and power to each FED is provided by the Interface Module. The Interface Module connects to the IN port of the first FED unit in the series. The first FED will typically be mounted to the first cell or container in the string. Communications and power are carried to the rest of the FED units in series.



The Interface Module allows for AC or DC power input (see above). For DC input, the Interface Module is wired to an unused CT port on the Frontier device in order to obtain 24V. For AC input, the Interface Module comes with an AC/DC adapter which can be plugged into a UPS outlet.

Note: If the Interface Module is plugged into a standard wall outlet that is not a UPS-backed power feed, the FED units will be unable to monitor electrolyte levels during a power loss event.



Example wiring of FED Interface Module using DC power from the Frontier's CT port.

Hardware Installation Process

The following section outlines the hardware installation process for FED units.

Preparation

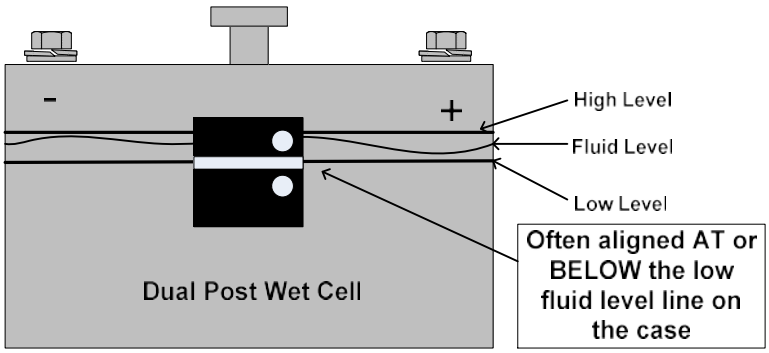
Each battery container should be thoroughly cleaned before FED devices are mounted. Debris and acid should be removed from the case to ensure an accurate measurement of electrolyte levels.

Mounting

Each FED unit is mounted using the guiding line on the sides of the device. Line up the guiding line with the fill line of the container. The placement of the FED will determine where it detects a low level. If desired, the guiding line can be placed above the fill line of the container for a "tighter" alarm limit. Placement is dependent on user preference for how quickly the container will be in alarm due to a drop in fluid level. Press firmly and hold the FED in place for 30 seconds to a minute to assure proper adhesion to the jar.

Note: The FED must be below the existing fluid level to calibrate properly. The container's fluid level should be at the desired height for normal operation.

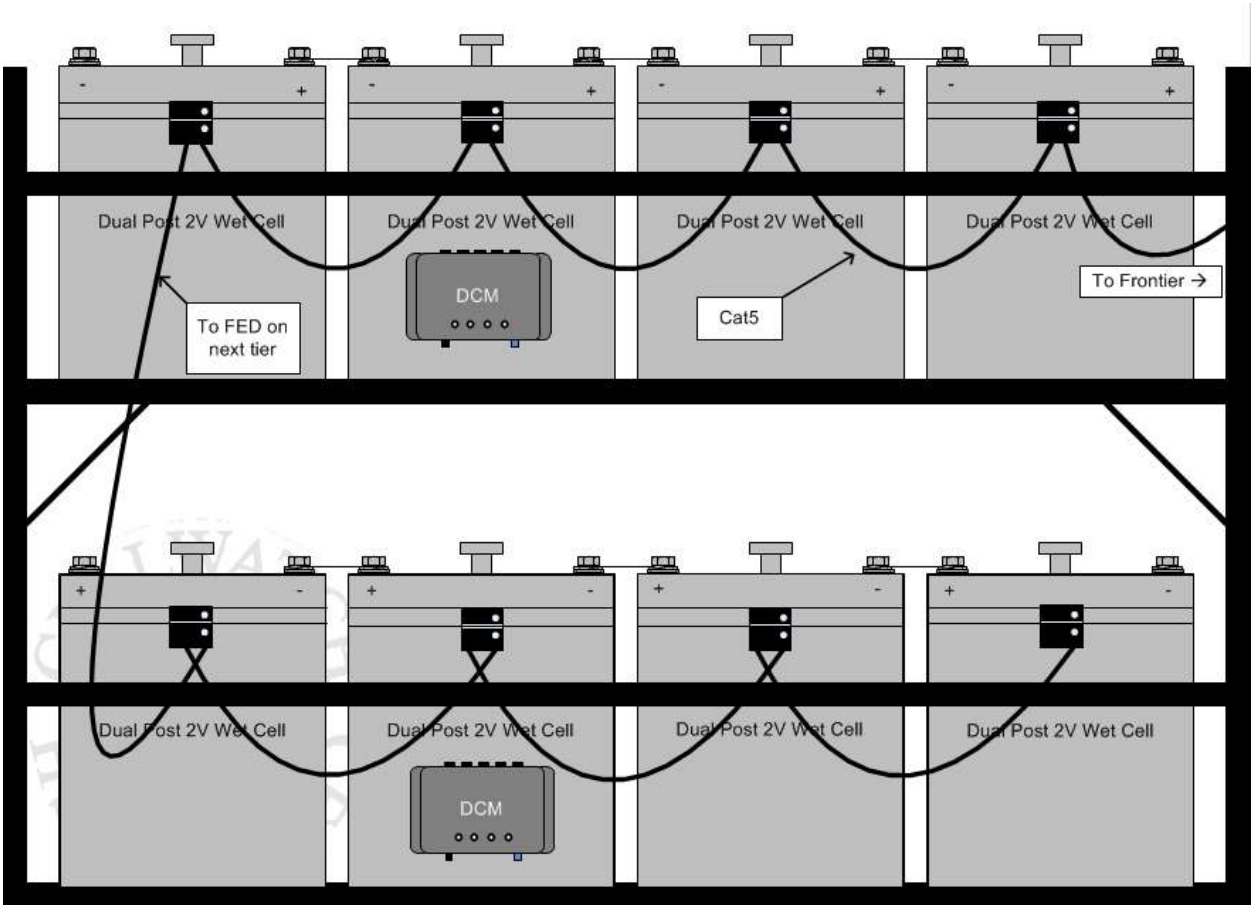
Note: Before proceeding to the next step (CAT5 connections), allow the FED tape to bond to the jar. This is best achieved by delaying connecting the CAT5 cables until 1-2 hours after the FEDs have been placed on the jars.



Example drawing of FED placement

CAT5 connections

The supplied CAT5 cables connect the FED units in series. FED #1 OUT port connects to FED #2 IN port. Connect the following FEDs in series up to the last FED. The last FED will not have an OUT connection and the software will identify it as the End of Line.



FED devices mounted and connected in series

Note: All FED units should be installed on batteries with cables connected BEFORE power is applied. If changes are made to the mounting of the FEDs after the first power up, the string of FED devices should be power cycled by pulling power to the first FED.

Powering up

Upon powering up, the FED units will need to adjust to the battery room environment. It is required to wait at least 5 minutes while the FED units stabilize before configuring them in the Frontier user interface.

For new installations, all FEDs will show fast flashing green LEDs the first time they are powered up to indicate that they have not yet been calibrated. Only after verifying that all FEDs are flashing green quickly should the installer move onto calibration.

A FED device error is indicated by a constant green LED. If this occurs, power cycle the FED chain by pulling power to the first FED unit. If one or more units do not return to a normal state, then these units should be returned to NDSL.

Removal Instructions

If FEDs must be moved or adjusted, take the necessary precautions when removing the FED from a container. Disconnect CAT5 cable from the FED before removing. The adhesive on the back of the FED to the container is very strong. Twist or rotate FED units to remove. Do not attempt to pull them straight off.

Section II – User Guide

Introduction

This user guide will walk through the basic functionality of the web-based graphical user interface (GUI) for the Frontier system. Advanced engineering features will not be covered in detail in this document.

Connecting to Frontier

The Frontier unit is accessible for configuration and operation using a password-protected web interface. To access the device, the user must enter the IP address of the device into a web browser. If the IP is unknown, the USB service port can be used to access the device. The device can be accessed by using either the Ethernet or USB connections. Use the USB service port if connecting to the Frontier device for the first time.

Compatible Browsers

The following web browsers are compatible with the Frontier system:

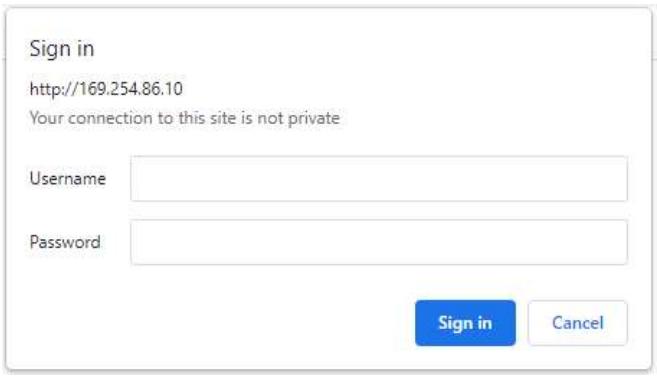
- Google Chrome
- Mozilla Firefox
- Microsoft Edge (version 79 onwards)

Using the USB Service Port

Connect a micro/mini-USB cable between a computer and the Frontier module. When a computer is connected to the Frontier device for the first time, it will attempt to install a compatible USB driver that will bridge the USB to a virtual Ethernet port on the Frontier device.

Note: It is highly recommended that the computer be connected to the internet to download the latest drivers for the Frontier unit. If needed an offline driver for Windows 7 and Windows 10 is available on the USB drive provided with the Frontier Unit.

While the driver version may vary between operating systems, the driver is for a USB to Ethernet/Gadget port. Once drivers have been installed, open a web browser and navigate to http://169.254.86.10. A login prompt should appear similar to the one below.



When prompted, enter the default credentials below:

Username	admin
Password	serial number of unit

Note: Starting with software version 3.15.5 (units with a barcode on the serial number label), Frontier units use the serial number of the unit for the password. On systems running older software, use admin for both the username and password.

To log in to the system with the 'Viewer' account, log in using the credentials below:

Username	viewer
Password	viewer

The viewer account allows access to the system's data but does not allow the user to make changes to the system.

That's it! The Home page will load, and the Frontier interface may report one or more errors on screen. No need to worry; this is simply because the Frontier device has not been configured yet. The rest of this manual will cover building a battery configuration using Battery Design, setting alarm limits for the measurements that Frontier collects and keeps track of, and configuring various hardware components. Continue to the next section titled *The Navigation Bar* to learn more about the Frontier web interface.

Using the Ethernet Port

When connected to the same network as the Frontier module, use an internet browser and navigate to the IP address of the device. When prompted, enter the username and password given in the previous section.

The Navigation Bar

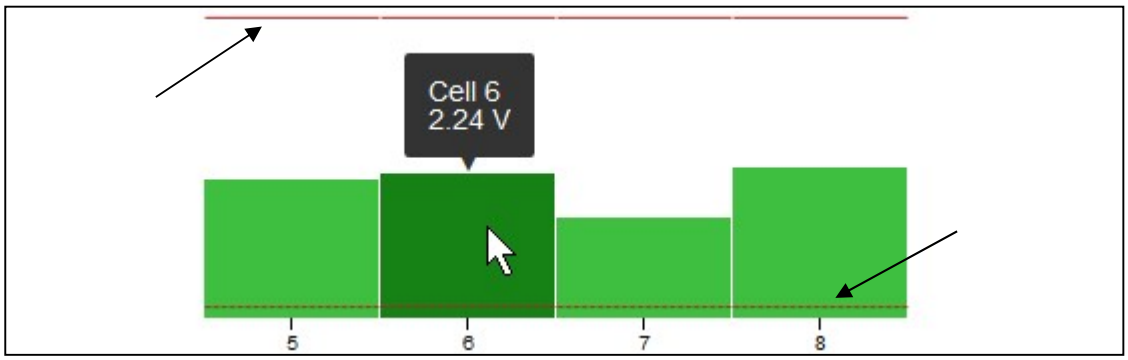
At the top of the page is the Navigation Bar. The Navigation Bar includes navigation drop-down menus and a health indicator alerting the status of the Frontier system.

Home Page

The Home page is the first page shown upon logging in to the Frontier web interface. On this page, pertinent battery information will be displayed once measurements and alarm status are available from the Frontier unit.

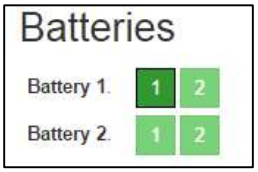
The Home page displays string and channel readings. Readings can include:

- Cell voltages
- Cell ohmic values
- Cell temperatures (if equipped with temperature sensing DCM)
- Alarm limits for cell voltages, ohmic values, and temperatures
- Inter-cell strap or bus cable resistance (if configured)
- String voltages
- Ambient temperatures
- Float and/or discharge current readings
- Discharge event records
- Frontier Electrolyte Detector (FED) status
- Alarm status for all of the above



The cell voltage alarm limits are indicated with red arrows.

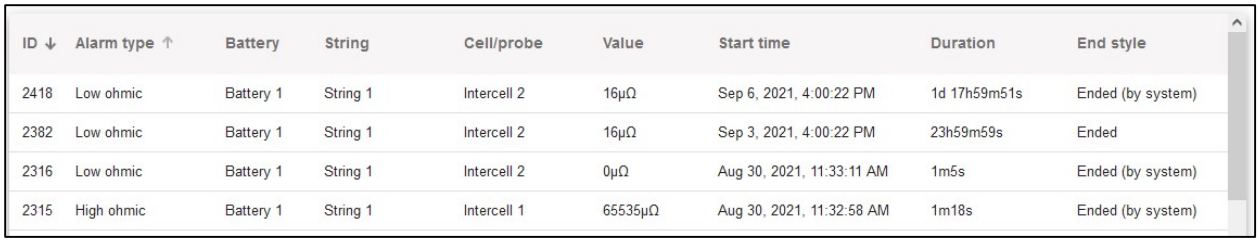
Hover over the bar graph of the associated cell to get the latest reading for that cell. The alarm limits for each measurement are represented by dashed lines on the graph.



Multiple strings can be accessed by selecting the battery and string number towards the top of the Home page.

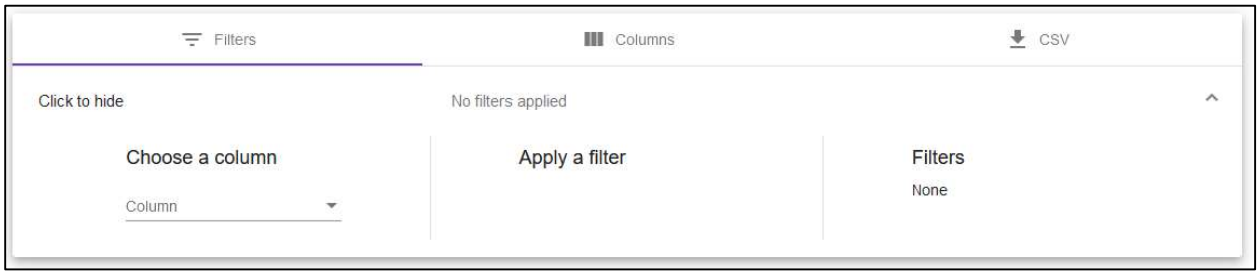
Alarm Viewer

To view a log of past and present alarm events in Frontier, choose the **Alarms** menu in the Navigation Bar at the top of the page. The **Alarm Viewer** can be sorted or filtered, as well as exported to a Comma-Separated Values (CSV) file. Results can be sorted by clicking on the arrow next to the column name.

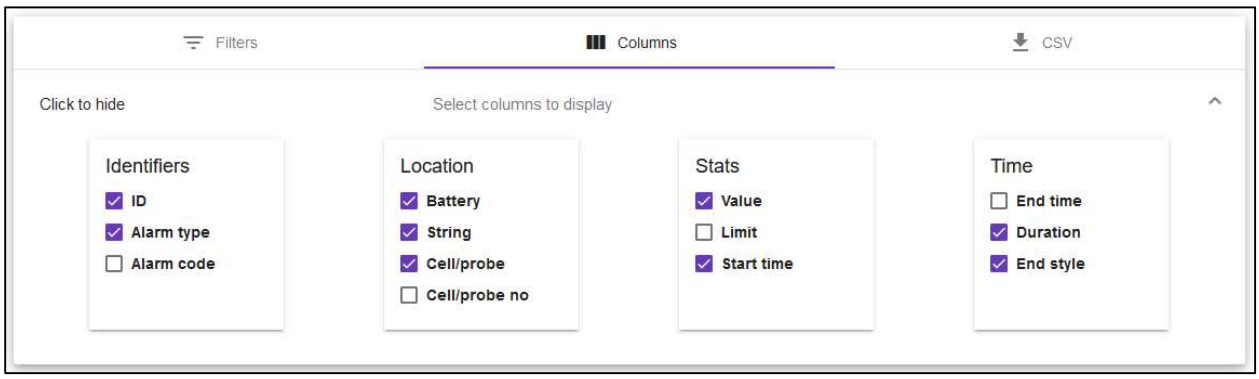


ID	Alarm type	Battery	String	Cell/probe	Value	Start time	Duration	End style
2418	Low ohmic	Battery 1	String 1	Intercell 2	16μΩ	Sep 6, 2021, 4:00:22 PM	1d 17h59m51s	Ended (by system)
2382	Low ohmic	Battery 1	String 1	Intercell 2	16μΩ	Sep 3, 2021, 4:00:22 PM	23h59m59s	Ended
2316	Low ohmic	Battery 1	String 1	Intercell 2	0μΩ	Aug 30, 2021, 11:33:11 AM	1m5s	Ended (by system)
2315	High ohmic	Battery 1	String 1	Intercell 1	65535μΩ	Aug 30, 2021, 11:32:58 AM	1m18s	Ended (by system)

To filter the list, click the 'Filters' to expand the options. Then choose which column you want to filter by. Under 'Apply a Filter', choose which value to apply and the data in the table will refresh. The column you choose to filter by will determine your 'Apply a Filter' options. Click the button to 'Remove Filters' to reset the table.



Clicking on 'Columns' will allow you to choose which columns to display in the table.

