About OutBack Power

OutBack Power is a leader in advanced energy conversion technology. OutBack Power products include true sinewave inverter/chargers, maximum power point tracking charge controllers, and system communication components, as well as circuit breakers, batteries, accessories, and assembled systems.

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Date and Revision

August 2020, Revision C

Part Number

900-0093-12-00 Rev C

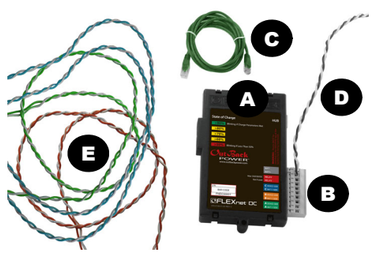
FLEXnet DC Battery Monitor

Introduction

OutBack Power's FLEXnet DC (FN-DC) is a battery monitoring device that serves as a window to the battery bank. By tracking battery voltage and the amount of incoming and outgoing current, the FN-DC indicates the battery bank's state of charge (SOC) and enables users to precisely configure charging parameters to maximize battery performance and lifespan. The FN-DC also provides an auxiliary relay that can activate a ventilation fan, low-battery warning alarm, or other low-voltage DC device. The MATE3s can use the FN-DC's information to stop all charging devices when the batteries are full.

Contents

Specifications	2
Installation	3
Wiring	4
Programming	6
Monitoring	8
Operation	12
Example Use Cases	16
Troubleshooting Guide	18
Calibration	19



Included

A: FLEXnet DC

B: 10-pin Wiring Block

C: 6' CAT5 cable for HUB connection

D: 10' Twisted-Pair (TP) cable for battery connection

E: Three 6' TP cables for shunt connections

F: Two #6 × ⅜" pan head machine screws (not pictured)

G: Colored labels (not pictured)

IMPORTANT:

This document provides instructions for installation, setup, and operation of the product. These instructions are for use by qualified personnel who meet all local and governmental code requirements for licensing and training for the installation of electrical power systems with AC and DC voltage up to 600 volts. Failure to install or use this equipment as instructed in the literature can result in damage to the equipment that may not be covered under the limited warranty. This product is only serviceable by qualified personnel.

NOTES:

- For programming and full functionality, this product requires the use of an OutBack Power system display such as the MATE3s. It is intended to monitor systems with OutBack Power inverters, charge controllers, and related products.
- This document assumes knowledge of features, functions, and operation of other OutBack Power products. Consult appropriate literature as necessary.

Features

A: State of Charge Indicator Lights
B: Mounting Screws
C: Hub Cable Port
D: Wiring Block

Specifications

Battery Voltage Input Range	8 to 80 Vdc
Battery Voltage Resolution	0.1 Vdc
Number of Current Channels	1 to 3 (source or load)
Current Range (Each Channel)	+/- 1000.0 amps DC
Current Resolution	0.1 amps DC
State of Charge Display	0 to 100% (1% increments)
Aux Relay Configuration	SPST magnetic latching relay
Aux Relay Max Rating	5 amps @ 30 Vdc
Current Shunt Type (not incl.)	500A / 50 mV
Display	MATE3s (not included) / LED indicators on unit
Battery Amp Hour Capacity Range	100 to 10,000 AH
Data Logging Memory	Most recent 128 days
Programmable **Aux** Relay Settings	8 to 80VDC / 0 to 100% SOC / 0 to 240 minutes
Accuracy	0.5% of reading
Operating Temperature Range	0 to 50°C / 32 to 122°F
Mounting	¾" panel mount breaker slot or surface mount using built-in mounting bars
Warranty	Standard 5 year
Weight	5 oz (0.14 kg)
Dimensions	0.7 × 3.7 × 6.6" (1.9 × 9.4 × 6.8 cm)

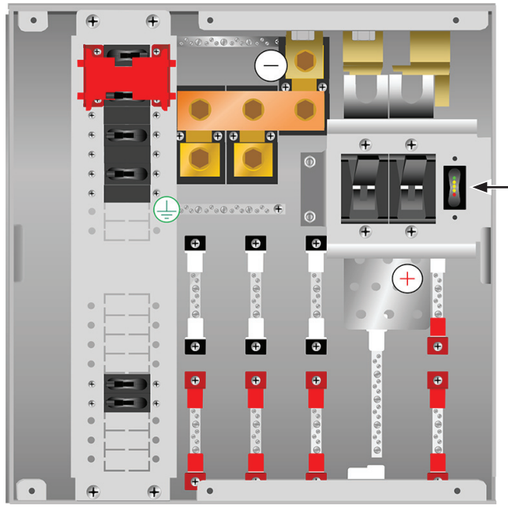
Installing the FLEXnet DC

The FLEXnet DC mounts in a ¾" DC circuit breaker slot installed inside an OutBack Power load center.

To mount the FLEXnet DC inside an OutBack Power enclosure:

1. Put the system into bypass mode.
2. Shut off all AC input to inverters.
3. Shut off all PV and DC breakers.
4. Disconnect the battery cables at the battery.
5. Remove the breaker bracket from its enclosure by removing the four corner screws.
6. Remove one of the DC breaker knockouts.
7. Insert the FN-DC unit into the rear of the breaker bracket so that the indicator lights fit in the breaker opening.
8. Mount the FN-DC securely using the two #6-32 screws provided.

Remove breaker knockout and install FN-DC using 2 #6-32 × ⅜" pan-head machine screws provided (torque to 5 to 8 inch-pounds).



The FN-DC mounting location will vary depending on the system. Here, for example, in the GSLC, the FN-DC is mounted adjacent to the main DC breakers for the battery bank.

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Installation

Wiring Connections

Color-coded twisted pair #18 AWG connects the wiring block and shunt(s) or battery. The wiring must be installed with the proper polarity to avoid corrupting the data.

- The wires connected to the wiring block should match the color-coded label where the wiring block inserts into the FLEXnet DC.
- The wiring block can accommodate wire sizes from #12 AWG to #26 AWG (2.5 mm² to 0.20 mm²). Remove ¼" (6 mm) of insulation.

