OutBack POWER™

member of The Group™

FLEXmax Extreme Charge Controller

GRIDHybrid™

Owner's Manual

About OutBack Power Technologies

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

Grid/Hybrid™

As a leader in off-grid energy systems, which are designed around energy storage, OutBack Power is an innovator in Grid/Hybrid system technology which provides the best of both worlds: grid-tied system savings during normal or daylight operation, and off-grid independence during peak energy times or in the event of a power outage or an emergency. Grid/Hybrid systems have the intelligence, agility, and interoperability to operate in multiple energy modes quickly, efficiently, and seamlessly, in order to deliver clean, continuous and reliable power to residential and commercial users while maintaining grid stability.

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Introduction

Thank you for purchasing a FLEXmax Extreme Series Charge Controller. These charge controllers offer an efficient, safe, multi-stage recharging process that prolongs battery life and assures peak performance from a PV array.

Audience

This manual is intended for use by anyone required to install and operate this equipment. Be sure to review this manual carefully to identify any potential safety risks before proceeding. Installers and operators must be familiar with all the features and functions of this equipment before proceeding. Failure to install or use this equipment as instructed in the manual can result in damage to the equipment that may not be covered under the limited warranty. This product is only serviceable by qualified personnel.

IMPORTANT:

This manual provides safety guidelines and installation information for the FLEXmax Extreme charge controller. It does not provide information about specific brands of PV modules and supplies limited information on batteries.

Contact the supplier of the PV modules or batteries for additional information.

Features

The FLEXmax Extreme charge controller uses continuous Maximum Power Point Tracking (MPPT). This function continuously seeks out the maximum power available from a PV array and harvests it. This power is used to recharge the batteries. Without MPPT, the system can only harvest power at the level of the battery voltage. See page 70 for a description of MPPT.

The FLEXmax Extreme has the following features:

- Designed for FLEXgrid™ operation as part of an OutBack Grid/Hybrid™ system
- Supports 12, 24, 36, 48, and 60 Vdc battery voltages
- Performs voltage step-down capability allowing the use of a higher-voltage PV array configuration
- Controls an equalization cycle manually or automatically
- Capable of delivering full current without derating in temperatures up to 45°C (113°F)
- Capable of full current without derating up to 55°C (131°F) when using optional fan kit
- Rain-proof enclosure
- Logs up to 128 days of operational data
- Field-upgradeable firmware
- Can be remotely monitored and configured (up to 300 feet or 100 meters away) using the optional MATE3 system display
- Can be remotely monitored and upgraded using the optional AXS Card product

Firmware

This manual covers FLEXmax Extreme firmware revision 001.xxx.000.

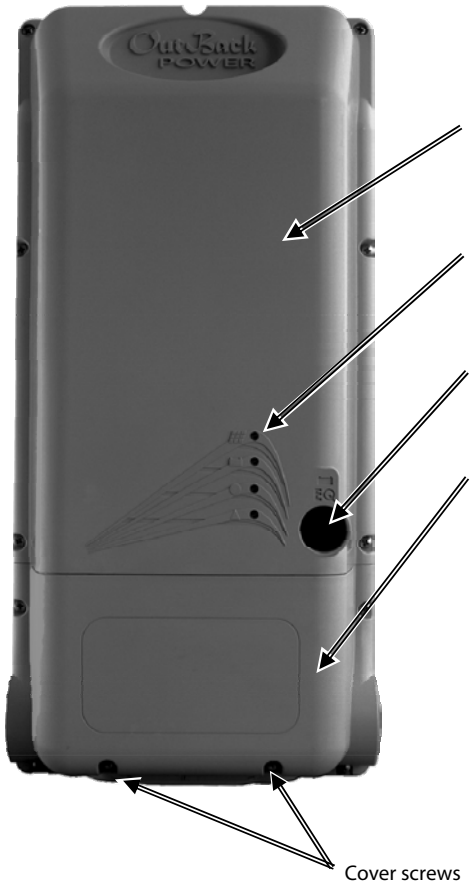
Components and Accessories

Table 1 Components Included

1 x FM Extreme-150VDC	
2 x Mounting Bracket	1 x Silicone Grease Package
2 x Ferrite Clamp, EMI Suppression (install on HUB/DEVICE port and RTS port; see page 16)	

WARNING: Shock Hazard

This unit is not provided with a GFDI device. This charge controller must be used with an external GFDI device as required by Article 690 of the National Electrical Code for the installation location.



To remove the wiring compartment cover:

1. Using a Phillips screwdriver, remove the two screws from the bottom of the compartment cover. (See above.)
2. Grasp the lower edge as shown. Swing the cover out while pulling downward.

Figure 1 Features & Wiring Cover

Battery Types

The FLEXmax Extreme charge controller works best with lead-chemistry batteries intended for deep discharge. These include batteries for marine, golf-cart, and forklift applications. They also include gel-cell batteries and absorbed glass-mat (AGM) batteries. OutBack Power recommends the use of batteries designed specifically for renewable energy applications. Lithium-based batteries and other advanced battery technologies may require special considerations. Please contact OutBack Technical Support at **+1.360.618.4363** before implementing advanced battery technologies.

Installation

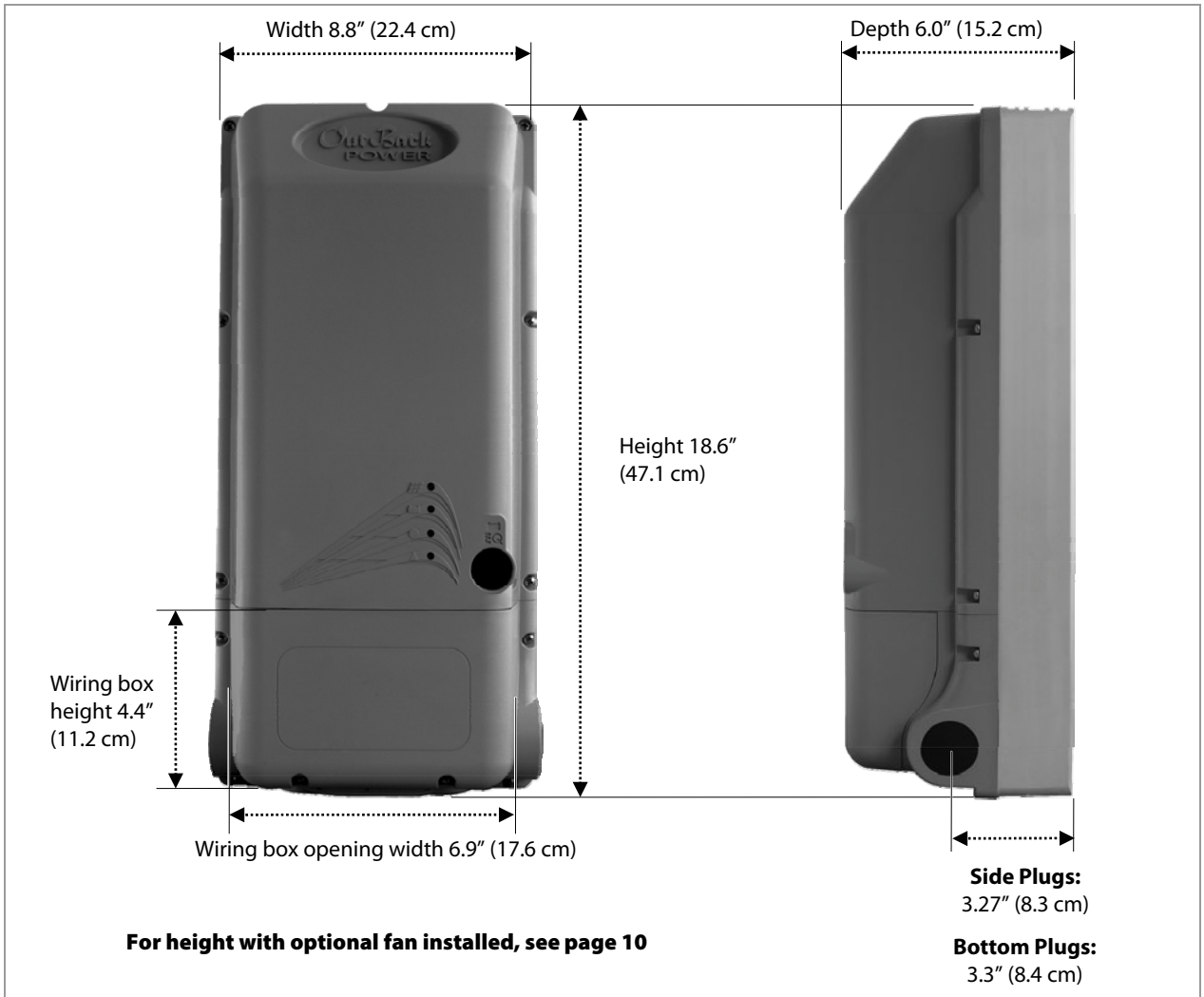
Standards and Requirements

All installations must comply with national and local electrical codes. Professional installation is recommended.

A FLEXmax Extreme charge controller operating in unventilated or in other conditions where the ambient temperature exceeds 45°C (113°F) will have a derated power output. See page 65 for more information.

If damaged or malfunctioning, the FLEXmax Extreme should only be serviced by qualified personnel. Please contact the local renewable energy dealer/installer for assistance.

Dimensions



For height with optional fan installed, see page 10

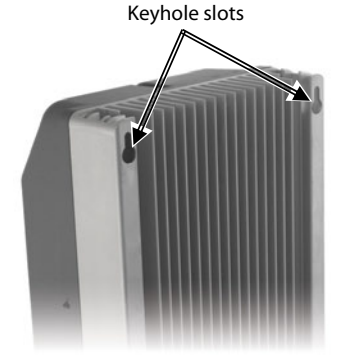
Figure 2 FLEXmax Extreme Dimensions

Mounting the Charge Controller

The FLEXmax Extreme must be mounted upright on a wall or similar flat upright mounting surface. It must be mounted at least 36" (91.4 cm) above the ground or floor. No other mounting positions are allowed. Installation in shade is recommended.

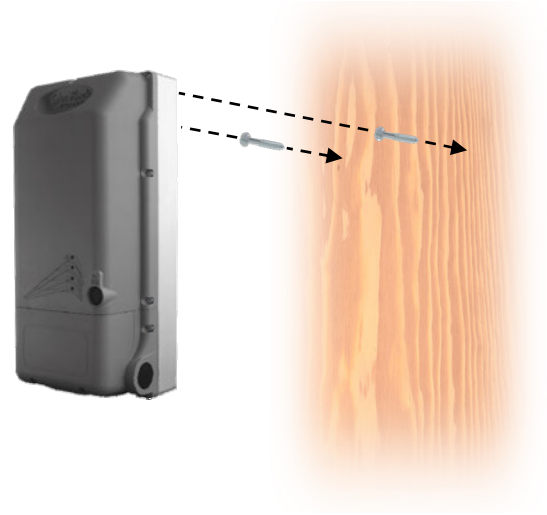
Clearance requirements are a minimum of 6" (15.2 cm) above and below the controller.

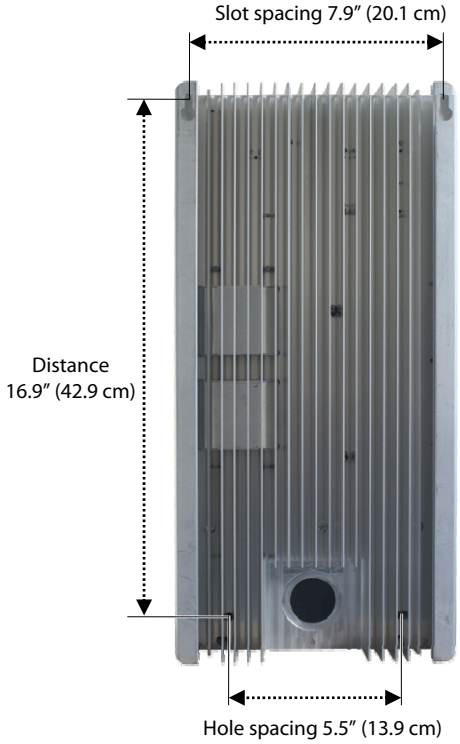
Two mounting methods are available. The first method uses keyhole slots on the back of the controller for hanging directly on a wall. This method is useful for a standalone installation.



To mount using keyhole slots:

1. Use two slotted #14 wood screws. The mounting surface must be strong enough to support the weight of the FLEXmax Extreme. **NOTE**: OutBack is not responsible for damage resulting from inadequate mounting hardware or preparation.
2. Mark the locations where the screws will be inserted on the surface. Space them according to the keyhole slot locations (see below). **NOTE**: The brackets included with the controller have holes with the same spacing which can be used as a marking template.
3. Using the appropriate tools, set the screws into the surface (see below). The heads should protrude by 1/8" (0.3 cm).
4. Hang the FLEXmax Extreme by placing its back against the mounting surface and aligning the keyhole slots with the screws. Settle the controller so that the screws are seated in the narrow end of each slot.
5. Secure the base of the controller to the surface by inserting two ¼" hex head lag screws into the holes shown to the left.

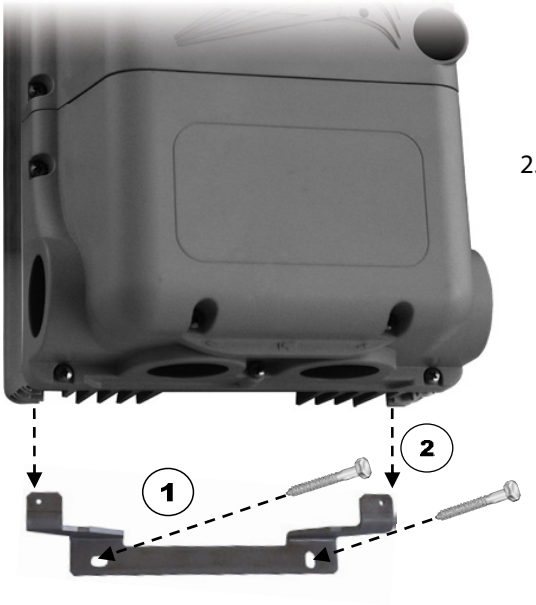


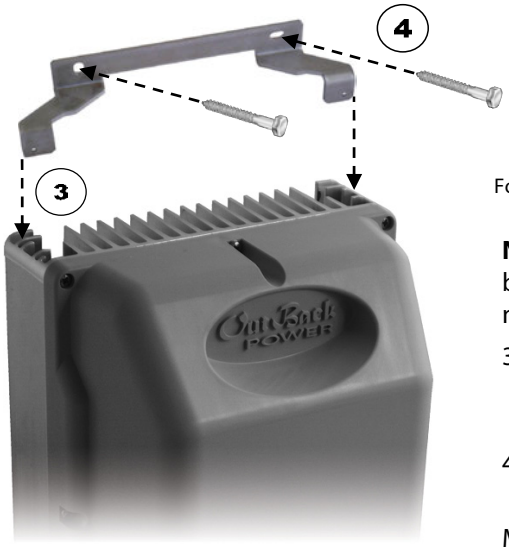


Mounting is complete. Proceed to charge controller wiring or other installation steps.

Figure 3 Mounting the Charge Controller (keyhole)

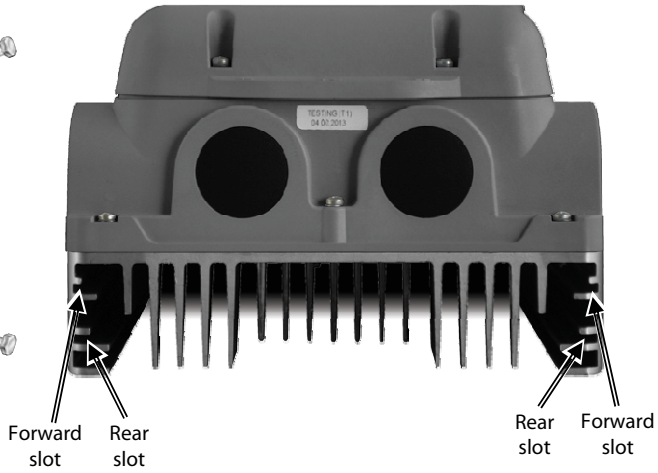
The second mounting method uses brackets on the top and bottom of the controller. This method is useful when mounting the controller next to an OutBack inverter system, as the conduit openings will align. It is also useful for mounting without making advance measurements. The FLEXmax Extreme controller comes with two identical brackets.





To mount using brackets:

1. Using two ¼" hex head lag screws, mount the lower bracket with the tabs facing upward. The mounting surface must be strong enough to support the added weight of the FLEXmax Extreme.
   NOTE: OutBack is not responsible for damage resulting from inadequate mounting preparation.
2. Lower the FLEXmax Extreme onto the bracket as shown to the left. The bracket tabs can be inserted in one of two positions: forward or rear.
   - To mount the controller flush against the wall, insert the tabs in the forward slots as shown below.
   - To mount the controller 0.83" (2.1 cm) from the wall to align with an OutBack mounting plate, insert the tabs in the rear slots as shown below.



NOTE: The charge controller can rest on the lower bracket for the rest of the procedure, although it will need at least one hand to steady it.

3. Insert the upper bracket into the same set of slots as were used with the lower bracket (forward or rear) as shown to the left.
4. Using two ¼" hex head lag screws, attach the upper bracket to the mounting surface as shown to the left.

Mounting is complete. Proceed to charge controller wiring or other installation steps.

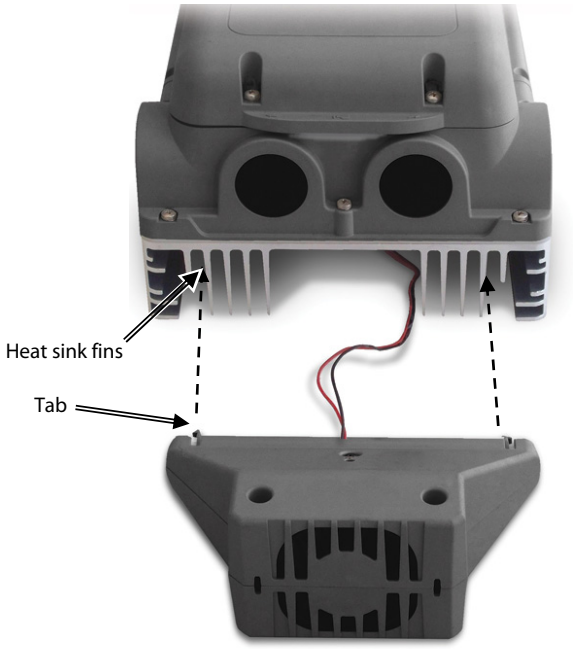
Figure 4 Mounting the Charge Controller (brackets)

Installing the Fan

An optional fan is available for the FLEXmax Extreme to provide additional cooling. The fan is mounted on the bottom of the charge controller. The total unit height with the fan attached is shown below. See page 65 for information on the fan's effects on unit performance.

To install the optional cooling fan:

1. Place the fan against the base of the FLEXmax Extreme. The fan is equipped with two locking tabs. Two of the heat sink fins have holes which receive the tabs. Align the tabs with these fins (see below).
2. Press the fan straight along the fins until the tabs snap into the holes.



3. Insert the fan connector into the fan port in the controller's wiring box. It may be necessary to remove the rear plug and insert a bushing. (See illustration to the left; also see page 16.)

Installation is complete. The fan will operate automatically based on the FLEXmax Extreme internal temperature.

See page 32 to read the temperature using the MATE3 System Display. This page also lists the temperatures at which the fan turns on and off.

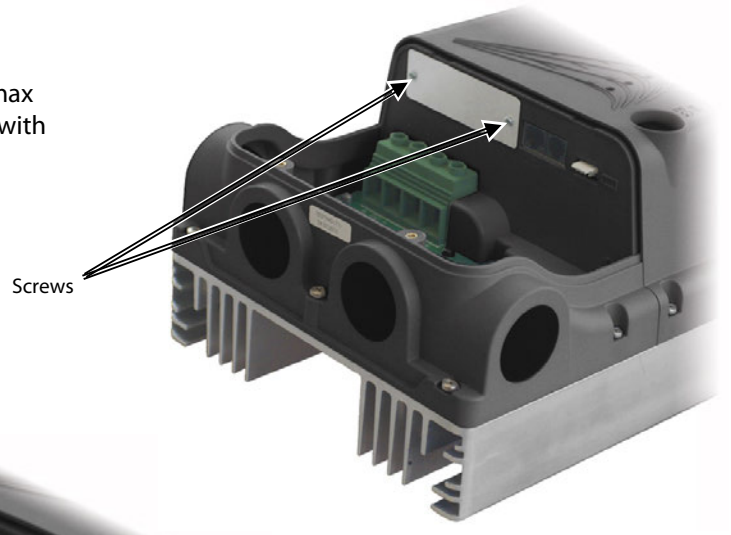
Figure 5 Installing the Fan

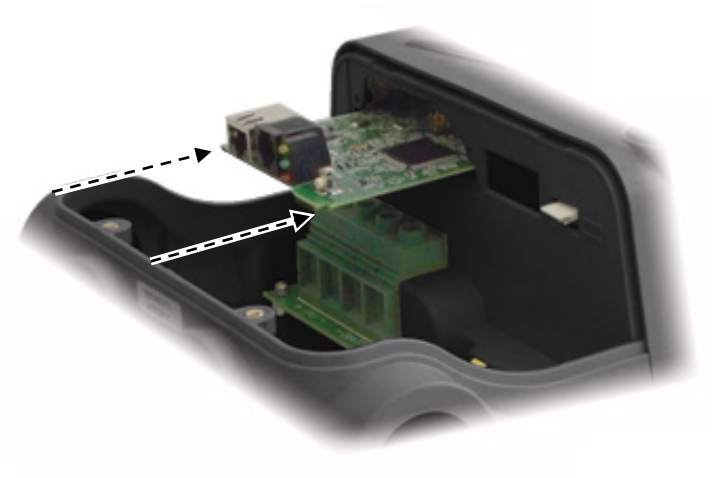
Installing the AXS Card

An optional AXS Card enables Ethernet access to the FLEXmax Extreme using the Modbus protocol. (The AXS Card is identical in function to the OutBack AXS Port product. See the *AXS Port SunSpec Modbus Interface Owner's Manual* for more information. **NOTE**: The AXS Port product is not interchangeable with the AXS Card and cannot be used in this compartment.

To install the AXS Card:

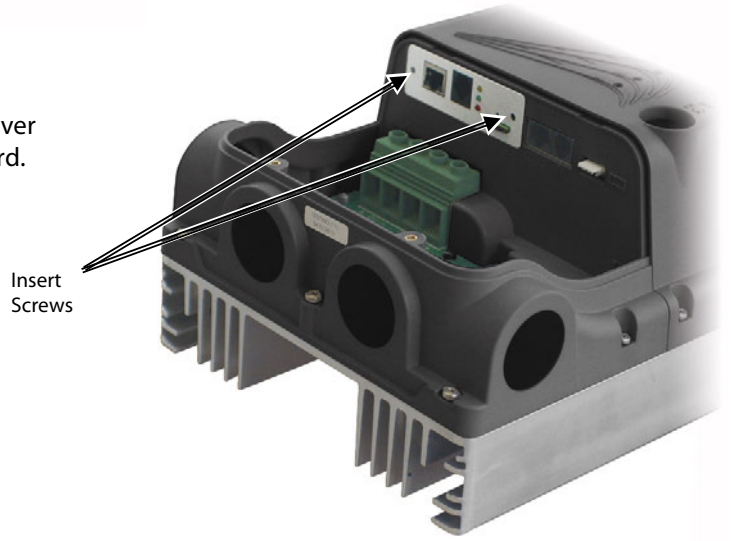
1. Remove the factory-installed blank compartment cover from the FLEXmax Extreme. The cover is held in place with two Phillips screws.





2. Insert the AXS Card onto the rails on each side of the compartment. Slide it in until the card presses firmly onto the connector at the rear of the compartment.

3. Install the alternate compartment cover which was included with the AXS Card. Use the Phillips screws which were removed from the blank cover.



Installation is complete. See the *AXS Port SunSpec Modbus Interface Owner's Manual* for information on use.

Figure 6 Installing the AXS Card

Wiring

This section provides instructions on installing PV array wiring into the charge controller. See page 69 for more notes on PV array sizing. All wiring must comply with local and national codes.

Grounding

This product is intended to be installed as part of a permanently grounded electrical system. This is shown in the wiring diagrams in this book. Grounding methods must comply with local and national codes.

The FLEXmax Extreme equipment ground is marked with this symbol: ⏚

IMPORTANT:

- Article 690 of the NEC requires ground-fault protection such as the OutBack GFDI.
- It is recommended to bond one of the DC conductors to the ground on the battery side of the system.
- The DC conductor is connected to the ground as a result of installing the OutBack GFDI. They should not be bonded separately. If a separate bond is already present in the system, it should be removed. If present, it will defeat the GFDI protection. (See page 19.)
- Bonding the negative and ground is most common. However, the FLEXmax Extreme can be used normally in either negative-ground or positive-ground systems. Page 14 shows examples of both types of system wiring. See below for restrictions on positive grounding. Also see page 74.