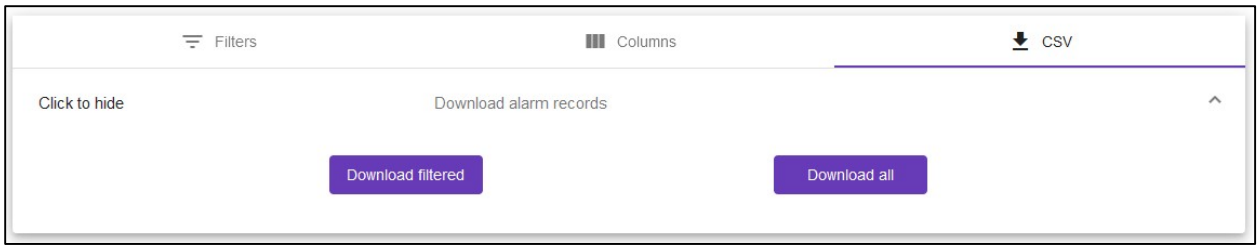


The description for each column can be found in the table below.

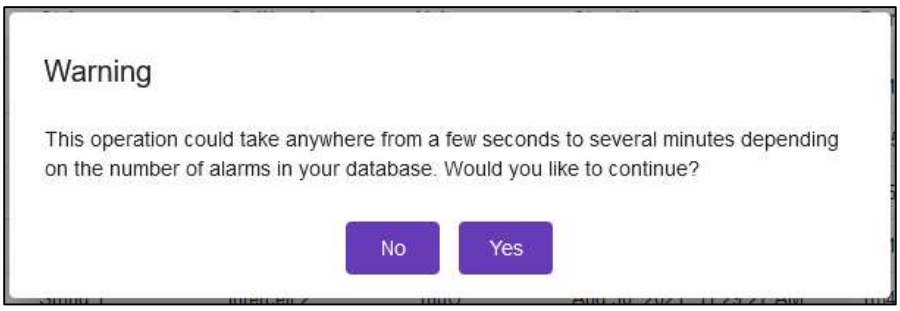
Column	Description
ID	The index of the alarm entry.
Alarm type	The type of alarm that occurred. An alarm type can be voltage, ohmic value, cell temperature, probe temperature, low float, discharge, charge, DIB, thermal runaway, or low electrolyte level.
Alarm code	A short abbreviation or "code" that can be used for quickly sorting and filtering alarms.
Battery	The name of the Battery in which the alarm occurred.
String	The name of the String in which the alarm occurred.

Cell/probe	The Cell (cell, intercell strap, intertier strap, or charger cable) or Probe (CT, TP, DIB, or FED) that triggered the alarm.
Cell/probe No	The Cell (cell, intercell strap, intertier strap, or charger cable) or Probe (CT, TP, DIB, or FED) number that triggered the alarm.
Value	The reading that triggered the alarm.
Low limit	The low limit configured for this channel or probe.
High limit	The high limit configured for this channel or probe.
Start time	The time when the alarm started.
End time	The time when the alarm ended.
Duration	The duration of the alarm.
End style	Specifies whether the alarm has ended or is currently active.

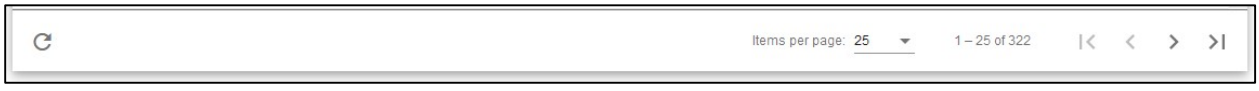
To export the alarm records, click the **Download as CSV** button and choose whether to export the filtered log (if filtering is checked) or all alarms.



The number of alarms in the database will impact how long the download takes. Filtering is a good way to reduce the time required for the download to complete.



Controls for navigating through the **Alarm Viewer** can be found at the bottom of the table.



The controls are as follows (from left to right):

- **Refresh**: Update the Alarm Log with any new alarm entries.
- **Items per page:** Set the number of alarms to display per page.
- **First Page**: Go to the first page of alarms.

- **Previous Page**: Go to the previous page of alarms.
- **Next Page**: Go to the next page of alarms.
- **Last Page**: Go to the last page of alarms.

History Graphing

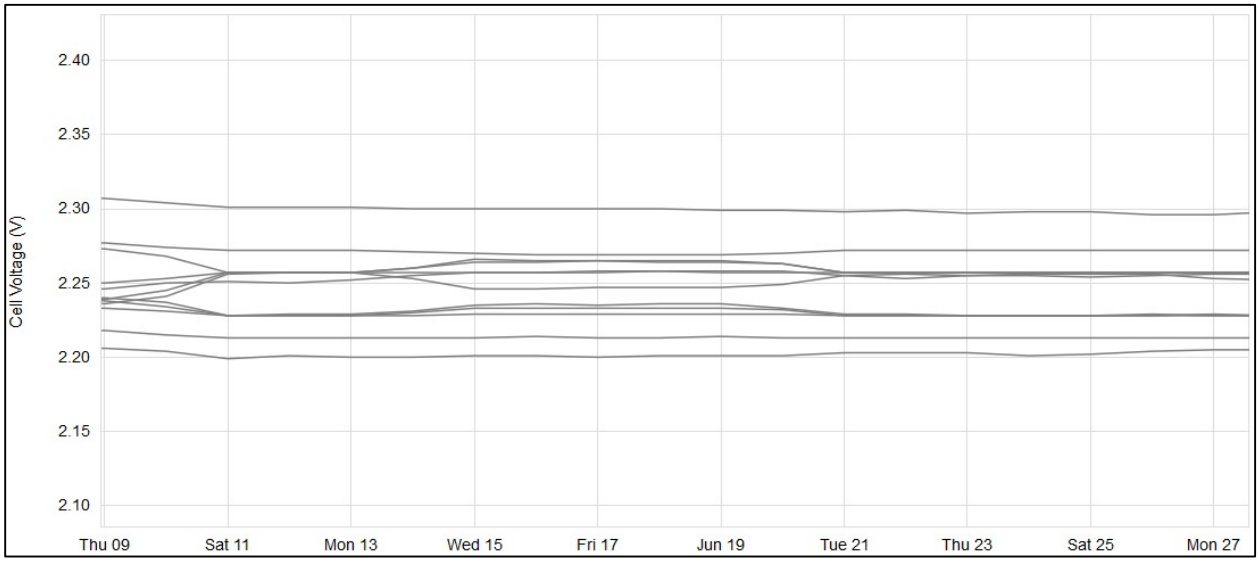
History graphing can be accessed by selecting **History** on the Navigation Bar. The table below can be used to help identify the types of graphs that can be displayed.

Data Source	
Historical Data	All data collected and stored during non-discharge scans is stored in an internal database for historical tracking and record keeping. Data resolution varies as noted below in *Timeframe*.
Discharge Data	Data is stored at a high-resolution during discharge events to maintain a record of how individual cells within the battery bank perform during the event.
Cell Audit (temp comp)	Choose this option if you want to graph the raw uncompensated ohmic and effective temperatures (when temperature compensated ohmic is enabled).
Unit	
Cell Voltage	Plots individual cell voltages.
Channel Ohmic Value	Plots individual cell ohmic values. This will be the compensated value when temperature compensation is enabled.
Channel Ohmic Value (uncompensated)	Plots the uncompensated ohmic value data before applying temperature compensation.
Cell Temperature	Plots individual cell temperatures.
Effective Temperature (for compensation)	Plots the average of the last N temperature readings (depending on settings). This value is used to calculate the compensated ohmic values.
String Current	Plots available string currents for selected string.
String Voltage	Plots string voltage for the selected string.
String Ripple	Plots string ripple voltage for the selected string.
Temperature	Plots available probe temperatures for the selected string.
Timeframe (History Data Only)	
Day	Display selected data for the day up to 15-minute intervals.
Month	Display selected data for the month in one day intervals.
Year	Display selected data for the year up in one day intervals.
Custom	Select the Start and End dates to plot data. The measurements will appear in one day intervals.

Discharges (Discharge Data Only)	
Select Discharge Event	Displays all recorded discharge data for selected event.
Data to Display	
Batteries	Plot one or more Batteries.
Strings	Plot one or more Strings.
Channels	Plot one or more Channels.

Using the Graphing Functions

When selecting a graph to plot, users will be asked to select the data set they wish to display. Once selected, an interactive graph will appear allowing the user to click on individual readings for additional information.



Graph Controls

- **Zoom:** Users can zoom in and out using the **Zoom out** and **Zoom in** buttons located below the graph or by using the scroll wheel on a mouse. Users can also double-click the graph to zoom into a data point. All zoom functions can be reset using the **Reset** button at the bottom of the graph.
- **Pan:** Left-click and hold to pan the graph. Only data from the selected time frame will be displayed.
- **Selecting a data plot:**
    - **Left-click plot line:** A box will appear providing cell/probe identification information and allows the user to disable the plot line or color the plot line.
    - **Left-click cell label below the graph:** The plot line will disappear or reappear in the graph above.
    - **Right-click cell label below the graph:** A box will appear allowing the user to disable the plot line or color the plot line.

- **Download CSV:** Users can export the displayed data into a comma-separated values (CSV) file.
- **Hide all:** Users can disable all selected cells to clear the graph.

Reports

The Frontier device can generate a battery report on the state of the system, including battery manufacturer and model, installation date, and the latest voltage, ohmic value, and temperature measurements for each cell and strap. These reports allow the user to print and export information about both the battery and the Frontier unit.

Battery Report

This report contains information pertinent to commissioning a system or recording "snapshot" information about the system. This report can be used to compliment the visual inspection of a scheduled battery maintenance and to record the battery health at the time it is executed.

Each battery report that is generated will include commissioning data which is completed by the installer or operator on the **Commissioning Data** page under the Settings menu. In addition, the battery report includes:

- String measurements: including string voltage, string current, and alarm limits associated with each
- Temperature probe measurements and alarm limits
- Cell and strap ohmic values and alarm limits
- Cell voltages and alarm limits
- Electrolyte status of each FED unit
- Serial numbers of Frontier hardware

Exporting a Battery Report

Battery reports can be exported using the buttons at the top of **View Battery Report** page, located under the Reports menu. The user has the option to download a comma-separated values (CSV) file or to save the HTML page to their desktop for later viewing.

Scheduled Battery Reports

Battery reports can be scheduled to automatically generate at a specified interval. The user has the option to schedule a battery report weekly, monthly, or quarterly. If a scheduled battery report interval is selected, the time and date of the next scheduled report

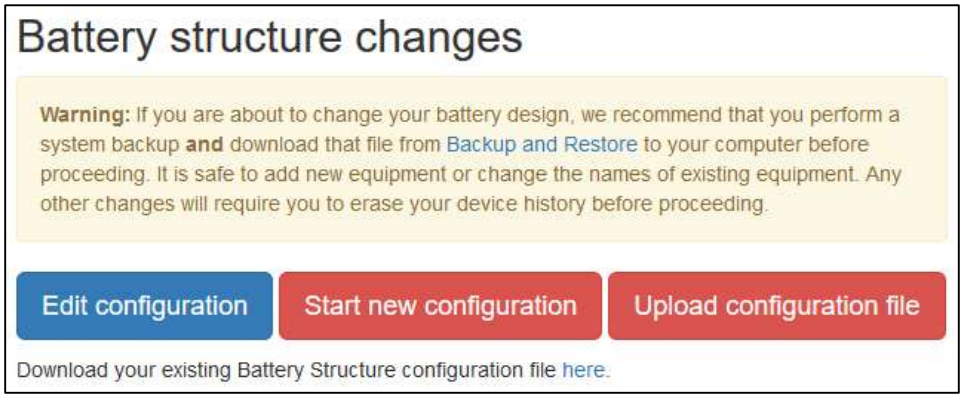
will be shown on the page. If any changes to settings are made, be sure to save them by clicking the **Save settings** button. Once a battery report is generated, the user will be presented with a list of saved reports that can be viewed at any time towards the bottom of the page, with options to export them as CSV or HTML page or delete from the system.

Frontier Settings

The Settings drop-down menu contains configuration information for the Frontier system. Here users can set alarm limits, change the battery configuration, as well as perform diagnostics on the Frontier module.

Battery Design

In Battery Design, users can create a new battery configuration or edit the existing battery configuration for the Frontier system. Simply answer questions about the available hardware, how components are connected, and the desired battery configuration to build all necessary battery configuration files automatically.



Before making any changes to an existing battery design, it is recommended that you initiate and download a backup of all Frontier data. Any changes to battery design, other than adding equipment (CT, TP, DIB) or changing names of existing equipment, will require you to erase your device history before proceeding.

Modifying the battery configuration will require users to enter new alarm settings.

A walkthrough and examples for building a new battery configuration are covered in *Section III – Configuration Build and Hardware Integration Guide*.

Battery Profiles

Battery profiles are used by the Frontier system to calculate the temperature compensated ohmic values. Battery Profiles can be created for each model of battery on a system. Once loaded into the

Frontier system, these profiles can then be assigned to specific strings. This is accomplished via the Battery Design wizard.

General

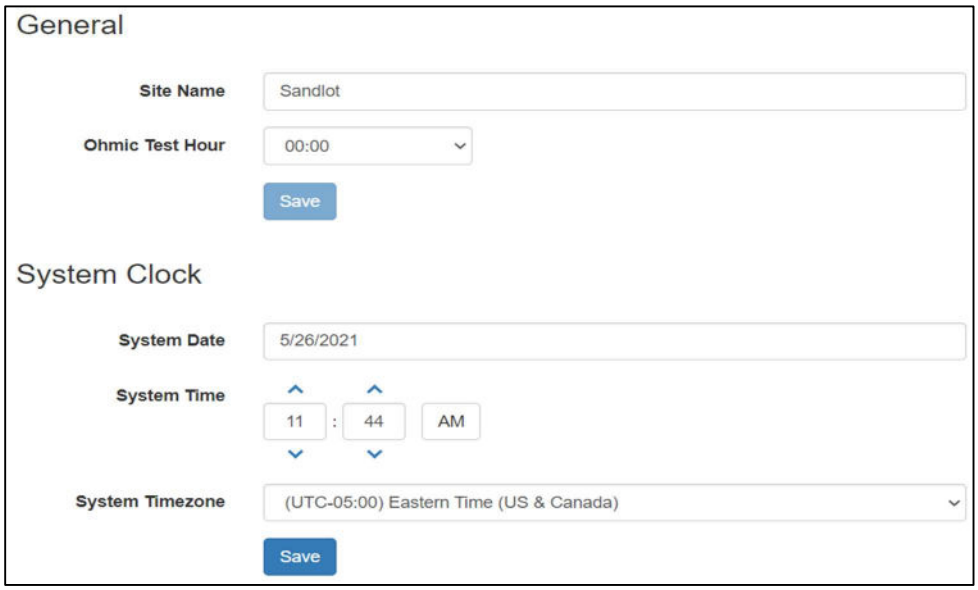
The following settings can be changed on the Device Settings page:

General

- *Site Name* – Sets the name of the Frontier system seen in the upper left-hand corner of the page. This can also be used to identify the site when accessing the system remotely.
- *Ohmic Test Hour* - Sets the time for which the daily ohmic scan occurs.

System Clock

- *System Date* - Sets the current date.
- *System Time* - Adjusts the clock on the Frontier unit. Synchronization can also be maintained through the network interface.
- *System Timezone* - Users can set the time zone of the Frontier device based on region. Numerous pull-down options are available to address any location where the system is deployed.



Note: System time and date must be set to the current time/date before any software updates can be performed.

Security

- Administrator Password - The login password for administrator access to the Frontier interface can be changed if desired. Once changed, the user will be required to log into the device again.

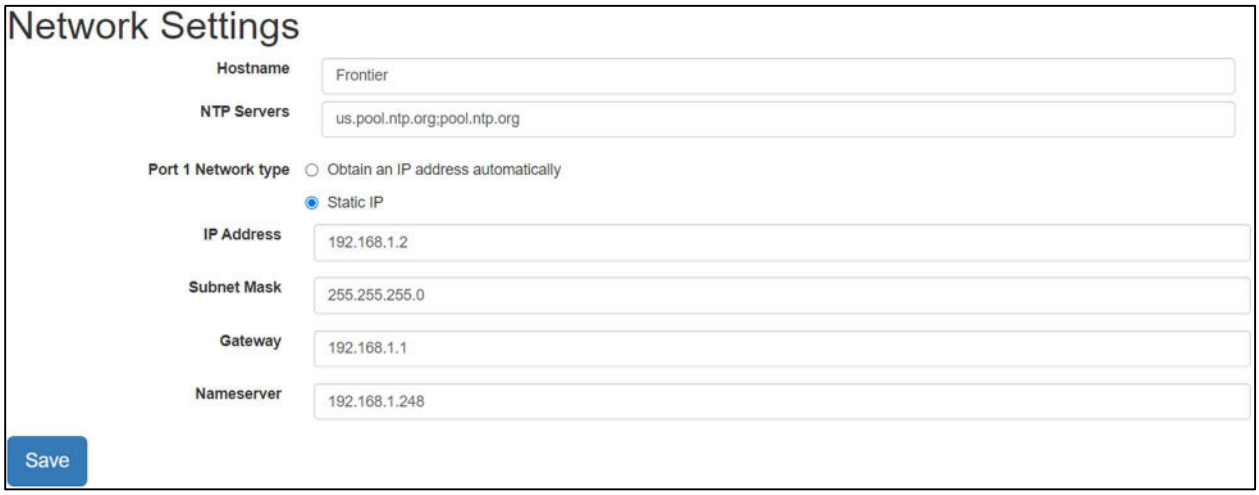
- Viewer Password – The login password for the viewer account on the system. This account has access to view the system but cannot make changes.

Upload Settings

A settings file can be uploaded to the system if desired. The file ends in settings.yaml and includes device settings such as network settings, commissioning data, DNP3 settings among others.

Network Settings

The Network Settings page allows users to adjust the IP settings of the device as well as configure NTP (Network Time Protocol) servers.



The Network page has options for changing the Frontier device hostname, configuring one or more NTP servers (separated by a semi-colon), and configuring Frontier for use on a network.

Configure a Dynamic IP (DHCP Enabled)

Select **Obtain an IP address automatically** to allow the Frontier unit to automatically request an IP address from the network. Pressing **Save** will store the new IP address for the Frontier unit. Frontier will readdress itself to an IP distributed by the network.

Users will be required to restart and log into the Frontier device once this setting is changed. It is best to perform this operation if you know what IP will be assigned by the network administrator or if connected via the USB service port.

Configure a Static IP (DHCP Disabled)

Select **Static IP** and fill in the information provided by the network administrator. IP Address, Subnet Mask, and Gateway are required to properly configure a static IP. Nameserver is only mandatory if required by the network.

Users will be required to restart the device and log into the Frontier device again. Following an IP address change, the user will need to access the device at the newly configured IP address.