To connect the FN-DC:

1. Connect the white wire from the **BAT–** terminal in the wiring block to the battery negative terminal; connect the black wire from the **BAT+** terminal in the wiring block to the battery positive terminal.
   NOTES:
   - ❖ Although the image shows the **BAT–** and **BAT+** terminals wired directly to the battery bank, it is common to wire them to the positive and negative bus connections in the load center. The battery readings, however, will be most accurate when wired directly to the batteries. It is prudent, though not required, to install a fuse on the positive wire (see **CAUTION**).
2. *Optional: connect relay wires from the* **RELAY** *terminals in the wiring block to a fan or other powered accessory that can be triggered using dry contacts (5 A @ 30 Vdc max.). See page 12.*
3. Connect the blue / white wire from the wiring block **C DEVICE SIDE** terminal to the terminal of Shunt C that connects to the device being monitored. Connect the solid blue wire from the **C BAT (–) SIDE** terminal to the terminal of Shunt C that connects to the battery.
4. Connect the orange / white wire from the wiring block **B DEVICE SIDE** terminal to the terminal of Shunt B that connects to the device. Connect the solid orange wire from the **B BAT (–) SIDE** terminal to the terminal of Shunt B that connects to the battery.
5. Connect the green / white wire from the wiring block **A DEVICE SIDE** terminal to the terminal of Shunt A that connects to the device. Connect the solid green wire from the **A BAT (–) SIDE** terminal to the terminal of Shunt A that connects to the battery.
6. Tighten all wiring block terminal screws to a torque value of 4 to 5 in-lb.
7. Connect the CAT5 cable from the FN-DC port labeled **HUB** to the HUB Communications Manager. Use Port 2 or higher, depending on the requirements of the configuration and the HUB literature.

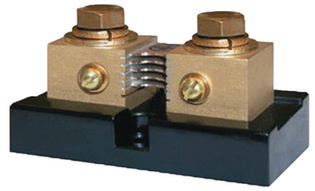
CAUTION:
Equipment Damage

Do not reverse the white and black wires (see step 1). This will damage both the FN-DC and the HUB Communications Manager. Installing a fuse on the positive wire (5 A maximum, 100 Vdc minimum) may help protect the devices.

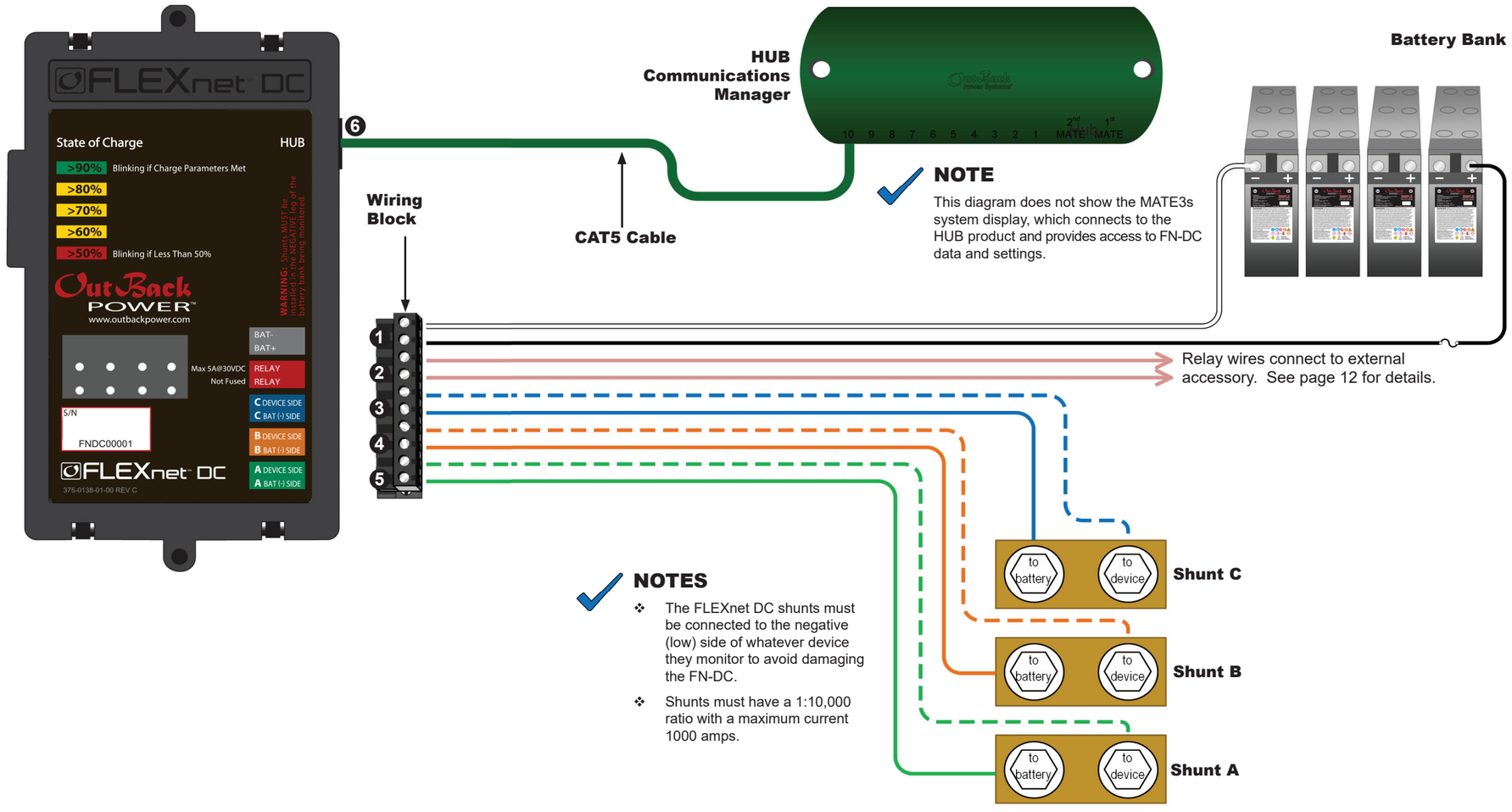
IMPORTANT:

Do not run these wires alongside the battery cables. This can induce voltage into the wires and corrupt the data.

Shunt Operation



The FN-DC uses shunts to measure electrical current. A shunt works by creating a low-resistance path for current between two points, resulting in a small voltage drop that can be measured and converted to amperes of current. The FN-DC can connect to as many as three shunts in order to monitor current between the battery bank and devices like an inverter or a charge controller. A typical setup uses one shunt to measure current between the battery bank and an inverter; a second shunt to measure current fed into the battery bank from a solar array charge controller; and a third shunt to measure a second charge controller. By tracking the current flowing into and out of a battery bank, as well as voltage, the FN-DC can monitor the battery bank's state of charge (SoC) more accurately than by simply tracking voltage. See page 14 for a more detailed discussion of SoC.



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Initializing the FLEXnet DC

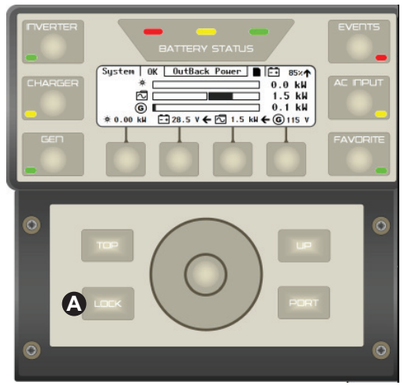
The FN-DC assumes that the batteries are fully charged when it is initially turned on. Prior to turning on the FN-DC, make certain the battery bank is charged to capacity. Use the battery manufacturer's instructions on how to commission and fully charge the battery bank to bring it to a full state of charge. This step may take several days depending on the system and the type of battery. Failure to take this critical step will result in a chronically undercharged battery and therefore a reduced performance and a reduced life.