CAUTION: Equipment Damage

The FLEXmax Extreme can be used in a positive-ground system when networked with one OutBack inverter. This requires a HUB Communications Manager. (See page 15.) It cannot be networked in a positive-ground system with multiple inverters. For use of the FLEXnet DC Battery Monitor or other devices in these applications, see page 74. Failure to follow these instructions can damage the controller and other devices. This damage is not covered under warranty.

The following important restrictions apply *unless superseded by local or national codes*:

- The grounding conductors must be routed separately from all battery conductors.
- The battery conductor (positive or negative) must be bonded to the grounding system at only *one* point.

Wiring Size and Requirements

IMPORTANT:

Wire sizes must comply with local and national codes. Input conductors and circuit breakers must be rated at 1.56 times the short-circuit current of the PV array (per NEC). OutBack 100% duty continuous circuit breakers only need to be rated at 1.25 times the short-circuit current.

- Please refer to the NEC and other electrical codes for PV array cable sizing, cable length, and cable ampacity.
- Use #4 AWG (25 mm^2) wire (minimum) for the output between the FLEXmax Extreme and the battery bus bar conductors. Smaller cables can reduce performance and possibly damage the unit.
- The output can accept up to #2 AWG (35 mm^2) wire. Larger conductors will reduce losses and ensure highest performance of the FLEXmax Extreme.
- Install properly sized overcurrent protection devices. The required AIC rating of the device is 4000 Adc.

- The largest PV array must have a rated short-circuit current of 64 amps or less under STC (Standard Test Conditions). The output current limit of the FLEXmax Extreme is 80 amps.
- DC battery overcurrent protection must be used as part of the installation. OutBack offers both circuit breakers and fuses for overcurrent protection.

Physical Requirements and Conduit

	IMPORTANT: Conduit hubs must connect to the conduit before connecting to the FLEXmax Extreme.
	WARNING: Burn Hazard The heat sink can become hot when the charge controller is operating. Use caution when touching it during operation.

- All wire lugs and ground terminals are to be tightened to a torque value of 4 Nm (35 in-lb).
- Use copper wiring only. Wiring must be rated at 90°C or higher.
- If installing in a wet location, any conduit hubs must comply with the requirements of UL 514B.
- Run positive and negative cables side by side.
  - ~ Tie or twist cables together as much as possible to allow the inductive currents to cancel.
  - ~ Ensure paired cables pass through the *same* knockout and conduit fittings.

PV and Battery Terminals

	WARNING: Shock Hazard When a PV array is exposed to light, it immediately generates a voltage. Make sure all DC circuit breakers are OFF (open) BEFORE making any wiring connections. Open both the battery disconnect devices and the array disconnect devices to ensure isolation of the controller. Use a DVM to check for voltage on all wires.
	CAUTION: Equipment Damage Each FLEXmax Extreme requires its own PV array. DO NOT PARALLEL PV+ and PV- TERMINALS OF MULTIPLE CONTROLLERS ON THE SAME ARRAY!

The negative (-) PV and negative (-) BAT terminals are connected internally. Only one wire is needed to connect to the negative (-) wire lugs if the negative (-) PV and BAT conductors are bonded at the negative bus bar.

See Figure 8, Figure 10, Figure 16, and Figure 17 for sample wiring diagrams.

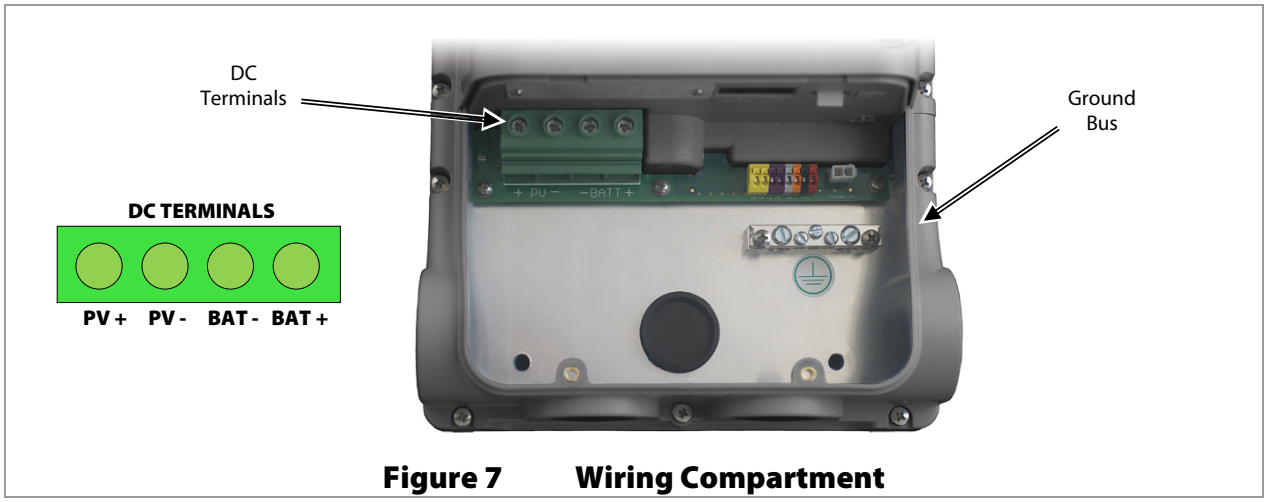


Figure 7 Wiring Compartment

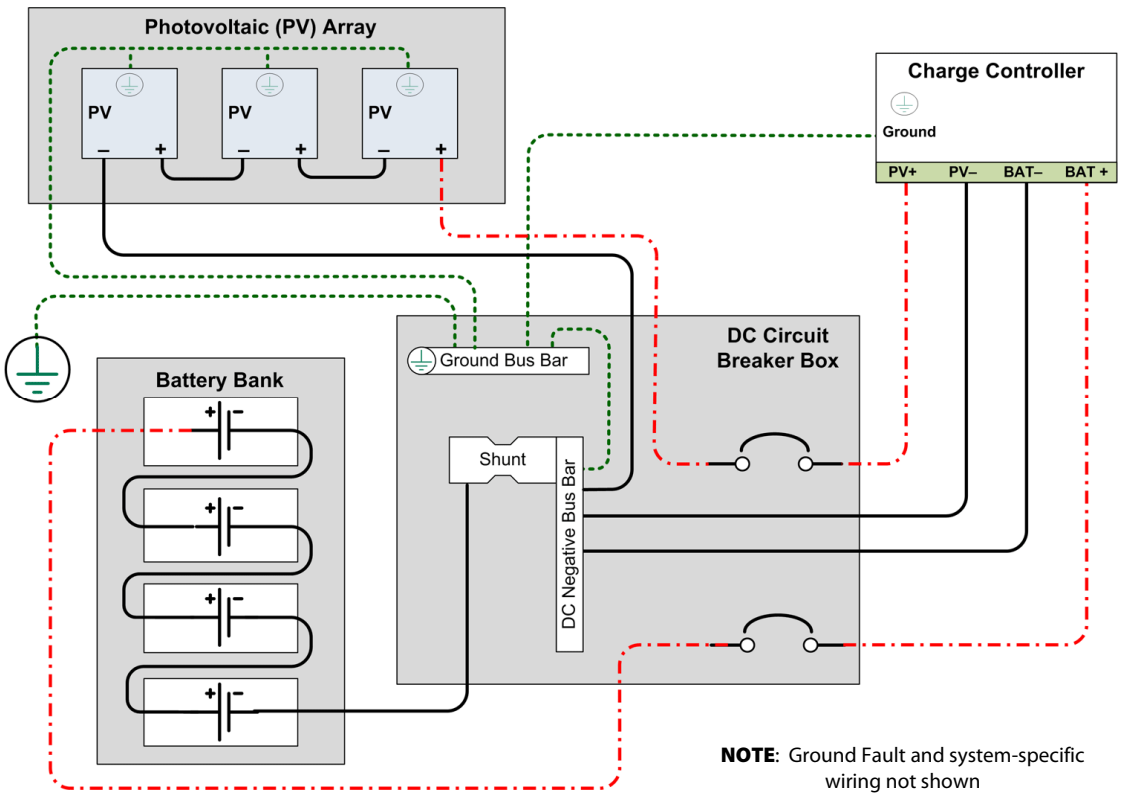


Figure 8 Wiring Diagram – Single Charge Controller with PV Array

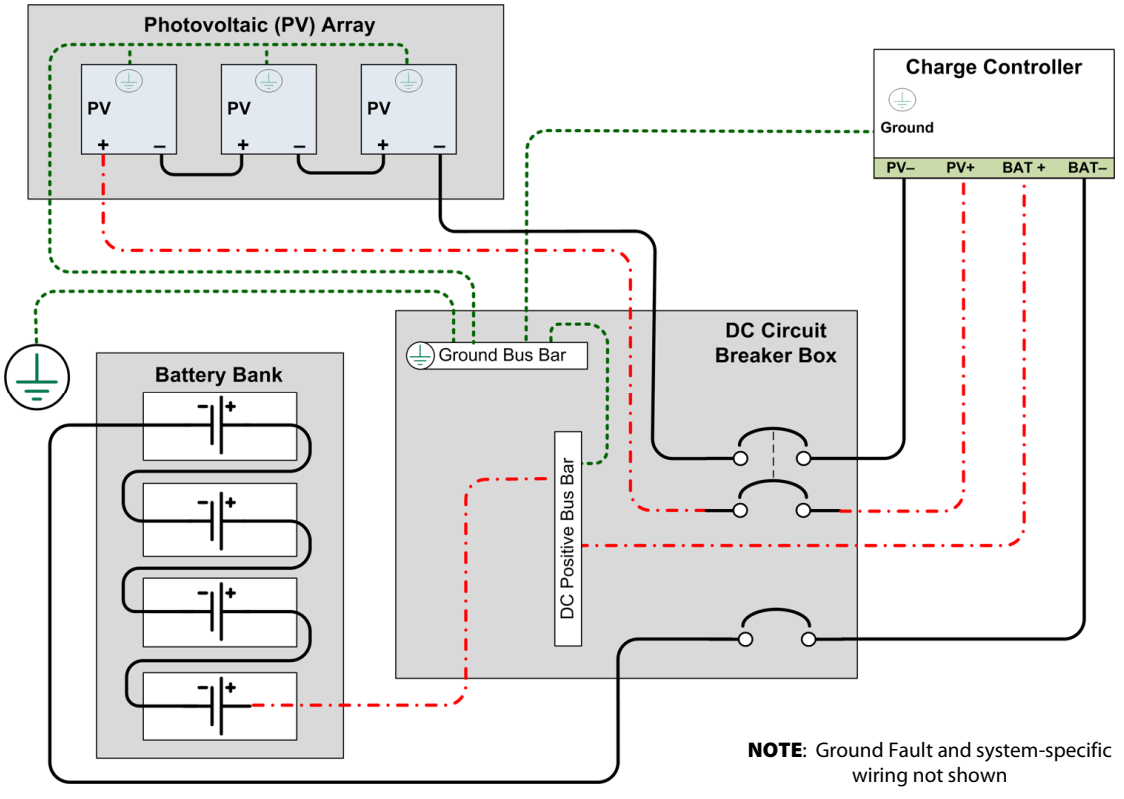


Figure 9 Wiring Diagram – Single Charge Controller (Positive-Ground)

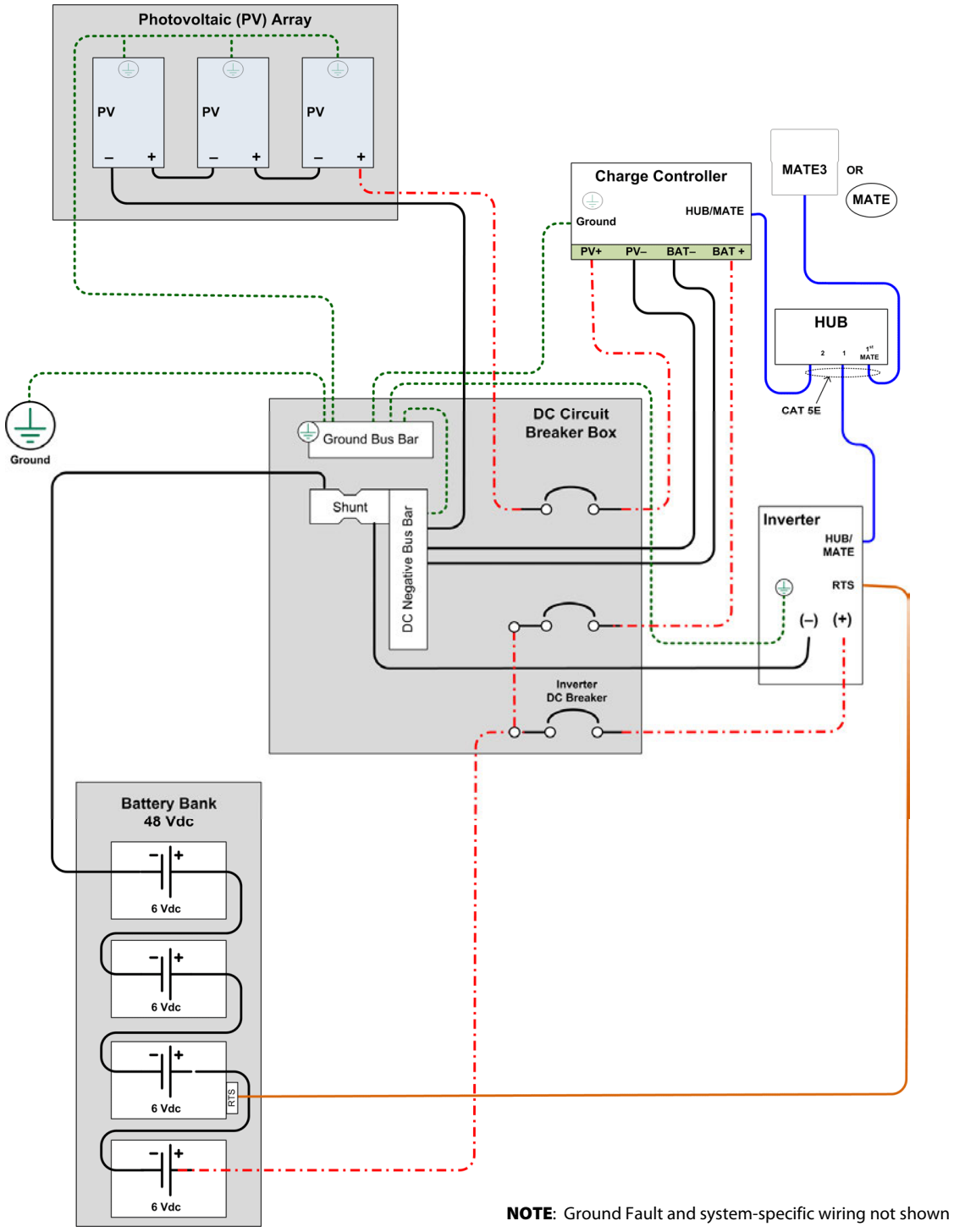


Figure 10 Wiring Diagram – Charge Controller with PV Array and Inverter

CAUTION: Equipment Damage

The FLEXmax Extreme can be used in a positive-ground system with one OutBack inverter as shown above. It cannot be used in a positive-ground system with multiple OutBack inverters. For other devices or configurations, see page 74.

Accessory Terminals and Ports

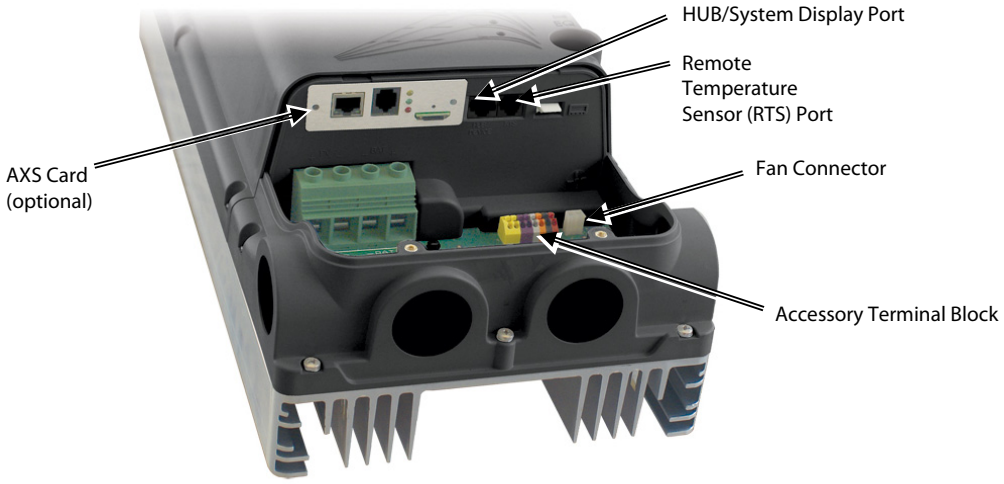


Figure 11 Wiring Compartment

HUB/Display Port

This is an RJ-45 port for a CAT5 cable to connect OutBack system displays or communications managers. A ferrite clamp (see page 6) should be installed on this cable inside the compartment.

Remote Temperature Sensor

An optional battery Remote Temperature Sensor (RTS) is recommended for accurate battery charging. A ferrite clamp (see page 6) should be installed on this cable inside the compartment.

When the system includes an OutBack HUB Communications Manager and a system display, only one RTS is needed for multiple inverters and charge controllers. Specialized temperature compensation is available. See page 38 for more information.

AXS Card

This is the location for the AXS Card, which is available as an option for the FLEXmax Extreme. See page 11.

Fan Port

This is the connection for the FLEXmax Extreme cooling fan. See page 10.

Accessory Terminal Block

This block of terminals has connections for the AUX output, for the Battery Sense function, and for the External Fault function. The terminals accept wire from 16 AWG to 24 AWG.

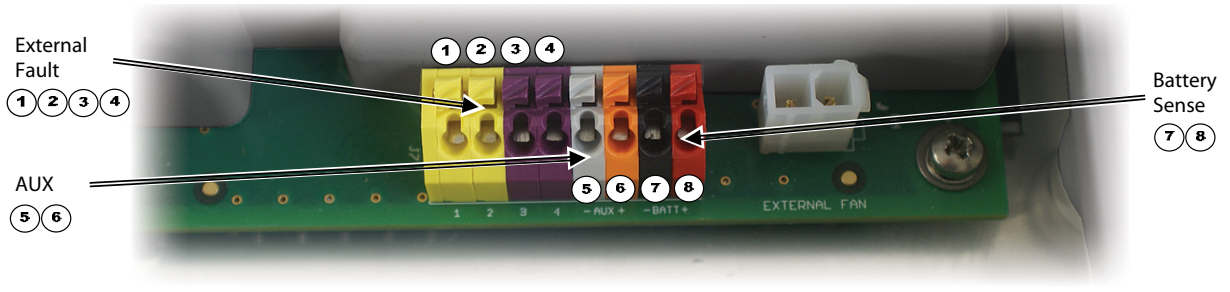


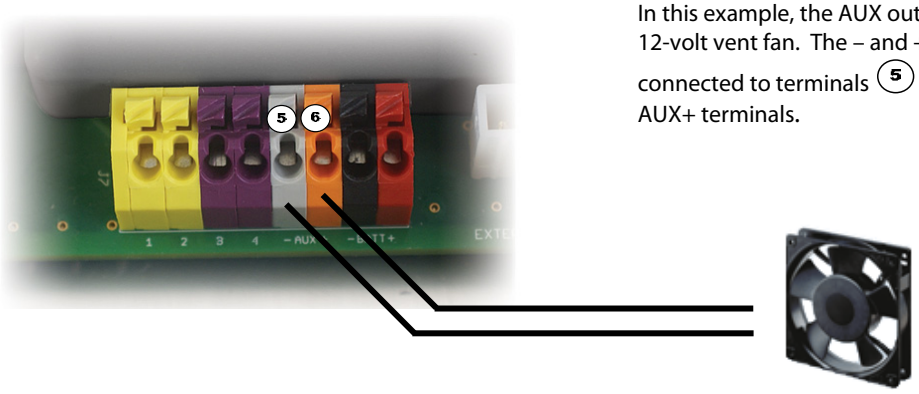
Figure 12 Accessory Terminal Block

AUX Terminals

The AUX (Auxiliary) output is a small power supply that provides a 12 Vdc output current to an isolated load. The AUX output can respond to many criteria and control many functions. These include cooling fans, vent fans, load diversion, fault alarms, and automatic generator control. The AUX can only control one function at a time.

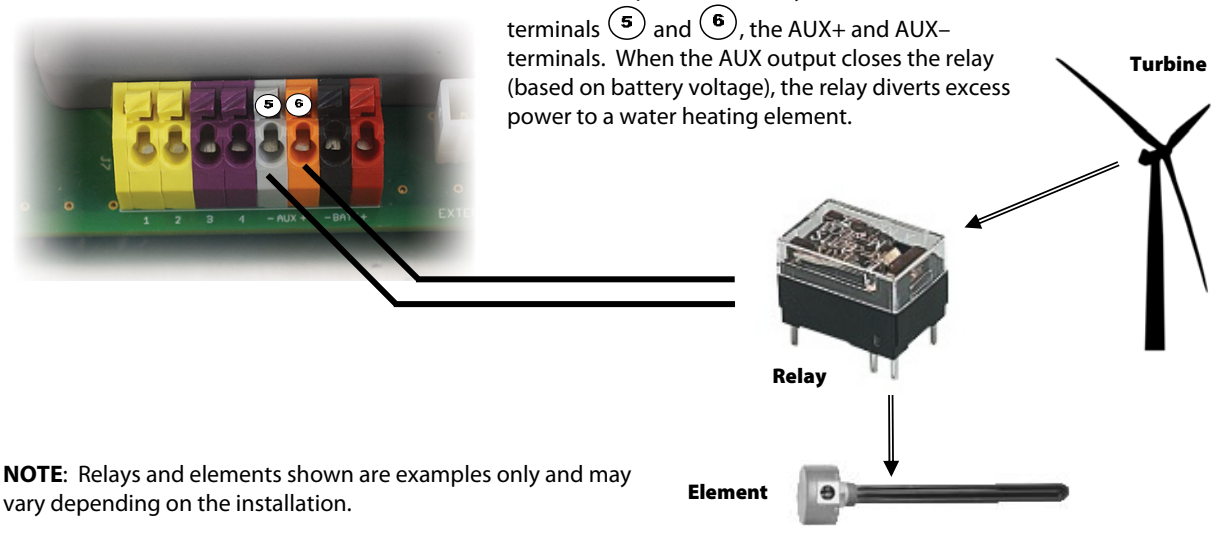
Terminals (5) and (6) are the + and – terminals for the AUX output. These terminals are colored gray (–) and brown (+) for easy reference. The terminals can supply up to 250 mA at 12 Vdc (3 W). The AUX circuit contains electronic overcurrent protection, which resets after being overloaded. No additional fuses are required for the AUX terminals.

The AUX LED illuminates when the output becomes active. (See page 23 for an illustration of LED indicators.)



In this example, the AUX output directly drives a 12-volt vent fan. The – and + wires on the fan are connected to terminals (5) and (6), the AUX– and AUX+ terminals.

Figure 13 AUX Vent Fan



In this example, the AUX output drives a relay that diverts wind power. The relay's coil is connected to terminals (5) and (6), the AUX+ and AUX– terminals. When the AUX output closes the relay (based on battery voltage), the relay diverts excess power to a water heating element.

NOTE: Relays and elements shown are examples only and may vary depending on the installation.

Figure 14 AUX Diversion Control

Battery Sense Terminals

The remote Battery Sense terminals are used for accurate voltage monitoring. These terminals connect directly to the batteries. Using the controller's main battery cables for voltage sensing is less accurate. This is due to voltage rise caused by charging currents on the battery conductors.

Terminals (7) and (8) are the – and + terminals for the Battery Sense function. These terminals are colored black (-) and red (+) for easy reference. A twisted-pair cable is recommended. (See wire sizing on page 16.)

IMPORTANT:

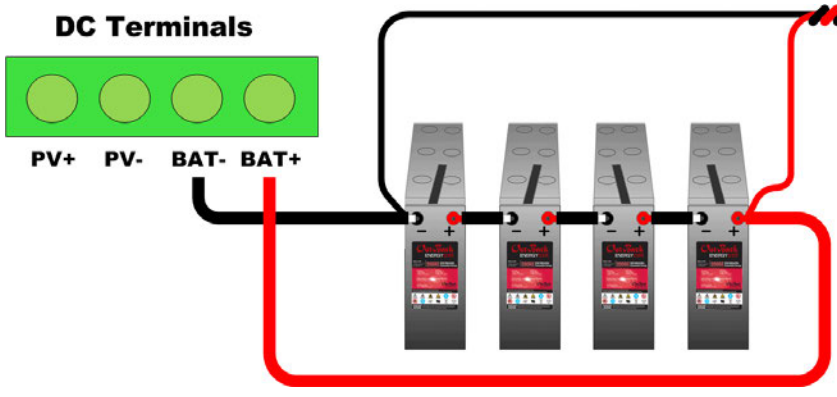
The MATE3 display shows the system voltage as measured at the battery terminals of various devices. (See Figure 26 on page 29.) This voltage is used for generator starting and other functions.