Note: The USB service port can be used at any time to access the device if it is unreachable on the network.

HTTPS Support

The Frontier web interface uses HTTP by default but can be set up to also use HTTPS. Frontier generates its own unique encryption key (the private key) which is signed by an SSL certificate from a Certificate Authority (CA) in order to encrypt traffic between the Frontier device and the user's web browser.

Generating a Certificate Signing Request

In order to issue an SSL certificate, the CA requires a Certificate Signing Request (CSR), which is generated by the Frontier device.

The information above is used by Frontier to generate a Certificate Signing Request (CSR).

To generate a CSR, complete the fields (shown above) according to the CA's instructions. The CA mandates the data they will accept for each field. For example, some CAs prohibit special characters such as ampersands in the organization name.

Once the requested information is entered, click the **Next** button. The private key and CSR will be automatically generated by the Frontier unit. This process can take up to 60 seconds to complete. The web interface will indicate "Generating private key…" and "Generating CSR…" during the process. Navigating away from this page during generation will not interrupt the process. The CSR is linked to a unique private key on each Frontier unit and is not valid for any other Frontier system. For security reasons, the private key is never exposed outside the Frontier system.

The CSR generated is a block of text that must be copied and pasted into the certificate request form on the CA's website. The CSR's block of text is bounded by begin and end markers which **must be included** when copying the CSR. The CSR will be invalid if any part of it is omitted.

Example of a Frontier generated CSR. Begin and end markers must be included when requesting a certificate.

The CSR is stored on the Frontier device and can be retrieved again at any time by navigating to the **Network** page.

Generating a new Certificate Signing Request

If the details of your CSR need to be changed, click the **Generate new CSR** button and a new set of details can be entered into the form. The existing CSR will be removed. Any existing certificate is also removed.

Uploading a signed certificate

After submitting the CSR to the Certificate Authority, a certificate file will be issued. This file should be downloaded and saved to your computer. A certificate file typically has a .crt file extension. If the certificate file is contained within an archive (such as .zip), be sure to extract it first before uploading the certificate file.

Select **Upload a certificate** and then click **Select file** to locate the certificate file on your local machine. Frontier will validate the certificate and match it against the Frontier device's private key. The user interface will indicate "Verifying certificate" during this process. Once successfully validated, a message to restart the device will appear. A device restart is required in order for the Frontier to start listening on the https:// address.

If an error appears, the contents of the certificate file are either not a valid certificate or the certificate does not match your private key. Verify that the CSR was generated by the corresponding Frontier device. If needed, a new CSR can be generated at any time by clicking the **Generate new CSR** button.

Deleting a signed certificate

To delete a signed certificate on the device, click the link shown in the screenshot above. Uploading a new certificate will also delete the existing certificate from the device. If the signed certificate is deleted, the Frontier configuration will be changed to use only HTTP and is reflected on the next device restart. This is to ensure that the Frontier is not left with HTTPS enabled but no certificate. For example, if the Frontier loses power after deleting a certificate, it will start up with HTTPS disabled.

Commissioning Data

The **Commissioning Data** page should be kept up-to-date by the installer or operator of the Frontier system. Information entered here is used when generating battery reports and stored on the Frontier device for future reference or modification. After completing the form, the user can click **View Battery Reliability Report** which will generate a battery report using the information provided. The battery report will contain the most recent measurements taken by the Frontier system, as well as information about the battery itself. Diagnostic information is also stored for the DCM units in the system, such as unit serial number and firmware versions.

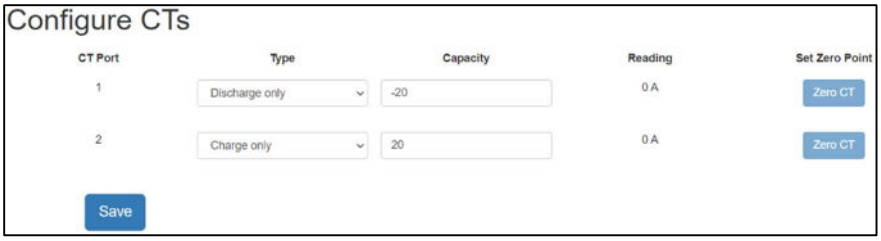
Configure TPs

Configuration settings for temperature probes are accessible under the Settings menu in the Navigation Bar.

In this menu the labels for the Temperature probes can be set, by default they are TP#. The Offset value will lower the temperature value by certain amount. For example, the temperature reading is 25 C and with an Offset value of -5 the temperature reading will go down to 20C.

Configure CTs

Users can configure the current transducer (CT) settings for each connected CT. Multiple CTs can be assigned to a given string, allowing the Frontier system to monitor discharge events with one CT and charge events with another CT. The proper CT must be used for each application (i.e. float CT versus discharge CT) so that proper float currents (less than 5A) can be measured with greater accuracy. This is also important in order to completely capture the discharge current range.



It is highly recommended that discharge current be monitored, however a CT is not required for the Frontier system to operate.

Type

The user can configure a CT to monitor for discharges or charges, depending on the design and capacity of the CT. A discharge only CT is typically combined with a charge only CT on a single string to represent one logical CT, but this option can be configured in Battery Design. A logical CT is a combination of two or more CTs, but it is displayed as a single reading in the Frontier system.

Note: A current transducer that is configured as a discharge CT can also be used to measure a recharge current, typically up to 20% of the current transducer's capacity.

Capacity

Enter the maximum capacity (rating) of the current transducer. For example, a CT with an input of 50A is capable of measuring a discharge current of up to 50A. In Frontier, this CT would be configured as a discharge only CT with a capacity of -50.

Reading

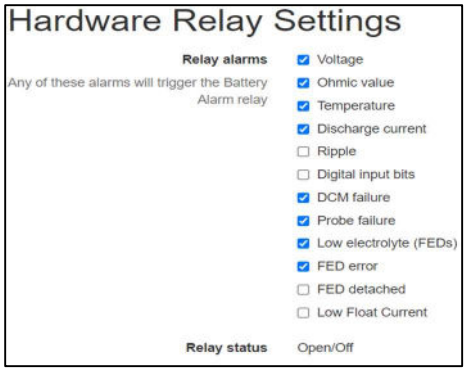
The value displays real-time readings from any current transducers connected to the Frontier unit. These readings can be used to verify the configuration is correct and to assess whether a CT should be zeroed.

Users can zero a CT to remove offsets in the reading. This should be done with the CT removed from the battery and closed, or with the string in an open state ensuring that there is no current flow.

Note: The capacity of the CT must be set before a user can zero the CT.

Hardware Relay

The hardware relay is a dry, volt-free contact that can be used to integrate alarm events into another system for alarm reporting or alerts. Users can assign which alarm events will trigger the system relay output on the Frontier device. Multiple alarm events can be chosen. If any of the chosen alarm events occur, the relay is triggered. Each relay is rated to 30V at 5Adc.



Electrolyte Levels

Use this option to calibrate Frontier Electrolyte Level Detector (FED) units once all FED units have been properly wired and installed. Ensure that all jars have been filled.

In the **Operations** tab, click **Calibrate** to set the 'full' level for each FED unit. A **Quick Calibrate** can be used if the FED string has already been enumerated. An example would be to recalibrate a string that has already been calibrated. A **Full Calibrate** will power cycle the FED units and re-enumerate the FED string in addition to setting the 'full' level. This process should be run when installing FED units for the first time on a system.

To update FED status, a **Manual Scan** can also be sent to the FED string from this page. The Frontier system will automatically scan the FED string every 15 minutes.

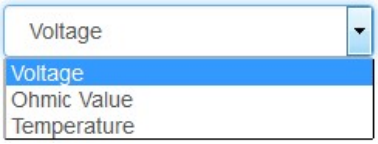
String/Channel Alarms

Voltage, ohmic, individual cell temperature (DCM 5T or 6T), and AC ripple voltage alarm limits are defined under the **String/Channel Alarms** menu. Alarms can be configured for the battery, for individual strings, or for individual channels. Use the **Battery** and **String** tabs at the top of the page to select which tier of alarms you wish to modify.

String Alarms

- Set the low and high voltage alarms for the string. This alarm can be used to monitor the DC charger to ensure the string has a proper float voltage.
- Set the high ripple voltage limit. High ripple voltages can indicate that the UPS has failing components. Large ripple levels can cause damage to a battery over time. This is an extended feature of the DCM and requires activation.

Channel Alarms



Cell voltage, ohmic value, and cell temperature alarm limits are configured here. Use the **Unit** drop-down box to select which values you wish to change. The unit of measure will change for the appropriate value. Alarms can be set for all channels globally (Fixed Value) or for each cell individually. Additionally ohmic value alarms can be set by specifying a % of last reading value. Charger Cables, inter-cell and inter-tier strap alarms can be set here based on the

configuration. The option to set All Channels will set all ohmic channels available based on the configuration.

- **Low Voltage:** Alarm will occur when a cell voltage drops below the set value. This is useful to ensure a proper charge voltage on a cell.
    - Recommended 2.16V per cell
    - Example: A 12V container would have a low voltage alarm limit of 13V
- **High Voltage:** Alarm will occur when a cell voltage rises above the set value. This is useful to ensure a proper charge voltage on the cell. Excessive voltage may lead to thermal runaway or may indicate a weaker cell in the string.
- **Low Ohmic Value:** Alarm will occur when a cell's ohmic value drops below the set value. Low ohmic value can indicate a possible short within the cell.
    - Recommend 75% of baseline reading
- **High Ohmic Value:** Alarm will occur when a cell's ohmic value rises above the set value. High ohmic value typically indicates that the cell is becoming more resistive and is losing capacity. A boost charge on the individual cell may restore it to normal operation. Many factors can affect ohmic value.
    - Recommend 125% of baseline reading
- **Low Temperature Limit:** Alarm will occur when the temperature on the cell terminal drops below the set value. The standard operating temperature for a lead acid battery is 25°C (77°F). Performance measured as a percentage of available capacity falls off rapidly as the temperature is reduced. At 10°C (50°F), battery performance is down to 85% to 90% compared to that available at 25°C.
- **High Temperature Limit:** Alarm will occur when the temperature on the cell terminal rises above the set value. The standard operating temperature for a lead acid battery is 25°C (77°F). For every 8°C (15°F) increase in temperature, the battery can experience a 50% drop in life expectancy.

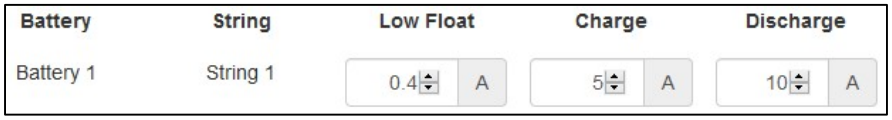
Temperature Probe Alarms

This page contains options for setting string level temperature alarms. These alarm limits are applied to any assigned temperature probes in the system, not including cell temperature measurements obtained from DCM hardware. Different alarm limits can be applied to each configured temperature probe if desired. The recommended ideal battery room temperature is 25°C or 77°F. Alarms are configurable in Celsius only.

- **Label:** Enter the desired label for the selected temperature probe. Ex. *Ambient* or *Top Right.*
- **Low Temperature:** An alarm will occur when temperature reading falls below the low temperature alarm limit.
- **High Temperature:** An alarm will occur when temperature reading rises above the high temperature alarm limit.

Current Alarms

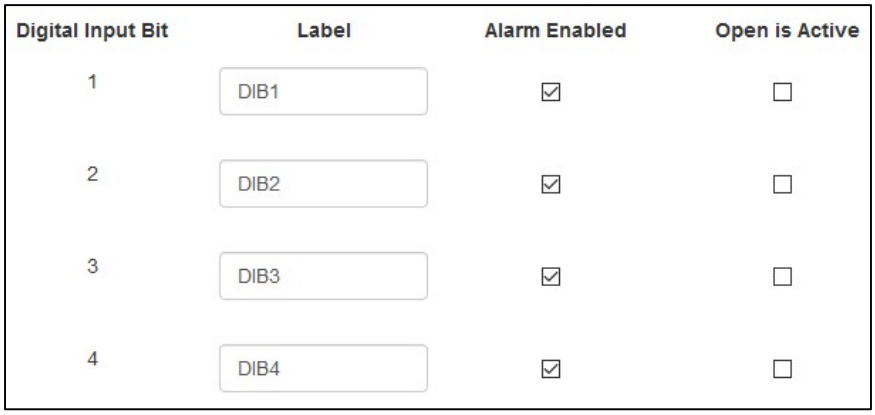
Users can configure thresholds for discharge alarms, recharge events, and low float alarms here. At least one current transducer must be configured for a string in order for current alarm limit settings to be available.



- **Low Float:** This setting will enable Frontier to monitor for low float current, or a break in continuity within the battery. This limit should be set above zero but significantly below the normal float charge current. A typical low float limit is at least 20mA.
- **Charge:** This setting allows users to monitor the recharge characteristics of the battery. This is an optional non-alarming event but will allow Frontier to monitor the charge status of the battery. This limit must be greater than the typical float current of the battery, but less than the typical charge current of the battery, in order for recharge events to be properly detected. This limit should be set between 2A and 5A depending on the float charge current of the charger.
- **Discharge:** This setting allows users to monitor the battery for any discharge events. During a discharge event, data readings are recorded at a high rate, allowing Frontier to plot the discharge of the battery with high resolution upon completion of the event. This limit must be set above the noise floor of the CT being used and must be less than typical discharge current based on the expected load. For US Utilities where expected loads can be as low as 5A or as high as 30A, a limit of 3A is recommended.

Digital Input Alarms

The **Digital Input Alarms** page allows configuring digital input bits (DIB) for integrating external monitoring devices into the Frontier system.



- **Digital Input Bit:** Each DIB as numbered on the back of the Frontier device.
- **Label:** The label to display on the Home page for each DIB.
- **Alarm Enabled:** Enable DIB to trigger alarm in Frontier.

- **Open is Active:** Check this box if an open circuit condition is considered an active state. Uncheck if closing the DIB to ground circuit is considered an active state.

SNMP

This page contains options for configuring SNMP on the Frontier system. For more information on setting up SNMP, see the section titled *Integration: SNMP*.

DNP3

This page contains options for configuring DNP3 on the Frontier system. For more information on setting up DNP3, see the section titled *Integration: DNP3.*

Software Activation

Optional features can be activated in this menu option. Additional features include AC ripple voltage measurements and higher resolution ohmic and voltage measurements. Contact your vendor to determine available features for activation. If DCMs with temperature probes are deployed, all optional features are automatically activated.

- **Serial number:** This is a randomly generated number, unique to each Frontier system. Provide this number to NDSL to activate new features.
- **Activation code:** This input field allows users to enter the activation code provided by NDSL to unlock features in the Frontier interface. Activation codes are available by calling NDSL Technical Support.

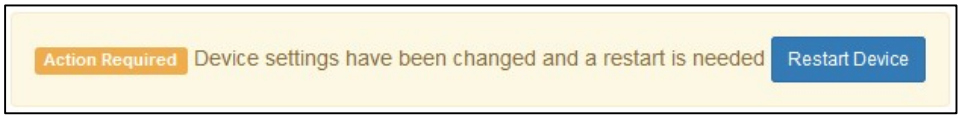
Upgrade Software

This setting allows the user to update the Frontier software. Only acceptable binary (.bin) files provided by NDSL should be uploaded.

To update the software, click **Select file** and locate the appropriate .bin upgrade package on your PC or networked drive. After choosing an upgrade package, press **Upload**.

Monitor the progress bar to ensure the file completes the upload process. Once it completes, the button to **Upgrade** will be enabled. Press **Upgrade**.

The software will begin the upgrade process. Do not navigate away from the page while the Frontier device is upgrading. Upon completion, the device will require a reboot. Press the **Restart Device** button to reboot the Frontier system.



Note: Software upgrades will not occur if the Frontier system clock is not set correctly. Updates with a release date beyond the Frontier system time and date will not install.

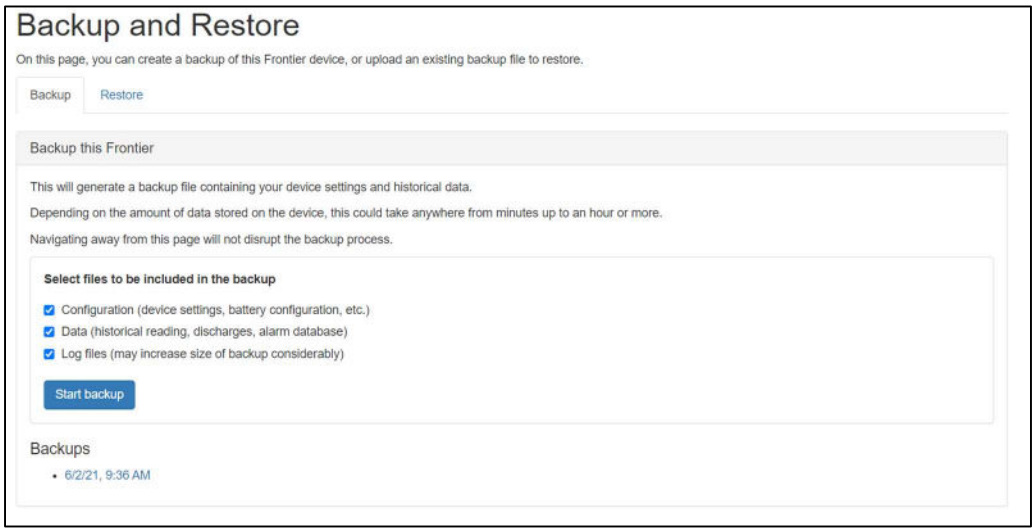
An upgrade package may require that the Frontier first be upgraded to a minimum level before it can be applied. If so, the Upgrade Software will indicate which version that the package requires. Upgrade the Frontier to the indicated version and then try again.

Cellwatch Central

This page contains options for configuring a Frontier system to communicate with Cellwatch Central. For more information on setting up this feature, see the section titled *Integration: Cellwatch Central*.