Programming with the MATE3s

The FLEXnet DC must be programmed using an OutBack Power system display such as the MATE3s.

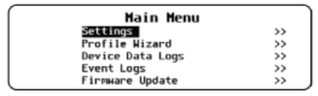
Without programming, the FN-DC will use its default settings, which are generic battery settings and not guaranteed to be appropriate to a given battery model.

Once the FN-DC settings are programmed, they will remain in nonvolatile memory. The measured values (amp-hours in and out, SoC) will be lost if system power is lost, but the recorded values will not be lost. The FN-DC will need a few charge / discharge cycles to gain accuracy as it will not have any initial discharge data to use in its calculations.

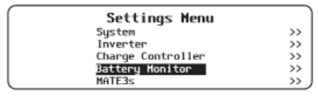


Steps to Program the FN-DC:

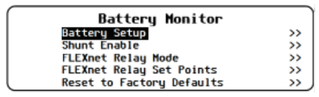
1. Access the ***Main Menu*** in the MATE3s by pushing the Lock navigation key **A**, entering the password **141**, and selecting ***Settings***.



2. From the ***Settings Menu*** select ***Battery Monitor***.



3. From the ***Battery Monitor*** settings, select ***Battery Setup***.



NOTE

MATE3s settings are discussed in greater detail in the *MATE3s Programming Guide* (available at www.outbackpower.com).

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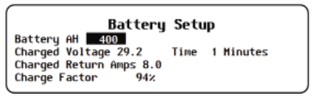
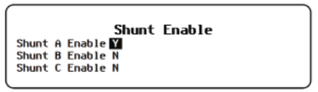


4. Enter the correct values for the battery bank (most of these figures are specified by the battery manufacturer):
   - ***Battery AH***: Identifies the total size of the battery bank in amp-hours.
   - ***Charged Voltage***: This is the minimum voltage that the batteries must reach during the Bulk or Absorption stages (see page 15) for the FN-DC to consider the batteries fully charged. This should be set to 0.4 Vdc below absorption voltage for 48-volt systems, 0.2 Vdc for 12-volt and 24-volt systems).
   - ***Charged Return Amps***: Sets the limit to which the current must "trickle down" or decrease before the batteries are considered charged. This is commonly 1 to 3% of the battery bank's amp-hour rating.
   - ***Time***: Sets the duration the ***Charged Voltage*** and ***Charged Return Amps*** must be maintained before the charging cycle is considered finished.
   - ***Charge Factor***: Adjusts the anticipated charging efficiency of the batteries. Because the batteries cannot be 100% efficient, the FN-DC discounts a certain percentage of the energy used to charge them. The default value is 94%, meaning that if 100 amp-hours are delivered to the battery bank during a cycle, only 94 amp-hours will actually be replenished. It would actually require a charge of 107 amp-hours to put 100 amp-hours into the bank. This percentage value is the battery efficiency, or round trip efficiency specification available from the battery manufacturer. This charge factor will likely change over time as the battery bank ages. Consult the battery manufacturer for recommendations.

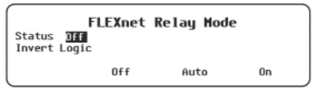
5. Return to the previous ***Battery Monitor*** screen by pushing the UP key, then select ***Shunt Enable*** to display the shunt options. Set each shunt to be enabled to ***Y***.



6. If the auxiliary relay is to be used (see page 12):

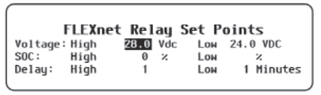
   Push the UP key again to return to the previous ***Battery Monitor*** screen, then select ***FLEXnet Relay Mode***. Set ***Status*** to ***On*** to enable the relay.

   If the auxiliary relay is not used, skip to Step 8.



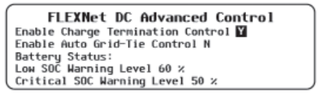
7. Return to the ***Battery Monitor*** screen and select ***FLEXnet Relay Set Points***. Adjust these items according to the application.

   For more details, see page 13 of this document, as well as the section of the *MATE3s Programming Guide* titled **Battery Monitor Settings**.



8. To select the ***FLEXNet DC Advanced Control*** settings, return to the ***Settings Menu*** by pressing the UP key twice, then select ***MATE3s***. Select the option ***FLEXNet DC Advanced Control***. This menu allows the MATE3s to control or turn off other networked OutBack Power devices in response to the operation of the FN-DC.

   (Usually this means it will turn other chargers off when the FN-DC shows the batteries are fully charged.)



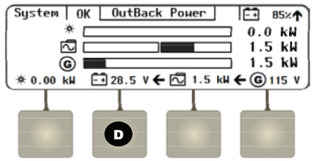
Operation

Viewing FN-DC Data

There are three main ways to view data recorded by the FN-DC:

- **LED Indicators (A and B)**: These indicate the approximate battery SOC "at-a-glance".
- **MATE3s System Display (beginning with C)**: This shows key data such as the exact battery SOC and voltage. A full range of detailed data can be viewed in various screens.
- **OPTICS RE (see pages 10-11)**: This allows for remote access to most FN-DC data using a web browser.

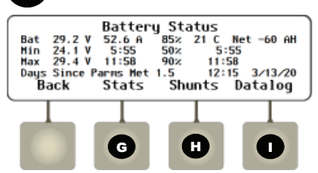
C MATE3s Home Screen



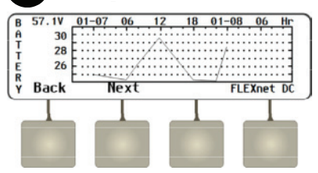
In the MATE3s, the <**Battery**> soft key **D** opens the ***FLEXnet DC*** screen. This allows access to additional menus with status and historical data.