- If no other devices are present, it will show the reading of the FLEXmax Extreme.
- If OutBack inverters are present, the inverter voltage replaces the FLEXmax Extreme as the system voltage reading.
- If the FLEXmax Extreme Battery Sense terminals are in use, this reading replaces the inverter or the regular charge controller readings as the system voltage.
- The FLEXnet DC Battery Monitor is the highest priority and will replace the Battery Sense reading as the system voltage.

The Battery Sense reading is still shown on the Charge Controller screen. (See Figure 27 on page 30.) This reading is still used to adjust the FLEXmax Extreme charging.

This function operates automatically when it detects a voltage within 2 volts of the battery voltage reading at the charge controller's main terminals. If the reading varies by more than 2 volts, the Battery Sense function is disabled. The assumption is that the terminals are not connected. (If the terminals are connected, there may be a wiring problem.)

The MATE3 allows the user to calibrate the battery meter at the charge controller's main terminals. (See page 45 and the MATE3 manual for more information.) This calibration does not affect the Battery Sense function. If Battery Sense is in use, calibration changes can be made, but will have no effect until Battery Sense is disabled.



NOTE: Overcurrent protection is not shown. Recommended protection for sense conductors is:

- Fast-acting device
- 80 Vdc or greater
- 1 A or smaller
- Cold resistance 10 ohms or less

Figure 15 Battery Voltage Sensing

External Fault Terminals

The External Fault terminals are used to make connections to the OutBack Ground Fault Detector/Interruptor (GFDI) product. A single wire is run from one of the yellow terminals ((1) or (2)). A second single wire is run from one of the purple terminals ((3) or (4)). Terminals (1) and (3) are the most commonly used. These wires are connected to a normally-open set of contacts on the OutBack GFDI. Figure 16 and Figure 17 show terminals (1) to (4) without the rest of the control terminal block.

The terminals detect electrical continuity. These contacts remain closed as long as the GFDI bonding switch remains closed. If a ground-fault event occurs, both the GFDI switch and the GFDI contacts will open. The External Fault circuit will detect the loss of continuity and will shut down the charge controller.

If multiple charge controllers are in use, they can be paralleled so that all controllers use a common GFDI. Terminals (2) and (4) are a parallel set of connections to terminals (1) and (3).

In the first controller, terminals (2) and (4) should have a parallel set of wires which connect to terminals (1) and (3) on the second controller. This allows the second controller to sense the same conditions as the first so that it will react accordingly. If a third controller is present, its terminals (1) and (3) should have wires connecting to terminals (2) and (4) on the second controller, and so on. (See Figure 17.) Additional controllers can be added as needed.

If the terminals are not in use, this function should be disabled. This is performed by directly shorting terminals (1) and (3) with a small jumper wire.

IMPORTANT:

The FLEXmax Extreme will not function unless either the OutBack GFDI or the disabling jumper is installed. Initial power-up will result in an External Fault signal. (See page 61.)

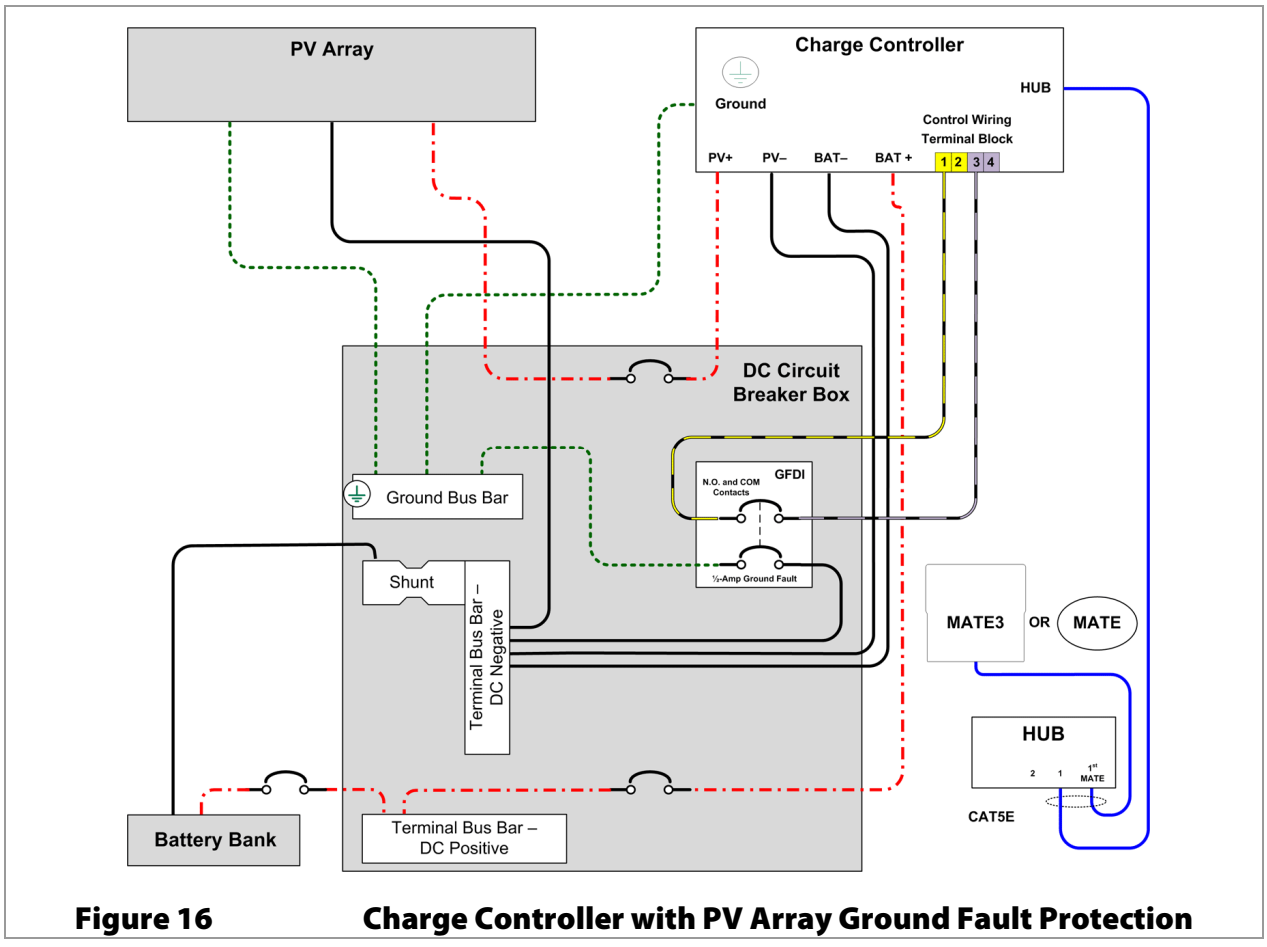


Figure 16 Charge Controller with PV Array Ground Fault Protection

In Figure 16, a wire has been run from terminal (1) to one of the dedicated GFDI terminals. A wire has also been run from terminal (3) to the other side of the GFDI. As long as the GFDI remains closed, that pole of the GFDI will read as electrically continuous to the External Fault circuit.

In the event of a ground fault or any other condition which trips the GFDI, these terminals will register loss of

continuity. The External Fault circuit will detect this loss immediately and shut down the the controller. The red Fault LED indicator will illuminate. See pages 24, 32, and 61.

Other possible uses for the External Fault terminals include devices such as arc fault protection, or an Emergency Power Off (EPO) switch for a fast manual shutdown. Any device with normally open contacts can work with this function. If more than one device is used, all contacts must be wired in series so that any one device will shut down the controller.

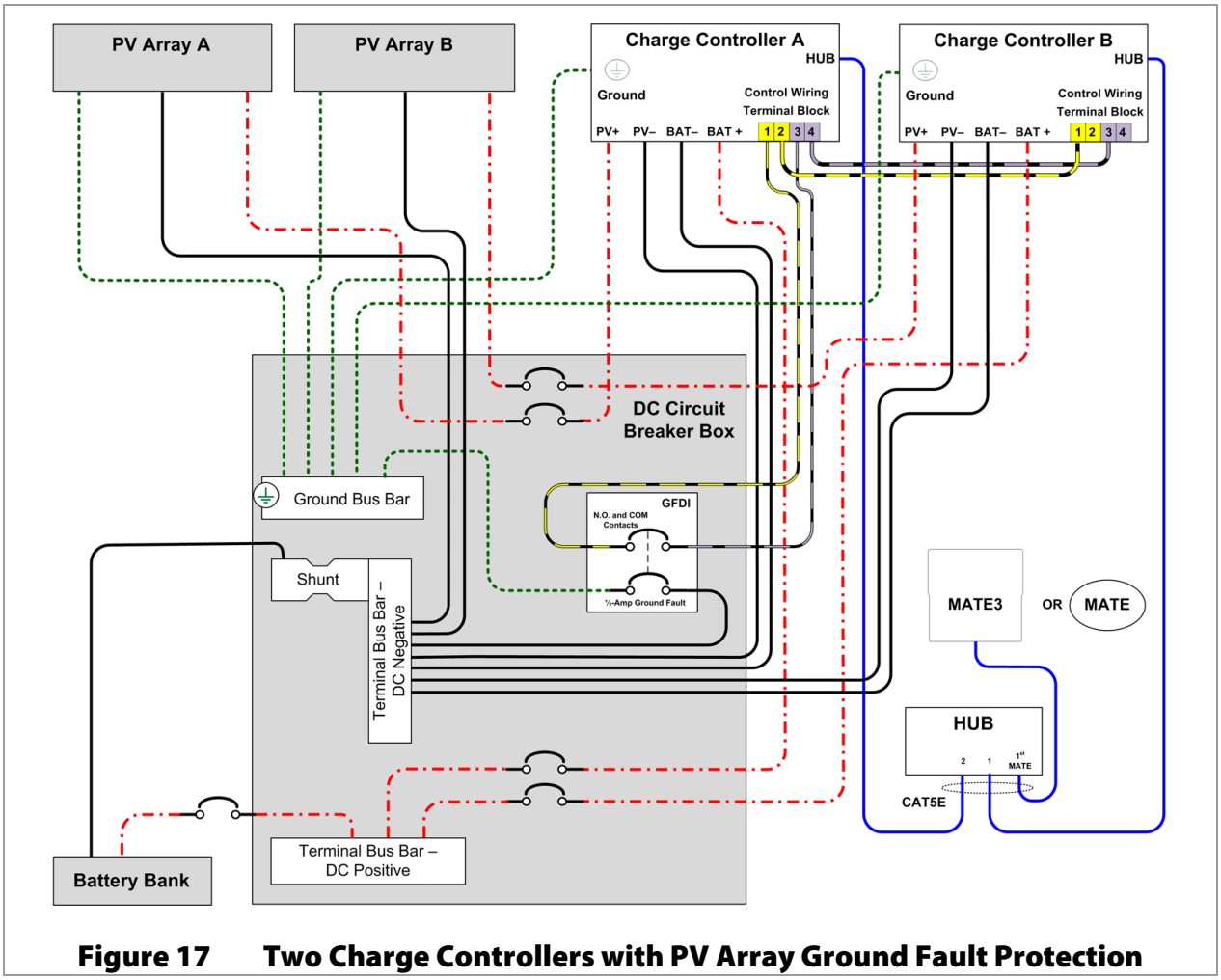


Figure 17 Two Charge Controllers with PV Array Ground Fault Protection

In Figure 17, a wire has been run from terminal (1) on Charge Controller A to one of the dedicated GFDI terminals. A wire has also been run from terminal (3) to the other side of the GFDI.
In addition, Terminal (2) on Charge Controller A has been connected to terminal (1) on Charge Controller B. Similarly, Terminal (4) on Charge Controller A has been connected to Terminal (3) on Charge Controller B. This places the External Fault circuits on both controllers in parallel.

As long as the GFDI remains closed, that pole of the GFDI will read as electrically continuous to the External Fault circuit on both controllers. In the event of a ground fault or any other condition which trips the GFDI, these terminals will register loss of continuity. The External Fault circuit on both controllers will detect this loss immediately. Both controllers will shut down and display the red Fault LED indicator. See pages 24, 32, and 61.

To reset the controller after an external fault:

1. Remove all sources of power (PV and battery) from the controller.
2. Correct the cause of the fault condition.
3. Follow the power-up procedure on page 21.

Power Up

IMPORTANT:

- The charge controller automatically senses the nominal battery voltage upon connection. Once set, it retains the nominal voltage setting. Following any type of shutdown or disconnect, it will return to operation automatically.
- The PV array voltage is automatically detected upon connection. The PV array voltage must never exceed 150 V_{oc}.
- It is recommended to restore the FLEXmax Extreme to factory default settings (see page 45) and reset the nominal voltage (see below) any time the system is substantially revised or the controller is relocated.

The FLEXmax Extreme uses power from the battery bank to operate. The battery voltage must be at least 10.5 volts or higher to power up the charge controller. When battery power is detected, the charge controller will flash each of its LED indicators twice in a self-test.

The Status indicator (see page 23) will then flash to show the nominal system voltage that was detected. Each flash indicates an increment of 12 volts; therefore, one flash = 12 Vdc, two flashes = 24 Vdc, and so on.

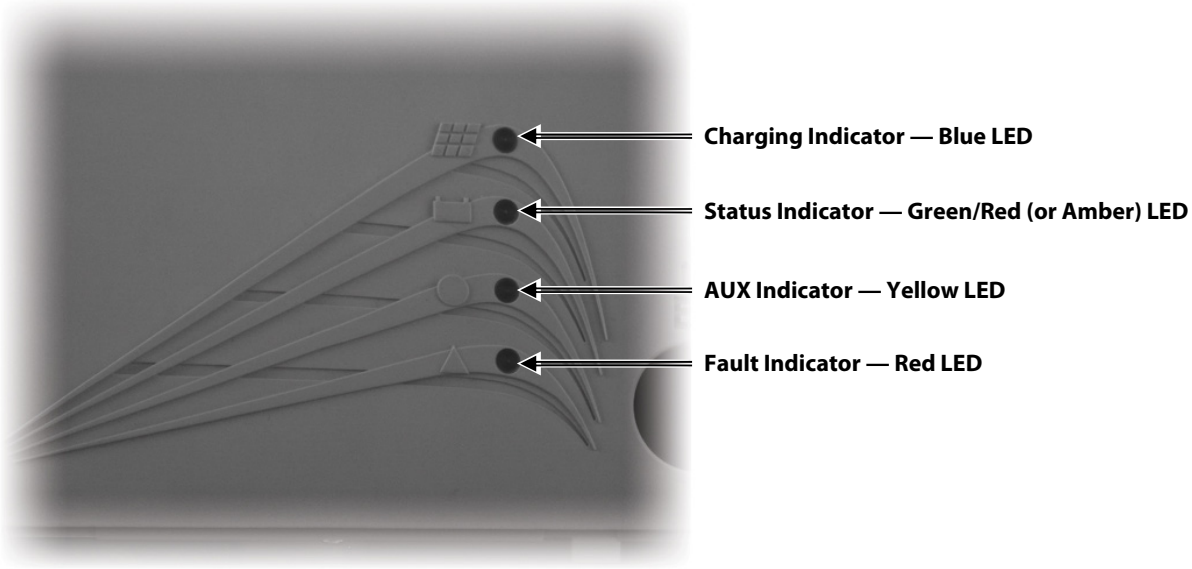


Figure 18 LED Indicators

Setting the Nominal Voltage

Upon initial power-up, the FLEXmax Extreme will sense the battery voltage and use this reading to determine the nominal system voltage — a battery bank of 12, 24, 36, 48, or 60 volts DC.

The ranges of detection for each nominal battery voltage are:

- 12-volt system — 10.5 Vdc to 15.7 Vdc
- 24-volt system — above 15.7 Vdc to 31.4 Vdc
- 36-volt system — above 31.4 Vdc to 43.2 Vdc
- 48-volt system — above 43.2 Vdc to 62.8 Vdc
- 60-volt system — above 62.8 Vdc to 78 Vdc

The batteries must be within the appropriate voltage range for the controller to take the correct reading. A severely discharged 24-volt battery bank, for example, could read as a 12-volt bank and cause the controller to

charge inappropriately (or not at all).

Normally the nominal system voltage is retained. If the FLEXmax Extreme is disconnected from the batteries or otherwise loses power, upon a new power-up it will continue using the nominal voltage and settings determined previously.

If it is necessary to change the nominal voltage:

1. Reset the FLEXmax Extreme to factory default settings as described below.
2. Remove all sources of power (PV and battery) from the FLEXmax Extreme and then reconnect battery power. The controller will sense the battery voltage and use this reading to determine the new nominal system voltage. This will not occur until the power is turned off and then on again.

Resetting to Factory Defaults

The MATE3 system display can be used to reset the FLEXmax Extreme to its factory default settings. See page 45 for more information.

To reset to defaults without using the MATE3:

1. Remove all sources of power (PV and battery) from the FLEXmax Extreme.
2. Press and hold the Equalize switch (see page 6) while reconnecting battery power.
3. Continue holding the Equalize switch. After approximately 10 seconds, the Status indicator will blink green rapidly. Continue holding the switch until the Status indicator begins blinking amber more slowly.
4. Release the Equalize switch and disconnect the batteries.

Initial Operation

When the PV input circuit breaker is turned on, the FLEXmax Extreme automatically detects the PV input voltage. It then enters the "Wakeup" state (see page 28) and prepares to charge the batteries by tracking the maximum power point of the solar array. During the initial tracking, the input PV source is gradually loaded from the open-circuit voltage (V_{oc}) to ½ of the V_{oc}. Within this range, the FLEXmax Extreme seeks the maximum power point. The amount of time required before starting operation is dependent on the module type, ambient temperature, and the amount of sunlight directly on the PV array. Normally, the FLEXmax Extreme starts in the morning within a few minutes of the PV array being exposed to direct sunlight.

Once the controller begins maximum power point tracking, it will enter a three-stage battery charging cycle. This cycle can be observed with the controller's LED indicators. (See page 23.) If the OutBack MATE3 or another system display is available, it is possible to observe the specific charging stage, mode messages, and readings of the charge controller.

Status and Information

LED Indicators

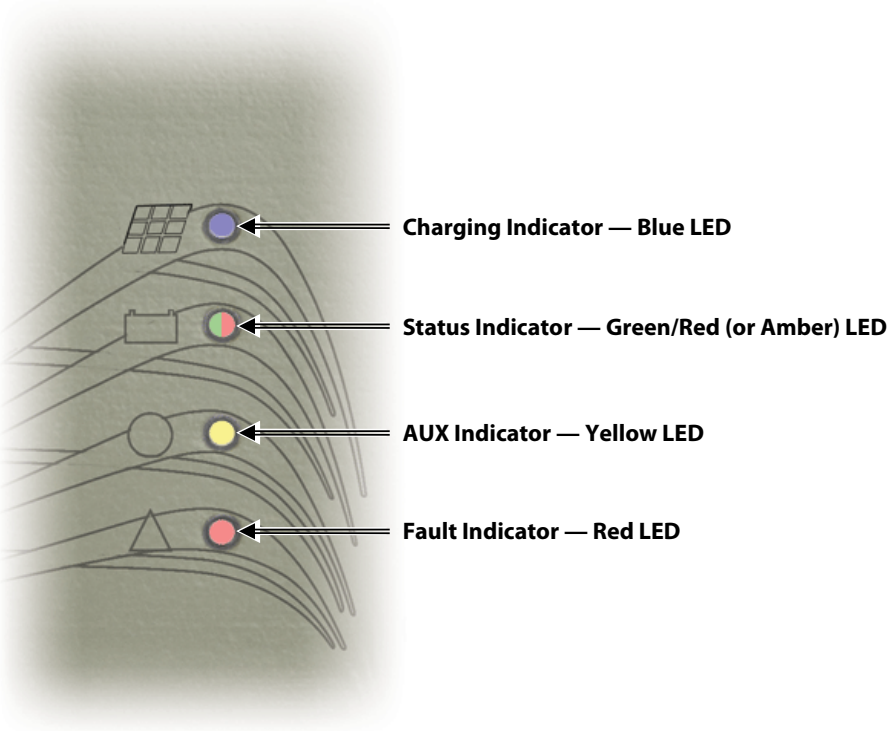


Figure 19 LED Indicators

The FLEXmax Extreme charge controller has no graphical display. It is equipped with four LED indicators that show the charge controller's condition.

- The top LED, the Charge indicator, is blue. It illuminates when more than 10 watts of PV power is available. It is solid when bulk or equalization charging. It flashes when absorption or float charging. The MATE3 system display represents these stages as operating modes in the Status menu. See page 30 for a list of modes. See page 71 for a description of charging stages.

  The Charge indicator will not turn solid if less than 10 watts of PV power is available. It will flash in constant-voltage charging regardless of how much PV power is available. Note that in some cases it may illuminate when power is available but the controller is not charging. (See Table 4 on page 28.)

  This indicator will flash while performing firmware updates to the FLEXmax Extreme (see page 46).

- The second LED down is the Status indicator. It is a tri-color LED which can be red, green, or amber. This LED is used to indicate either battery voltage or charger status. See Table 2 on page 24.

  The following patterns usually indicate particular charging stages.

  ~ The indicator turns amber (a combination of the red and green colors) if the batteries are equal or greater than 1.91 volts per cell (Vpc). This often accompanies Bulk or Absorption stage.

  ~ It turns green upon entering the Float stage. It will remain green regardless of the battery voltage until it falls below 2.08 Vpc. This will trigger a new charge cycle.

  ~ It will alternate amber/green during equalization. It can also flash amber/red. (See pages 27 and 72.)

NOTE: The Status indicator turns red if the battery voltage falls below 1.91 Vpc. The red color shows an urgent condition, indicating that the batteries are discharged. A red flash means the batteries have fallen below 1.75 Vpc, a critically low voltage. These patterns will appear regardless of the charging stage. If it appears, the Status indicator cannot show the stage, although it may still be shown by the blue Charge indicator.

IMPORTANT:

The LED indicators do not necessarily tell the amount the controller is actively charging. The Charge indicator may still indicate Absorption and the Status indicator may indicate rising battery voltage, even if another charging source is doing most of the work.

Table 2 LED Indicators

Indicator			Controller State					Voltage
Name	**Color**	**Pattern**	**Bulk**	**Absorb**	**Float**	**EQ**	**Other**	
Charge	Off	Off	N/A				< 10 W PV available	Battery rest
	Blue	Solid	X			X		
	Blue	Flash long (see page 26)		X				
	Blue	Flash short (see page 27)			X			Float
Status	Amber	Solid	X	X				≥ 1.91 Vpc
	Green	Solid			X			
	Red	Solid	X	X			Battery discharge	<1.91 Vpc
	Red	Flash	X	X			Critical battery discharge	<1.75 Vpc
	Amber/Green	Flash (see page 26)				X		≤ EQ
	Amber/Red	Flash (see page 27)				X	Critical battery discharge	<1.75 Vpc
AUX	Yellow	Solid (see page 17)	Any				AUX active	
Fault	Red	Solid	N/A				External Fault	

- The third LED, the AUX indicator, is yellow. This indicator illuminates when the AUX output becomes active.
- The fourth (bottom) LED, the Fault indicator, is red. It will turn solid if the charge controller shuts down due to an External Fault condition. See pages 19 and 20 for more information on the External Fault circuit. If the MATE3 System Display is present, it will deliver a ***Fault Input Active*** error message (see page 32).

  See Table 7 beginning on page 61 for information on resetting this error.

Modes of Operation

The FLEXmax Extreme goes through many states during its operation. Figure 20 shows an example of the various stages of battery charging and several states when the controller is not charging. (The graph in Figure 20 shows a typical day of charging with a nominal 24-volt system. Charging is described in detail on page 71.)

The MATE3 system display has five "mode" messages which represent all states of operation. The following sections use the names displayed by the MATE3. (See page 30.) These sections describe the controller operation and show the LED indicators illuminated in each mode.