Backup and Restore

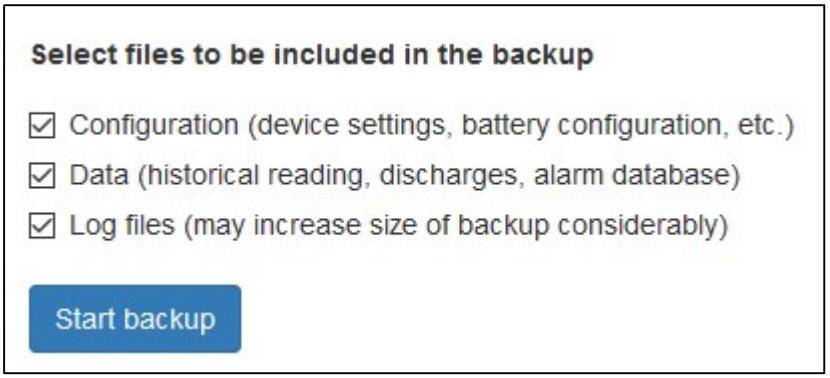
Frontier has the ability to create a backup file which will contain all history and discharge data, as well as all device configuration files and settings. The most recent backup created will remain on the device, giving the user the option to download the file to local storage at any time. Frontier backup files have an .frb extension.



Initiate and download a backup file

To initiate a backup:

1. From the **Settings** menu, select **Backup and Restore**.
2. In the **Backup** tab, you will be prompted to select which files you want included in the backup. Choose the appropriate files.
3. Click the **Start backup** button located under the Backup section of the page. This button will be disabled if a backup is already in progress.

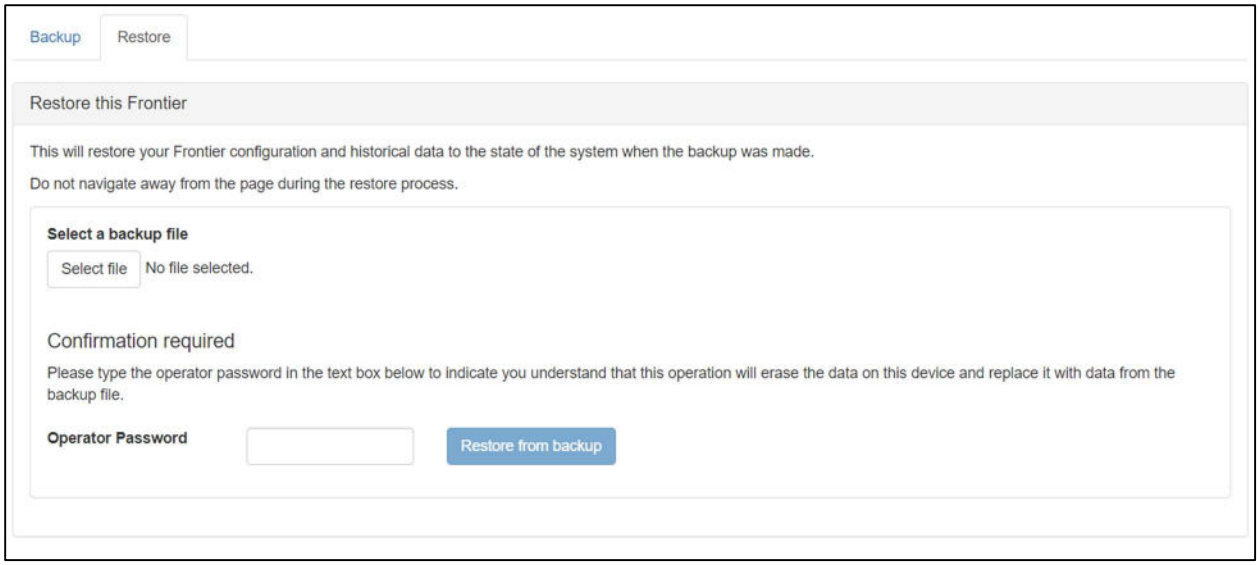


Depending on the amount of data on the device, Frontier may take from a few seconds to 20 minutes to complete the backup. Navigating away from this page will not interrupt the backup process.

Once the backup has been created, a new link will appear on the page under the **Backups** heading. Click this link to download a copy of the backup file to your PC.

Restoring Frontier from a backup file

A Frontier device can also be restored from a pre-existing backup. When restoring from backup, any existing history and database data, as well as device settings, are replaced with the data from the backup file. Only Frontier backup files (.frb) are accepted.



To restore from a Frontier backup:

1. From the **Backup and Restore** page, click the **Select file** button.
2. Choose the appropriate backup file located on your PC.

3. Enter the operator password (“deafcat”).
4. To start the restore, click the **Restore from backup** button. The maximum size that Frontier can restore from backup is 2GB (gigabytes).
5. Wait for the backup file to upload to the Frontier device.

The amount of time needed for the restore process will be largely dependent on the size of the backup and the speed of your connection to the Frontier device. A backup file that is 100 megabytes (MB) in size takes roughly 2 minutes when restoring over a local area network (LAN). It is not recommended attempting to restore over a slow or unstable connection, as the process may take hours or fail to complete. It is highly recommended that your machine and the Frontier device are inside a LAN before attempting to restore from a backup.

The operator password must be entered into the text area above before the restore process can be started.

During the restore process, a progress bar is shown to indicate the progress of the restore. Once the backup has been processed, Frontier will prompt the user to restart the device to complete the restore procedure.

Important: Do not navigate away from the page during the restore process.

Once the restore procedure completes, a status message will display to indicate if the restore was successful or not. If one or more files from the backup fail to restore, a restore log can be viewed to see which file(s) failed during the restore process by clicking the **View Details** button.

Diagnostics

The Diagnostics menu contains additional information about the Frontier system and allows users to resolve issues with system operation.

View Frontier Log

The **View Frontier Log** contains messages from the underlying software within the Frontier system. Viewing the Frontier log can be beneficial in troubleshooting any issues occurring with the Frontier unit. An option to save the complete log of events to a PC or onto a network storage device is available by clicking the **Download Frontier Log** button.

Users can download configuration files for later viewing by selecting the **Download Configuration** button. The hardware configuration file is what is built during the Battery Design process. The device configuration file stores information such as network and report generation settings.

Users can also save the alarms, history, discharge, or FED databases to their PC for later viewing by selecting the **Download Database** button.

Device Data

The device data table contains information about the Frontier device.

Name	Description
Frontier Serial Number	The hardware serial number of the Frontier device.
DCMs	The number of DCMs detected in the fiber loop connected to the system.
Current Probes	The number of configured current transducers in the system.
Temperature Probes	The number of configured temperature probes in the system.
Ethernet Port IP address	The IP address assigned to the specified Ethernet port on the Frontier device.
Ethernet Port MAC address	The MAC address of the specified Ethernet port on the Frontier device.
USB Gadget Port Address	The IP address assigned to the micro/mini-usb port on the Frontier device.
USB Gadget Port MAC Address	The MAC address of the micro/mini-usb port on the Frontier device.

Activation and Features

The activation and features table contains information about DCM activation.

Name	Description
Activation	Reports whether the Frontier system has DCM5 Enhanced Features activated or not.
Battery/String	Each Battery/String row defines which features are available for the individual string. This can include features activated through the software or features available through specific hardware (ex. Temp probe DCM units).

Tests and Actions

- **DCM Data:** This tool allows users to interrogate DCM devices individually to gather the most up-to-date readings and information.
- **Ping Channels in Alarm:** Use this feature to activate the LED and buzzer on DCM units connected to channels in alarm.
- **Manual Ohmic Scans:** This function allows users to initiate an ohmic value scan. The option to scan the entire system or individual strings is available.
- **Resume Scan:** This activates the scan routine again following a system stop due to fiber break or maintenance.
- **Test Hardware Relays:** Activate individual relays to verify proper configuration.
- **Test Fiber Optic Loop:** Users can perform a fiber optic check. During this check, a pulse will be transmitted through the fiber optic loop once per second. All DCMs that receive the signal will beep, flash, and pass the signal to the next DCM until the signal is returned to the Frontier module. This test can be used to troubleshoot a break in the fiber optic loop of a Frontier system by using the DCM units to identify where the break has occurred in the loop.
- **View logs:** Lists all log files that are available for download. Can be used to troubleshoot issues and investigate events.
- **Scaling Factor:** Click to set or clear ohmic value scaling factors on cells, straps or charger cables.
- **Device Restart:** Click this button to restart the Frontier device.

Troubleshooting

This section will address the most common errors reported by the Frontier system and solutions for each.

Channel Mismatch Error

DCM fiber loop is complete, but channels detected do not match the number of channels configured.

Resolution: Check the fiber loop. Likely a DCM was skipped when routing fiber. Also check the configuration to ensure it is correct.

DCM Error

Indicates there is a break in the fiber loop.

Resolution: Check fiber loop using Test Fiber Optic Loop in Diagnostics. Likely a fiber connection isn't secure, or a DCM is not regenerating the fiber signal.

Data Interpretation

Proper use of the battery monitoring system is critical to monitoring battery health. If the Frontier system is not monitored regularly or connected to proper alert management systems, users will not know of potential issues exposing their battery system to risks.

Voltage Alarms

Voltage alarm limits will vary with the chemistry of the battery. Always refer to manufacturer's specifications for voltage alarms.

Individual cell voltage alarms

Individual cell voltage alarms should be based on normal float conditions and by following battery manufacturer recommendations. This should not be confused with equalization charge alarms.

String voltage alarms

String voltage can be used as the first step in preventing thermal runaway and ensuring the DC charger is configured correctly. The low string voltage alarm limit is often calculated by multiplying the low cell voltage alarm limit by the total number of monitored cells. Likewise, the high string voltage alarm limit is found by multiplying the high cell voltage alarm limit by the total number of monitored cells. Verify with the battery manufacturer what the recommended string voltage alarm limits should be set to.

Example: 2.21V (low cell voltage alarm) * 30 cells = 66.3V (low string voltage alarm)

Temperature Alarms

Temperature will vary depending on airflows around the battery string and/or the battery room. Allowances for fluctuations in the environment should be considered. Most battery manufacturers recommend electrolyte temperatures of 77°F or 25°C. Increasing temperatures can have detrimental effects on the life of the cell but will increase available power. Decreasing temperatures can have detrimental effects on the power capabilities of the cell, but typically will increase the lifespan of the cell.

Ohmic Alarms

The ohmic value measurement consists of both a physical resistance and a chemical resistance. Thus, ohmic value can change based on torque or changes in the conductive path of the plates (physical) or due to changes in electrolyte or reactive area (chemical). While not directly linked to ampere hour capacity (AH), increases in ohmic value often indicate a decrease in the ability for the cell to perform during a discharge event.

Warning: It only takes one open cell to cause a string failure.

Identifying failures

Ohmic value can change depending on the state of charge of the cell. Any time a high ohmic value is detected, the cell torque and state of charge should be checked to determine if the cell simply needs to be boost charged or if it should be replaced.

High ohmic value readings are often an indication of a failing cell. If a high ohmic value cell is identified with a low charge voltage and a poor discharge performance, it should be considered for immediate replacement.

Variability with other instruments

The DCM can and likely will vary slightly from hand-held battery testers as each device uses different test methods. While nearly all devices will use the same equation from Ohms Law, the sampling method, current draws, and depth of discharge will vary. These variances will cause inconsistencies between devices.

Current Alarms

Current flow events are indicated by the direction of current either into or out of the battery. Current flowing out of the battery as a load is placed on the system is considered a **discharge event**. Once the load is removed and a charger provides current flow into the battery, this is considered a **charge event**.

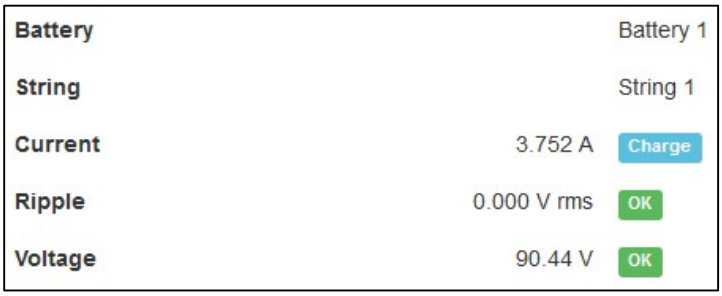
Discharge events

A discharge event occurs when the DC charger is not capable of supporting the load and the battery is utilized to supplement the power required by the system. Load amounts and discharge rates will vary depending on the size of the system and the size of the load. It can be useful to capture discharge data for analysis of the overall state of the battery. Frontier collects voltage, current, and temperature during a discharge event, allowing the user to see how well the battery performs under expected loads over a period of time.

Charge events

Charge events indicate current flowing into the battery. A higher precision probe is required to monitor float current. Analysis of this data can be used to show the length of time required for the battery to return to a fully charged state and will record voltages to show the overall performance of each individual container.

Setting a charge limit does not place the Frontier system into alarm if triggered, but it can be used to optionally monitor charge events for graphing and data analysis.



An example of Frontier monitoring a charge event.

Low float current (continuity)

Frontier includes a low float alarm that is triggered when current measured is less than the intended float charge. This can be indicative of a battery internal disconnect or possibly switched-off charger. This limit must be less than the charge current limit, and a Float Charging Current Probe (FCCP) should be used as the charge CT in a logical CT configuration.

Note: This alarm's condition is set up specifically for use with FCCP units. This type of current probe takes 20 minutes for readings to stabilize. Thus, a low float current alarm will not trigger until the current measured by the FCCP is less than the low float current limit continuously for 20 minutes.

A low float current event takes lower priority to discharge and charge events. This means that a low float current alarm will never trigger during the event of a discharge or charge. If a low float current alarm has triggered, the detection of a discharge event or a charge event will cause the low float current alarm to turn off.

Section III – Configuration Build and Hardware Integration Guide

Introduction

This guide will explain in detail the Battery Design walkthrough to build the configuration file and setting parameters for the hardware portions of the Frontier system.

Building a Battery Configuration

The **Battery Design** wizard is accessible under the **Settings** menu in the Navigation Bar.

The user will be presented with three options when building a battery configuration. If this is a new installation, select **Start new configuration** to build a battery configuration for the first time. For adding or removing hardware, or changing aspects of an existing installation, select **Edit configuration**.

For examples of common battery configurations, continue to the *Configuration Build Examples* section below following the functional explanations.

To restore a previously saved battery configuration, click **Upload configuration file**. Select the battery configuration file, continue with the wizard to make any needed modifications, and click **Save** at the end. The Battery Design wizard displays an error if the selected file is not a valid battery configuration file. The battery configuration can be saved to a file for later restoration by selecting **Download your current hardware configuration file here**.

Use the **Previous** and **Next** buttons to navigate backwards and forwards through the pages of the Battery Design walkthrough. Using the **Back** button on the browser interface will leave Battery Design and go to the previous page.

Hardware

The battery configuration is built by answering questions pertaining to the number of probes installed, whether straps will be measured separate from cells, and which digital input bits (DIB) are being used for this system.

A simple set of questions defines the parameters for the configuration file. These questions help define the expected number of hardware components, how they are arranged, and proposed usage in the system.

Which wiring pattern is being used?

Frontier has the ability to measure inter-cell straps or links separately from cells. This allows for ohmic value analysis and trending that isolates and monitors the changes of the cell and the straps independently. Select the **Cells and Straps** option if the DCM hardware is installed to measure straps separately and ensure the appropriate number of DCMs have been acquired. Choose **Cells only** if this is

not the case. Inter-tier straps, charger cables or string voltage/ripple channels can be specified on the Batteries page using the cells only configuration.

Which temperature probe (TP) ports are being used?

There are four hardware connections on the Frontier unit for temperature probes. These are probes that can be placed throughout the string or used for ambient temperature readings. Check the number of temperature probes to be used and ensure that the hardware is plugged into the corresponding TP# port on the Frontier unit. Any combination of TP ports can be used.

Which current transducer (CT) ports are being used?

There are 2 (or 4, depending on the Frontier model) hardware connections on the Frontier unit for current probes. Current probes can be placed on the charger cable or a bus cable in the string to measure the current flow. Different models of current probes may be used to monitor float, discharge, and charge currents. Check the number and type of current probes to be used and ensure that the hardware is plugged into the corresponding CT# port on the Frontier unit.

Digital input bits (DIB)

Frontier has 4 digital input bits (DIB) available in order to incorporate third party devices into the system. Examples of devices that can be integrated into Frontier include ground fault detectors, hydrogen sensors, or electrolyte leak detection systems. Once battery design is completed, any DIBs being used can be configured by navigating to **DIB Alarms** under the Settings menu.

Individual cell temperatures

Frontier will automatically detect a system with temperature sensing DCM units and will display individual cell temperature readings on the Home page along with voltage and ohmic value measurements. No further configuration is required for this feature.

When completed, press the **Next** button at the top of the page to continue to the next step.

Batteries

Frontier uses terminology in line with industry standards to describe the parts of the battery system.

Terminology

- Battery – A battery is the entire unit connected to the DC charger
- String – A number of containers connected in series which can be a parallel feature of the battery
- Jar, container, or cell – The lowest changeable unit of a string

How many batteries?

Up to four batteries can be monitored by a single Frontier unit. This is due to the limited number of CT ports available in Frontier. Each battery must have at least one CT assigned to it. Edit this field with the number of batteries in the system and the page will update with available settings for each. Batteries hold their properties along with the corresponding string properties nested underneath them in the user interface.

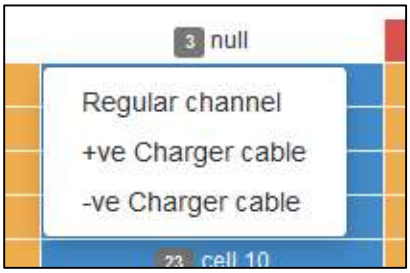
Batteries

- **Battery name –** The name of the battery can be changed to facilitate identification. It is recommended to leave the word "Battery" in the name.
- **String count –** Enter the number of strings that are in parallel for the corresponding Battery. Refer to the terminology above if there are questions on how many strings are connected to the Battery.

Strings

- **String name** – The name of the string can be changed to facilitate identification. It is recommended to leave the word "String" in the name.
- **Assigned TPs** – One or more available temperature probes can be assigned to a string. Select the checkbox next to the desired TP port to assign it to the string.
- **Assigned CTs** – One or more available current transducers can be assigned to a string. Select the checkbox next the desired CT port to assign it to the string.
- **Assigned Digital Input Bits** – Number of digital input bits (DIB) to be assigned to a string.
- **Channel Count** – The total number of DCM channels in the Frontier system. Each DCM has four channels, so this number can be calculated by multiplying the number of DCM units in the system by four. A channel map will display based on the channel count.

Channel Map



A corresponding **Channel map** will display, allowing the user to specify each channel as a cell, inter-cell strap, inter-tier strap, or charger cable. The screenshot below is an example channel map for a string with 30 cells (two tiers of 15 containers each), monitoring inter-cell links, inter-tier straps, and charger cables separately. The number of each channel is shown in grey, next to the assignment description for that channel. A channel dedicated to monitoring a cell is shown in blue, while a channel dedicated to monitoring an inter-cell link is shown in gold. Inter-tier straps and charger cables are shown in brown and red, respectively.