D FLEXnet DC

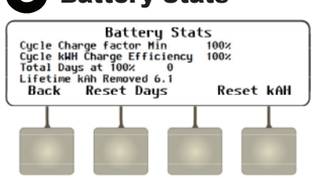
E Battery Status



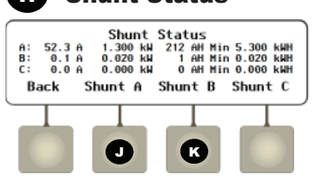
F Graph



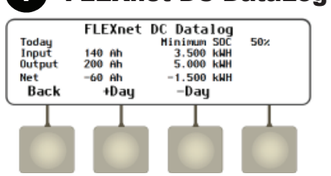
G Battery Stats



H Shunt Status

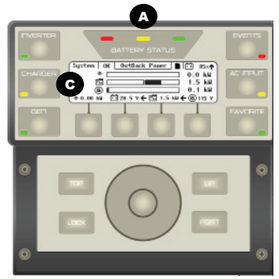


I FLEXnet DC DataLog



Note

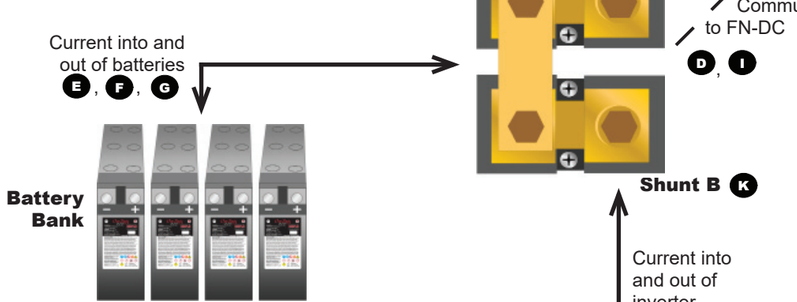
MATE3s readings are also discussed in detail in the *MATE3s Overview Guide* (available at www.outbackpower.com).



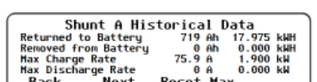
A MATE3s Battery Status LED Indicators

Three colored LED indicators show the battery SOC:

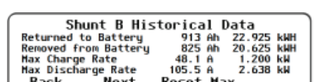
- Green: above 80% SOC
- Yellow: 60-80% SOC
- Red: less than 60% SOC



J Shunt A Historical Data

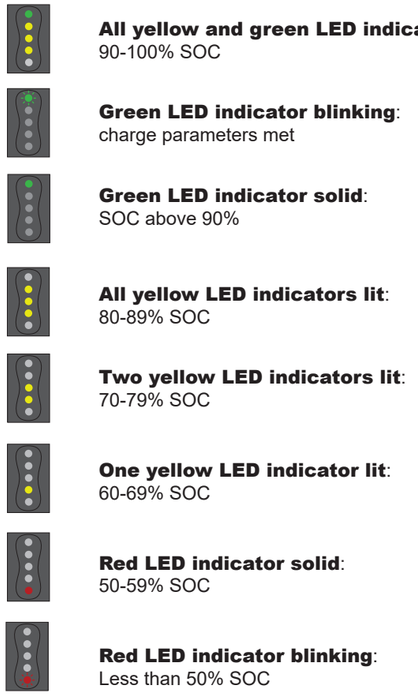


K Shunt B Historical Data



B FN-DC LED Indicators

The FN-DC indicates the battery bank's SOC with a set of 5 LED indicators. These are displayed in the breaker panel opening where the unit is installed. See page 3.



- **All yellow and green LED indicators lit**: 90-100% SOC
- **Green LED indicator blinking**: charge parameters met
- **Green LED indicator solid**: SOC above 90%
- **All yellow LED indicators lit**: 80-89% SOC
- **Two yellow LED indicators lit**: 70-79% SOC
- **One yellow LED indicator lit**: 60-69% SOC
- **Red LED indicator solid**: 50-59% SOC
- **Red LED indicator blinking**: Less than 50% SOC

900-0093-12-00 Rev C

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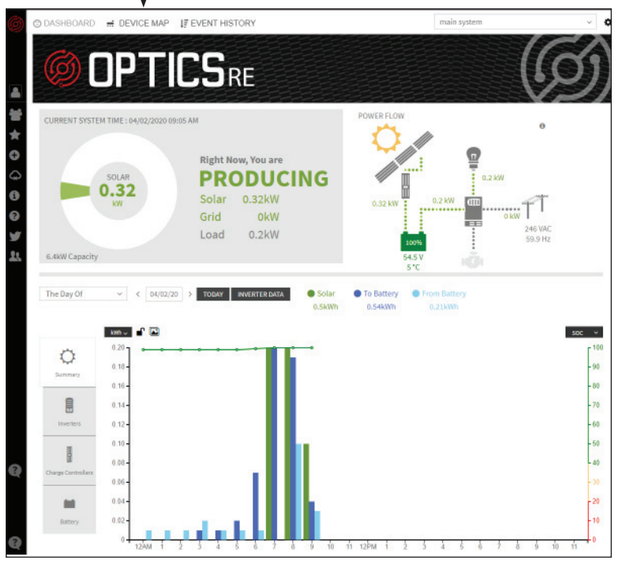
Click **DEVICE MAP**