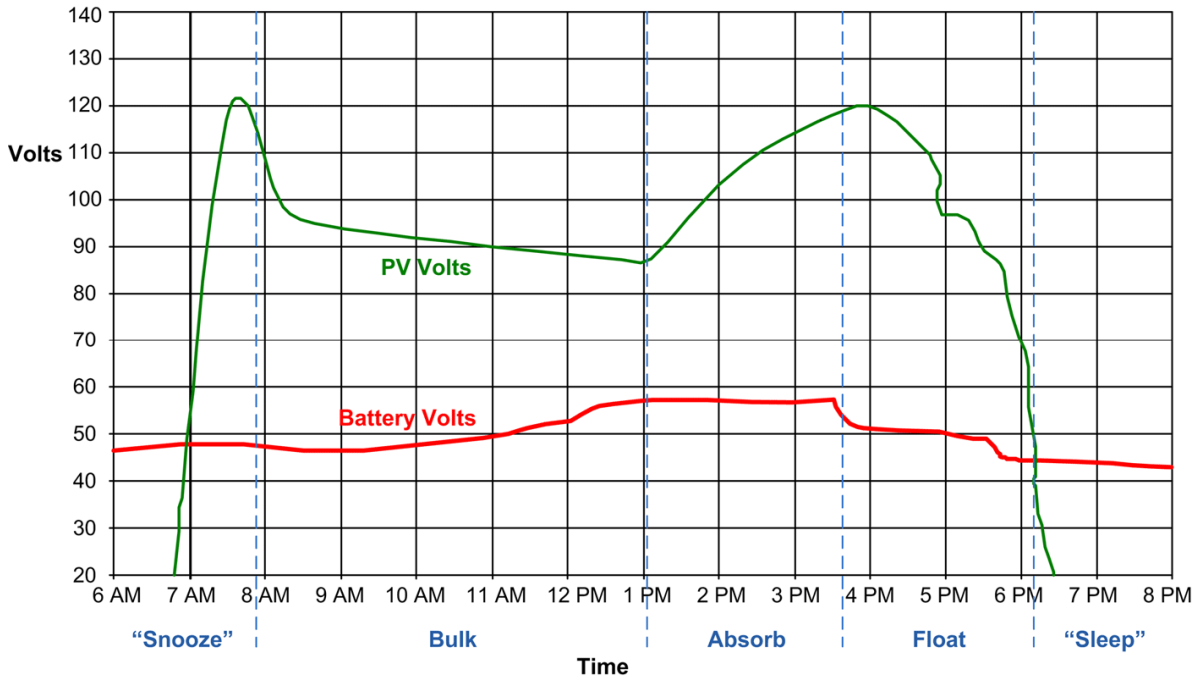
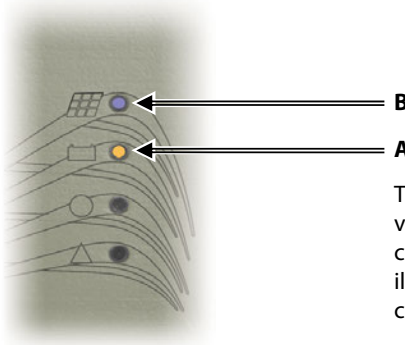


Figure 20 FLEXmax Extreme Battery Charging and Modes

Bulk

This is a Maximum Power Point Tracking mode which harvests the maximum wattage available from the PV array. The controller is trying to regulate the battery voltage towards the ***Absorb Voltage*** set point. Normally the charge controller enters this mode at the beginning of the day or when a new charge cycle begins. The controller may also enter this stage if there is not enough PV energy to maintain a different stage such as Absorption. See page 26 for more information.



Blue (solid)

Amber (solid)

The Status indicator will remain amber as long as the battery voltage remains above 1.91 volts per cell (Vpc), even if no charging is occurring. The Charging indicator, however, will not illuminate if less than 10 watts is used by the PV. This may occur if charging is performed by another source.

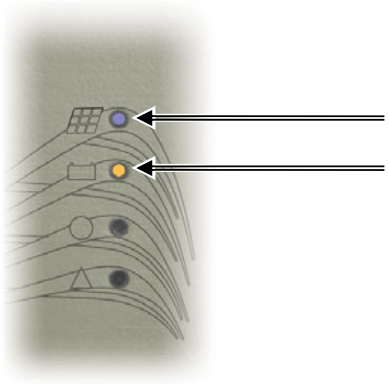
Figure 21 LED Indicators (Bulk)

Absorb

The MATE3 displays this message for the Absorption stage of a three-stage cycle. In this stage, the FLEXmax Extreme regulates the battery voltage at the ***Absorb Voltage*** set point. Absorption is a constant-voltage, variable-current charging stage. It usually involves a tapering current flow. However, it may deliver no current and still display ***Absorb*** if another source maintains the batteries above the ***Absorb Voltage*** set point.

While the batteries are held at this voltage, the internal timer counts up from zero toward the ***Absorb*** time setting. (See pages 30, 36, and 71.) The charger will exit this stage and enter the Float stage if the timer reaches the time limit, or if the ***Absorb End Amps*** setting is reached. (See page 36.)

The absorption timer is internal to the FLEXmax Extreme and is not displayed as a real-time reading. However, the ***Absorb*** reading shown on page 30 will display the total time spent in Absorption that day.



Blue (flash on 2 seconds, off ½ second)

Amber (solid)

Both indicators will remain in these states as long as the battery voltage remains above 1.91 volts per cell (Vpc), even if no charging is occurring. This may occur if charging is performed by another source.

Figure 22 LED Indicators (Absorb)

If the battery voltage drops below the ***Absorb Voltage*** set point (see page 36), the FLEXmax Extreme reverts back to the Bulk charge stage. The MATE3 displays ***Bulk*** as shown on page 25.

The internal timer may not always begin at zero if the last charge was interrupted or ended early. If the batteries drop below the voltages noted on Table 3, the timer will begin counting down toward zero. This adds to the duration of the next Absorption stage. If the timer reaches zero, it will last for the full duration of the ***Absorb*** time setting (see page 36).

Lower voltages will cause the timer to subtract minutes at a faster rate, as shown on Table 3. These voltages indicate a significantly greater battery discharge, requiring a much longer charge cycle.

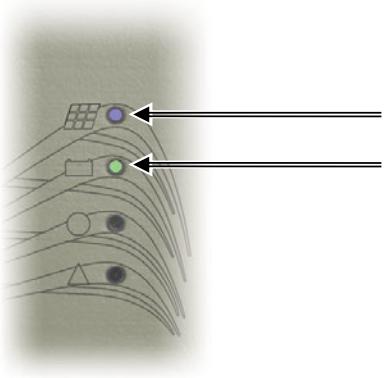
Table 3 Absorption Timer

Battery Voltage	Timer Activity
≥ 12.4 V, 24.8 V, 37.2 V, 49.6 V, or 62.0 V, *and less than the Absorbing voltage*	No change.
<12.4 V, 24.8 V, 37.2 V, 49.6 V, or 62.0 V	For every minute elapsed, 1 minute is subtracted from the timer
<12.0 V, 24.0 V, 36.0 V, 48.0 V, or 60.0 V	For every minute elapsed, 2 minutes is subtracted from the timer
< 11.6 V, 23.2 V, 34.8 V, 46.6 V, or 58.0 V	For every minute elapsed, 4 minutes is subtracted from the timer.

Floating

The MATE3 displays this message for the Float stage of a three-stage charging cycle. In this stage, the FLEXmax Extreme regulates the battery voltage at the ***Float Voltage*** set point. This stage is temperature-compensated. (See page 72.) Float is a constant-voltage, variable-current charging stage. It usually involves a minimal (maintenance) current flow. However, it may deliver no current and still display ***Float*** if another source maintains the batteries above the ***Float Voltage***.

If the battery voltage drops below the ***Float Voltage***, the FLEXmax Extreme will employ the MPPT function to draw more power from the PV array. (This may occur if the batteries are powering loads.) If this occurs, the operation may change to constant-current, variable-voltage. The mode will still show ***Float***.



Blue (flash on ½ second, off 2 seconds)

Green (solid)

This indicator will remain green if the voltage rises or drops, unless it decreases below 2.08 Vpc. This will trigger a new charge cycle.

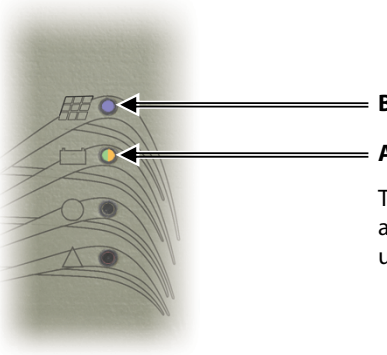
Figure 23 LED Indicators (Float)

EQ

The MATE3 displays this message if the charger is in a cycle of equalization. (See page 72 for an explanation of equalization.)

Before equalizing, battery loads should be turned off and the battery should be charged so the charge controller can quickly reach the ***Equalization Voltage*** set point. (See page 38.) Otherwise, the charge controller may have difficulty reaching or maintaining the equalization process.

Equalization is not battery temperature compensated.



Blue (solid)

Amber/green (alternating once per second)

This indicator will alternate amber and red if the batteries are below 1.75 volts per cell (Vpc) while equalizing. This is usually a temporary condition.

Figure 24 LED Indicators (Equalization)

Silent

The MATE3 displays the operating mode as ***Silent*** if the charge controller has stopped charging. This message represents a variety of conditions, many of which are common. For example, ***Silent*** is shown at night or any period of insufficient light. Table 4 lists the indicators and the PV open-circuit voltage which show specific Silent conditions. In these cases, no indicators will be illuminated.

However, ***Silent*** may also appear in the event of an error shutdown. If the mode is ***Silent*** and the red Fault indicator is illuminated, an External Fault may have occurred. See pages 19, 20, and 61.

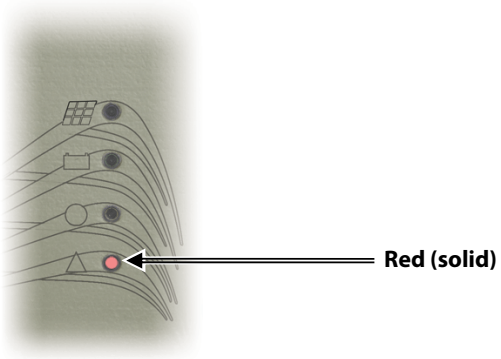


Figure 25 LED Indicators (Fault)

Table 4 Reasons for Silent Mode

Charge LED	Status LED	Fault LED	V_{oc}	Other
No	No	No	Below battery	No PV energy or "Sleep" mode. If the V_{oc} is less than battery voltage, the controller is "sleeping". This is normal at night. The threshold for Sleep mode is settable. See page 37.
			Above battery	Low light or "Snooze" mode. V_{oc} is greater than battery voltage but not enough array current is available for charging. This is normal in the morning, evening, or in heavy clouds (low light). The threshold for Snooze mode is settable. See page 37.
Intermittent	Any	No	Above battery	"Wakeup" mode. The controller has detected more than the required 10 watts, but has not yet begun charging. This condition only lasts a short time. The blue Charge indicator may turn on and off briefly while the controller is performing initial power tracking. This can also occur if PV conditions change and the controller has to calculate a new power point. If continuous, this behavior may also indicate an "unloaded output" condition where the batteries have been disconnected from the charge controller.

MATE3 System Display and Controller

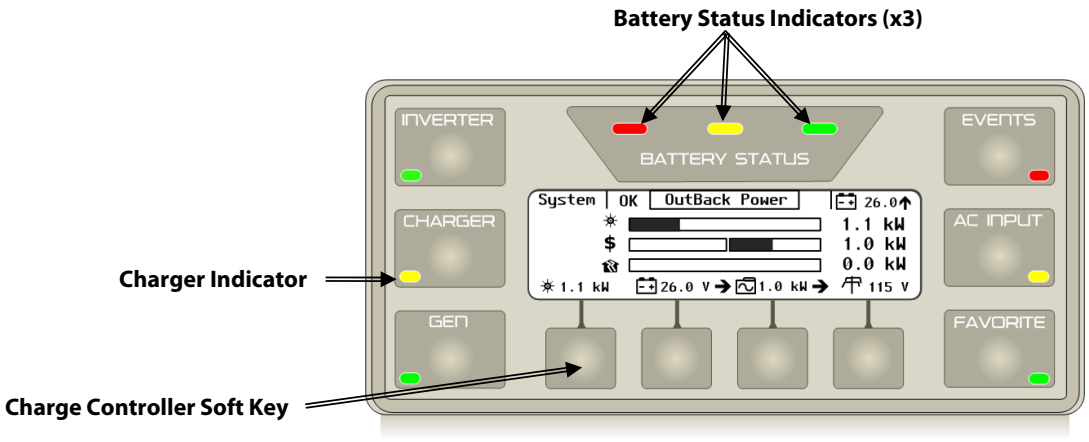


Figure 26 Display and LED Status Indicators

The MATE3 System Display and Controller is a display which allows the user to read the operating mode, measurements, and any status messages from the FLEXmax Extreme charge controller. It can also change the charge controller's settings when the default settings are not enough.

Battery Status Indicators

Three LED indicators provide a visual reference to indicate the condition of the battery bank.

- A GREEN LED means the batteries have an adequate charge at that time. It does not always mean they are full. If the FLEXnet DC battery monitor is installed, this means the batteries are ≥ **80%** State of Charge (SOC).
- A YELLOW LED means the batteries are somewhat discharged. If the FLEXnet DC is installed, this means the batteries are ≥ **60%** and ≤ **70%**.
- A RED LED means the batteries are greatly discharged and may require attention. If the FLEXnet DC is installed, this means the batteries are **< 60%**.

Table 5 Battery Status LED Indicators

Color	12 Vdc Unit	24 Vdc Unit, ± 0.2 Vdc	36 Vdc Unit, ± 0.3 Vdc	48 Vdc Unit, ± 0.4 Vdc	Battery Status
GREEN	12.5 Vdc or higher	25.0 Vdc or higher	37.5 Vdc or higher	50.0 Vdc or higher	ACCEPTABLE
YELLOW	11.5 to 12.4 Vdc	23.0 to 24.8 Vdc	34.5 to 37.2 Vdc	46.0 to 49.6 Vdc	MARGINAL
RED	11.4 Vdc or lower	22.8 Vdc or lower	34.2 Vdc or lower	45.6 Vdc or lower	LOW

NOTES:

- Gaps in the table (higher-voltage units) are due to the resolution of the charge controller's DC meter.
- The Battery LED settings cannot be changed.
- Voltages higher than shown in the GREEN row usually means that the batteries are charging.

Charger Indicator

The MATE3 is equipped with several LED indicators denoting status. The Charger indicator (see Figure 26) will illuminate if the charge controller is delivering more than a minimal amount of charging power to the batteries. It will flash if the charge controller is equalizing the batteries.

NOTE: The Charger indicator will illuminate for any device on the HUB Communications Manager that is charging, including OutBack inverters. If a FLEXmax Extreme charge controller is accompanied by other devices, this indicator may indicate charging by any device, not just that controller.

Charge Controller Soft Key

The MATE3 is equipped with a series of "soft" keys with varying functions. From the Home screen, the far left key is designated as the Charge Controller soft key any time a charge controller is connected. Pressing it will enter the Status menu for the charge controller. (See page 30.)

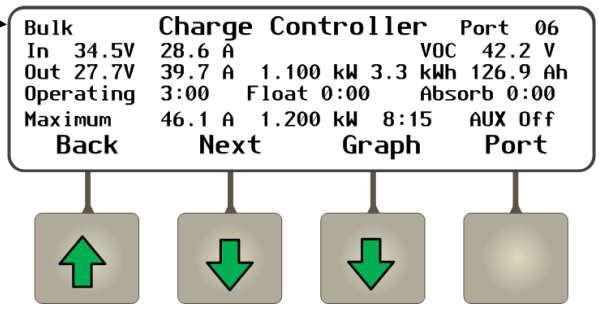
Status Screen

Modes of Operation:

- ***Bulk***
- ***Absorb***
- ***Float***
- ***EQ***
- ***Silent***

See page 25 for a description of modes.

See page 71 for a description of battery charging.



Soft Keys:

<Next> brings up a series of screens with current statistics, totals, and other data. The internal temperatures and any fault messages are also displayed here. These screens are all shown beginning on page 31.

<Graph> brings up a series of screens that plot various charge controller information over time. The graphs include inverter and charger wattage, power imported from an AC source, battery voltage, and others. These screens are all shown beginning on page 34.

<Port> cycles through each device connected to the network. If more than one charge controller is installed in the system, pressing the **<Port>** soft key will cycle through each controller.

<Back> returns to the previous screen.

Screen Items:

The upper left corner of the screen shows the FLEXmax charge controller's current mode of operation. ***Bulk*** is shown in this illustration.

In displays the present PV array operating voltage and the current being harvested from the array.

VOC displays the open-circuit voltage available from the PV.

Out displays the present battery voltage and the current being delivered from the charge controller(s) to charge the battery bank. To the right, this line displays the number of kilowatt-hours and amp-hours accumulated that day.

Operating displays the total hours the charger has operated that day in any stage.

Float displays the amount of time the controller has been in the Float stage.

Absorb displays the amount of time the controller has been in the Absorbing stage. The maximum duration is the Absorb time setting. (See pages 26, 36, and 71.)

Maximum displays the maximum amperage and wattage harvested from the PV array that day, and the time both were recorded.

The lower right corner shows the current status of the charge controller's Auxiliary (AUX) output. (See page 39.)

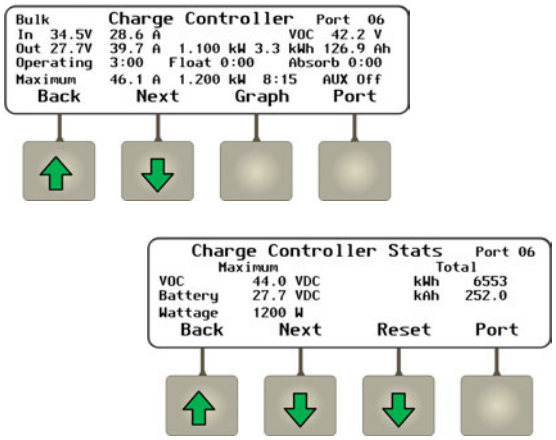
Figure 27 Charge Controller Soft Key Screens

NOTE: If the FLEXmax Extreme shuts down due to a fault condition, the MATE3 status messages do not indicate the cause. The MATE3 will display the status as ***Silent***. However, the ***Error*** screen (see page 32) will show the cause if it is one of the defined errors on that screen. The MATE3 will show an Event in the appropriate menu. (See the MATE3 manual for more information.).

See page 61 for additional information on troubleshooting ***Error*** conditions and faults.

Stats Screen

From the ***Charge Controller*** screen, the **<Next>** soft key proceeds to the ***Charge Controller Stats*** screen. This screen shows data which has been accumulated since the system went online, or since the last reset.



Soft Keys:

<Next> proceeds to the ***Error***, ***Datalog***, and ***Temps*** screens (see pages 32 and 33).

<Reset> proceeds to the ***Reset*** screens for the items under ***Maximum*** and ***Total***. (See Figure 29.)

<Back> returns to the previous screen.

<Port> cycles through each device connected to the network.

Screen Items:

The items under ***Maximum*** are not incremental. They are updated only if a higher value is measured.

VOC displays the highest measured V_{oc} value. (See the ***VOC*** reading on page 30 for the current V_{oc}.)

Battery displays the highest measured battery voltage. (See the ***Out*** reading on page 30 for the current battery voltage.)

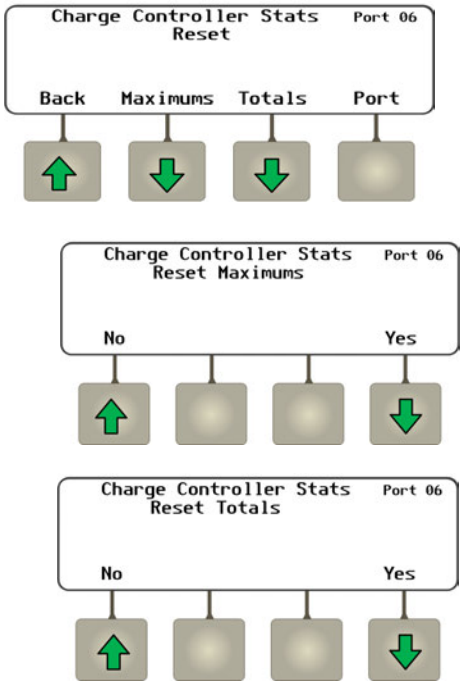
Wattage displays the highest measured wattage harvested from the PV. (See the ***Out*** reading on page 30 for the current wattage. See the ***Maximum*** reading for the highest wattage that day.)

The items under ***Total*** are incremental. These items are updated daily with higher totals.

kWh displays a historical accumulation of the kilowatt-hours harvested by the controller. (See the ***Out*** reading on page 30 for the daily accumulation.)

kAh displays a historical accumulation of the kiloamp-hours used to charge the batteries. (See the ***Out*** reading on page 30 for the daily accumulation.)

Figure 28 Stats Screen



Screen Items:

The ***Reset*** screens allow the items in the ***Stats*** screen to be reset to zero. The ***Yes*** soft key is used for resetting. The items under ***Maximum*** and ***Total*** can be reset independently. Until then, they will continue to register higher numbers or greater accumulations.

Soft Keys:

<Maximums> proceeds to the ***Reset*** screen for the ***Maximum*** statistics (see Figure 28).

<Totals> proceeds to the ***Reset*** screen for the ***Total***.statistics (see Figure 28.)

<Back> returns to the previous screen.

<Port> cycles through each device connected to the network.

<No> returns to the previous screen without resetting.

<Yes> proceeds to a confirmation screen after resetting the item (see example to the right). **<Continue>** returns to the ***Charge Controller Stats*** screen.

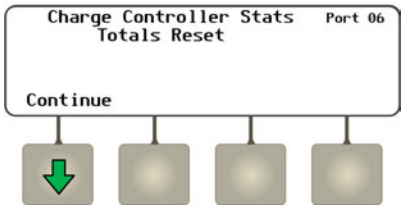
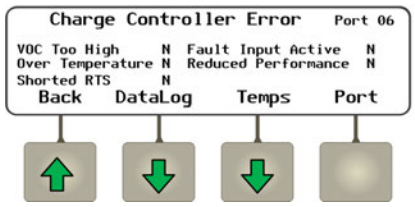


Figure 29 Stats Reset Screens

Error Screen

From the ***Charge Controller Stats*** screen, the **<Next>** soft key proceeds to the ***Charge Controller Error*** screen. This screen displays fault conditions for the FLEXmax Extreme. If an item displays ***Y***, the error is active. Some errors accompany a controller shutdown; others simply report status.



Soft Keys:

<DataLog> proceeds to the ***Datalog*** screen (see page 33).

<Temps> proceeds to the ***Temps*** screen (see Figure 31.)

<Back> returns to the previous screen.

<Port> cycles through each device connected to the network.

Screen Items:

VOC Too High The PV array V_{oc} has exceeded 145 Vdc and has shut down. This error can clear automatically. (See the Troubleshooting guide on page 61.)

Over Temperature The FLEXmax Extreme is too hot to operate and has shut down. This error can clear automatically. (See the Troubleshooting guide on page 61. Also see the temperature readings in Figure 31.)

Shorted RTS The Remote Temperature Sensor (RTS) has malfunctioned. This error will not shut down the controller, but the controller cannot compensate for temperature while the error is present. (See the Troubleshooting guide on page 61.)

Fault Input Active The External Fault terminals have detected an open circuit. The controller has shut down. This is the only error in this menu that illuminates the Fault indicator (see page 24).

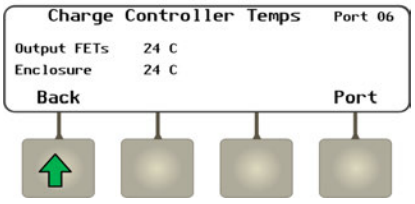
This error requires a manual reset. See pages 18 and 19. This error can also occur from an "Overcurrent" condition. (See the Troubleshooting guide on page 61.)

Reduced Performance One of the two internal temperature sensors (see below) has failed. If a failure is detected, the FLEXmax Extreme will operate with a maximum output current of 20 Adc.

Figure 30 Error Screen

Temps Screen

From the ***Charge Controller Error*** screen, the **<Next>** soft key proceeds to the ***Charge Controller Temps*** screen. This screen shows internal temperatures as measured at several locations in the controller. These measurements are used for fan control, temperature derating, or to trigger a shutdown in extremely hot temperatures. If any of these events occur, this screen can be used to check the temperatures.



Soft Keys:

<Back> returns to the previous screen.

<Port> cycles through each device connected to the network.

Screen Items:

Output FETs The internal temperature as measured on the controllers's Field Effect Transistor (FET) heatsink.

Enclosure The internal temperature as measured on the controller's housing.

The list below shows the readings at which the FLEXmax Extreme performs certain functions. See pages 10, 61, and 65.

Event	Output FETs	Enclosure
Over Temp error	130	78
Output derates	86	73
Fan turns on	76	72
Fan turns off	61	67

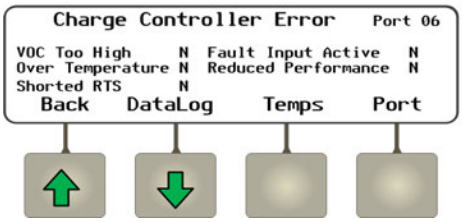
Figure 31 Temps Screen

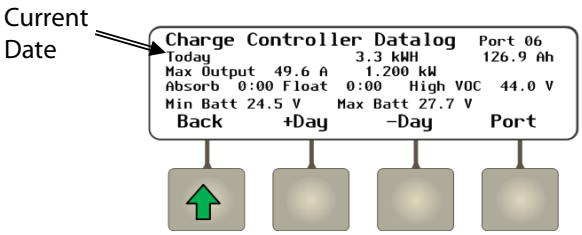
DataLog Screen

From the ***Charge Controller Error*** screen, the **<DataLog>** soft key proceeds to the ***Charge Controller Datalog*** screen. This screen shows accumulated daily amp-hour and watt-hour statistics, as well as maximum current, wattage, and maximum and minimum voltage figures. These maintain a continuous daily log, up to 128 days, which can be recalled. One day can be displayed at a time.