To change the assignment of a channel, left-click the channel and select one of the assignment menu options. A channel can be assigned as a cell, inter-cell strap or link, inter-tier strap, or a charger cable (either positive or negative).

To restore all channel assignments back to their defaults, select **Reset All Channels**.

Null channels

If a channel will not be used for monitoring, it will need to be nulled. To null a channel, left-click on the desired channel and select the option **Null channel**. Selecting this option will turn the channel white and display "null" for that channel.

DCM 1	1 null	2 null	3 null	4 +ve charger
DCM 2	5 cell 1	6 intercell 1	7 cell 2	8 intercell 2
DCM 3	9 cell 3	10 intercell 3	11 cell 4	12 intercell 4
DCM 4	13 cell 5	14 intercell 5	15 cell 6	16 intercell 6
DCM 5	17 cell 7	18 intercell 7	19 cell 8	20 intercell 8
DCM 6	21 cell 9	22 intercell 9	23 cell 10	24 intercell 10
DCM 7	25 cell 11	26 intercell 11	27 cell 12	28 intercell 12
DCM 8	29 cell 13	30 intercell 13	31 cell 14	32 intercell 14
DCM 9	33 cell 15	34 intertier 15	35 cell 16	36 intercell 16
DCM 10	37 cell 17	38 intercell 17	39 cell 18	40 intercell 18
DCM 11	41 cell 19	42 intercell 19	43 cell 20	44 intercell 20
DCM 12	45 cell 21	46 intercell 21	47 cell 22	48 intercell 22
DCM 13	49 cell 23	50 intercell 23	51 cell 24	52 intercell 24
DCM 14	53 cell 25	54 intercell 25	55 cell 26	56 intercell 26
DCM 15	57 cell 27	58 intercell 27	59 cell 28	60 intercell 28
DCM 16	61 cell 29	62 intercell 29	63 cell 30	64 intercell 30
DCM 17	65 null	66 null	67 null	68 -ve charger

In Frontier, each string has its own channel map. If all strings require modifications to the channel map, then the changes must be made for each string.

Electrolyte Level Detectors (FEDs)

- **This string does not have FEDs/This string has FEDs** – Select **Change** to alter FED settings within this string.
- **String coverage** – Select **Full string** if every container within the string has at least one FED unit attached for active electrolyte level monitoring. Select **Partial string** if there are containers within the string that will not have active electrolyte level monitoring. Choose **No FEDs** if FEDs are not being utilized.
- **Number of FEDs** – If Partial string is selected, this specifies the number of FED units to be assigned to the string.
- **FEDs per channel** – The number of FED units per cell. For containers with multiple cells with individual electrolyte, multiple FED units will be needed per container.

Click **Apply Changes** to save any changes made in this section. The section will then update to indicate:

- if the string does not have FEDs,
- or the number of FEDs and the string coverage.

Temperature Compensation

- **This string has temperature compensation** – This feature uses a temperature profile to adjust cell ohmic value readings based on the temperature recorded.
- **Battery Profile** - The Battery Profile to measure ohmic value temperature compensation can be selected for the individual string.
- **Temperature Source** - The temperature compensation source is specified using either an assigned temp probe or individual cell temperatures.

Press the **Next** button at the top of the page to continue to the next section.

Saving your configuration

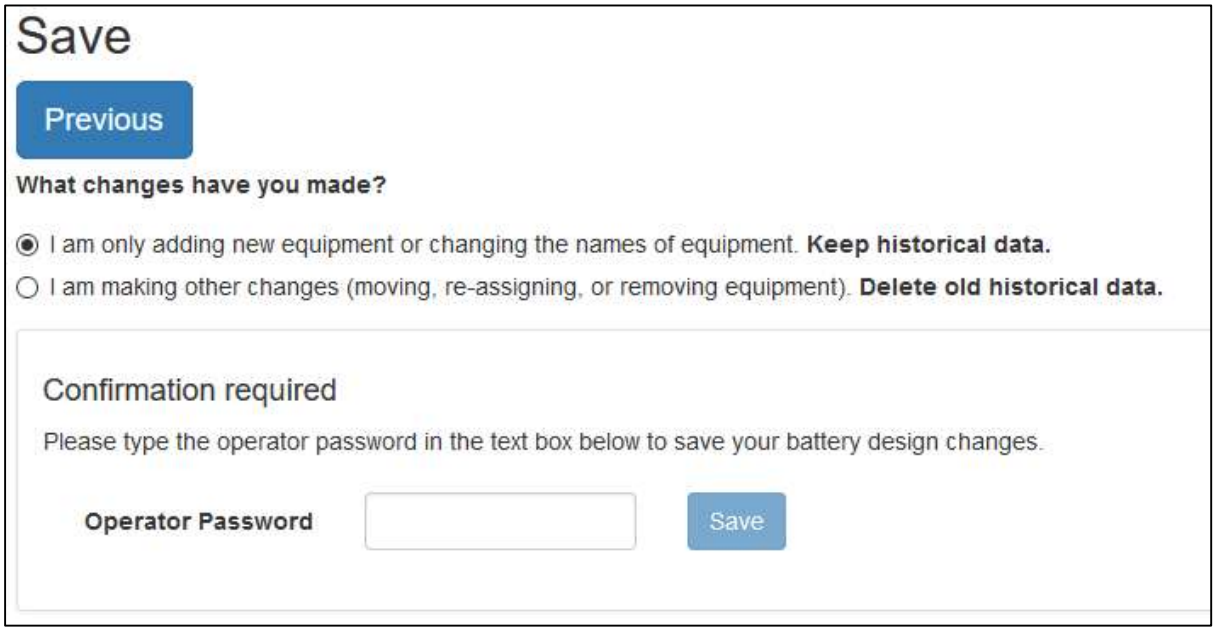
Once the battery configuration is completed, it will need to be saved in order for the proper configuration files to be written. If you were editing an existing configuration, you may need to reset your historical data depending on the changes you made to your configuration.

If adding new equipment or changing the labels for existing equipment in the system, then it is safe to keep your historical data.

Examples of adding new equipment include:

- Installing additional TPs or CTs
- Adding one or more batteries or strings to the system

Select **Keep historical data** to keep the existing history database on the device and append any new data.



If you performed any of the following actions, you will need to reset your historical data:

- Removing equipment (such as a CT or TP, removing a battery or string)
- Re-assigning equipment (such as re-assigning a CT or TP to a different battery or string, or changing channel assignments)

Select **Delete old historical data** to clear the existing history database. In the above cases, if the existing history database is not reset, no future data will be collected.

If this is a new installation, then select **Delete old historical data**.

Final options:

- **Previous** button – click this to alter your configuration before saving.
- **Operator Password** – In order to save the new configuration, you must enter in the operator password:

Operator Password	deafcat

- **Save** button – this will commit your changes. Wait for the progress bar to complete.

Return to the Home page to see the latest measurements.

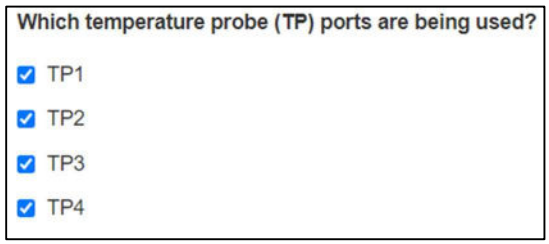
If there are errors shown on the Home page or the data does not appear as expected, continue to the *Battery Configuration Troubleshooting* section of this guide.

Note: The cells will appear grey after you have saved a new Battery Configuration. Once alarm limits have been set and the Frontier system executes an initial scan, individual channels will appear green or red if in an alarm state.

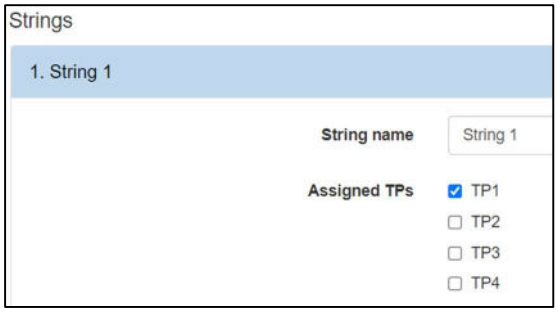
Configuring Temperature Probes (TP)

Configuration settings for Temperature Probes are accessible under the Settings menu in the Navigation Bar.

During setup of the battery configuration, the option is presented to select which TP ports will be used for the configuration. One can select from TP1 to TP4 as seen in the below screen capture.

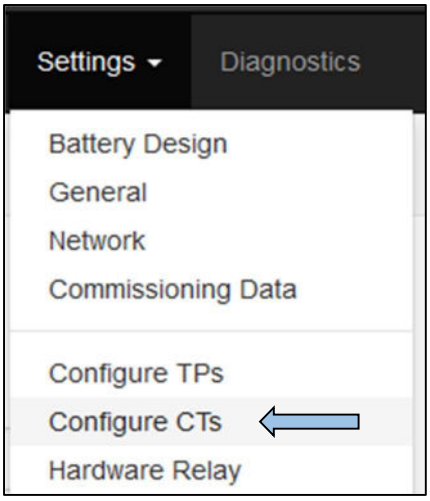


On the next page of the configuration setup is where the TPs can be assigned to certain strings matching up with the actual hardware installation. In the example below, TP 1 is assigned to monitor String 1.



Configuring Current Transducers (CT)

Configuration settings for current transducers are accessible under the Settings menu in the Navigation Bar.



Terminology and Implementation

Multiple CTs can be assigned to a single string to combine readings into a single value. Physical and Logical CTs will not be addressed in the web interface but it is important to know how the data is being returned and why multiple CTs can be assigned to a single string.

The explanation of terminology is below:

Physical CT

A physical CT is each current transducer hardware component that is plugged into a port on the Frontier unit.

Logical CT

A logical CT is the current output shown through the web interface or communication protocol. This output can be the combination of multiple physical CTs. When using a CT for monitoring charge current and another CT for monitoring discharge current on the same string, these two readings can be shown as a single reading for the string since only one of the two measurements will be used at any time during the operation of the battery. When the string is in discharge, the current output relies on the CT assigned for monitoring discharge. When the string is charging, the current reading displayed is the output from the charging CT. The charge CT will generally have higher resolution at lower current values.

In summary, the logical current output for the string switches between the two CTs depending on the present state of charge/discharge. This gives a higher resolution of the current reading and integrates the functionality into a single output for ease in monitoring.

Type and Assignment

The CTs selected in the Battery Design wizard are available to be configured by Type and Capacity. Frontier allows the use of different styles of CTs and different monitoring capabilities.

CT types

- **Discharge only** – Usually implemented with standard CT rated at +/-50 to +/-1000A. Used primarily for monitoring precise current readings on higher discharge load events.
- **Charge only** – A CT dedicated to monitoring low float charge currents at a higher precision and resolution.

Note: A current transducer that is configured as a discharge CT can also be used to measure a recharge current, typically up to 20% of the current transducer's capacity.

Capacity

The capacity of the CT is a manufacturing specification that determines how high of a current reading the CT can measure. This is generally noted on the side of the physical CT. Check the CT being used for its capacity specification.

Assigning properties

The CTs are numbered based on their port location. Multiple CTs can be assigned to a single string and the output will be a "Logical" data return. Logical CT data is based on which CT is being implemented according to the state of charge.

If two CTs are assigned to a single string, they will need to be assigned separate types. You cannot have two of the same type on one string. If a string has a charge CT and discharge CT assigned to it, no other CTs can be assigned to it.

Reading

The value displays real-time readings from any current transducers connected to the Frontier unit. These readings can be used to verify the configuration is correct and to assess whether a CT should be zeroed.

Zero CT

Zeroing a current transducer is setting the baseline for the current readings. Before zeroing a CT, be sure that the CT is removed from the bus/charger cable so that no current is flowing through. Once the reading has settled, press the **Zero CT** button next to the corresponding CT number.

After pressing the **Zero CT** button, the current state of the readings in the CT are set to zero and any changes to the magnetic field from that point will be considered actual current readings from the charger cable. The **Zero CT** button can be used at any time to recalibrate a current transducer.

Be sure to press the **Save** button before leaving the page to save any changes that were made.

Float Charging Current Probe (FCCP)

A standard CT used for measuring discharge current is not sensitive enough to measure float charge current accurately. When an accurate float charge current measurement is required, a Float Charging Current Probe (FCCP) should be used. The FCCP can measure typical float currents of 50-100mA with higher precision and has a measurement range of 0-5A.

It has a long integration time constant to reduce sensitivity to noise, so an FCCP unit will take 20 minutes of stable current to deliver an accurate measurement. This means that any fluctuations in current during this time will prolong the stabilization of the probe measurement and can delay any charge or low float alarms from triggering.

Installation Guidance

- To minimize noise that may interfere with the output signal of the probe, the converter box must be mounted close to the FCCP. It is suggested to mount the converter box in the Panduit tray or on a fire-retardant mounting board using the provided wings. It is not recommended to mount the converter in the cabinet.
- The screened cable from the probe must have the screen connected to the ground lug on the converter box.
- The Frontier Interface Cable will connect into an unused Current Probe port on the Frontier system. This port must be programed in the current settings to measure charge current as opposed to discharge current.
- Excess cables should be coiled and dressed or shortened. When shortening cables, play close attention to the cable terminations and tin cables if necessary.

FCCP Calibration - When setting up an FCCP, it is recommended that the unit is allowed to stabilize for 25 minutes with no current flowing through the sensor before zeroing the CT in Frontier. The FCCP interface unit will also need to be zeroed before the FCCP is installed. Follow these steps to calibrate and zero the probe before finishing installation.

1. If installed over the inter-tier strap or inter-cell cable connection, remove the probe from the current carrying cable.
2. Ensure the probe is closed and latched. Place the latched closed probe next to the monitored cable.
3. Disconnect the power to the converter box. Press and hold the two buttons on the front of the converter box while powering the unit back on, holding until all LEDs on the converter box turn Red. This will take approximately 10-15 seconds.
4. Once lit, release the buttons and wait until all LEDs go out. This will take approximately 10-15 seconds.
5. Once LEDs have gone out, cycle the power on the converter box one more time.
6. In Frontier, go to the settings menu and select Configure CTs. The CT should be set as a charge only CT with a range of 5 amps.
7. On the same configuration page, click on ‘Zero CT’.
8. Verify under **Reading** that the float current is zero.
9. Refit the CT around the cable and verify float current (typically 0.100-0.200 A).

The arrow on a FCCP should be oriented with the flow of current (away from the battery if on the negative bus and toward the battery of on the positive bus) to display float current as a positive value.

Configuring Frontier Electrolyte Level Detectors (FEDs)

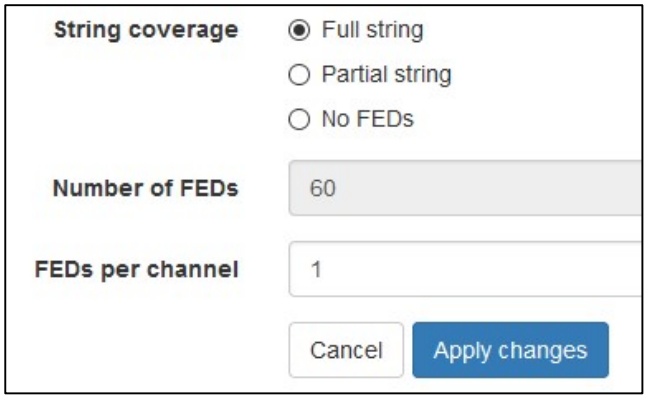
For new installations, all FED units will quickly flash their green LEDs upon initial power up. Only after verifying that all FEDs are flashing green should the installer move onto configuration and calibration. Refer to the section titled *Installation: Frontier Electrolyte Level Detectors* if FEDs are not flashing green.

Configuration: Battery Design

The battery configuration must be updated to include any new hardware that is added to the Frontier system. The saved settings of the current battery configuration can be modified to easily add the number of installed FEDs.

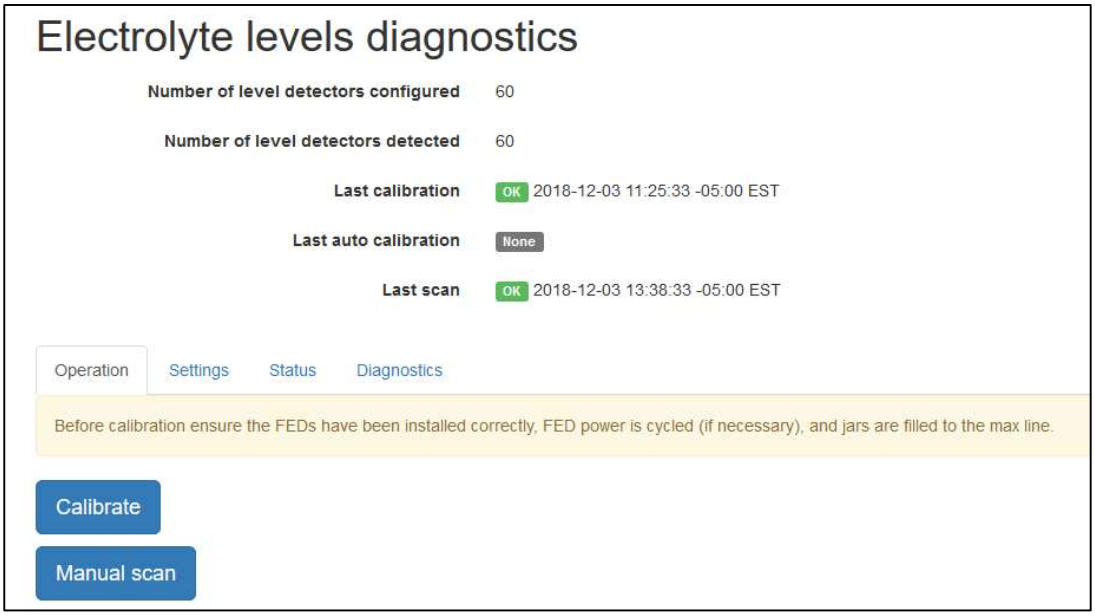
Steps for adding FEDs to an existing system (see *Configuration Build Examples-Standard System with FEDs* section below for adding FEDs with a new configuration)

1. Select **Battery Design** from the Settings menu.
2. Select **Edit Configuration**.
3. Verify that all settings on the Hardware page look correct. Click **Next**.
4. For each string that contains FED units, scroll to the "Electrolyte Level Detectors (FEDs)" section and select **Change** to add FEDs.
5. If there are FED units on every container in the string, then for "String coverage" select **Full string**. If one or more containers in the string will not be actively monitored for electrolyte levels, select **Partial string**. Choose **No FEDs** to remove FEDs from the string.
6. If **Partial string** is selected, enter the number of FEDs that will be monitoring electrolyte levels on the string in the **Number of FEDs** field.
7. If each container in the string has multiple FED units attached, place this number in the **FEDs per channel** field. This will automatically populate the **Number of FEDs** field if **Entire string** is selected.
8. The Channel Map on this page will update to indicate which cells are monitored with FEDs. Verify that the channel map looks correct. Click **Apply changes** to save FED settings.
9. Click the **Next** button, choose Keep historical data, enter the operator password 'deafcat', and click **Save**.