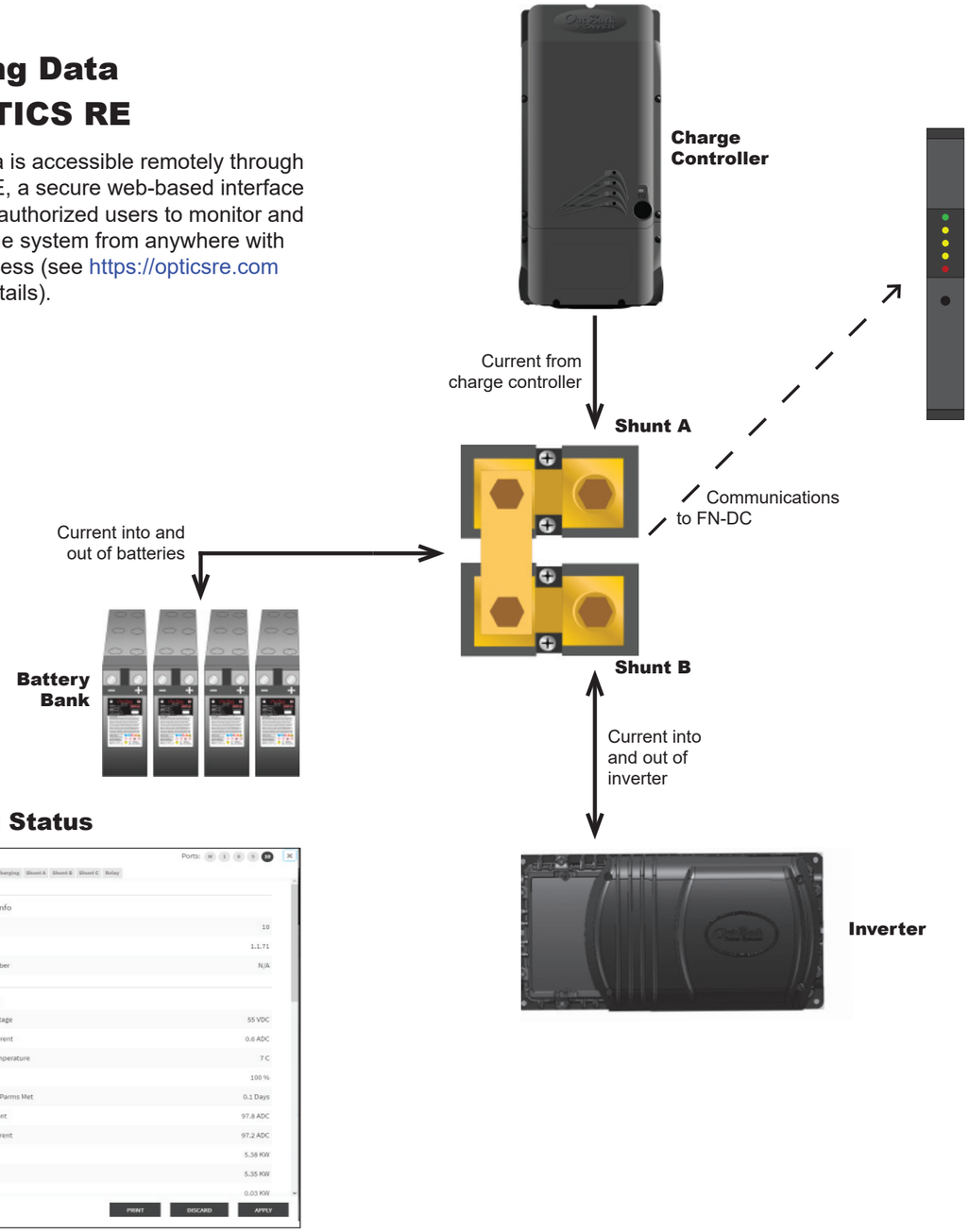
1

OPTICS RE Dashboard



Viewing Data on OPTICS RE

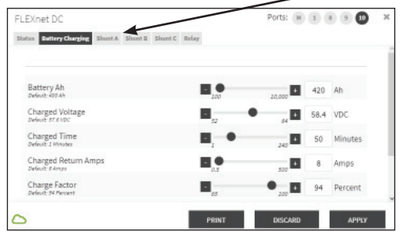
FN-DC data is accessible remotely through OPTICS RE, a secure web-based interface that allows authorized users to monitor and configure the system from anywhere with internet access (see https://opticsre.com for more details).



Click **Shunt A**

4

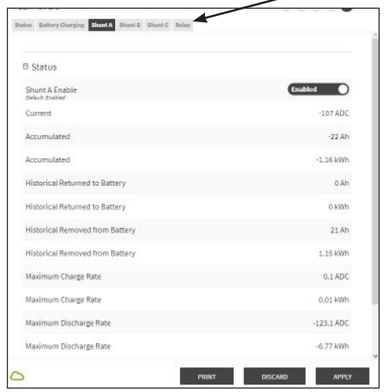
3 Battery Charging



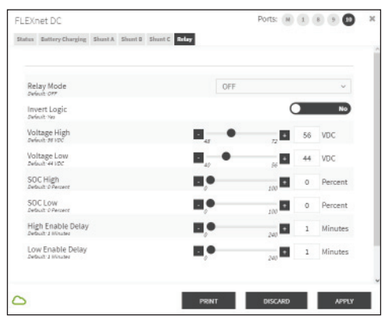
Click **Shunt B** for a similar displays, then **Relay**

5

4 Shunt A



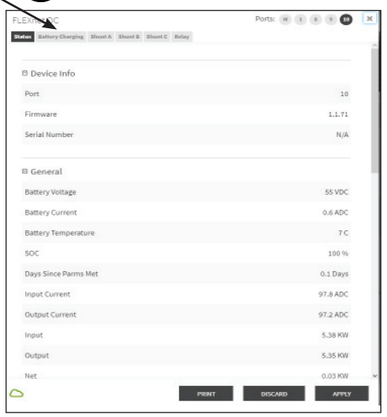
5 Relay



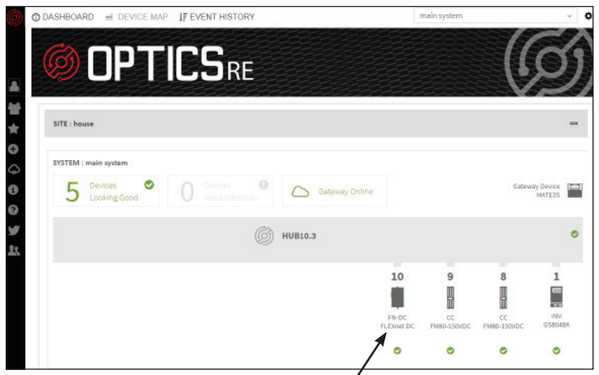
Click **Battery Charging**

3

2 Status



1 Devices



Click **FN-DC**

2

900-0093-12-00 Rev C
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Operation

Programming the Auxiliary Relay

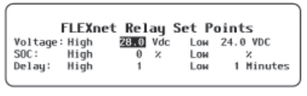
The FLEXnet DC provides an auxiliary (**Aux**) relay to activate a DC accessory like a ventilation fan or light. The **Aux** relay is a "dry contact" that does not supply power. The contacts are rated at 5 amps @ 30 Vdc. The relay requires appropriate sized wiring and overcurrent protection. Note that damage due to unprotected relay devices is not covered by the warranty.

Configuring and monitoring is done with the MATE3s system display (or OPTICS RE). See page 6 of this document for specific steps to access the relay settings in the MATE3s.

FLEXnet Relay Mode

This menu allows the user to turn the **Aux** relay on or off, either manually or using automatic criteria.

- ***Status*** — The Relay output status is controlled by the <**Off**>,<**Auto**>, and <**On**> soft keys.
  - <**Off**> deactivates the relay and prevents any of the ***FLEXnet Relay Set Points*** options from working. Note that even if the relay output is set to <**Off**>, it may still be activated by an external option such as AGS.
  - <**On**> activates the relay immediately. Its contacts will remain continuously closed until <**Off**> is selected.
  - <**Auto**> activates the relay based on user-selected battery voltage, percentage of SOC, delay times, and invert logic settings. In the ***FLEXnet Relay Set Points*** menu, six user adjustable set points govern the control logic of **Auto** mode:
    - ***Voltage: High*** — 0 to 99.9 Vdc
    - (Voltage) ***Low*** — 0 to 99.9 Vdc
    - ***SOC: High*** — 0 to 100%
    - (SOC) ***Low*** — 0 to 100%
    - ***Delay: High*** — 0 to 240 minutes
    - (Delay) ***Low*** — 0 to 240 minutes



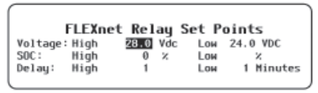
NOTES

- If the ***Voltage*** set points are not met, then the ***SOC*** set points are evaluated.
- If ***SOC*** set points are not met, then no action is taken.
- If either ***Voltage*** or ***SOC*** set points are met, then the ***Delay*** timer runs.
- When the set points have been satisfied for a ***Delay*** time (either ***Delay: High*** for the ***Voltage: High*** or ***SOC: High*** set points), or (Delay) ***Low*** for the ***Low*** set points) the relay is energized.
- To defeat the ***Voltage*** set points and skip directly to using ***SOC***, change ***Voltage: High*** to a very high setting (higher than the operating range of the battery). Change ***Low*** to a similarly low setting.