IMPORTANT:

If two or more charge controllers are used in the same system and are started or cleared on different days, their numeric dates will not be the same. This can lead to some misunderstandings when looking back and comparing data between the two or more units. A user looking back at day 12 on both units would find very different results.





Soft Keys:

<+Day> advances the display forward by a single day. If the display reads "Today", it does nothing.

<–Day> advances the display backward by a single day and will display the selected date.

<Back> returns to the previous screen.

<Port> cycles through each device connected to the network.

Screen Items:

The upper left corner shows the date of the selected ***Datalog*** screen. (The current ***Datalog*** screen reads "Today.") To the right, this line also displays the kilowatt-hours and amp-hours accumulated that day.

Max Output displays the maximum current and wattage recorded that day. (See the ***Maximum*** reading on page 30.)

Absorb The amount of time the Absorbing timer ran that day. (See the ***Absorb*** timer on page 30.)

Float The amount of time the Float timer ran that day. (See the ***Float*** timer on page 30.)

High VOC displays the highest open-circuit voltage (V_{oc}) recorded that day.

Min Batt displays the lowest battery voltage recorded that day.

Max Batt displays the highest battery voltage recorded that day.

Figure 32 DataLog Screen

Graph Screens

The **<Graph>** soft key brings up the following screens which plot various types of data over time. The first screen shows changes in PV wattage over time.

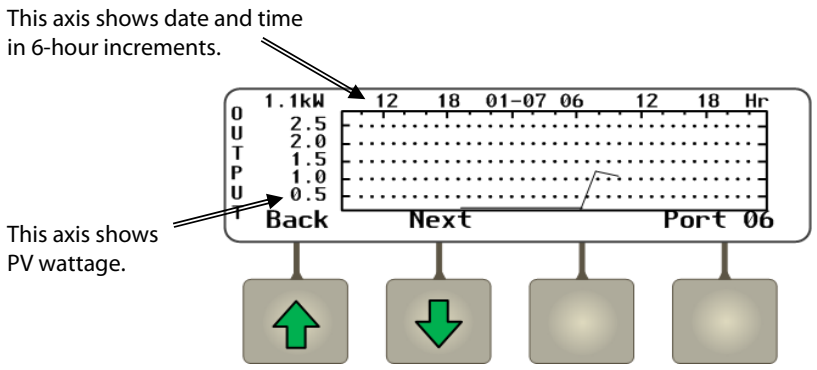


Figure 33 Output Graph

The **<Next>** soft key brings up a screen showing changes in battery voltage over time.

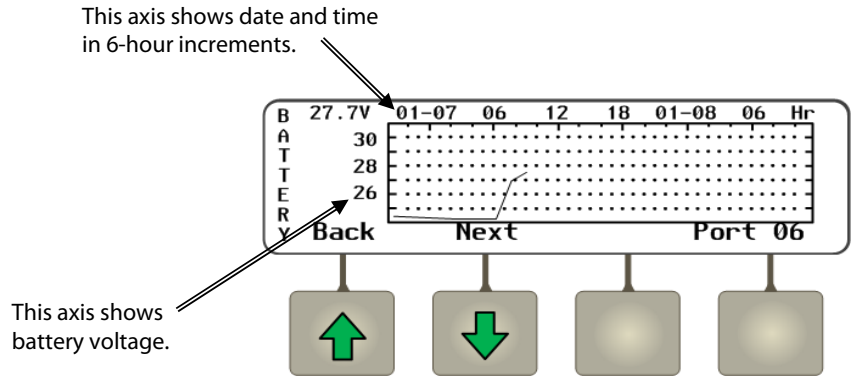


Figure 34 Battery Graph

The **<Next>** soft key brings up a screen showing changes in PV voltage over time.

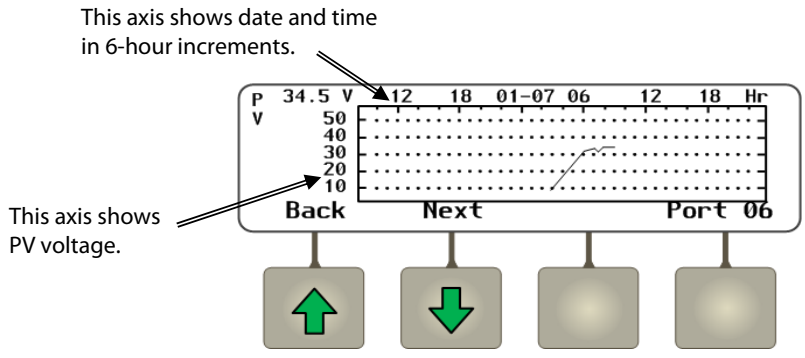


Figure 35 PV Graph

Continuing to press the **<Next>** soft key will proceed through the same graphs again from the beginning.

Programming the FLEXmax Extreme

Menu Structure in the MATE3

Figure 36 shows the MATE3 menu structure for adjusting the charge controller settings.

The ***Main Menu*** shown below is accessed with the LOCK button and a password. Use the MATE3's control wheel to move up and down between menus (or options within a menu). Use the center button on the control wheel to make a selection. (See the MATE3 manual for more information.)

Some menus may not be accessible if the user access levels are restricted.

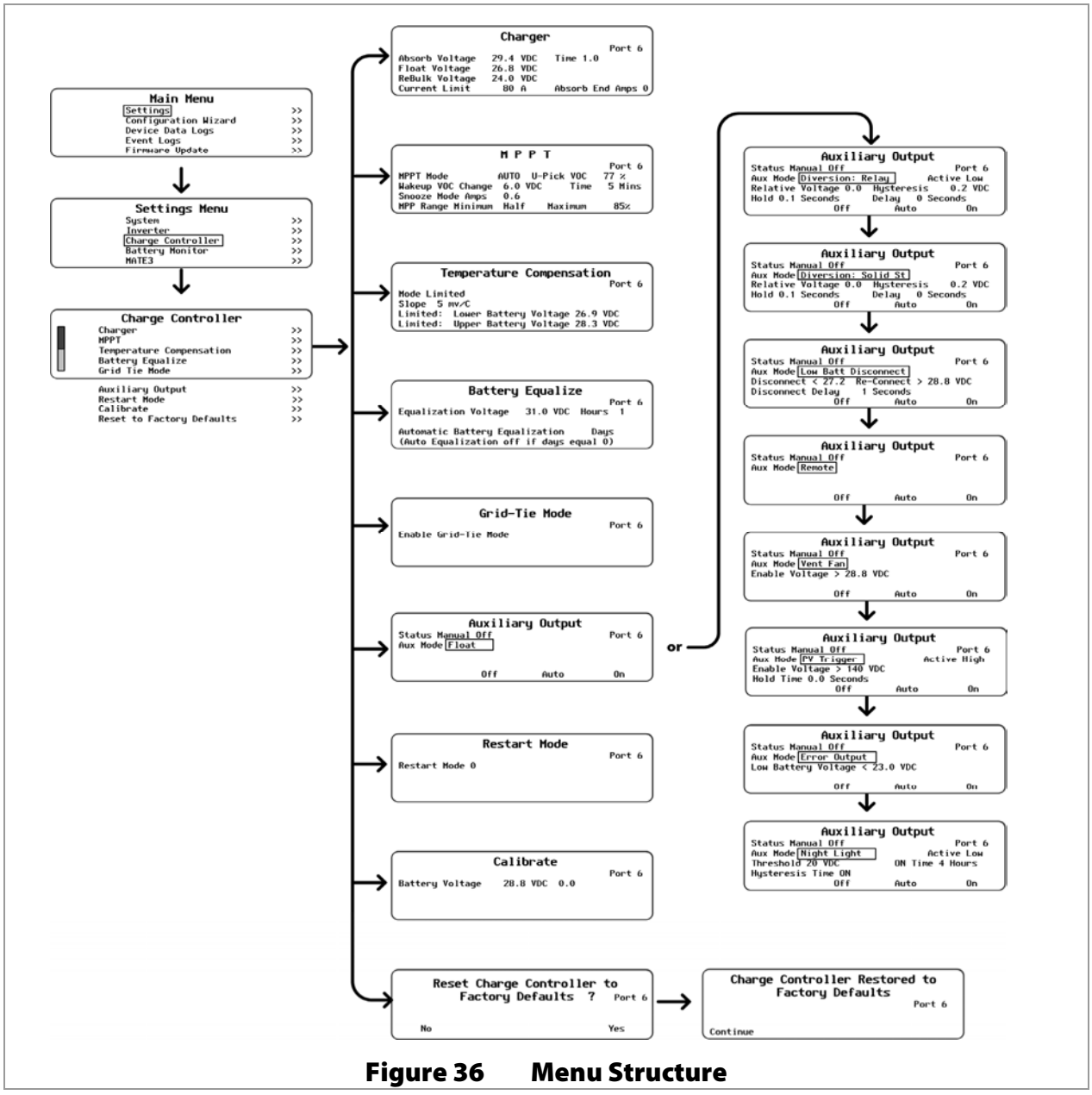


Figure 36 Menu Structure

Charge Controller Settings

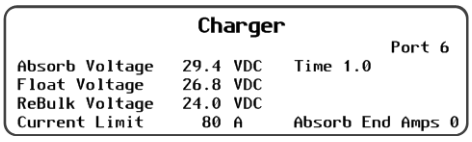
Charge Controller menu options include the following:

Charger

IMPORTANT:

- Battery charger settings need to be correct for a given battery type. Always follow battery manufacturer recommendations. Making incorrect settings, or leaving them at factory default settings, may cause the batteries to be undercharged or overcharged.
- An appropriate circuit breaker, or overcurrent device, must be used between the battery and the charge controller.
- If a battery remote temperature sensor (RTS) is used, set the ***Absorb*** and ***Float*** setting voltage based on a 25°C/77°F setting.

The charge controller uses a "three-stage" battery charging cycle which utilizes multiple settings. This menu controls the voltages and timers for the battery charger. See page 71 for an explanation of the three-stage cycle and a description of individual stages. See page 25 to see what indicators and messages appear at each stage.



Set Points:

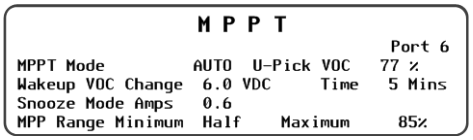
- ***Absorb Voltage*** – Target voltage for bulk stage. Utilizes constant-current charging.
- ***(Absorb) Time*** – Amount of time held at Absorb voltage. Utilizes constant-voltage charging.
- ***Float Voltage*** – Final stage after completion of charge. Utilizes constant-voltage charging.
- ***Rebulk Voltage*** – Low voltage trigger for new charge.
- ***Current Limit*** – Maximum DC amps from that controller.
- ***Absorb End Amps*** – Low current that indicates completed charging. It triggers Float stage regardless of Absorb time.

Figure 37 Charger

- ***Absorb Time*** is adjustable from 0 to 24 hours (consult the battery manufacturer's recommendations).
- When the ***Absorb Time*** is reached, the charge controller goes into Float stage and the MATE3 will display ***Float***. When the battery voltage drops below the ***Float Voltage*** set point, the charge controller will return to MPP operation to draw more PV energy to maintain this set point.

MPPT

The charge controller uses a maximum power point tracking (MPPT) algorithm which manipulates the output of the PV array to harvest maximum wattage. Although this function is automatic, this menu allows the user to adjust many of its parameters for special applications. See page 73.



Set Points:

- ***MPPT Mode* –** Selects between ***Auto*** (which allows automatic MPPT) and ***U-Pick*** (which limits the maximum power point tracking to a specified voltage).
- ***U-Pick VOC%* –** The percentage of the open-circuit voltage (V_{oc}) used as the MPP tracking limit in ***U-Pick*** mode.
- ***Wakeup VOC Change VDC* –** The change in V_{oc} which will bring the controller out of "Sleep" or "Snooze" operation regardless of ***Change Time***. The controller will enter MPPT. (The change in V_{oc} means that power may be available).
- ***(*Wakeup VOC) *Change Time* –** The timer setting to leave "Sleep" or "Snooze" operation regardless of ***Change VDC***. The controller will enter MPPT. (It may re-enter "Snooze" and restart the timer if no power is available).
- ***Snooze Mode Amps* –** The output current limit below which the controller enters "Snooze" due to inactivity.
- ***MPP Range Minimum* –** Adjusts the lower limit of the controller's tracking algorithm. This can narrow the focus of the initial tracking process.
- ***MPP Range Maximum* –** Sets the upper limit of the tracking algorithm as a percentage of the V_{oc}.

Figure 38 MPPT

The ***MPPT Modes*** perform the following functions:

- ***Auto Track*** (default) automatically measures the PV upon wakeup and then tracks the array MPP. If ***Restart Mode*** is set to 1 or 2, the controller awakens every 1.5 hours and does an initial tracking. (See page 70.)
- ***U-Pick*** allows the user to manually adjust the MPP tracking limit as a percentage of the array's open-circuit voltage (V_{oc}). ***U-Pick %*** acquires a new V_{oc} value every 1.5 hours if ***Auto Restart*** is set to 1 or 2.

The ***Wakeup*** settings adjust the V_{oc} conditions that cause the charge controller to wake up during "Sleep" or "Snooze" operation. (See Table 3 on page 26.) Both settings may help adjust for varying conditions. Since environmental conditions impact the open-circuit voltage of an array, the ***Wakeup VOC Change VDC*** can be based on the last measured V_{oc} value.

Before changing these values, monitor the system for a week or so using the factory defaults and then gradually adjust the set points. If the set points are set too high, the charge controller might not wake up soon enough or often enough, which means a loss of power production.

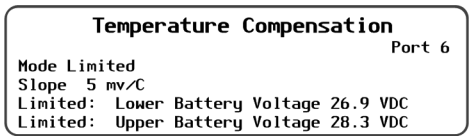
The ***Mpp Range*** settings adjust the upper range limit of the charge controller's maximum power point (MPP) tracking.

- The default ***Max*** MPP voltage limit is set at 90% of the V_{oc} and should not normally be adjusted for a PV array. If necessary, the adjustable limits are 80%, 85%, 90%, and 99% of the V_{oc}.
- ***Min*** optimizes the tracking window for MPPT. The default setting of ***Half*** establishes the lower limit of this window as one-half the V_{oc}.

The ***Min*** range limit setting may be set to ***FULL*** if something other than a PV array is connected to the input of the charge controller, such as a hydroelectric turbine (see page 73). However, the input voltage must never exceed 150 Vdc at any time.

Temperature Compensation

The ***Temperature Compensation*** screen allows the user to control the Absorbing and Float voltage limits during charging when using a Remote Temperature Sensor (RTS). The RTS adjusts charging voltage depending on battery temperature. See page 72 for an explanation of compensation.



Set Points:

- ***Mode –*** Selects between ***Limited*** (which uses the upper and lower voltage settings below) and ***Wide*** (which uses the entire range of compensation).
- ***Slope –*** The amount of temperature compensation. This is measured in millivolts per degree C per battery cell.
- ***Limited: Lower Battery Voltage –*** The lowest range for temperature compensation in ***Limited*** mode.
- ***Limited: Upper Battery Voltage –*** The highest range for temperature compensation in ***Limited*** mode.

Figure 39 Temperature Compensation

NOTE: If the ***Slope*** setting is adjusted to any specialized value other than 5 mV, the MATE3 will communicate this value to other networked OutBack devices. The other devices will use the same value. This system-wide compensation only works if there is a single RTS on the system and it is connected to the FLEXmax Extreme.

In all cases, the batteries should be monitored to ensure they are being charged according to the battery manufacturer's recommendations.

Battery Equalize

CAUTION: Battery Damage

- Do not equalize any sealed battery types (VRLA, AGM, Gel, or other) unless approved by the manufacturer. Some batteries may suffer severe damage from equalization.
- Contact the battery manufacturer for recommendations on equalization voltage, duration, schedule, and/or advisability. Always follow manufacturer recommendations for equalization.

Equalization is a controlled overcharge that is part of regular battery maintenance. See page 72 for an explanation of equalization. The ***Battery Equalize*** screen allows the user to control the settings for the equalization process.

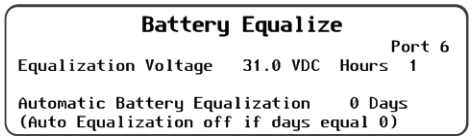


Figure 40

Set Points:

- ***Equalization Voltage –*** Target voltage for equalization.
- **(Equalization) *Hours –*** Amount of time held at Equalization voltage.
- ***Automatic Battery Equalization –*** The number of days between equalization cycles.

Equalization can be triggered manually. (See pages 27 and 72.) Equalization can also be triggered automatically on a schedule. The ***Days*** setting controls this schedule, setting a delay of the appropriate number of days between the end of one cycle and the beginning of the next. If this item is set to zero, the controller will not perform automatic equalization.

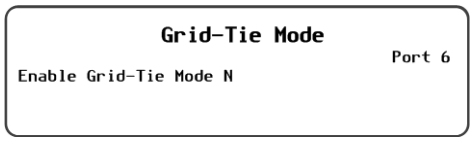
Grid-Tie Mode

IMPORTANT:

- This mode requires a grid-interactive inverter model (also known as grid-tie enabled). Not all inverters are grid-interactive. Also, the inverter's SELL mode must be enabled. If the system is connected to an inverter that is not grid-interactive or not enabled, ***Grid-Tie*** mode will not function.
- This mode also requires both the inverter and the charge controller to be connected to the HUB for communication. If an OutBack grid-interactive inverter is present but both devices are not on the HUB, ***Grid-Tie*** mode will not function.

Grid-Tie mode allows the FLEXmax Extreme to work more effectively with any grid-interactive inverter installed on the HUB. This setting automatically raises the charge controller's Float voltage to equal its Absorption voltage. Since the inverter sells power to maintain its own Float, Absorption, or Sell settings (all of which should be lower than those of the controller), this mode makes it easier for the inverter to sell power.

See page 65 for more information on this mode.



Set Points:

- Two options are available in this menu; ***N*** and ***Y***:
  - ***N*** (No) disables Grid-Tie Mode;
  - ***Y*** (Yes) enables Grid-Tie Mode

Figure 41 Grid-Tie Mode

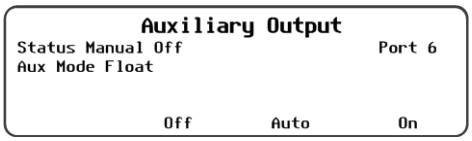
Auxiliary Output

The AUX (Auxiliary) is a secondary control circuit — essentially, a small power supply that provides a 12 Vdc output current (up to 250 milliamps or 3 watts) to an isolated load. It can be ***ON*** with 12 Vdc available at the output, or ***OFF*** with 0 Vdc at the output. It can also be set to ***AUTO.*** In this setting, the AUX output turns on or off according to specific criteria such as high or low voltage. In some cases, such as the ***PV Trigger***, ***Night Light***, or ***Diversion: Relay*** applications, the polarity of the output can be reversed so that the behavior is reversed.

The AUX output can control devices such as cooling fans, vent fans, load diversion, fault alarms, and automatic generator control. See page 17 for examples of applications.

- Only one ***AUX MODE*** can be selected or operate at a time (even if other modes have criteria preset).
- See Figure 43, page 44, for an auxiliary setup wiring diagram example.

NOTE: ***Diversion: Relay*** and ***Diversion: Solid St*** can be used for AC coupling applications.



Set Points:

- ***Status*** – The ***Auxiliary Output*** status is controlled by the **<Off>**, **<Auto>**, and **<On>** soft keys.
- ***Aux Mode*** –Selects one of nine options: ***Vent Fan***, ***PV Trigger***, ***Error Output***, ***Night Light***, ***Float***, ***Diversion:Relay***, ***Diversion:Solid St***, ***Low Battery Disconnect***, and ***Remote***.

Figure 42 Auxiliary Output

Auxiliary Mode Screens

The nine options appear in the following order when the wheel is drawn clockwise. The ***Vent Fan*** option appears first if the charge controller is set at factory default values; otherwise, it will tend to display the last option selected.

Table 6 AUX Mode Functions

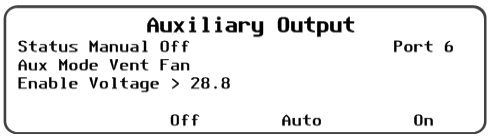
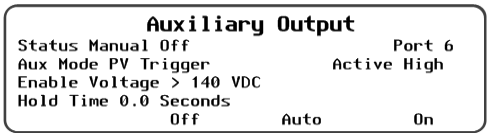
Mode Name	Function/Purpose	Set Points	Aux Polarity
Vent Fan	 **Function:** When the ***Enable Voltage*** set point is exceeded, the AUX output will activate for at least 15 seconds. If the set point continues to be exceeded, the output will remain active until the voltage falls below the set point. Once the voltage decreases below the set point, the AUX output will remain active for another 15 seconds. It will then deactivate. **Purpose:** This mode is intended to operate a vent fan to ventilate hydrogen gas from a battery enclosure.	➢ ***Enable Voltage***	Not Available
PV Trigger	 **Function:** When the ***Enable Voltage*** set point is exceeded, the AUX output will activate. Once the voltage decreases below the set point, the output will remain active for the duration of the ***Hold Time*** set by the user. **Purpose:** This mode operates an alarm or a PV cutoff relay when PV voltage exceeds a safe value.	➢ ***Enable Voltage*** ➢ ***Hold Time***	***Active High***: Activates the output when the voltage exceeds the set point. ***Active Low***: Activates the output when the voltage drops below the set point; deactivates the output when the voltage exceeds the set point.
		CAUTION: Hazard to Equipment Do not exceed 150 Vdc or the FLEXmax Extreme could be damaged.	

Table 6 AUX Mode Functions

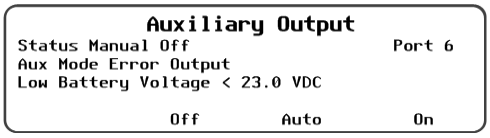
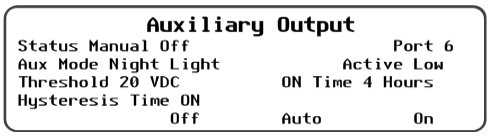
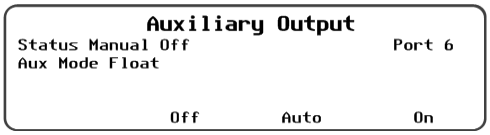
Mode Name	Function/Purpose	Set Points	Aux Polarity
Error Output	 **Function:** This mode responds to two emergency conditions: low battery or failure to charge. Low battery is defined by the ***Low Battery Voltage*** set point. Failure to charge means the PV has not exceeded the battery voltage by 3 Vdc or more for 26 consecutive hours. Either case may mean an array problem. This mode is *Active Low* only. The AUX output is normally active. When either condition is met, the AUX output will deactivate. **Purpose:** This mode is useful for monitoring remote sites. It indicates when the controller has not charged the batteries for 26 hours or more or if the voltage remains too low for other reasons. Deactivation is intended to operate a remote alarm. It can send a signal through a modem to alert a computer of the problem.	➢ ***Low Battery Voltage***	*Active Low* only. Deactivates the output when the voltage drops below the set point for a set amount of time.
Night Light	 **Function:** When the battery voltage drops below the ***Threshold*** voltage set point for the ***Hysteresis Time***, the AUX output changes states and remains in that state for the ***ON Time*** setting. **Purpose:** This mode is intended to illuminate a user-provided, low wattage light for as long as the charge controller remains in ***Sleep*** mode or for the ON time set by the user.	➢ ***Threshold*** voltage ➢ ***ON Time*** ➢ ***Hysteresis Time***	***Active High****:* Activates for a set amount of time when the voltage drops below the set point for a set amount of time. ***Active Low:*** Activates for a set amount of time when the voltage exceeds the set point for a set amount of time. Deactivates when the voltage drops below the set point.
Float	 **Function:** When the FLEXmax Extreme is in the Float stage, the output activates. **Purpose:** This mode is intended to operate a device such as a "battery full" indicator when the FLEXmax Extreme is in the Float stage of battery charging.	None	Not Available

Table 6 AUX Mode Functions

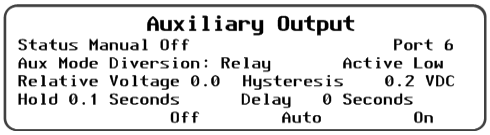
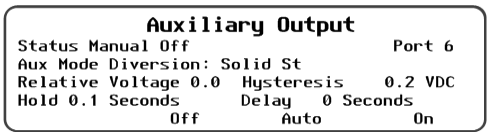
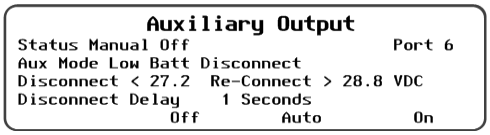
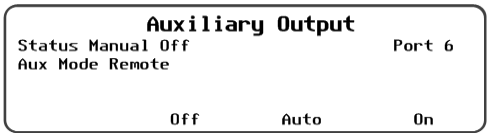
Mode Name	Function/Purpose	Set Points	Aux Polarity
Diversion: Relay	 **Function:** When the battery voltage increases, the AUX output changes state. The response is relative to the charger's present stage of operation. The voltage must exceed the charger setting (Absorb, Float, or EQ) by the value of the ***Relative*** voltage. This condition must last for the ***Delay*** time for the AUX to respond. The AUX returns to its previous state when the voltage drops below the ***Relative*** setting by an amount equal to the ***Hysteresis*** voltage. This condition must last for the ***Hold*** time for the AUX to respond. For a wiring diagram illustrating how to connect this function, see Figure 43 on page 44. **Purpose:** This mode is intended to divert power from the batteries to prevent overcharging by operating a diversion load at the appropriate time. The AUX output operates a mechanical relay which controls the diversion load. Often used with wind or hydroelectric sources.	➢ ***Relative*** voltage ➢ ***Hold*** time ➢ ***Delay*** time ➢ ***Hysteresis*** voltage	***Active High***: Activates when battery voltage exceeds the set point. Usually controls an auxiliary load to divert power away from the batteries when voltage is too high. ***Active Low***: Activates when battery voltage drops below the set point; deactivates when the voltage exceeds the set point.
Diversion: Solid St	 **Function:** When the battery voltage increases, the AUX output goes into pulse-width modulation at a rate of 200 Hz. The response is relative to the charger's present stage of operation. The voltage must exceed the charger setting (Absorb, Float, or EQ) by the value of the ***Relative*** voltage. This condition must last for the ***Delay*** time for the AUX to respond. The AUX returns to its previous state when the voltage drops below the ***Relative*** setting by an amount equal to the ***Hysteresis*** voltage. This condition must last for the ***Hold*** time for the AUX to respond. For a wiring diagram illustrating how to connect this function, see Figure 43 on page 44. **Purpose:** This mode is intended to divert power from the batteries to prevent overcharging by operating a diversion load at the appropriate PWM level. The AUX output operates a solid-state relay for fast and precise control of the diversion load. Often used with wind or hydroelectric sources.	➢ ***Relative*** voltage ➢ ***Hold*** time ➢ ***Delay*** time ➢ ***Hysteresis*** voltage	Not Available **IMPORTANT:** ➢ Do not use ***Diversion: Solid St*** to control a mechanical relay. The PWM action could cause irregular relay activity. ➢ Do not use ***Diversion: Solid St*** to operate a diversion load that has anything other than purely resistive elements. The PWM action may work poorly with mechanical loads.