Calibration

After configuring the number of FED units in Battery Design, the FEDs will need to be calibrated to accurately detect low electrolyte levels. Calibration of FED units is done in Settings by selecting the **Electrolyte Levels** menu option. This brings up the Electrolyte Levels Diagnostics page. The options to Calibrate or force a Manual Scan are found in the Settings tab.



This page will show the time and date of the last FED calibration that occurred, in addition to the last FED scan. The number of level detectors configured should match the number of level detectors detected. If these two values do not match, refer to the section titled *Common Errors*.

Note: Any changes to the **Battery Design** will cause the **Number of level detectors detected** above to reset to "Not detected" until a new FED calibration or scan is performed.

Calibration Process

During calibration of FED units, **Operation** and **Progress** fields will display to give the user status information pertaining to the calibration or scanning process. The Operation field will report the current

action being performed, which will either be **Discovery**, **Calibration**, or **Scan**. The **Progress** field reports the current progress of each action.

Steps for Calibrating FEDs

1. Select **Diagnostics**.
2. Under **Test and actions**, select **Electrolyte Levels**. The number of level detectors configured should match the number of level detectors detected. If these two values do not match, refer to the section titled *Common Errors*.
3. Press the **Calibrate** button. The button state will change to "Calibration Requested" while the Frontier system calibrates each FED unit in series.
    a. **Quick Calibrate** sets the 'full' level for each FED unit.
    b. **Full Calibrate** will power cycle the FED units and set their addresses (enumerate operation), it will then calibrate the units at the 'full' level.

    A Full Calibration will take a few minutes to complete. For example, 60 FED units will take around five minutes to complete. Do not navigate away from this page while FED units are calibrating.
4. Once calibration is complete, the **Calibrate** button will return to its normal state and the **Last calibration** field will update with the time and date that the most recent calibration occurred.
5. Return to the Home page to verify that all alarm statuses are being returned properly.

Alarm Status in User Interface

Each FED reading will be represented by a block in the user interface and each block will have a color to indicate the state of alarm.

Color Indicator	Description
Green	Electrolyte Level is normal.
Red	Electrolyte Level is low.
Orange	Level Detector is detached.
Grey	Level Detector in error state.

On-screen electrolyte level status is updated at least once every hour.

Other FED Diagnostic Functions

The Electrolyte Levels Diagnostics page also contains an additional three tabs which can be used to configure auto calibration, as well as display and export FED status data.

Settings

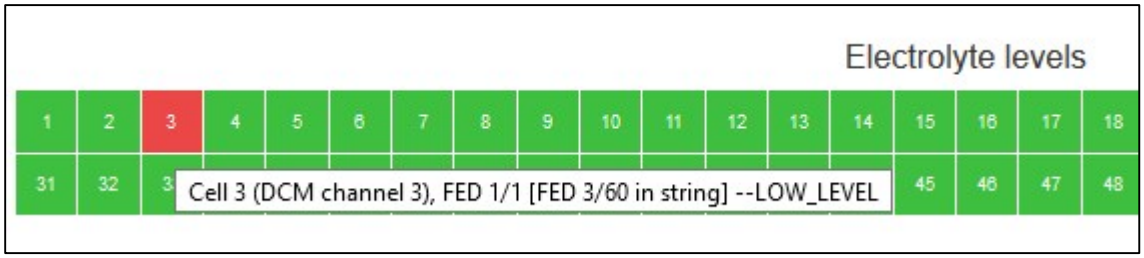
The Settings tab allows the user to enable/disable the auto-calibration, set the scheduled time for calibration, and enable/disable detach detection.

- The **Enable Auto Calibrate** turns on the function to calibrate if the luminosity has changed due to changes in the color of the positive plate. As some batteries age, the light reflected back from the positive plate changes gradually. This function compensates for that change.

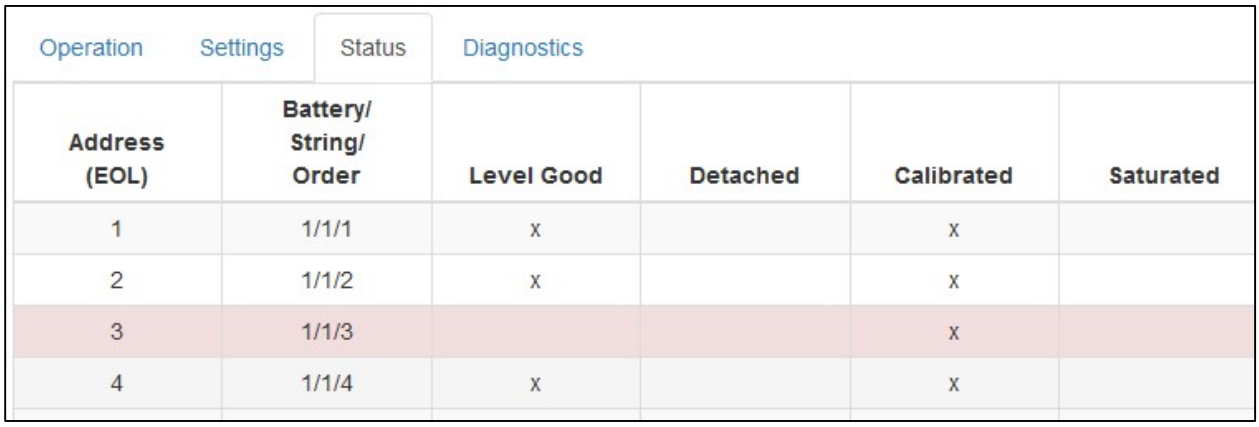
- **Auto Calibrate Scheduled Time** sets the time each day for the auto calibration to occur.
- The final option on this tab is to **Enable Detachment Detection**. Enabling this option turns on all falloff and plate dimming features. Disabling will prevent the system from sending out alarms if a falloff or post dimming state is detected.

Status

The Status tab allows the user to gain additional insight to the status of each FED unit. Pressing the Load/Refresh FED Status button will list each FED unit along with their latest level/detached status, calibration status along with other possible error states. While the LED indicator on the FED will show there is a problem, this page will give the reason for the alarm or error. For example, if a FED has detected a low level on a jar, the Home page will show an alarm.

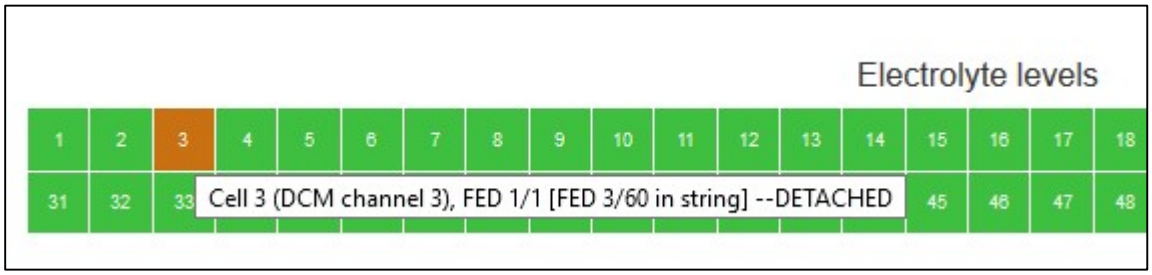


Further investigation on the Status tab shows this FED is in alarm for low level (Level Good not checked).



Address (EOL)	Battery/ String/ Order	Level Good	Detached	Calibrated	Saturated
1	1/1/1	x		x	
2	1/1/2	x		x	
3	1/1/3			x	
4	1/1/4	x		x	

If a FED has detected a falloff state, the Home page will change the color of that FED indicator to orange.

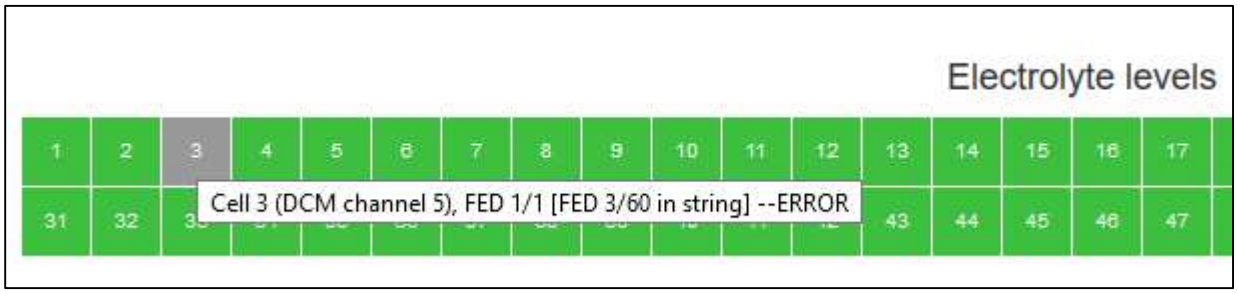


The Status tab will then show the state as Detached.

Operation | Settings | Status | Diagnostics

Address (EOL)	Battery/ String/ Order	Level Good	Detached	Calibrated
1	1/1/1	x		x
2	1/1/2	x		x
3	1/1/3		x	x
4	1/1/4	x		x

If an error state is reached, the Home page will change the color of that FEDs indicator to gray.



The Status tab will then give some additional information as to the reason for the error. Likewise, a 'Not Reliable' error will display on the Electrolyte Levels Diagnostics page.

Operation | Settings | Status | Diagnostics

Address (EOL)	Battery/ String/ Order	Level Good	Detached	Calibrated	Saturated	Unknown
1	1/1/1	x		x		
2	1/1/2	x		x		
3	1/1/3			x		x
4	1/1/4	x		x		

Diagnostics

The Diagnostics tab allows the user to pull down FED diagnostic data for later evaluation. The List Registers button will display the latest FED register data. This information can then be downloaded as a .csv file or as a .txt file. The FED database pulls down historical data from the system.

Common Errors

A configuration or communication error can be returned from the FEDs for two main reasons.

1. The number of configured FEDs in Battery Design does not match the number of FED devices discovered.

   Reason: The Battery Design was configured for the wrong number of FEDs.

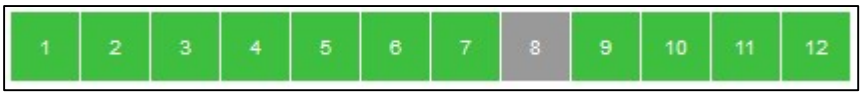
   Fix: Return to Battery Design and confirm that the correct number of FEDs have been configured for each string. Save your changes and recalibrate. Force a manual scan in Diagnostics or allow the status of each FED to update on the next hourly scan.

2. The number of FEDs discovered during the previous scan does not match the configuration.

   Reason: The communication has been broken at the FED connections.

   Fix: Identify location of the break using the Frontier user interface and reseat the connection at the FED. Force a manual scan in Diagnostics or allow the FED to update on the next hourly scan.

A break in FED communications will be easy to spot on the Frontier Home page. The location of the break can be seen as the first cell that is colored grey in a string. The previous FEDs in the string returned their readings but the break in communications began at the FED that is colored grey.



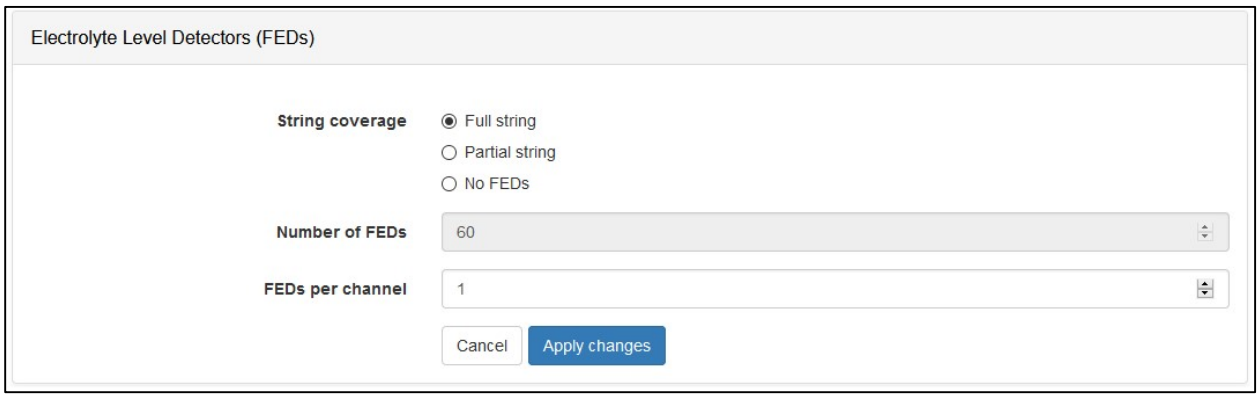
A break in communication has occurred at FED #8.

Configuration Build Examples

Standard System with FEDs

Example Configuration: 1 Battery, (2) 60 jar strings with standard DCM wiring, 2 temperature probes, 2 current probes

1. Select **Battery Design** from the Settings menu.
2. Select **Start new configuration**.
3. Hardware
    a. Wiring Pattern: Cells only.
    b. Temperature probes: TP1 and TP2.
    c. Current transducers: CT1 and CT2.
    d. Leave all digital bits checked unless they need to be disabled.
4. Click **Next**.
5. How may batteries = 1, name the Battery or leave the default number.
6. String count = 2, name the String or leave the default number.
7. Assign TP1 to String 1 by clicking the corresponding check boxes.
8. Assign CT1 to String 1 by clicking the corresponding check boxes.
9. Assign TP2 to String 2 by clicking the corresponding check boxes.
10. Assign CT2 to String 2 by clicking the corresponding check boxes.
11. Assign DIBs as needed.
12. Enter “60” into the Channel count field for String 1 and String 2.
    a. Make note of the number of DCMs needed for this configuration. Ensure the correct amount of hardware is used.
13. Click **Change** in the Electrolyte Level Detectors section.
    a. Choose **Full string** for string coverage.
    b. Verify the number of FEDs reported is as expected, 60 in this case.
    c. Leave FEDs per channel as 1.
    d. Click **Apply changes** to save the FED settings.



14. Make no changes to the Temperature Compensation (no).

15. Click **Next**.
16. Enter in the operator password of 'deafcat'.
17. Click **Save** and wait for the "Settings Saved" confirmation.
18. Select **Home** from the Navigation Bar to see the new readings.
19. Assign alarms to the Frontier unit.

Inter-cell Straps

Example Configuration: 1 Battery, (1) 30 jar string measuring inter-cell straps, no inter-tier straps, 2 temperature probes, 2 current probes

1. Select **Battery Design** from the Settings menu.
2. Select **Start new configuration**.
3. Hardware
    a. Wiring Pattern: Cells and Straps.
    b. Temperature probes: TP1 and TP2.
    c. Current transducers: CT1 and CT2.
    d. Leave all digital bits checked unless they need to be disabled.
4. Click **Next**.
5. Name the Battery and String.
6. Assign TP1 and TP2 to String 1 by clicking the corresponding check boxes.
7. Assign CT1 and CT2 to String 1 by clicking the corresponding check boxes.
8. Assign DIBs as needed.
9. Enter "59" into the Channel count field (30 jars + 29 straps).
    a. Left-click the 4th channel on the last DCM to null the last channel. This will not be measured since that channel is a negative bus cable. See snapshot below for example layout.
    b. Make note of the number of DCMs needed for this configuration. Ensure the correct amount of hardware is used. The channels for the inter-cell links will be numbered independently of the cells. An example of the channel map is below.

DCM 1	1 cell 1	2 intercell 1	3 cell 2	4 intercell 2
DCM 2	5 cell 3	6 intercell 3	7 cell 4	8 intercell 4
DCM 3	9 cell 5	10 intercell 5	11 cell 6	12 intercell 6
DCM 4	13 cell 7	14 intercell 7	15 cell 8	16 intercell 8
DCM 5	17 cell 9	18 intercell 9	19 cell 10	20 intercell 10
DCM 6	21 cell 11	22 intercell 11	23 cell 12	24 intercell 12
DCM 7	25 cell 13	26 intercell 13	27 cell 14	28 intercell 14
DCM 8	29 cell 15	30 intercell 15	31 cell 16	32 intercell 16
DCM 9	33 cell 17	34 intercell 17	35 cell 18	36 intercell 18
DCM 10	37 cell 19	38 intercell 19	39 cell 20	40 intercell 20
DCM 11	41 cell 21	42 intercell 21	43 cell 22	44 intercell 22
DCM 12	45 cell 23	46 intercell 23	47 cell 24	48 intercell 24
DCM 13	49 cell 25	50 intercell 25	51 cell 26	52 intercell 26
DCM 14	53 cell 27	54 intercell 27	55 cell 28	56 intercell 28
DCM 15	57 cell 29	58 intercell 29	59 cell 30	60 null

10. Make no changes to the Electrolyte Level Detectors (no FEDs) and Temperature Compensation (no).
11. Click **Next**.
12. Enter in the operator password of ‘deafcat’.
13. Click **Save** and wait for the “Settings Saved” confirmation.

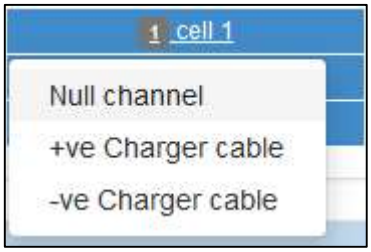
14. Select **Home** from the Navigation Bar to see the new readings. The strap readings will be included as a separate graph on the Home page.
15. If enabled, the inter-tier strap would be included as a line item on the Home page.
16. Select **Configure CTs** in the Settings menu, located in the Navigation Bar.
17. Select Type of CT that is connected to the corresponding ports.
18. Select the Capacity rating of the CT.
19. Zero if needed.