- ***Invert Logic*** — **N** (no) or **Y** (yes).
  This switches the relay's function from N.O. (a normally open state) to N.C. (a normally closed state). Since the default condition is N.O., the **N** selection means it remains in this state. Selecting **Y** inverts the logic to N.C. The relay will close with an audible click when this occurs.

FLEXnet Relay Set Points

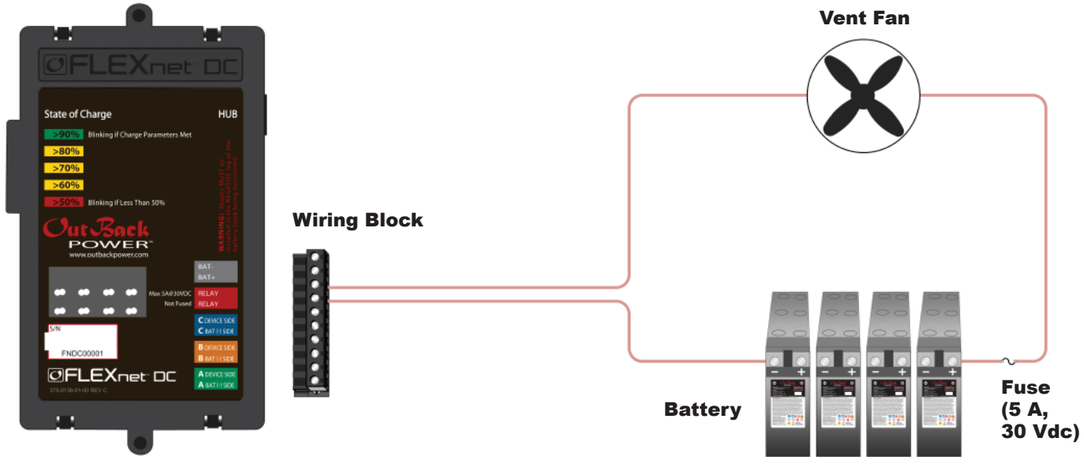
This menu allows the user to adjust the criteria used by the **Auto** selection in the ***FLEXnet Relay Mode*** menu.



NOTES

- The following set points assume N.O. logic as described on the previous page. If N.C. logic is used, all uses of the words "close" or "open" are reversed.
- See the previous page for available setting ranges.
- When the MATE3s Advanced Generator Start (AGS) function is active and set to control the FN-DC **Aux** relay, it will override the set points shown here. For generator control, OutBack Power strongly recommends using the AGS function rather than the FN-DC set points, as described in the MATE3s literature.

- ***Voltage: High*** — The relay will close upon reaching a specified high voltage level following the appropriate delay.
- (Voltage) ***Low*** — After the relay was closed according to the ***High*** voltage set point, it will open again upon reaching a specified ***Low*** voltage level (following the appropriate delay; see below).
- ***SOC: High*** — If voltage conditions are not met, the relay will close when the battery state of charge (SOC) increases to a specified percentage following the appropriate delay.
- (SOC) ***Low*** — After the relay was closed according to the ***High*** SOC set point, it will open again upon reaching a specified low SOC level following the appropriate delay.
- ***Delay: High*** — Sets the delay time before the relay closes due to a ***High*** set point. This applies to either the SOC or voltage settings.
- (Delay) ***Low*** — Sets the delay time before the relay opens due to a ***Low*** set point. This applies to either the SOC or voltage settings.



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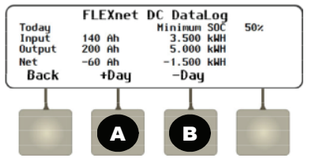
Operation

Accessing Historical Data

The FN-DC keeps a data log containing the previous 128 days of data. The MATE3s can save this data to an SD card so that it can be viewed elsewhere on a spreadsheet. The daily log includes minimum SOC, number of amp hours and kilowatt hours put into and taken out of the battery bank, and the battery bank's net gain or loss of amp hours and kilowatt hours. Data is logged each night at midnight. Be sure the MATE3s clock is set to the correct local time.



FLEXnet DC DataLog

To access the FLEXnet DC DataLog, use the MATE3s system display. See page 8 of this document to access the ***DataLog*** screen using the <**Battery**> soft key.

The upper left corner shows the date of the selected screen. (The present ***Datalog*** screen reads ***Today***).

The <**-Day**> soft key **B** brings up the previous day's log (with a date shown). The <**+Day**> soft key **A** advances the log to the next day. If ***Today*** is shown, it does nothing.

- ***Minimum SOC***: The lowest SOC for that day.
- ***Input*** and ***Output***: The number of amp-hours and kilowatt-hours brought into or removed from the batteries that day.
- ***Net***: The net gain or loss in amp-hours or kilowatt-hours that day. This is the difference between the ***Input*** and ***Output*** fields.

FN-DC and the Charging Cycle

One of the primary benefits of the FLEXnet DC is its ability to accurately monitor a battery bank's state of charge (SOC). While voltage gives an approximation of SOC, this is only accurate if the battery has stabilized in a resting state for a period of several hours at room temperature. The FN-DC measures voltage as well as current. This enables the FN-DC to track a net total of how many amp-hours (AH) or kilowatt-hours (kWh) are removed from, and returned to, the batteries.

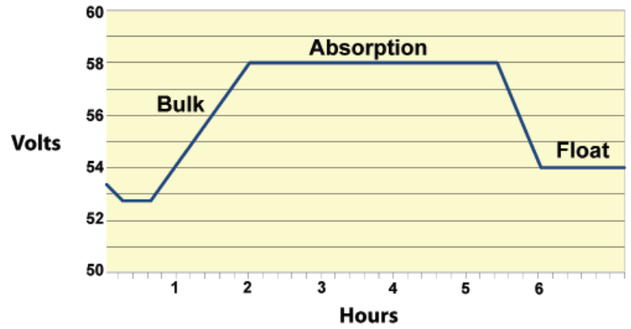
A small amount of energy is lost during the charging process, meaning battery charging is not 100% efficient. The FN-DC compensates by incorporating the ***Charge Factor*** setting in its calculations (typically 94% with flooded lead-acid batteries). This is the percentage of the energy that is calculated to be used for charging. The rest is discounted as efficiency losses.

The FN-DC uses the values entered into the ***Battery Setup*** screen in the MATE3s (see page 7) to determine the battery bank's SOC as a percentage, with 100% being fully charged. In addition to tracking the amount of energy removed from and returned to the batteries, the FN-DC also checks that the battery has attained a specified voltage and that the charging current has dropped to the specified ampere level for the specified amount of time before the FN-DC considers the battery bank fully charged (in FN-DC parlance, the "charging parameters" have been met). Once the FN-DC reports that charging parameters have been met and the battery bank is fully charged, the charging cycle is complete.