Table 6 AUX Mode Functions

Mode Name	Function/Purpose	Set Points	Aux Polarity
Low Battery Disconnect	 **Function:** When the battery voltage falls below the ***Disconnect*** voltage following the ***Disconnect Delay***, the AUX output activates. When the battery voltage rises above the ***Re-Connect*** voltage, the AUX deactivates. **Purpose:** This mode is intended to turn off "extra" or noncritical loads when the batteries are low. This will reduce usage and save battery capacity. These loads are usually separated from the main battery loads. They are switched off with a relay which is controlled by the AUX output. Any loads not controlled this way may continue discharging the batteries.	➢ ***Disconnect*** ➢ ***Re-Connect*** ➢ ***Disconnect Delay***	Not Available
Remote	 **Function:** An OutBack system display such as the MATE3 can send external commands to control the AUX output. (See the system display manual for details.) **Purpose:** This mode is intended to allow functions such as AGS to control the AUX output according to external priorities.	None	Not Available
		IMPORTANT: The ***Remote*** option allows the MATE3 to use the AUX output for Advanced Generator Start (AGS). AGS is intended for systems with a HUB, inverter, and FLEXmax Extreme. If the MATE3 connects only to a FLEXmax Extreme, AGS will only work with DC genset programming. The other AGS functions will not work properly. See the MATE3 manual for information on AGS.	

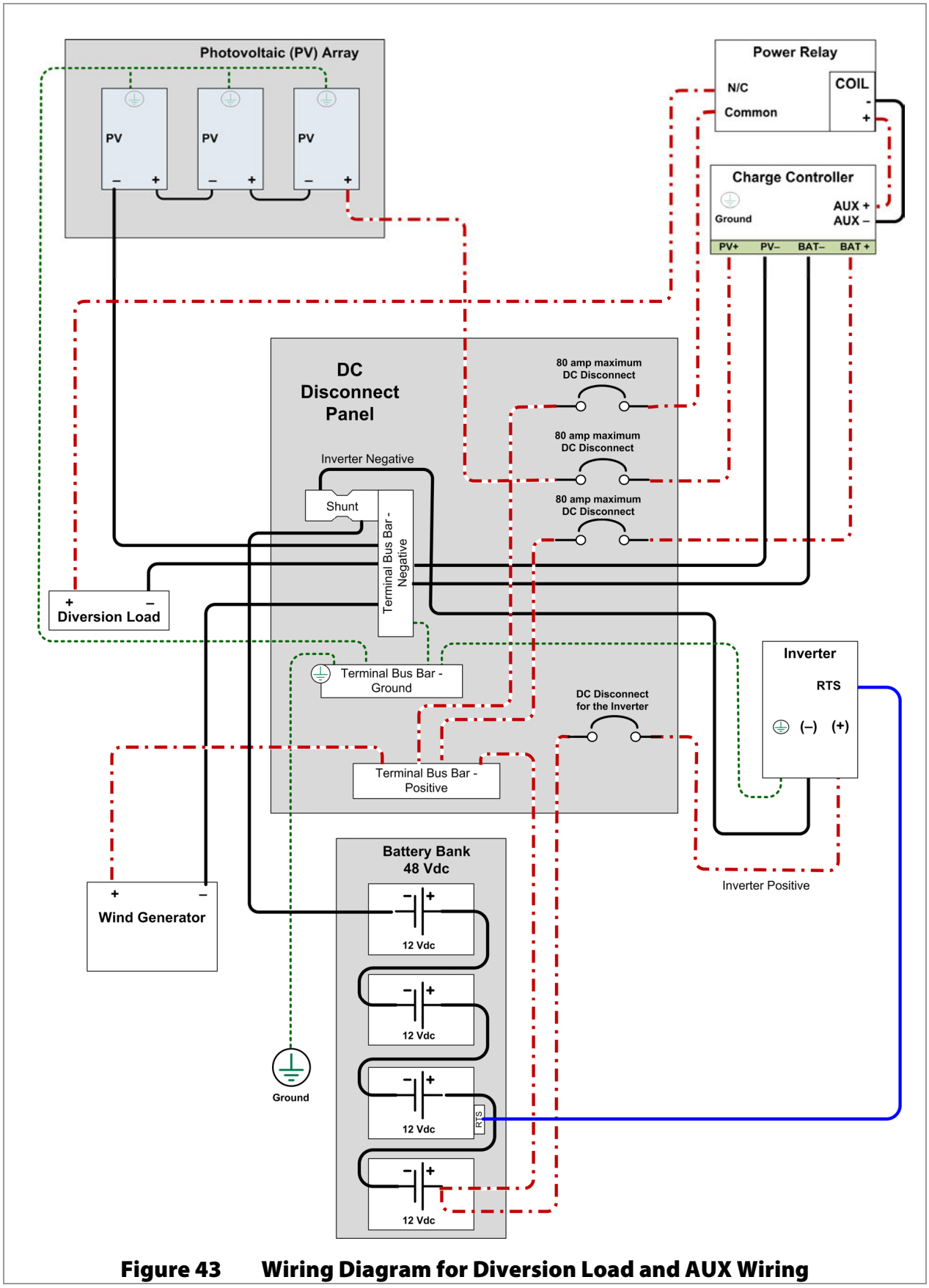


Figure 43 Wiring Diagram for Diversion Load and AUX Wiring

Restart Mode

This setting allows the user to choose between continuous maximum power point (MPP) tracking, or occasional restarts of the sweeping process. A restart means the controller abandons the existing maximum power point value it was using and "re-sweeps", or begins gathering new power point data. (See page 70 for more information on MPP tracking.)

ReStart Mode has three options available:

- ***Mode 0*** – Initial sweep only and then continuous MPP tracking. ***ReStart*** is disabled. The FLEXmax will continously track the maximum power point without starting over.
- ***Mode 1*** – Automatic re-sweep every 90 minutes if controller is in MPPT operation. This will not reset any counters, charging stages, or statistics.
- ***Mode 2*** – Automatic re-sweep every 90 minutes if controller is in any charging mode. This will not reset any counters, charging stages, or statistics.

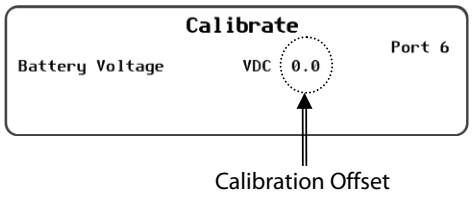
Set Points:

- ***0*** – Continuous MPPT, ***1*** – Automatic re-sweep every 90 minutes in MPPT charging, ***2*** – Automatic re-sweep every 90 minutes in any mode.

Figure 44 Restart Mode

Calibrate

The Calibrate menu allows adjustment of the controller's battery voltmeter. If a particular controller's readings do not match those of another device or a hand-held meter, the calibration feature may improve consistency.



Set Points:

- ***Battery Voltage –*** Calibrates the Vdc measurement made at the controller's battery terminals

Figure 45 Calibrate

NOTE: Calibration does not change the actual voltage of the charge controller, only the reading of that voltage.

Also, measurements in places other than the charge controller's terminals may differ regardless of calibration. For example, it is possible to get a different reading at the charge controller's DC terminals than on the batteries. Connection problems, corrosion, and the effects of induction and resistance may all result in voltage differences. If this occurs, it is an issue with the system, not the charge controller. Calibration cannot correct for it.

Also note that this function does not affect voltages displayed by the MATE3 from other sources such as the FLEXnet DC Battery Monitor or an inverter. It also does not affect voltages displayed using the FLEXmax Extreme Battery Sense terminals (see page 18). If any of these readings are displayed on the MATE3, adjusting the ***Calibrate*** menu will have no effect.

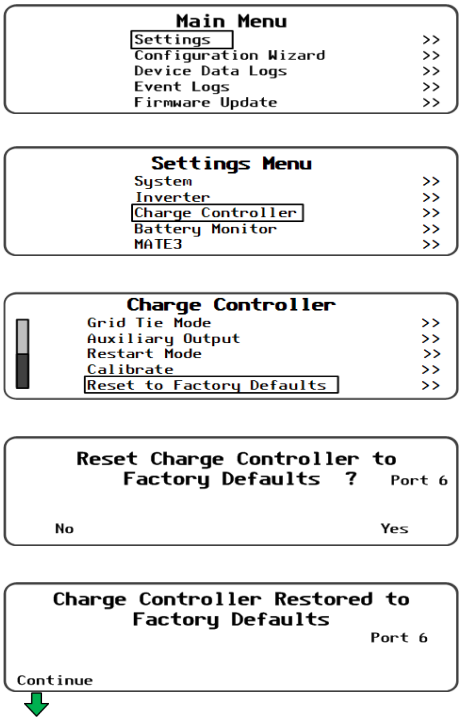
Reset Charge Controller to Factory Defaults

This menu allows the user to erase all settings from the selected charge controller and start over with the values programmed at the factory. These values are listed on page 66. This procedure is recommended any time the controller is relocated or the system is substantially revised.

This procedure is a requirement for resetting the nominal battery voltage of the system (see page 21).

To access the Reset to Factory Defaults menu:

1. Access the main menu as shown on page 35.
2. Select the ***Settings*** menu. (This option may be highlighted by default.)
3. Select ***Charge Controller*** in the device ***Settings*** menu.
4. Select the ***Reset to Factory Defaults*** menu.
5. Use the soft keys to select ***No*** or ***Yes***.
   - If **<No>** is selected, the screen returns to the ***Charge Controller*** menu. No changes will be made to any settings.
   - If **<Yes>** is selected, the inverter's settings will immediately change to the original factory values. The screen will display the message ***Charge Controller Restored to Factory Defaults.*** A **<Continue>** soft key will appear. Pressing this key will return the screen to the ***Charge Controller*** menu.
6. After resetting the charge controller to factory default parameters:
   - press the **<Continue>** soft key or the Up navigation key to return to the ***Charge Controller*** menu, or
   - press the Top key to return to the ***Settings*** menu.



Press **<Continue>** to return to the ***Charge Controller*** menu.

Figure 46 Restoring the Charge Controller to Factory Default Settings

Firmware Revision

To access the FLEXmax Extreme's firmware revision:

1. Access the ***Main Menu*** as shown on page 35.
2. Select the ***Settings*** menu. (This option may be highlighted by default.)
3. Select ***System*** in the device ***Settings*** menu.
4. Select the ***Firmware Versions*** menu.
5. The current firmware revision of the FLEXmax Extreme will be displayed along with that of the MATE3 and other devices.

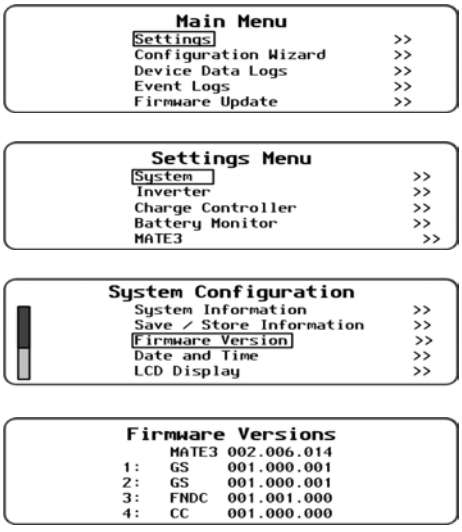


Figure 47 Reading the Firmware Revision

Updating the Firmware

The MATE3 is used to update the firmware revision. It is necessary to use an SD memory card loaded with the latest revision. Instructions for the update process are provided in the *MATE3 System Display and Controller Owner's Manual***.**

During the update process, the blue Charging indicator LED (see page 23) will flash.

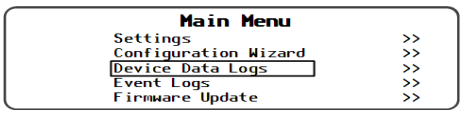
Device Data Logs

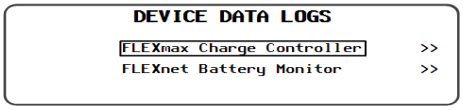
Users of the MATE3 can create Device Data Logs for the FLEXmax Extreme charge controller. The Data Logs can then be uploaded and saved to an SD card.

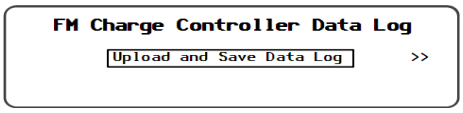
Saving Data Logs for the FLEXmax Extreme

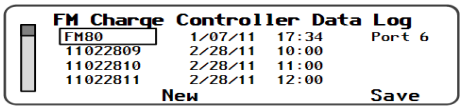
To create a data log for the FLEXmax Extreme:

1. Access the ***Main Menu*** as shown on page 35.
2. Select the ***Device Data Logs*** menu.
3. Select ***FLEXmax Charge Controller*** menu.
4. Select ***Upload and Save Data Log*** on the ***FM Charge Controller Data Log*** menu.
5. Select one of the two options.
   - Press **<New>** to give the new data log a unique name. Or
   - Press **<Save>** to save the data log over the name that is highlighted on the list.
6. After saving the data log is complete, press **<Continue>** to return to the ***Upload and Save Data Log*** screen.



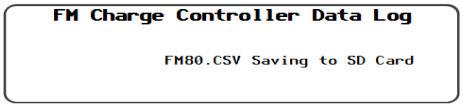


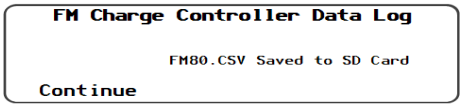




To save a new data log over the name highlighted on the list:

1. Use the control wheel to scroll through the list.
2. When the name to be replaced is highlighted, press **<Save>**.
3. Wait for the message confirming that the profile has been saved to the SD card.
4. Press **<Continue>** to return to the ***Upload and Save Data Log*** menu.

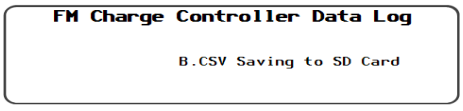


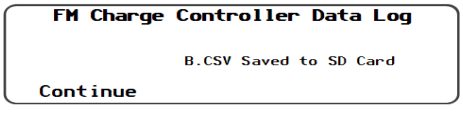


Returns to the ***Upload and Save Data Log*** screen.

To create a new name for the data log (up to 8 characters maximum):

1. Use the control wheel to scroll through the available characters.
2. Use **<➔>** and **<🡐>** to move to the next character location.
3. Press **<Delete>** to erase the character that is highlighted.
4. Press **<Save>** to save the new data log on the SD card.
4. Press **<Continue>** to return to the ***Upload and Save Data Log*** menu.





Returns to the ***Upload and Save Data Log*** screen.

Figure 48 Uploading and Saving a Data Log for the FLEXmax Extreme

Data Log File Format

Information generated by this function will be saved on the SD card in a generic **.csv** file format, which can be read by most spreadsheet programs.

Data Logging example:

NOTE: This header line is NOT included in the download.

Date	AH	Kwh	Max Amps	Max Watts	Absorb Time	Float Time	Min Battery V	Max Battery V	MAX V_{oc}
6/13/11	0	0	1.2	29	0:00	0:00	24.1	29.1	122
6/12/11	38	0.9	5.5	143	0:00	0:00	24.1	29	122
6/11/11	32	0.8	5.6	144	0:00	0:00	24.1	28.7	120
6/10/11	9	0.2	3.5	89	0:00	0:00	24.1	28.9	120
6/09/11	31	0.7	6.8	173	0:00	0:00	24.1	28.8	119

Figure 49 Data Log Example for the Charge Controller

MATE/MATE2 Screens

The MATE and MATE2 system displays can be used for monitoring FLEXmax Extreme activity. Not all information shown in the MATE3 is equally available in the MATE.

Summary Screens

The Summary screens show real-time and accumulated system information. The FLEXmax Extreme Summary screen appears at the bottom of the screen order.

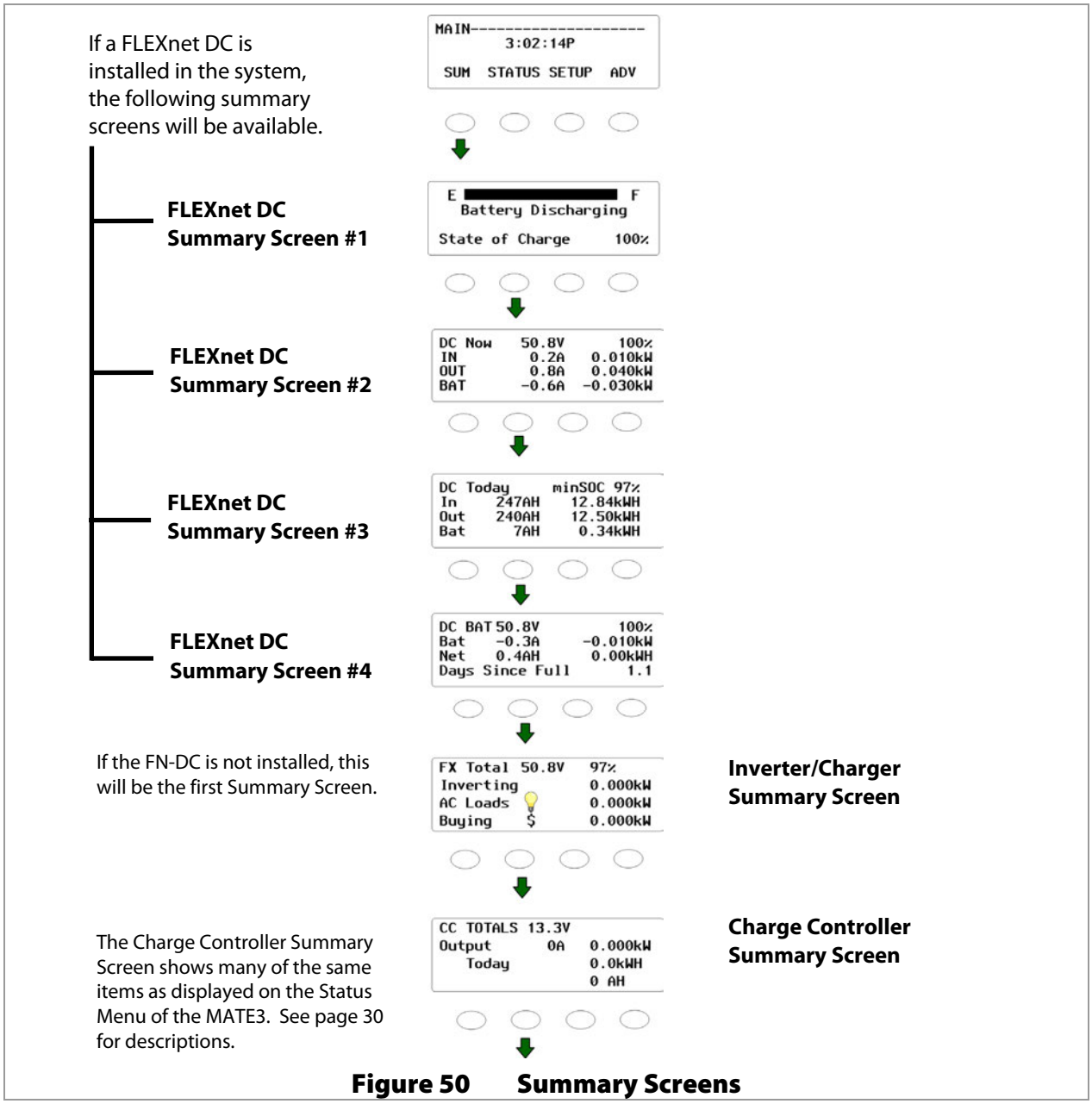
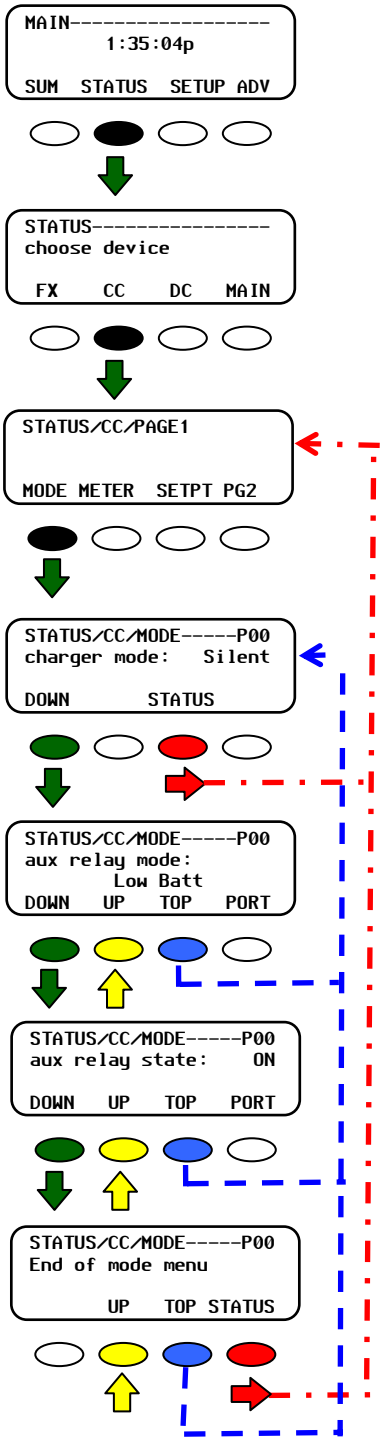


Figure 50 Summary Screens

Status Screens

To view the status screens of a FLEXmax Extreme using a MATE, follow the illustration below. Changes to FLEXmax Extreme settings cannot be made when viewing these screens on a MATE.

MODE Screens



Navigation for STATUS/CC/MODE

- **<STATUS>** returns to the ***STATUS/CC/PAGE1*** screen.
- **<DOWN>** moves to the next menu item in the diagram.
- **<UP>** moves to the previous menu item in the diagram.
- **<TOP>** returns to the first ***CC/MODE*** screen for the port shown.
- **<PORT>** directs the MATE to read the next device (port) on the HUB.

Charge Controller Modes

The MODE screens describe the current operating mode for the FLEXmax Extreme charger (see page 25) and AUX output (see page 40).