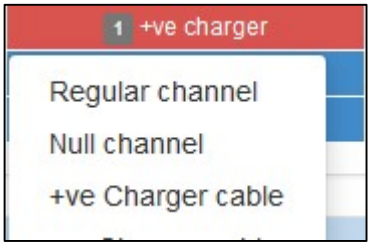
20. Assign alarms to the Frontier unit.

Charger Cables

Example Configuration: 1 Battery, (1) 60 jar string measuring charger cables, with DCM 5T, 2 temperature probes, 2 current probes

1. Select **Battery Design** from the Settings menu.
2. Select **Start new configuration**.
3. Hardware
    a. Wiring Pattern: Cells only.
    b. Temperature probes: TP1 and TP2.
    c. Current transducers: CT1 and CT2.
    d. Leave all digital bits checked unless they need to be disabled.
4. Click **Next**.
5. Name the Battery and String.
6. Assign TP1 and TP2 to String 1 by clicking the corresponding check boxes.
7. Assign CT1 and CT2 to String 1 by clicking the corresponding check boxes.
8. Assign DIBs as needed.
9. Enter “62” into the Channel count field (60 jars + 2 charger cables).
    a. Based on the hardware layout, the channels needed for monitoring the charger cables will need to be left-clicked and changed to a status of “Charger cable.” This will change the color of the channel to red and reorder the cell labeling.





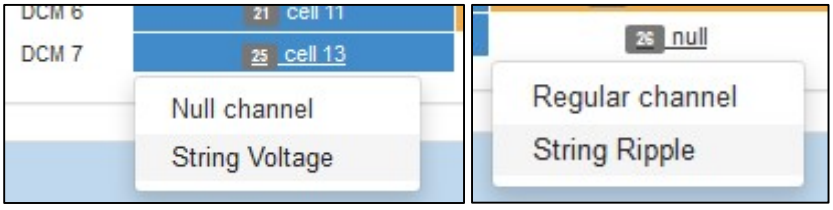
    b. Make note of the number of DCMs needed for this configuration. Ensure the correct amount of hardware is used.
10. Make no changes to the Electrolyte Level Detectors (no FEDs) and Temperature Compensation (no).
11. Click **Next**.
12. Enter in the operator password of ‘deafcat’.
13. Click **Save** and wait for the “Settings Saved” confirmation.
14. Select **Home** in the Navigation Bar to see the new readings. The charger cable’s ohmic values will be included as a separate line item on the Home page.

15. Select **Configure CTs** in the Settings menu, located in the Navigation Bar.
16. Select the Type of CT that is connected to the corresponding ports.
17. Select the Capacity rating of the CT.
18. Zero if needed.
19. Assign alarms to the Frontier unit.

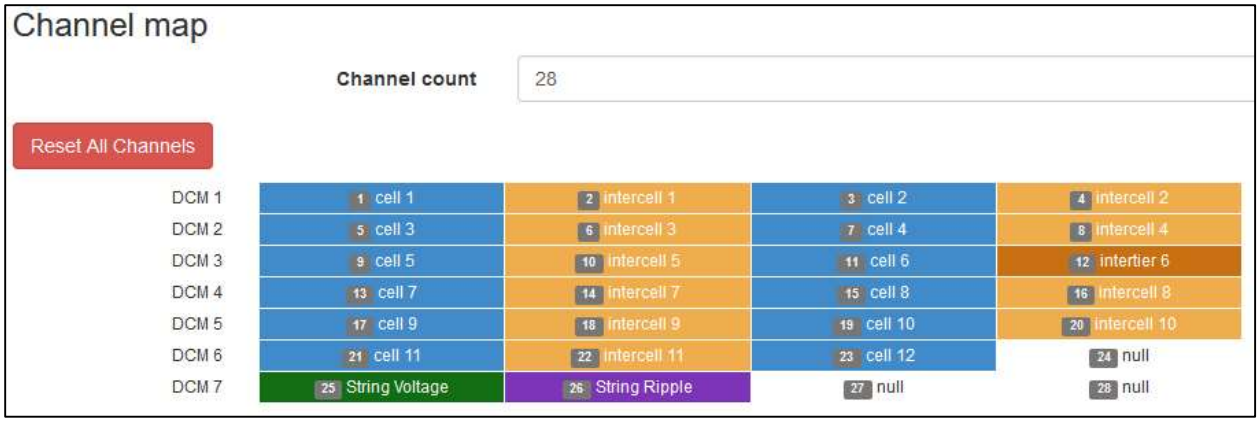
DCM6-R

Example Configuration: 1 Battery, (1) 12 jar string with DCM 6-L and a single DCM 6-R measuring string voltage and ripple, 1 temperature probe, 1 current probe

1. Select **Battery Design** from the Settings menu.
2. Select **Start new configuration**.
3. Hardware
    a. Wiring Pattern: Cells and Straps.
    b. Temperature probes: TP1 and TP2.
    c. Current transducers: CT1 and CT2.
    d. Leave all digital bits checked unless they need to be disabled.
4. Click **Next**.
5. Name the Battery and String.
6. Assign TP1 to String 1 by clicking the corresponding check boxes.
7. Assign CT1 to String 1 by clicking the corresponding check boxes.
8. Assign DIBs as needed.
9. Enter “28” into the Channel count field (7 DCM units * 4 channels each).
    a. Left click the 4th channel on DCM #6 to null the last channel. This channel will not be measured.
    b. Left click the 1st channel on DCM #7 and choose ‘String Voltage’. Left click the 2nd channel on DCM #7 and choose ‘String Ripple’. This should be the DCM6-R unit used to measure string voltage and ripple.



    c. Make note of the number of DCMs needed for this configuration. Ensure the correct amount of hardware is used. See snapshot below for example layout.



10. Make no changes to the Electrolyte Level Detectors (no FEDs) and Temperature Compensation (no).
11. Click **Next**.
12. Enter in the operator password of 'deafcat'.
13. Click **Save** and wait for the "Settings Saved" confirmation.
14. Select **Home** in the Navigation Bar to see the new readings. The charger cable's ohmic values will be included as a separate line item on the Home page.

15. Select **Configure CTs** in the Settings menu, located in the Navigation Bar.
16. Select the Type of CT that is connected to the corresponding ports.
17. Select the Capacity rating of the CT.
18. Zero if needed.
19. Assign alarms to the Frontier unit.

Battery Configuration Troubleshooting

Incorrect Number of DCMs

This error code is showing that the scan start-up process tried to initialize all of the DCMs on the fiber loop and found the incorrect number to match the configuration file. This could be an indicator of an improperly built configuration file or the incorrect number of DCMs are connected in the fiber loop.

1. Check the fiber wiring to the DCMs to ensure the communications are not broken. Ensure the correct number of DCMs are wired into the fiber loop.
2. Use **Test Fiber Optic Loop** button under Diagnostics menu option.
3. Trace the repeating fiber signal to the DCM that is not passing the signal.

4. Walk back through the Battery Design to make sure the configuration file was built correctly. Choose **Use Saved Settings** and check the current layout. Make changes as needed.

CT Readings Incorrect

1. Check CT wiring at Frontier connection.
2. Check wiring at adapter box for the clamp. Verify the CT is plugged into the correct port number.
    a. Port assignments can be checked by selecting **Configure CTs**.
3. Follow steps in Configure CTs option to Zero the readings before placing on the charger cables.
4. Verify CT configurations are correct according the type and capacity of the corresponding CT.
    a. Type and capacity can be checked by selecting **Configure CTs**.
5. Check Physical CT Readings in **Diagnostics**.
    a. Live output shows the constantly updating current readings for each physical CT.

TP Readings Incorrect

1. Check TP wiring at Frontier connection.
2. Ensure the TP Offset in **Configure TPs** is either not set or set correctly.
3. Check TP placement in string.
    a. Avoid mounting the probe in areas where air changes or moves throughout the day. (Air conditioning, heating, etc.)

Section IV – Integration Guide

Introduction

This guide will walk through integrating the Frontier device into a SCADA (Supervisory Control And Data Acquisition) environment or BMS (Building Management System). Frontier supports Modbus TCP/IP, SNMP (SNMPv2c, SNMPv3), and DNP3 communication protocols. Note that collecting battery data alone is not a suitable solution to monitoring batteries. The collected data should be recorded for historical purposes, evaluated, and trended to help determine how much a cell has changed from baseline values and whether parameters are within acceptable limits.

Integration: Modbus TCP/IP

Frontier is capable of integrating into a building management system or SCADA system by utilizing Modbus TCP/IP. For more information, please see the *Frontier Modbus Protocol User Guide* document.

Integration: SNMP

Frontier supports transporting battery data and system information using the Simple Management Network Protocol (SNMP) over UDP. The settings for SNMP can be found by selecting the **SNMP** option in the Settings menu. Frontier supports both Community-Based SNMP version 2 (SNMPv2c) and SNMP version 3 (SNMPv3). The SNMP service is configured to support the standard SNMP ports only (UDP 161, UDP 162 for traps).

Note: Use the specified MIB (Management Information Base) designed for your Frontier system. A download link for the MIB can be found on the SNMP page under the **General** tab.

General

To enable the SNMP service, toggle the checkbox next to **Enable SNMP** under the General tab. Other configuration options under **General** include:

- **Version**: Select which SNMP version to use. Changing SNMP versions will wipe out any existing SNMP settings. Only one SNMP version can be used at a time.
- **Engine ID**: The SNMP engine ID is used for configuring SNMP at the receiver.
- **Download MIB**: Contains a link to download the Management Information Base (MIB) file for the Frontier device.

To apply any changes to settings on this page, click the **Save settings** button. Modifying any SNMP settings on this page will require a restart of the device.

SNMPv2c

The **SNMPv2c** tab contains options for configuring Community-Based SNMP version 2 (SNMPv2c):

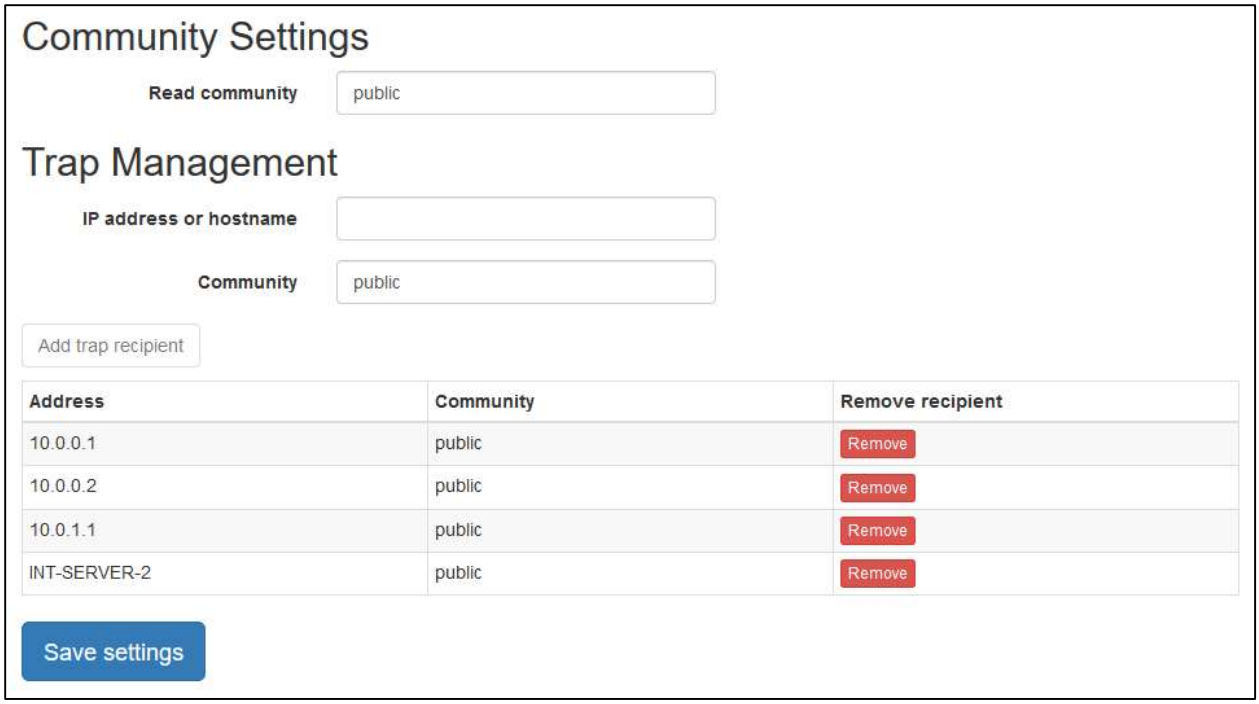
- **Read community**: The string name used to allow read-only access to the device. This name can be up to 64 characters in length. It is recommended that the default read community string be changed if Frontier data is sensitive. Write access to the Frontier is not supported.

Adding and removing trap recipients

The **Trap Management** section of the page allows you to add or a remove a trap recipient. Frontier is designed to send SNMPv2c unacknowledged traps (TRAP), and any number of recipients can be specified.

To add a trap recipient, enter the following information:

- **IP address or hostname**: The IP address or hostname of the trap recipient. This must be network reachable from your Frontier device.
- **Community**: An alphanumeric identifier (0-9, a-z, A-Z) that allows your network management system (NMS) to identify and receive traps from this device. This name can be up to 64 characters long. For simplicity, we recommend making this the same as the **Read community** above.
- Click the **Add trap recipient** button.



SNMPv2c settings tab

To remove a trap recipient, click the **Remove** button next to the recipient you wish to remove.

To apply any changes to settings on this page, click the **Save settings** button. Modifying any SNMP settings on this page will require a restart of the device.

SNMPv3

SNMP version 3 (SNMPv3) can be enabled in the **General** tab. Frontier supports the User-based Security Model (USM) and allows SNMPv3 trap notifications to be configured. Inform traps are not supported.

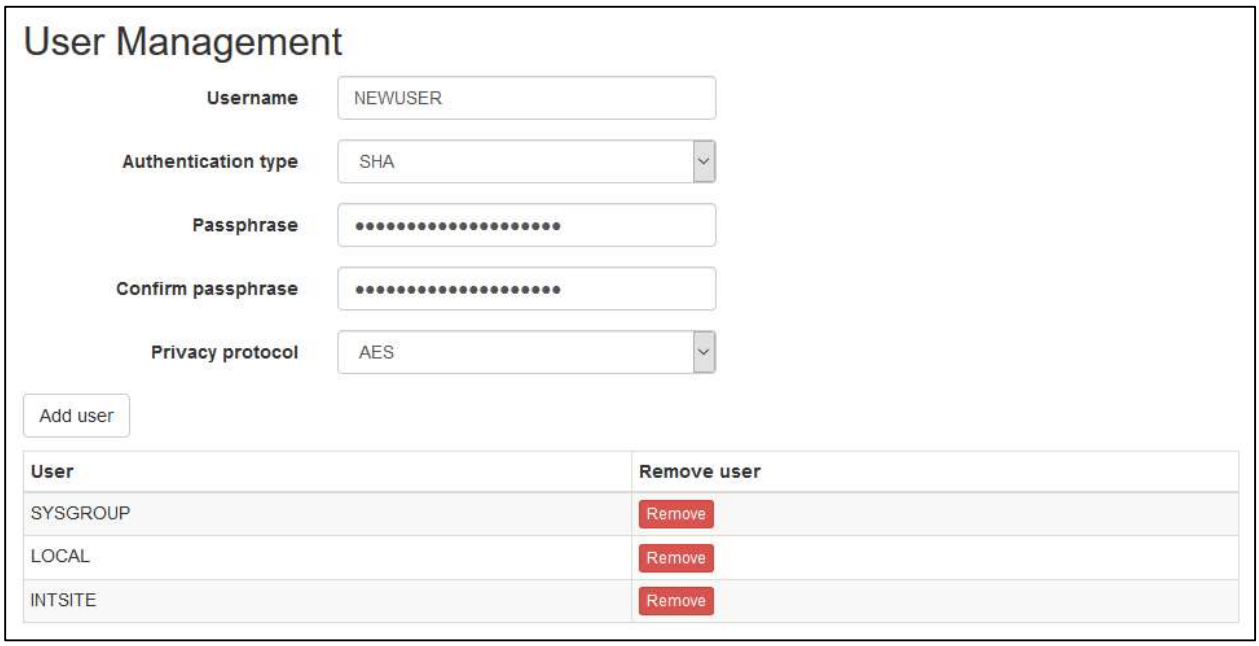
User Management

Options for adding or removing a SNMPv3 user is located under the **SNMPv3 Users** tab.

Options for creating a new SNMPv3 user are:

- **Username**: The name of the user to create for accessing data using SNMPv3. This name can be up to 64 alphanumeric (0-9, a-z, A-Z) characters in length.
- **Authentication type**: The type of hash function to use for authentication. Options are **MD5**, **SHA** (SHA-1), or if no authentication is desired, **None**.
- **Passphrase**: A passphrase used for both user authentication (if selected) and privacy (if selected). The minimum length is 8 characters and cannot contain single or double quotes. An authentication type of **None** does not require a passphrase.
- **Confirm passphrase**: To confirm that your passphrase matches the above.
- **Privacy protocol**: The encryption protocol to use for privacy. Options are **DES** (DES), **AES** (AES128), or if no privacy is desired, **None**. Note that authentication is required in order to configure a privacy protocol for a given user.

Once the required fields are completed, click the **Add user** button to add the new user to the system. Clicking **Add user** will immediately add the user to the USM user table, so a restart of the Frontier device is not required.



An example of a SNMPv3 user “NEWUSER” being created.

To remove an existing SNMPv3 user, click the **Remove** button next to the user in the table that you wish to remove from the system. Clicking **Remove** will immediately remove the user from the USM user table, so a restart of the Frontier device is not required.