Three-Stage Charging Cycle

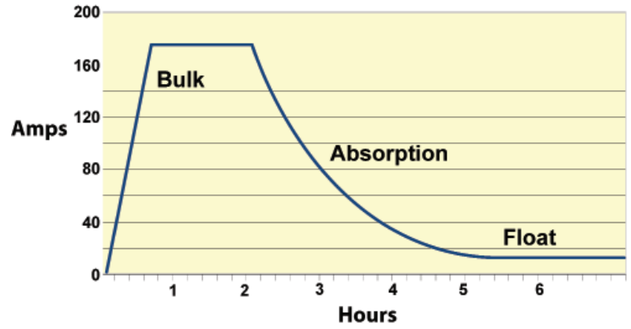
Bulk Stage

The bulk stage is a constant-current stage. The charge current is maintained at a constant high level until the voltage reaches the absorption set point. This voltage is specified by the battery manufacturer. It is typically between 14.1 and 14.6 Vdc in a 12-volt system (58 to 59 Vdc in a 48-volt system, as shown to the right). This setting must equal or exceed the ***Charged Voltage*** setting on page 7. At the end of the bulk stage the battery will reach 85 to 90% SOC.



Absorption Stage

Absorption is a constant-voltage stage that begins when voltage reaches the absorption set point. The charger limits the current flow to only what is necessary to maintain this voltage. A high current is required to raise the voltage to the absorption level. After reaching this voltage, as long as it is maintained, the "return amps" requirement is reduced. The tapering current decreases to a minimal level, about 1 to 3% of the battery's amp-hour capacity. This "tops off the tank," leaving the battery at 100% SOC.



Float Stage

The float stage maintains the battery at a full state of charge, since batteries will slowly self-discharge when charging current is removed. Float voltage is typically between 13.0 and 13.5 Vdc in a 12-volt system (54 to 55 Vdc in a 48-volt system, as shown to the right).

Some chargers maintain the float stage as long as power is available ("24/7" mode). Others maintain it for a few hours, then go silent until the batteries self-discharge to a "refloat" setting (not shown). This cycle of float and refloat continues until the battery discharges to a much lower "rebulk" setting. This prompts the charger to restart at the bulk stage, beginning a new charging cycle.

Equalization

Some batteries require a periodic equalization (EQ) charge to maintain optimal battery health. The EQ process involves applying a charge voltage usually equal to or exceeding the absorption voltage for a specified amount of time. Equalization is usually specified to occur at intervals of weeks or months, or after a certain number of charge/discharge cycles. Refer to the equalization instructions provided by the battery manufacturer.

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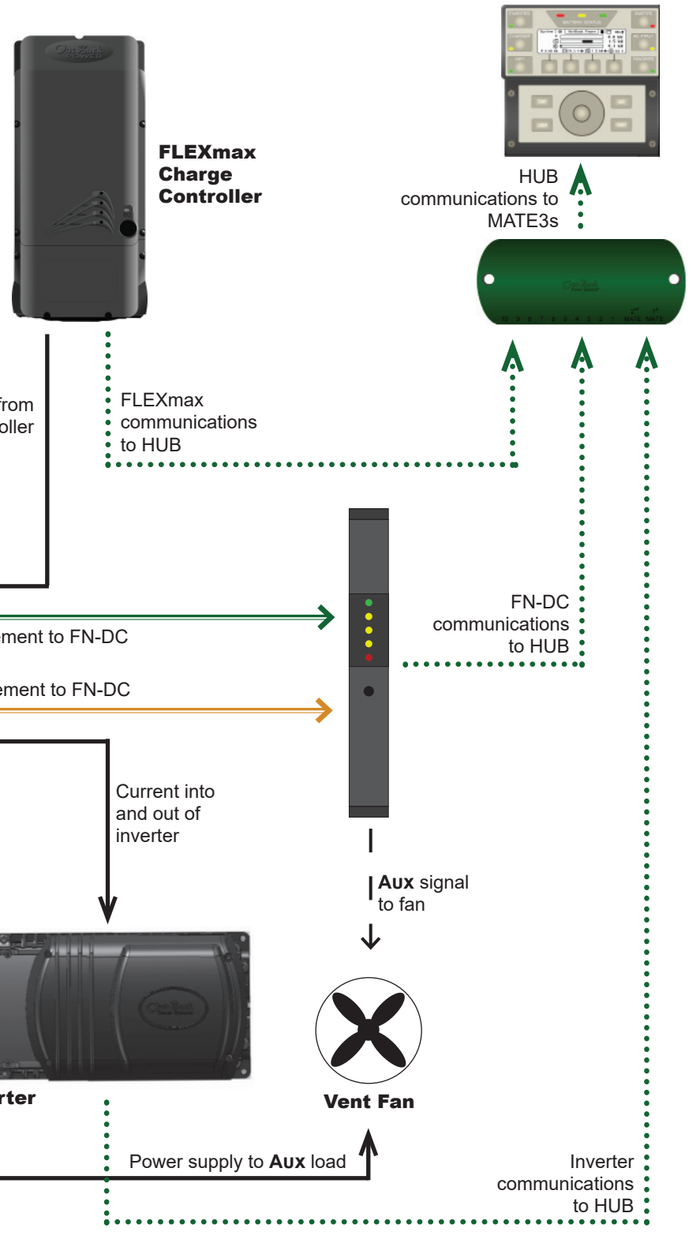
Example Use Cases