The modes shown here are the same as those displayed in the Status Menu of the MATE3. See page 30 for descriptions.

charger mode:

- ***Bulk***
- ***Absorption***
- ***Float***
- ***Silent***
- ***Equalization***

aux relay mode:

- ***vent fan***
- ***pv trigger***
- ***error output***
- ***night light***
- ***float***
- ***diversion: relay***
- ***diversion: solid st***
- ***low batt***(ery) ***disconnect***
- ***remote***

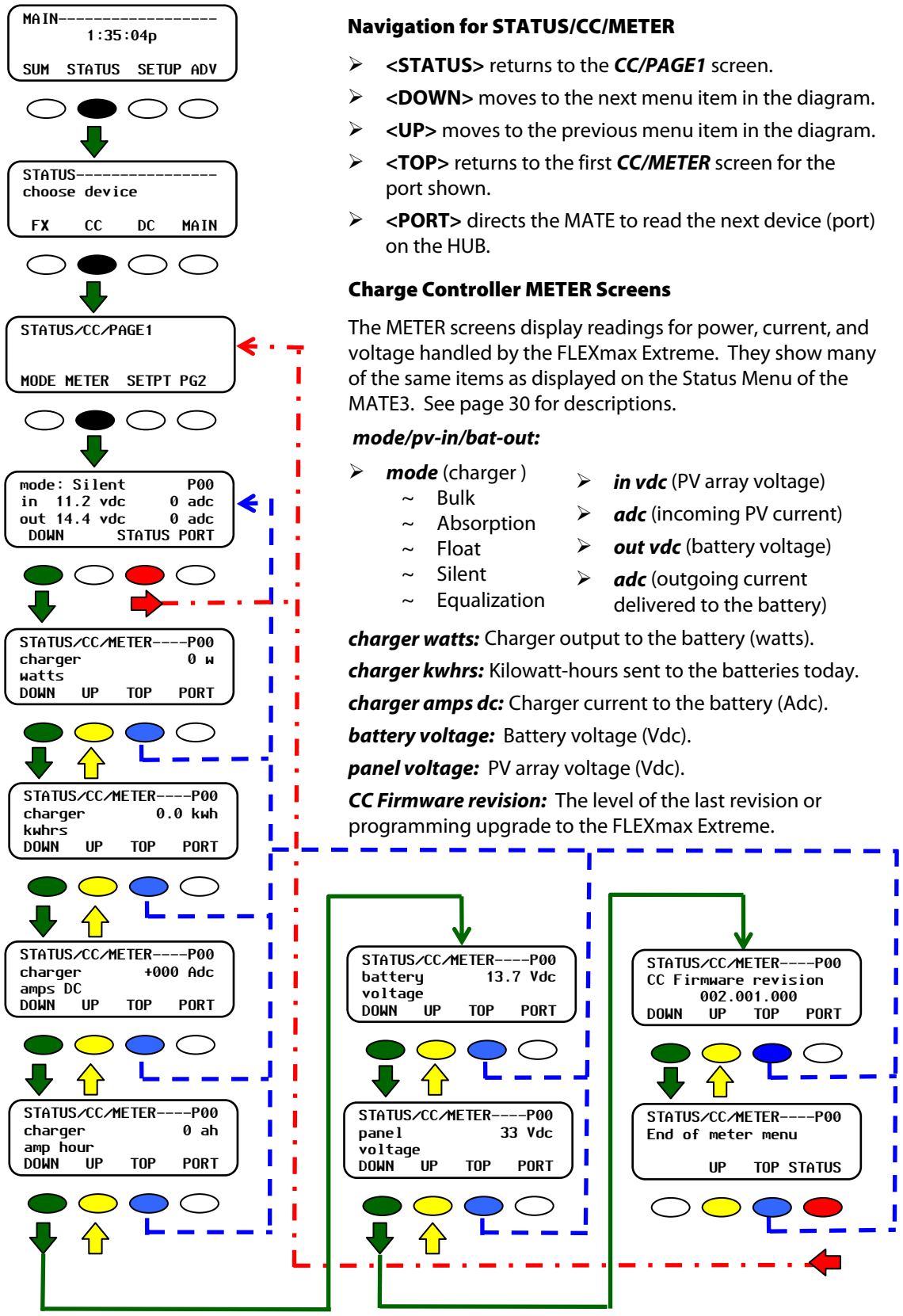
aux relay state:

This screen indicates if the AUX output is

- ***ON***
- ***OFF***

Figure 51 MODE Screens

METER Screens



Navigation for STATUS/CC/METER

- **<STATUS>** returns to the ***CC/PAGE1*** screen.
- **<DOWN>** moves to the next menu item in the diagram.
- **<UP>** moves to the previous menu item in the diagram.
- **<TOP>** returns to the first ***CC/METER*** screen for the port shown.
- **<PORT>** directs the MATE to read the next device (port) on the HUB.

Charge Controller METER Screens

The METER screens display readings for power, current, and voltage handled by the FLEXmax Extreme. They show many of the same items as displayed on the Status Menu of the MATE3. See page 30 for descriptions.

mode/pv-in/bat-out:

- ***mode*** (charger)
  - ~ Bulk
  - ~ Absorption
  - ~ Float
  - ~ Silent
  - ~ Equalization
- ***in vdc*** (PV array voltage)
- ***adc*** (incoming PV current)
- ***out vdc*** (battery voltage)
- ***adc*** (outgoing current delivered to the battery)

charger watts: Charger output to the battery (watts).

charger kwhrs: Kilowatt-hours sent to the batteries today.

charger amps dc: Charger current to the battery (Adc).

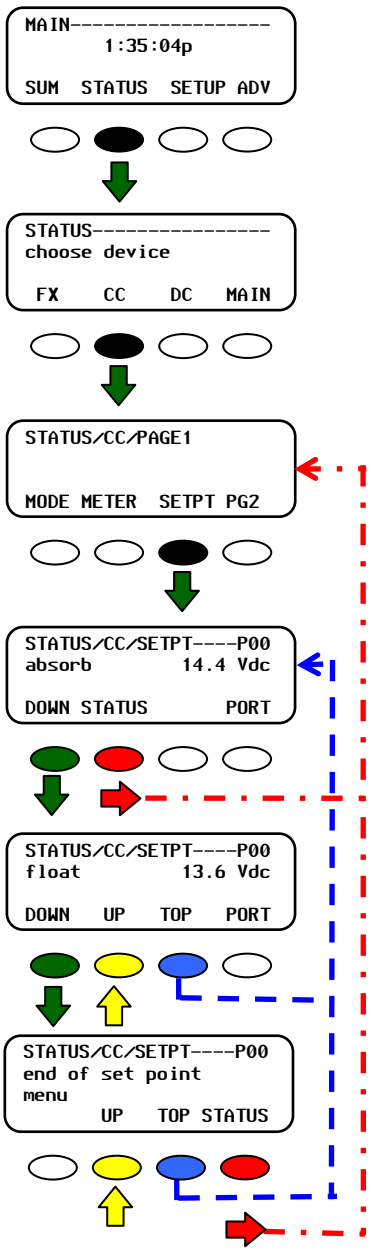
battery voltage: Battery voltage (Vdc).

panel voltage: PV array voltage (Vdc).

CC Firmware revision: The level of the last revision or programming upgrade to the FLEXmax Extreme.

Figure 52 METER Screens

SETPT Screens



Navigation for STATUS/CC/SETPT

- **<STATUS>** returns to the ***CC/PAGE1*** screen.
- **<DOWN>** moves to the next menu item in the diagram.
- **<UP>** moves to the previous menu item in the diagram.
- **<TOP>** returns to the first ***CC/SETPT*** screen for the port shown.
- **<PORT>** directs the MATE to read the next device (port) on the HUB.

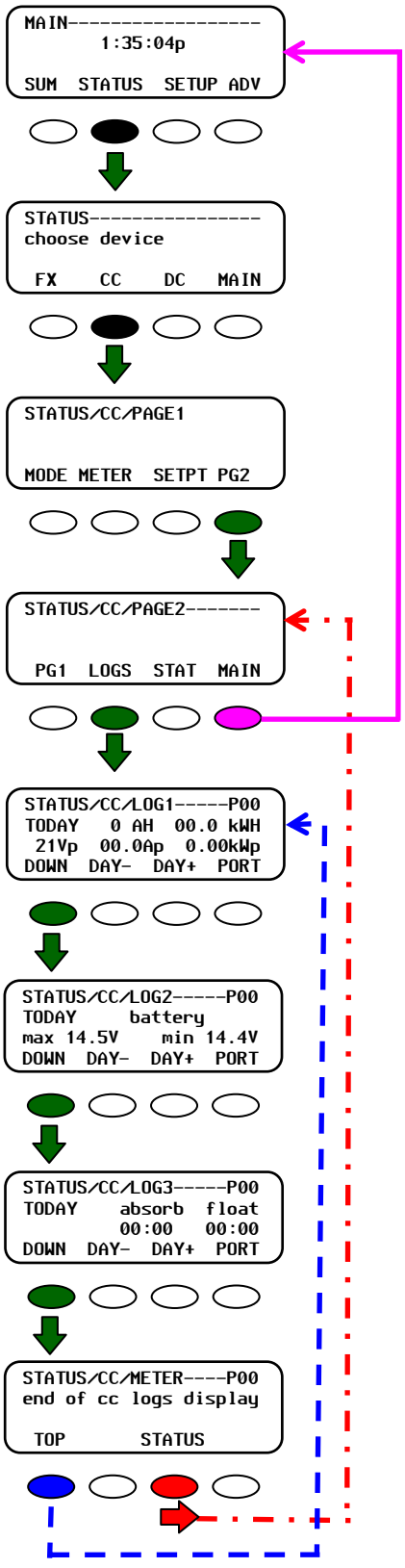
Charge Controller SETPT (set point) Screens

The SETPT screens display the current settings for the FLEXmax Extreme battery charger, as described on page 71.

- ***Absorb***
- ***Float***

Figure 53 SETPT Screens

LOG Screens



Navigation for STATUS/CC/LOGS

- **<STATUS>** returns to the ***CC/PG2*** screen.
- **<DOWN>** moves to the next menu item in the diagram.
- **<UP>** moves to the previous menu item in the diagram.
- **<TOP>** returns to the 1st ***CC/LOG1*** screen for the port shown.
- **<PORT>** directs the MATE to read the next device (port) on the HUB.
- **<DAY–>** displays log information from one day earlier. Logs can be displayed from as far as 128 days in the past.
- **<DAY+>** displays log information from one day later. If the present day is displayed, then pressing this key will return the log to 128 days in the past.

Charge Controller Logs

The LOG screens contain information collected from the FLEXmax Extreme on individual days. These logs include the same information shown in the ***DataLog*** screen of the MATE3. See page 29 for descriptions.

Log 1 Today:

- ***AH*** (accumulated battery amp-hours)
- ***kWH*** (accumulated battery kilowatt-hours)
- ***Vp*** (peak PV voltage)
- ***Ap*** (peak PV current)
- ***kWp*** (peak PV kilowatt-hours)

Log 2 Today:

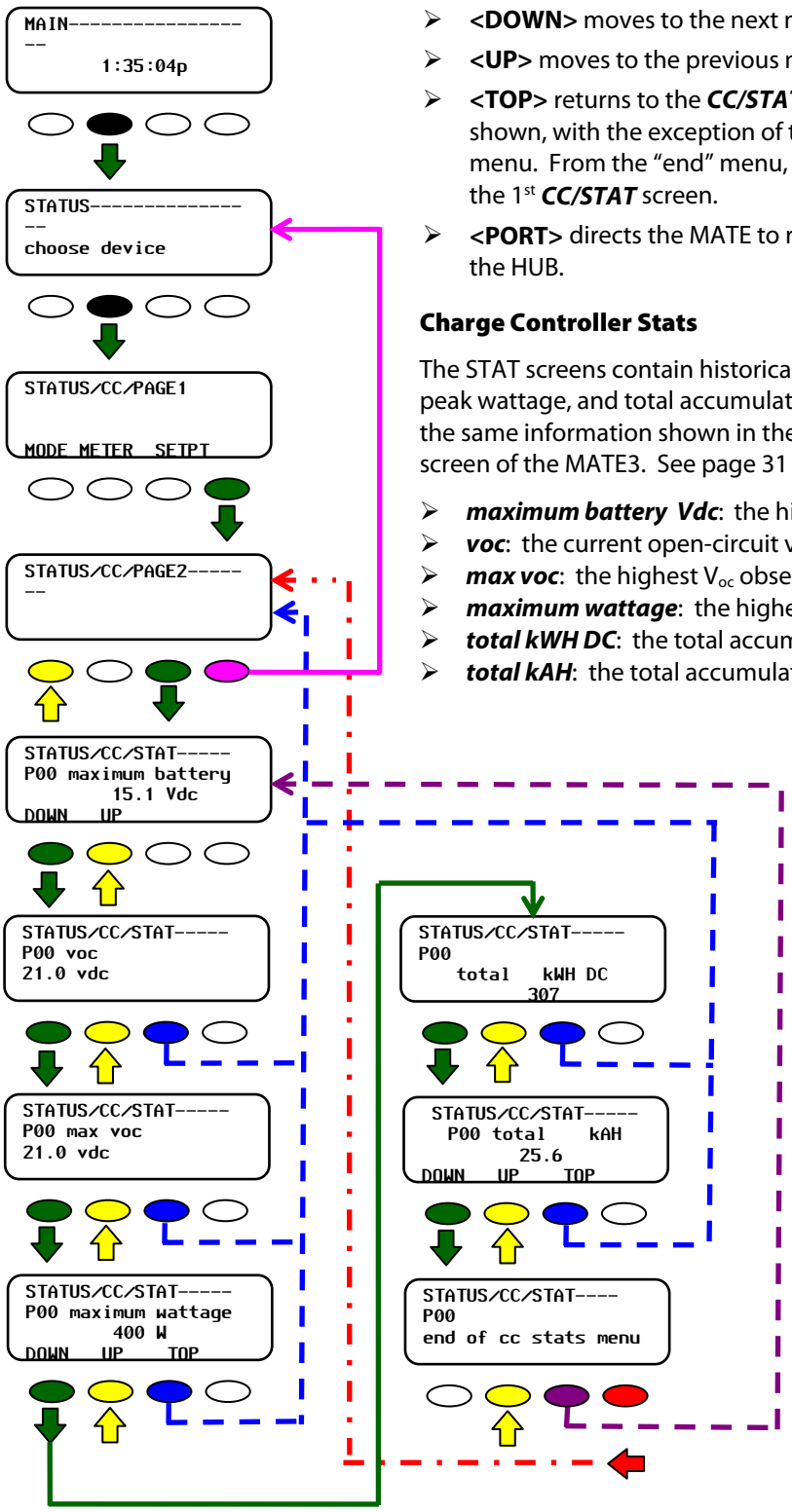
- ***max V*** (maximum battery voltage)
- ***min V*** (minimum battery voltage)

Log 3 Today:

- accumulated ***absorb*** time
- accumulated ***float*** time

Figure 54 LOG Screens

STAT Screens



Navigation for STATUS/CC/STAT

- **<STATUS>** returns to the ***CC/PAGE2*** screen.
- **<DOWN>** moves to the next menu item in the diagram.
- **<UP>** moves to the previous menu item in the diagram.
- **<TOP>** returns to the ***CC/STAT/PAGE2*** screen for the port shown, with the exception of the "end of the cc stats" menu. From the "end" menu, the **<TOP>** soft key returns to the 1st ***CC/STAT*** screen.
- **<PORT>** directs the MATE to read the next device (port) on the HUB.

Charge Controller Stats

The STAT screens contain historical data, including peak voltages, peak wattage, and total accumulations. These statistics include the same information shown in the ***Charge Controller Stats*** screen of the MATE3. See page 31 for descriptions.

- ***maximum battery Vdc***: the highest voltage observed to date
- ***voc***: the current open-circuit voltage
- ***max voc***: the highest V_{oc} observed to date
- ***maximum wattage***: the highest wattage observed to date
- ***total kWH DC***: the total accumulated kilowatt-hours to date
- ***total kAH***: the total accumulated kiloamp-hours to date

Figure 55 STAT Screens

Advanced Menus

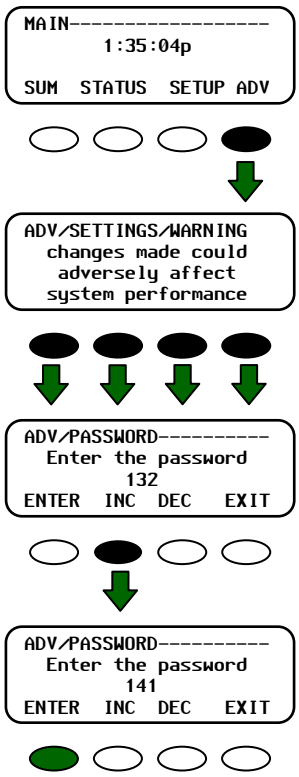
The Advanced menus available in the MATE or MATE2 system display allow the following options:

- Change the settings of the FLEXmax Extreme battery charger, with the following exception: The MATE and MATE2 system display cannot adjust the rate of temperature compensation (the "slope"); see page 38
- Change the parameters of the MPPT process
- Change the settings of the equalization process
- Calibrate the FLEXmax meters
- Change the settings of the Auxiliary output to run small AC or DC loads
- Start a generator using Advanced Generator Start (AGS) Mode
- Adjust the settings or functions of other OutBack devices which are connected to the system display (see appropriate manuals)

The following pages detail the MATE, or MATE2, Control Modes. Please note that whenever a password is called for, the system password is:

141

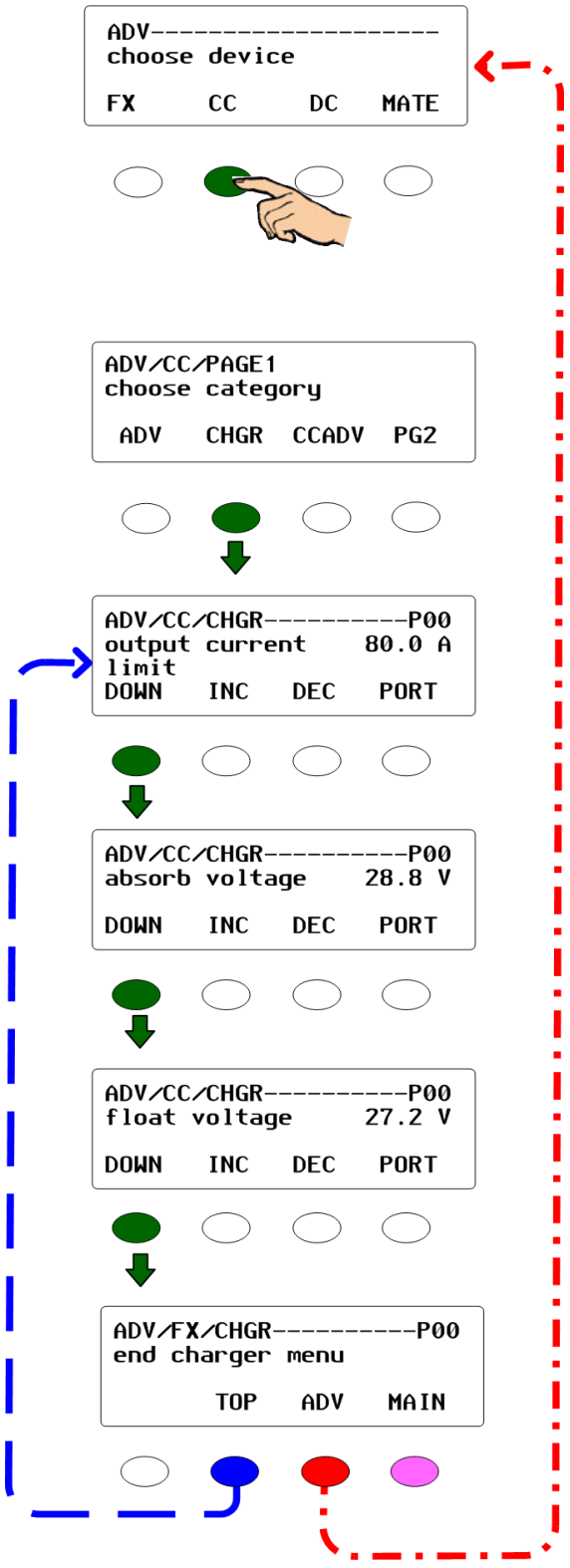
Accessing the Advanced Menus



- Press any soft key to advance to the next screen.
- Press the **<INC>** soft key until **132** becomes **141**.
- Press **<ENTER>** when the number **141** is displayed. This will proceed into the ***ADV choose device*** menu in the Advanced menu map.
- Press **<EXIT>** to return to the main menu without changing the password.

Figure 56 Accessing the Advanced Menus

CHGR Menu



Navigation for ADV/CC/CHGR

- **<DOWN>** moves to the next menu item in the diagram.
- **<INC>** increases the value of the selection.
- **<DEC>** decreases the value of the selection.
- **<PORT>** directs the MATE to read the next device (port) on the HUB.
- **<ADV>** returns to the ***CC/PAGE1*** screen.
- **<TOP>** returns to the ***CC/CHGR*** screen.
- **<MAIN>** exits the Advanced menus and returns to the main menu (see page 55).

CC/Charger

The CHGR screens adjust most of the same settings that are available on the ***Charger*** screen in the MATE3 (see page 36).

- ***output current limit***
- ***absorb voltage***
- ***float voltage***

Figure 57 ADV Menu for Charging Features

CC ADVANCED Menu

CC/Advanced

The ADVANCED screens include a series of settings which are located in a variety of places in the MATE3. These include the MATE3 ***Charger*** screen (see page 36), the ***MPPT*** screen (see page 37), the ***Temperature Compensation*** screen (see page 38), the ***Grid-Tie Mode*** screen (see page 39), the ***Auxiliary Output*** screen (see page 39), the ***Restart Mode*** screen (see page 45) , and the ***Calibrate*** screen (see page 45.

- **<DOWN>** moves to the next menu item in the diagram.
- **<INC>** increases the value of the selection.
- **<DEC>** decreases the value of the selection.
- **<PORT>** directs the MATE to the next device (port) on the HUB.
- **<TOP>** returns to the ***CC/ADVANCED*** screen.
- **<ADV>** returns to the ***CC/PAGE1*** screen.
- **<MAIN>** exits the Advanced menus and returns to the main menu (see page 55).

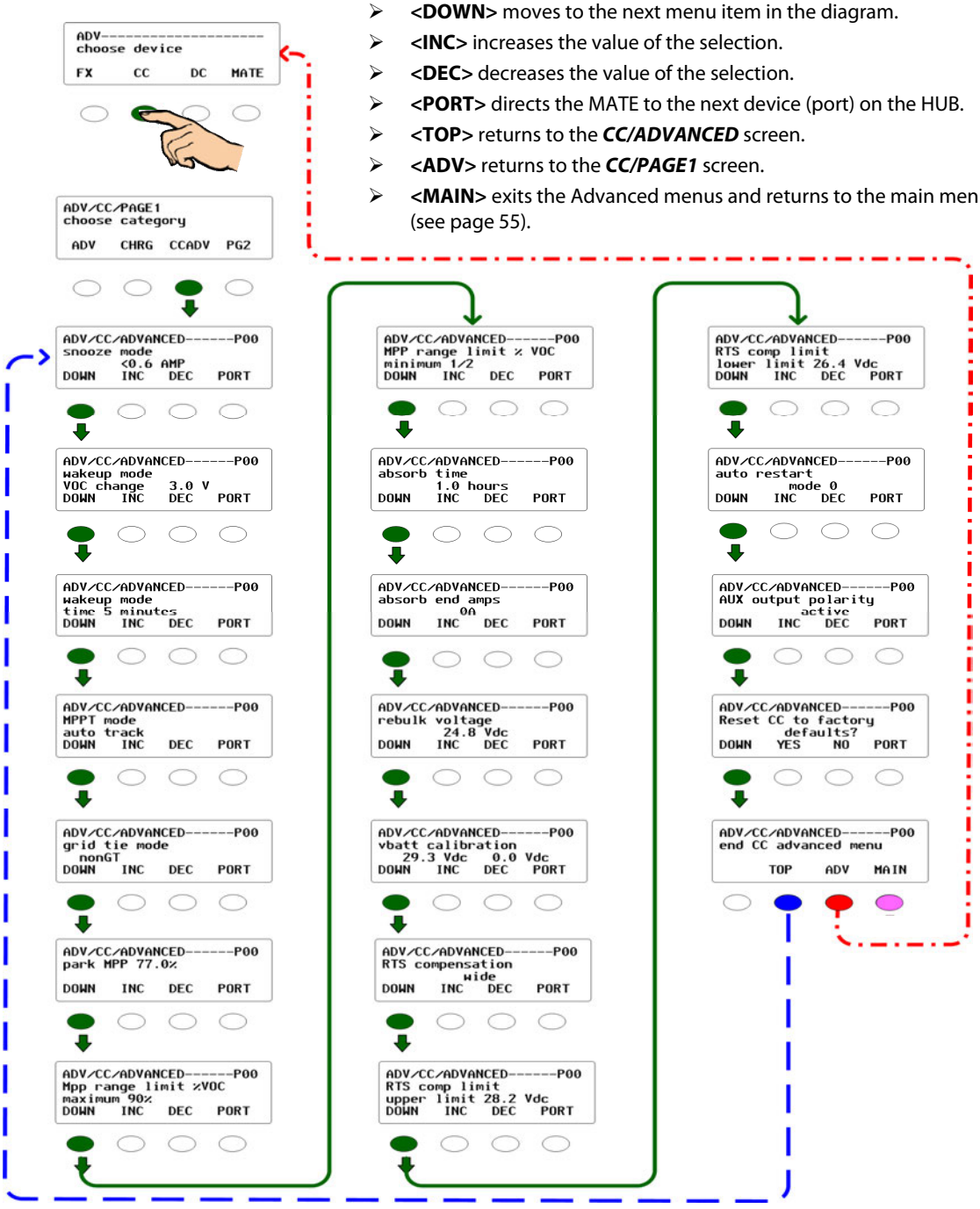
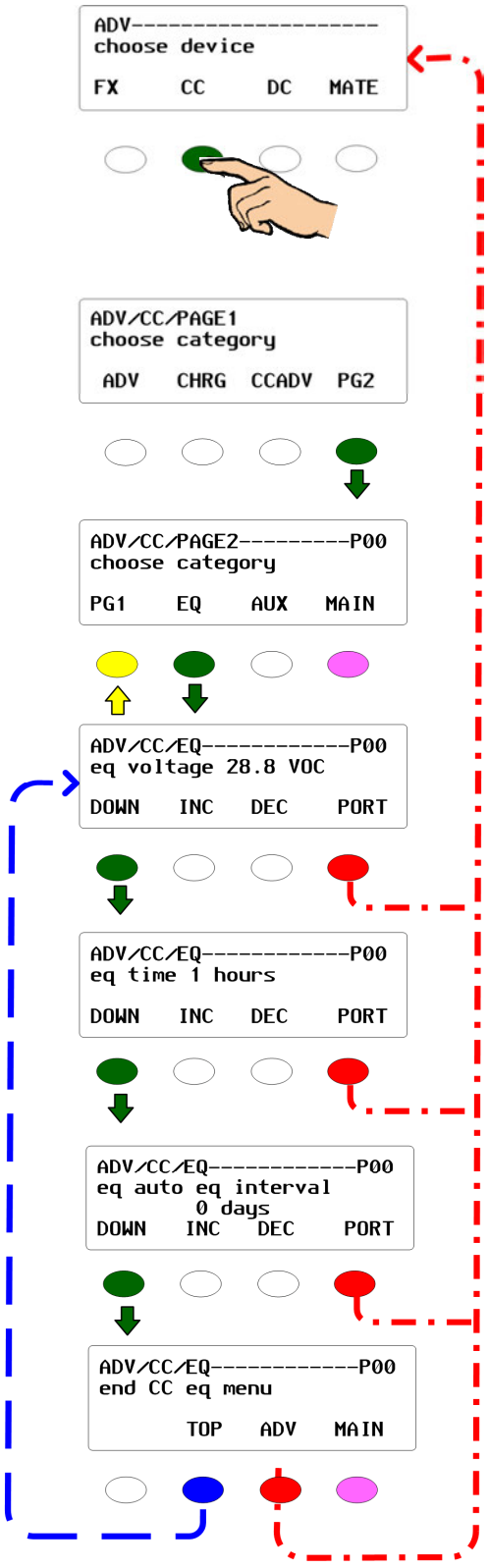


Figure 58 ADV Menu for the Advanced Charging Features

EQ Menu



Navigation for ADV/CC/EQ

- **<DOWN>** moves to the next menu item in the diagram.
- **<INC>** increases the value of the selection.
- **<DEC>** decreases the value of the selection.
- **<PORT>** directs the MATE to read the next device (port) on the HUB.
- **<TOP>** returns to the ***CC/EQ*** screen.
- **<ADV>** returns to the ***choose device*** screen.
- **<MAIN>** exits the Advanced menus and returns to the main menu (see page 55).