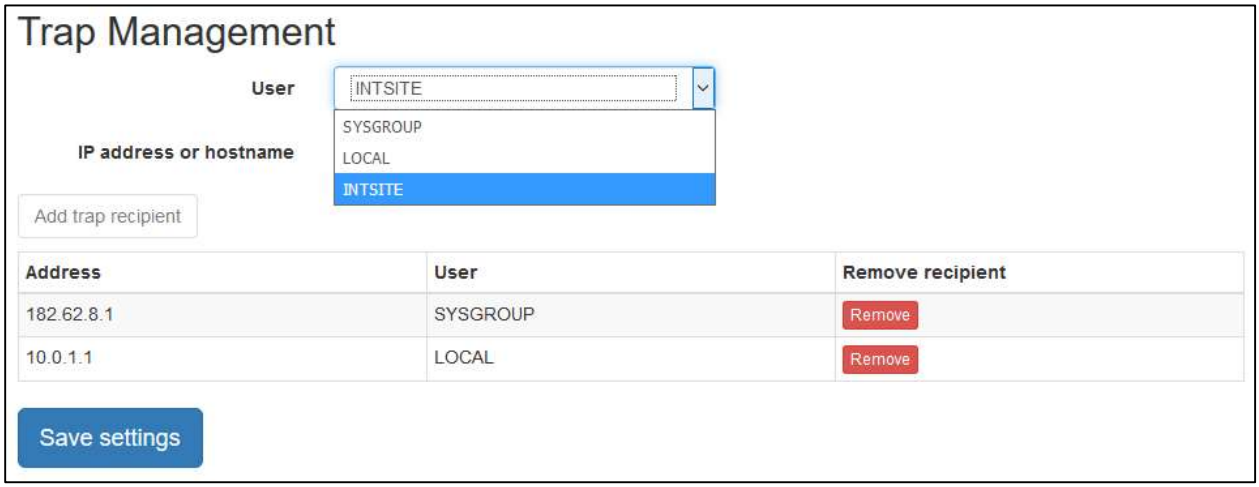
If any other SNMP settings are modified and changes are saved (by clicking the **Save settings** button), SNMPv3 user management will be unavailable until the Frontier device is restarted.

Trap Management

SNMPv3 trap management is located under the **SNMPv3 Traps** tab.

In order to configure a SNMPv3 trap recipient, at least one SNMPv3 user must be created that will be used to authenticate the trap. Choose the SNMPv3 user that you wish to use to send the trap in the **User** dropdown box, then fill in the **IP address or hostname** of the trap recipient. To add the trap recipient, click the **Add trap recipient** button.

Any number of SNMPv3 trap recipients can be added to a Frontier system. Inform traps are not supported in Frontier.



Select an existing SNMPv3 user from the **User** dropdown box.

To remove a trap recipient, click the **Remove** button next to the trap recipient that you wish to remove.

To apply any changes to trap recipients on this page, click the **Save settings** button. Modifying any SNMP settings on this page will require a restart of the device.

Advanced

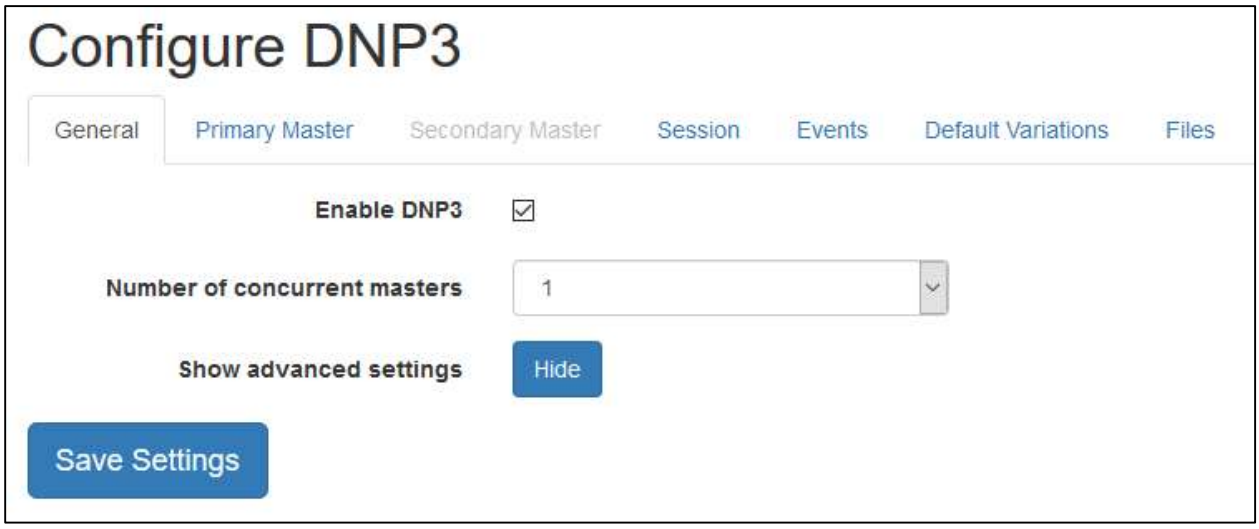
The **Advanced** tab allows saving the SNMP configuration file to your computer or restoring a previously saved configuration file.

The SNMP configuration will be downloaded as a text file with a **.conf** extension. This file may be renamed but the **.conf** extension must remain in order to be uploaded.

Please note that only SNMPv2 settings can be exported in a configuration file. Any SNMPv3 users you have configured will *not* be exported and must be re-created if this file is uploaded.

Integration: DNP3

Frontier supports the DNP3 (Distributed Network Protocol) communication standard for sending data to a SCADA or other data acquisition system. To access DNP3 settings, choose **DNP3** in the Settings menu.



The DNP3 configuration page showing the General tab

General

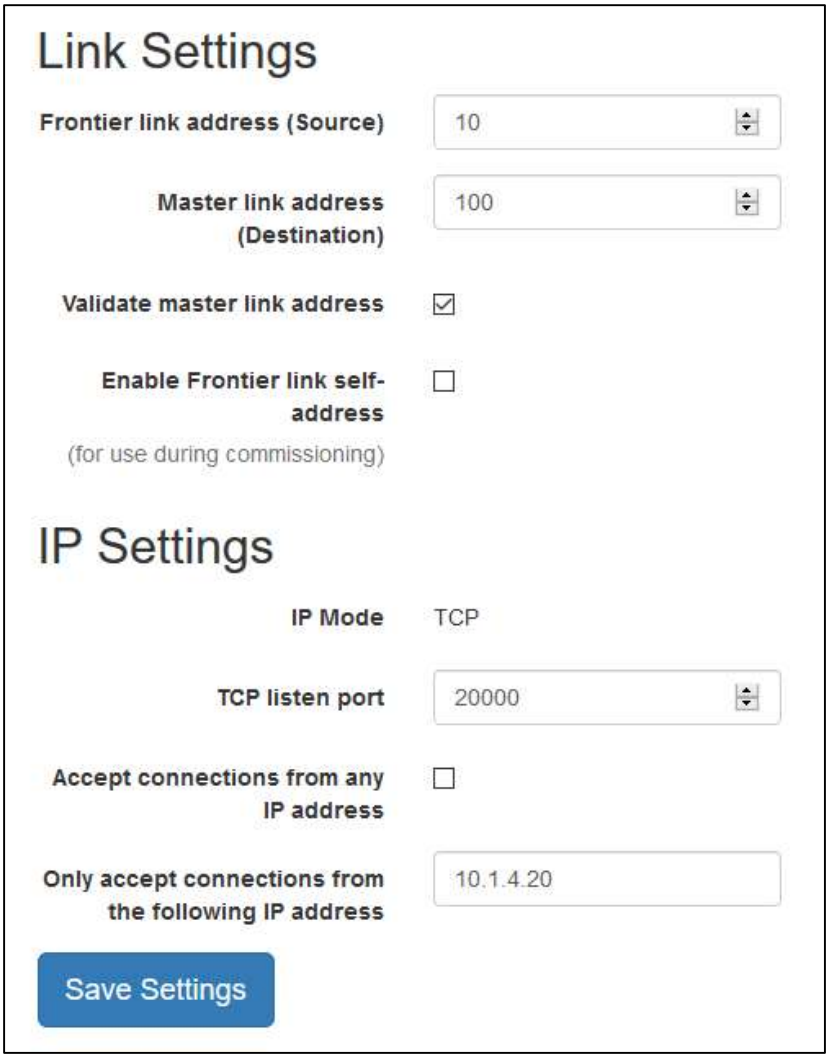
To enable the DNP3 service, toggle the checkbox next to **Enable DNP3** under the General tab. Other configuration options under **General** include:

- **Number of concurrent masters**: Select how many master stations will connect to Frontier to retrieve data. Frontier supports 1 or 2 master stations.
- **Show advanced settings**: To configure any "advanced" DNP3 settings, click the **Show** button to display them.

To apply any changes to settings on this page, click the **Save settings** button.

Master

The **Master** tab contains options for configuring each specific master station (Primary and/or Secondary), such as link and IP settings.



The description for each option can be found in the table below.

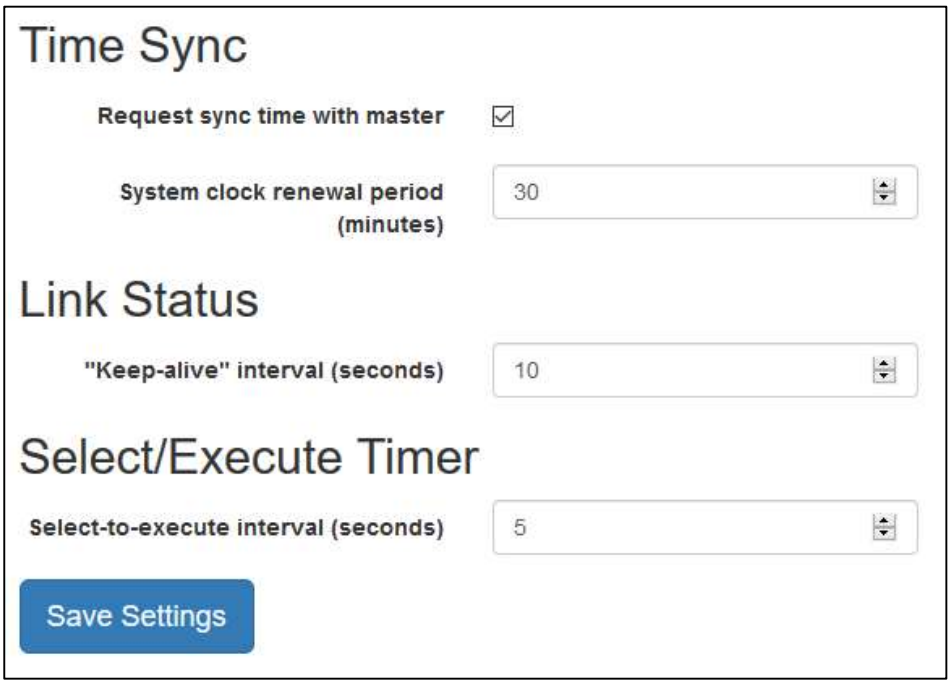
Link Settings	Description
Frontier link address (Source address)	The local or "slave" DNP3 address of Frontier. The Frontier link address should be unique on the user's network. The address must be between 0 and 65519.
Master link address (Destination address)	The DNP3 address of the master station. The address must be between 0 and 65519.
Validate master link address	When enabled, only a master station indicating the **Master link address (Destination)** may connect.
Enable Frontier link self-address	When enabled, Frontier will respond to DNP3 frames with destination address 65532. This feature can be used to simplify commissioning and troubleshooting, allowing the user to discover the destination device's true address and configure proper link addresses accordingly.

IP Settings	Description
IP Mode	The type of IP connection to establish with a master station. Frontier supports TCP mode only.
TCP listen port	The port to listen on for incoming TCP requests. The port must be between 1025 and 65535.
Accept connections from any IP address	When enabled, accept incoming connections from any IP address.
Only accept connections from the following IP address	When **Accept connections from any IP address** is unchecked, specify the IP address that can connect to Frontier.

To apply any changes to settings on this page, click the **Save settings** button.

Session

The **Session** tab includes options for synchronizing time using DNP3 and various interval settings.



The description for each option can be found in the table below.

Time Sync	Description
Request sync time with master	When enabled, request a periodic time synchronization from the master station.
System clock renewal period (minutes)	Specifies how long (in minutes) the system time will remain valid until a time update request is sent.

Link Status	Description
"Keep-alive" interval (seconds)	The amount of time (in seconds) to keep connection sessions open. Frontier will keep a session open for the specified amount of time after losing connection with a master station.
Select/Execute Timer	**Description**
Select-to-execute interval (seconds)	The amount of time (in seconds) that a master station has to perform an Execute operation following a Select operation on an object index before the operation expires.

To apply any changes to settings on this page, click the **Save settings** button.

Events

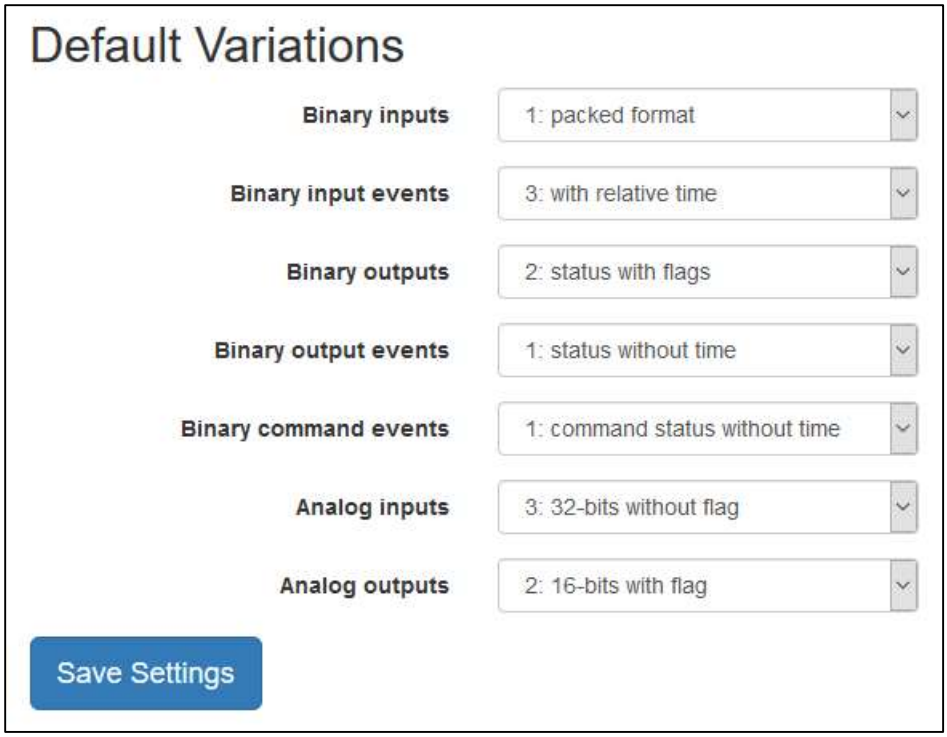
The description for each option on the **Events** tab can be found in the table below.

Unsolicited Events Mask	Description
Do not present or send the following classes of events	Select which classes (Class 1, Class 2, Class 3) to not send when a class poll is requested by the master station.
Event Class Queues (Class 1, Class 2, Class 3)	**Description**
Queuing Delay (seconds)	The number of seconds to hold an Event in the Unsolicited Event queue before transmitting.
High Water (event occurrences)	The maximum number of Events to collect in queue before transmitting.

To apply any changes to settings on this page, click the **Save settings** button.

Default Variations

The **Default Variations** tab contains fields allowing the user to configure the default variation used when responding to class polls or reporting events to the master station.



The description for each option can be found in the table below.

Object Type	Description
Binary inputs	**(1) packed format:** Send binary inputs as single bit packed. **(2) status with flags**: Send binary inputs with status.
Binary input events	**(1) without time:** Send binary input change event without time. **(2) with absolute time:** Send binary input change event with absolute time. **(3) with relative time:** Send binary input change event with relative time.
Binary outputs	**(1) packed format:** Send binary outputs as single bit packed. **(2) status with flags:** Send binary outputs with status.
Binary output events	**(1) status without time:** Send binary output change event without time. **(2) status with time:** Send binary output change event with time.
Binary command events	**(1) command status without time:** Send binary command event without time. **(2) command status with time:** Send binary command event with time.
Analog inputs	**(1) 32-bits with flag:** Send analog inputs as 32-bits with flag. **(2) 16-bits with flag:** Send analog inputs as 16-bits with flag. **(3) 32-bits without flag:** Send analog inputs as 32-bits without flag. **(4) 16-bits without flag:** Send analog inputs as 16-bits without flag.
Analog outputs	**(1) 32-bits with flag:** Send analog outputs as 32-bits with flag.

	(2) 16-bits with flag: Send analog outputs as 16-bits with flag.

To apply any changes to settings on this page, click the **Save settings** button. Modifying any DNP3 settings on this page will require a restart of the device.

Files

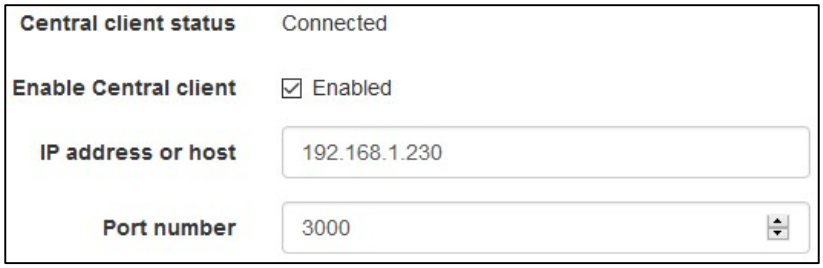
The **Files** tab provides access to the DNP Profile:

- **DNP Profile**: Industry standard file used to configure your master station. The DNP profile describes the available data points on this device and must be re-generated when you change your configuration. This is an XML-formatted file with a .xml file extension.

Important: Before downloading the profile, confirm that the battery design matches your physical hardware. If you have changed any settings, ensure that DNP is enabled and the device has been restarted so that the profile is correctly regenerated.

Integration: Cellwatch Central

Frontier can easily be integrated with an existing Cellwatch Central server. To configure the Frontier system to communicate with Cellwatch Central, navigate to the **Cellwatch Central** page in the Settings menu.



The IP address and port are needed in order for Frontier to establish a connection to Cellwatch Central. Once you have entered in the IP address and port of the Cellwatch Central server, select the checkbox to enable. Frontier will indicate when it has established a connection by displaying “Connected” next to the Central client status, as shown above.

If Frontier is unable to connect to Cellwatch Central:

- Verify that IP address and port are correct. Cellwatch Central listens on TCP port 3000 by default.
- Verify that both the Frontier system and Cellwatch Central server have network connectivity.
- It is possible that one or more firewalls are between the Frontier device(s) and the Cellwatch Central server. Ensure that the proper ports are opened in any existing firewall before attempting to connect a Frontier system to Cellwatch Central. IT staff or a Network Administrator may be required for this step.