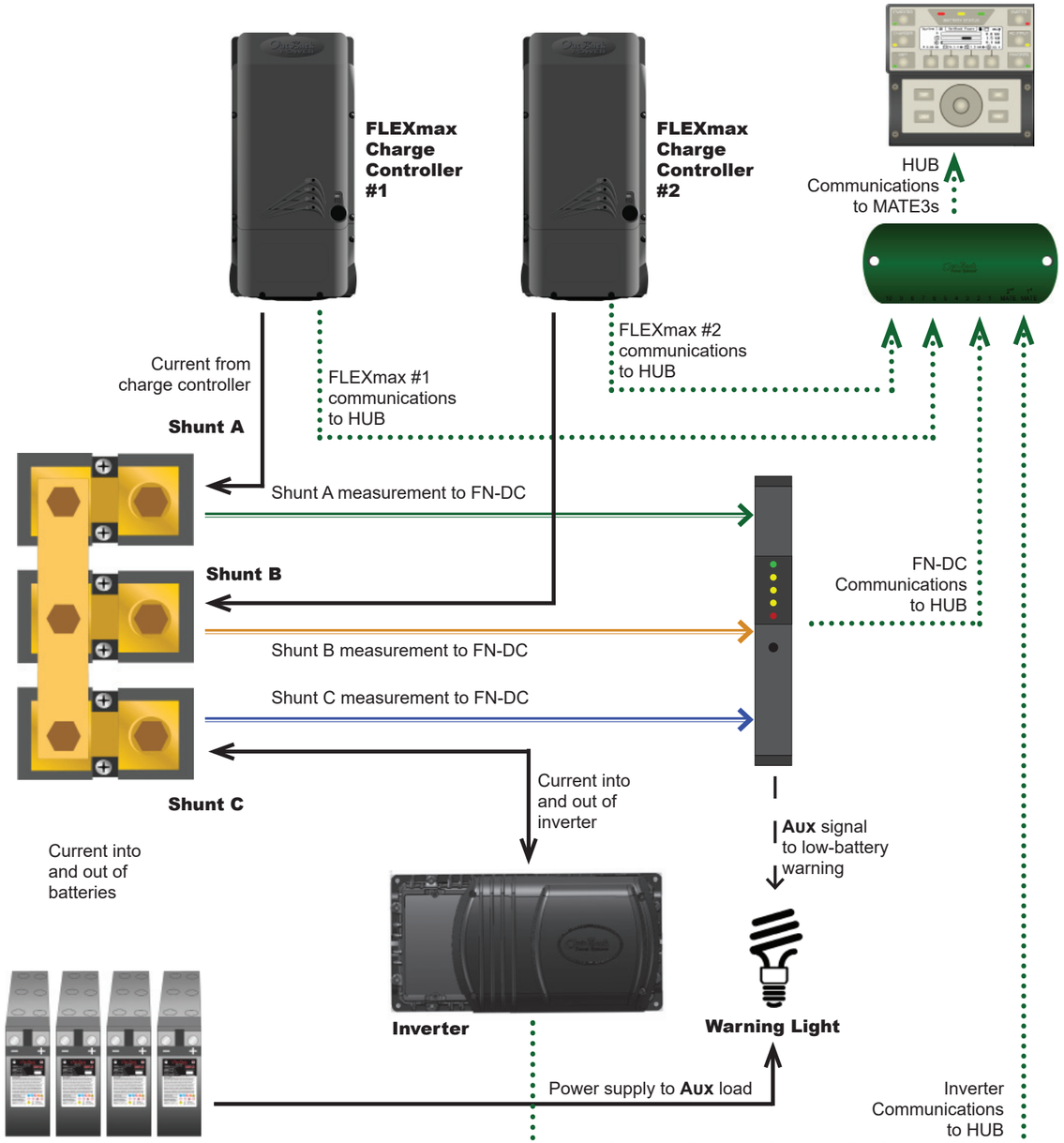
One Inverter, One Charge Controller

NOTE:

Other configurations or systems are possible from what is depicted here. Other shunt designations are also possible, as any device may be placed on any shunt. The layouts shown on these pages may be different than factory-built systems.



One Inverter, Two Charge Controllers



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Common Problems

Symptom	Possible Cause	Possible Remedy
Current readings are inaccurate or reversed.	Shunt(s) miswired.	Confirm correct wiring on all shunts. See page 5.
Current reading is zero with current confirmed present.	Shunt not enabled.	Enable all shunts that are in use. See page 7.
Current or SOC readings are inaccurate.	Unused shunt is still enabled and is picking up electrical noise.	Disable any shunts not in use. See page 7.
SOC readings are inaccurate.	❖ SOC setting was not set to match battery capacity. ❖ Unit was not configured and was left at factory defaults; the factory default settings may not be accurate for a given system. ❖ System has not been through a complete charge cycle recently. Multiple partial charge cycles can introduce errors. ❖ Battery charger settings are not accurate for the system. Along with potentially undercharging the batteries, this can cause the MATE3s Charge Termination Control to stop charging at the wrong time. ❖ ***Charge Factor*** is set inappropriately for the batteries. ❖ FN-DC may require calibration.	❖ Ensure the SOC setting matches the rated capacity of the battery bank. See page 7. ❖ Follow all programming instructions. See page 6. ♦ Ensure the SOC setting matches the rated capacity of the battery bank. ♦ Ensure the full-charge settings in Battery Setup match both the charger settings and the battery manufacturer's requirements. See page 7. ❖ Complete one or more full charge cycles, then begin discharging the batteries to force a reset. ❖ Check all settings and follow all programming instructions. Set the charging source according to the battery manufacturer's requirements. ❖ Set ***Charge Factor*** according to the battery manufacturer's requirements. See page 7. ❖ See **FN-DC Field Calibration**.
Aux relay is not operating according to the previous settings.	A reset to factory defaults may have reset the relay settings to a 12-volt system.	Set ***FLEXnet Relay Set Points*** to the voltage and other settings appropriate to the system. See pages 12 and 13.
Battery voltage reading is not accurate.	FN-DC may require calibration.	See **FN-DC Field Calibration**.

FN-DC Field Calibration

This section outlines the procedure for calibrating a FLEXnet DC Battery Monitor that has already been installed in a system.

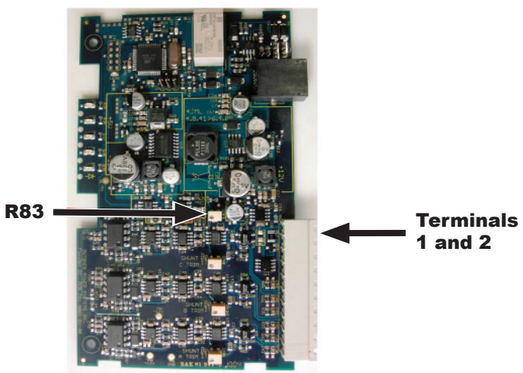
Required Equipment

- Digital Multi-Meter (DMM)
- Jeweler screwdriver
- Previously existing system (MATE3s, HUB, inverter, and/or charge controller)

IMPORTANT:
Take all necessary safety precautions when working on energized equipment.

To Calibrate:

1. Ensure battery bank is fully charged.
2. De-energize system.
3. Remove FN-DC from its mounting location. Maintain all wired connections, including green communications cable to HUB.
4. Remove FN-DC front cover.
   - Ensure informational sticker is facing up and terminal block is at the far end. Using the two push tabs, remove the front cover.
5. Remove red sealant from the R83 trim pot (potentiometer). See figure below.
6. Energize system.
7. Measure battery voltage with DMM at terminals 1 and 2 on FN-DC inputs.
8. Read battery voltage from the MATE3s ***FLEXnet DC*** screen. (See page 8.)
9. With a jeweler's screwdriver, adjust the R83 trim pot until the displayed voltage from the ***FLEXnet DC*** screen matches battery voltage measured with the DMM.
10. Replace front cover.
11. Replace FN-DC in system.



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