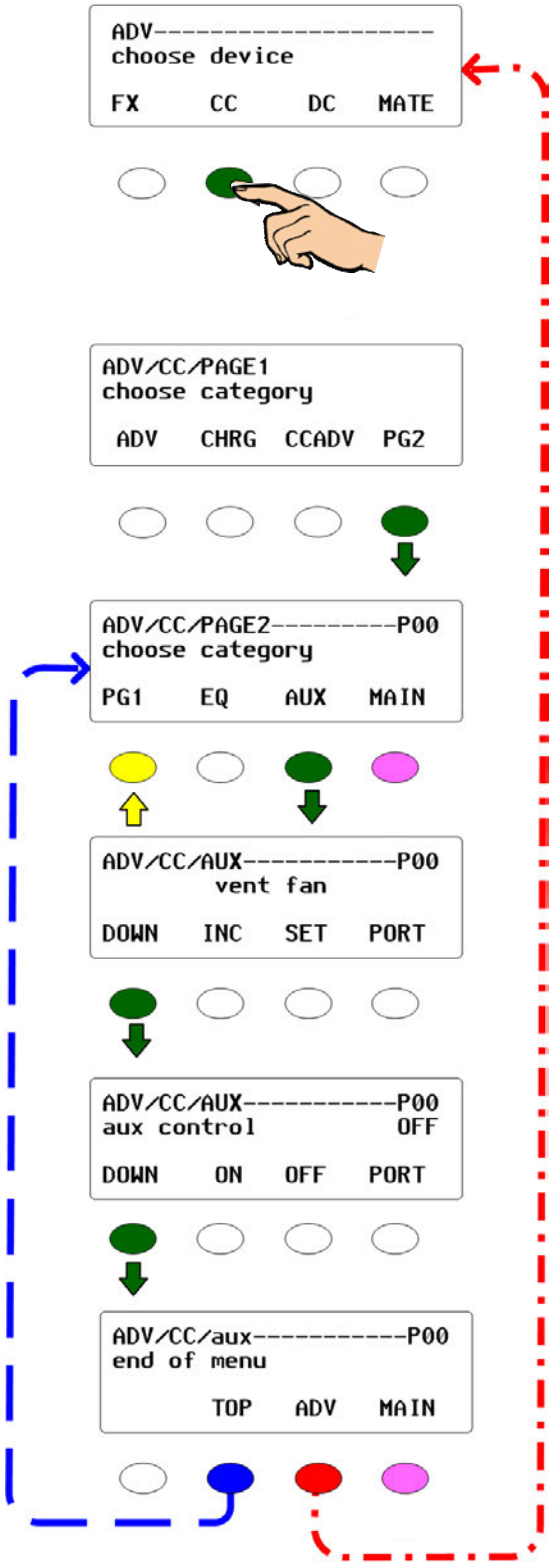
CC/Equalization

The EQ screens adjust the same settings that are available on the ***Battery Equalize*** screen in the MATE3 (see page 38).

- ***eq voltage***
- ***eq time***
- ***eq auto eq interval***

Figure 59 ADV Menu for EQ Charging Features

AUX Menu



Navigation for ADV/CC/AUX

- **<DOWN>** moves to the next menu item in the diagram.
- **<INC>** increases the value of the selection.
- **<DEC>** decreases the value of the selection.
- **<PORT>** directs the MATE to read the next device (port) on the HUB.
- **<TOP>** returns to the ***CC/PAGE2*** screen.
- **<ADV>** returns to the ***choose device*** screen.
- **<MAIN>** exits the Advanced menus and returns to the main menu (see page 55).

CC/AUX

The AUX screens adjust the same settings that are available on the ***Auxiliary Output*** screen in the MATE3 (see page 39).

AUX mode:

- ***vent fan***
- ***pv trigger***
- ***error output***
- ***night light***
- ***float***
- ***diversion: relay***
- ***diversion: solid st***
- ***low batt(ery) disconnect***
- ***remote***

The ***remote*** mode also can be used for the MATE's AGS function.

NOTE: The MATE must have firmware revision 4.1.6 or higher for AGS to work.

aux control

- ***ON***
- ***OFF***

Figure 60 ADV Menu for the AUX Features

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Troubleshooting

IMPORTANT:

Check the OutBack customer and user forum at www.outbackpower.com/forum/ for more FLEXmax Extreme information.

A MATE3, or other OutBack system display, may be required for many of the troubleshooting steps in Table 7.

Table 7 Troubleshooting

Symptom	Remedy
Unit does not power up upon initial connection (no LED indicators or MATE3 operation)	➢ Check the battery connection and polarity. Reverse polarity or an improper connection will cause power-up issues. ➢ Check the battery circuit breaker or device. Ensure all items are sized appropriately. ➢ Check the battery voltage at the FLEXmax Extreme terminals. A battery voltage below 10.5 Vdc may not power up the charge controller. A poor connection may not allow sufficient voltage to reach the charge controller.
Unit powers up but does not operate. PV voltage is present but drops to a few volts when connected.	➢ Check PV wiring. This will occur if the PV array wiring polarity is reversed. The heatsink may grow warm after a short time due to internal current flow.
Unit not producing expected power	➢ Check PV conditions. Clouds, shading, or dirty modules can cause poor performance. ➢ Check settings using the system display. ~ The current limit set point in the ***Charger*** menu may restrict the charging current even if more is available. ~ If the controller is in ***U-Pick*** mode, it may not track at the maximum power point. This mode is not normally selected when using PV. ➢ Check battery conditions and charging stage. If the batteries are charged (if the controller is in the Absorbing or Float stage), the controller will produce only enough power to regulate the voltage at those set points. Less power is required. ➢ Determine the specified short-circuit current of the PV array. The MPP current is related to this number. Use a multimeter to determine if the short-circuit current is in the expected range. Array or wiring problems may restrict the available power. ➢ Check the PV array temperature. At high temperatures, the maximum power point voltage may be near or lower than the battery voltage. ➢ Check FLEXmax Extreme external temperature. The output is derated above ambient temperatures of 45°C (113°F), or 55°C (131°F) with the optional fan kit. Also check FLEXmax Extreme internal temperature using the MATE3. See page 32. If a temperature reading is greater than 142°C or less than -40°C, a sensor may have failed. This will show ***Y*** in the ***Reduced Performance*** error (see page 32). **NOTE:** If the temperature is high, check the condition of the heatsink. This may require dismounting the controller. If the heatsink is blocked with mud, organic material, etc., the controller will not receive normal ventilation. Clean it by scraping between the fins with a thin wooden stick. Spraying is not recommended. **CAUTION: Hazard to Equipment** Do not scrape the two metal modules that protrude into the fin area. These modules are visible in Figure 3 on page 8.

Table 7 Troubleshooting

Symptom	Remedy
Unit in equalization cycle but not achieving expected results	➢ Check equalization settings using the system display. (See pages 38 and 72). The default settings are not sufficient for many batteries and may need to be adjusted. ➢ The cycle will begin when the ***Equalization Voltage*** set point has been reached. A small array or cloudy weather will delay the equalization cycle. Running too many battery loads will also delay the cycle. ➢ Check the PV array temperature. At high temperatures, the maximum power point voltage may be near or lower than the battery voltage. This can delay the cycle.
Battery Calibration setting does not respond	The system display will not report this setting if remote battery sensing is connected. To test this function, temporarily disconnect remote battery sensing. (See page 18.)
Unit not operating; unit had worked normally before; no Fault LED indicator (see page 23); MATE3 displays ***Silent***	This behavior is normal in cases of low light; unit may be in "Sleep", "Snooze", or "Wakeup" modes. Confirm external conditions and behavior using Table 4 on page 28.
Unit not operating; unit had worked normally before; normal light conditions; no Fault LED indicator (see page 23); MATE3 displays ***Silent***	➢ "High V_{oc} " fault. Check PV array voltage. If it is greater than 145 Vdc, the open-circuit voltage (V_{oc}) is too high for the controller to safely operate. The MATE3 ***VOC Too High*** error will indicate ***Y***. (See page 32.) This should only occur with systems using 72 Vdc nominal PV arrays in very cold temperatures (below -15°C or 5°F). The FLEXmax Extreme will automatically restart operation once the V_{oc} falls to a safe level (145 Vdc or lower). **CAUTION: Hazard to Equipment** Voltages in excess of 150 Vdc are likely to damage the FLEXmax Extreme. The PV array should be designed to avoid ever reaching these voltages. ➢ "High temperature" fault. Check controller temperature (see page 32). The FLEXmax Extreme will stop functioning at an ***Enclosure*** reading of 78°C and an ***Output FETs*** reading of 130°C. The MATE3 ***Over Temperature*** error will indicate ***Y***. (See page 32.) ➢ "Battery too hot" fault. Check battery temperature (see MATE3 manual). If the RTS reads in excess of of 50°C, it indicates a battery too hot to safely operate.
Unit not operating; Fault LED indicator illuminated (see page 23); MATE3 displays ***Silent***	➢ ***Fault Input Active*** error. An open circuit was detected on the External Fault terminals. (See page 18.) If the OutBack GFDI was installed, this could indicate a ground fault condition. The MATE3 ***Fault Input Active*** error will indicate ***Y.*** (See page 32.) To restart the FLEXmax Extreme, remove all power from the controller and then reconnect the batteries. If this error occurred upon initial power-up, the External Fault terminals may be wired incorrectly. (See page 19.) These terminals must have either a jumper or a ground-fault device installed. ➢ "Overcurrent" fault. This occurs if more than 6 amps flow from the battery to the FLEXmax Extreme, or if more than 100 amps flow from the controller to the battery. An overcurrent fault will show ***Y*** in the ***Fault Input Active*** error (see above) even though it is a different problem (see page 32.) To restart the FLEXmax Extreme, remove all power from the controller and then reconnect the batteries.
Fan runs continuously; charging is not temperature compensated	Remote Temperature Sensor (RTS) damaged. The MATE3 ***Shorted RTS*** item will indicate ***Y***. (See page 32.) To test, remove or replace the RTS.

Specifications

Electrical and Mechanical Specifications

Table 8 Electrical and Mechanical Specifications for Model FM Extreme-150VDC

Specification		Value
Maximum Continuous Output Current		80 amps
Maximum Input Current (short-circuit)		64 amps
Nominal Battery System Voltage		12, 24, 36, 48 or 60 Vdc (adjustable)
PV Open-Circuit Voltage		145 Vdc temperature corrected V_{oc} (operational maximum)
Operating Voltage Range	Low	10.5 Vdc (lowest battery voltage for functionality)
	High	150 Vdc (highest open-circuit voltage before equipment damage)
Standby Power Consumption		Less than 1 watt typical
Charge Cycle		Three-stage
Minimum Battery Bank Size		100 Ah
Charging (Output) Range		13 to 80 Vdc
Temperature Compensation		Adjustable from 2 mV/cell/°C to 6 mV/cell/°C
Remote Interface		RJ45 modular connector (CAT 5 8-wire cable)
Conduit Openings		Front, rear, sides (plugs inserted)
Dimensions (H x W x D)		18.56" x 8.8" x 6.0" (47.1 cm x 20.9 cm x 15.2 cm)
Shipping Dimensions (D x W X L)		9.69" x 11.75" x 22.0" (24.6 cm x 29.8 cm x 55.9 cm)
Weight		21.0 lb (9.5 kg)
Shipping Weight		21.5 lb (9.7 kg)

Environmental Specifications

Table 9 Environmental Specifications for Model FM Extreme-150VDC

Specification	Value
Operating Temperature Range	Ambient -20°C to 45°C (-4°F to 113°F)
Output Power Temperature Derating	Ambient 45°C to 60°C (113°F to 140°F)
Ingress Protection Rating	IP 54
Enclosure Type	NEMA 3R
Maximum Altitude Rating	10,000 ft

Regulatory Specifications

This product is certified to the following standards:

- UL1741 — *Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources* — Issue: 2010/1/28 Ed: 2
- CSA C22.2 — *General Use Power Supplies,* No. 107.1-01 — Issue: 2001/09/01 Ed:3 (R2011)
- AS/NZS 3100:2009 — *Approval and Test Specification – General Requirements for Electrical Equipment* — Issue: 2002/05/13
- ROHS: Directive 2011/65/EU — *"The restriction of the use of certain substances in electrical and electronic equipment"*
- IEC 61000-6-1 (EMC Standard: Immunity for Residential, Commercial, and Light-Industrial Environments)
- IEC 61000-6-3: 2007; also CISPR 22: 2008 Class B; also EN 55022 (EMC Standard: Emissions for Residential, Commercial, and Light-Industrial Environments);
- FCC Part 15.109(G): 2012 Class B

This product is CE compliant for all applications.

FCC Information to the User

This equipment has been tested and found to comply with the limits for a Class B digital device when powered by a DC source, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- ~ Reorient or relocate the receiving antenna.
- ~ Increase the separation between the equipment and the receiver.
- ~ Consult the dealer or an experienced radio/TV technician for help.

Firmware Revision

This manual applies to FLEXmax Extreme charge controllers with a firmware revision of 001.xxx.000 or higher.

To check the current revision using the MATE3 system display, see page 46.

To check the current revision using the MATE or MATE2 system display, see page 51.

For instructions on updating the firmware revision, see page 46.

Temperature Range and Derating

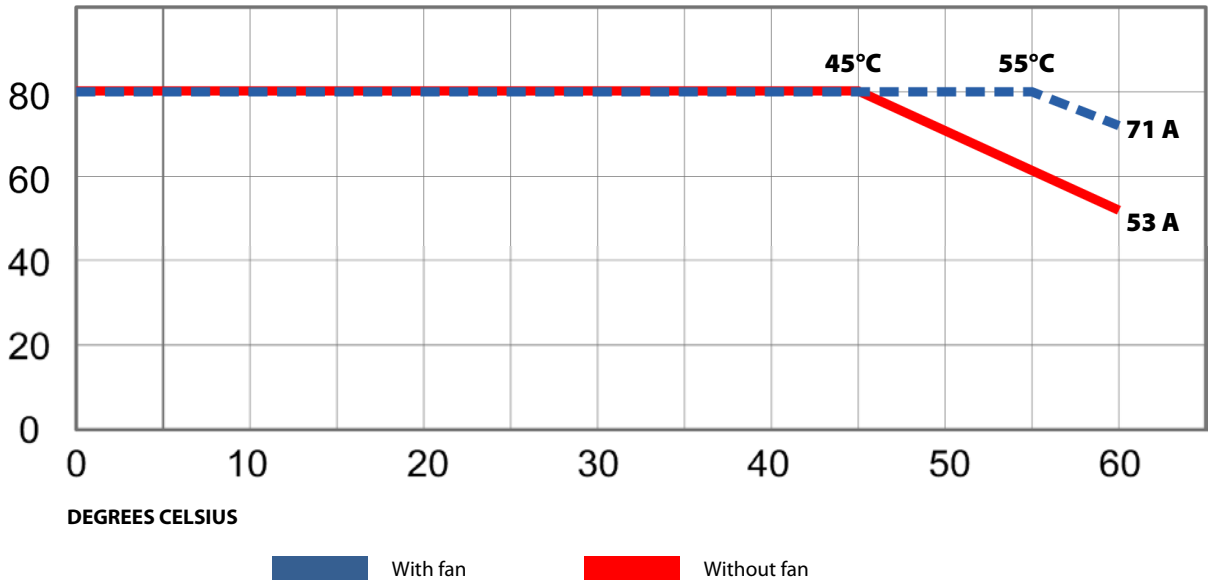

Figure 61 Temperature Range

In standard installations, the FLEXmax Extreme can operate at its full 80-amp capacity at ambient temperatures up to 45°C (113°F). Above this temperature, its output is derated as shown in Figure 61. At 60°C (140°F), the output is derated to a maximum of 53 Adc. The controller is not rated for operation above this temperature.

If the optional fan is installed (see page 10), the FLEXmax Extreme does not begin to derate until it reaches 55°C (131°F). At 60°C (140°F), the output is only derated to 71 Adc. The controller is still not rated above this temperature, even with the fan installed.

See page 32 for the internal temperature readings which can cause temperature derating.

Default Settings and Ranges

The settings in this table are as displayed in the MATE3 system display for a 12-volt system.

Table 10 FLEXmax Settings (MATE3)

Mode	Menu Item	Setting
Charger	***Absorb Voltage***	Default 14.4 Vdc Range: ***Float*** setting to 80 Vdc
	(Absorb) Time	Default 01.0 hours Range: 00.0 to 24 hours
	Float	Default 13.8 Vdc Range: 12.0 Vdc to ***Absorbing*** setting
	Rebulk Voltage	Default 12.0 Vdc Range: 12.0 Vdc to ***Float*** setting
	Current Limit	Default 80 Adc Range: 5 to 80 Adc
	Absorb End Amps	Default 00 Adc Range: 00 to 55 Adc
MPPT	***MPPT Mode***	Default **<Auto >** **<Auto>** or **U-Pick>**
	U-Pick VOC	Default 77% Voc Range: 40 to 90% Voc
	Wakeup VOC Change	Default 1.5 Vdc Range: 1.5 to 9.5 Vdc
	(Wakeup VOC) Time	Default 05 minutes Range: 05 to 15 minutes
	Snooze Mode Amps	Default 0.6 Adc Range: 0.2 to 1.0 Adc
	MPP Range Minimum	Default <**Half>** **<Half or Full>**
	(MPP Range) Maximum	Default **<90%>** **<80, 85, 90, 99%>**
Temperature Compensation	***Mode***	Default **<Wide >** **<Wide>** or **<Limited>**
	Slope	Default 5 mV Range: 2 to 6 mV
	Lower Battery Voltage	Default 14.1 Vdc Range: 10 Vdc to ***Upper Battery Voltage*** setting
	Upper Battery Voltage	Default 14.1 Vdc Range: ***Lower Voltage*** setting to 80 Vdc
Battery Equalize	***Equalization Voltage***	Default 14.4 Vdc Range: ***Absorb Voltage*** setting to 80 Vdc
	(Equalization) Hours	Default 01 hours Range: 1 to 7 hours
	Automatic Battery Equalization	Default 0 days Range: 0 to 250 days
Grid-Tie Mode	***Enable Grid-Tie Mode***	Default ***N*** Range: ***Y*** or ***N***
Auxiliary Output	***Diversion:Relay***	Default **<Off>** **<On, Auto, Off>**
	Active	Default ***Active High*** Range: ***Active High*** or ***Active Low***
	Relative Voltage	Default 0.0 Vdc Range: 0.0 to 5.0 Vdc
	Hysteresis	Default 00.2 Vdc Range: 0.0 to12.0 Vdc
	Hold	Default 0.1 second Range: 0.0 to 25 seconds
	Delay	Default 0.0 seconds Range: 0.0 to 24 seconds

Table 10 FLEXmax Settings (MATE3)

Mode	Menu Item	Setting
Auxiliary Output	***Diversion:Solid St***	Default **<Off>** **<On, Auto, Off>**
	Relative Voltage	Default 0.0 Vdc Range: 0.0 to 5.0 Vdc
	Hysteresis	Default 0.2 Vdc Range: 0.0 to12.0 Vdc
	Hold	Default 0.1 second Range: 0.0 to 25 seconds
	Delay	Default 0.0 seconds Range: 0.0 to 24 seconds
	Low Batt Disconnect	Default **<Off>** **<On, Auto, Off>**
	Disconnect	Default 13.6 Vdc Range: 10 to 80 seconds
	Reconnect	Default14.4 Vdc Range: 10 to 80 seconds
	Disconnect Delay	Default 01 second Range: 0 to 250 seconds
	Remote	Default **<Off>** **<On, Auto, Off>**
	Vent Fan	Default **<Off>** **<On, Auto, Off>**
	Enable Voltage	Default 14.4 Vdc Range: 10. 0 to 80.0 Vdc
	PV Trigger	Default **<Off>** **<On, Auto, Off>**
	Active	Default ***Active High*** Range: ***Active High*** or ***Active Low***
	Enable Voltage	Default 140 Vdc Range: 20 to150 Vdc
	Hold Time	Default 01.1 second Range: 0 to 25 seconds
	Error Output	Default **<Off>** **<On, Auto, Off>**
	Low Battery Voltage	Default 11.5 Vdc Range: 10 to 80 Vdc
	Night Light	Default **<Off>** **<On, Auto, Off>**
	Active	Default ***Active High*** Range: ***Active High*** or ***Active Low***
	Threshold	Default 010 Vdc Range: 5 to 150 Vdc
	ON Time	Default 4 hours Range: 00 to 23 hours
	Hysteresis Time ON	Default 1 minute Range: 1 to 255 minutes

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Applications

Array Design

Sizing Guidelines

Below is a list of maximum array wattages for the FLEXmax Extreme for various nominal voltage batteries. This should be used for sizing an array. Note that every PV module is different. The specifications for every model should be consulted before designing or assembling a PV array.

Table 11 Maximum Input Wattage Per Charge Controller

Nominal Battery Voltage	Maximum Array Size (in watts, Standard Test Conditions)
12 V	1000 W
24 V	2000 W
36 V	3000 W
48 V	4000 W
60 V	5000 W

Maximum-Power Voltage (V_{mp})

Maximum-power voltage (V_{mp}) is the operating voltage for the PV array at which the array generates the most wattage. When designing the PV array, it is recommended for the V_{mp} to be approximately 12 to 24 volts higher than the nominal battery voltage for optimum performance. This will ensure that the V_{mp} is always above the battery voltage, which is required for charging. Higher voltages are not recommended, as they may reduce the FLEXmax Extreme conversion efficiency.

IMPORTANT:

Check the PV array voltage before connecting it to the FLEXmax Extreme.

Open Circuit Voltage (V_{oc})

Open-circuit voltage (V_{oc}) is the *unloaded* voltage generated by the PV array. The FLEXmax Extreme controller can withstand V_{oc} of up to 150 Vdc. However, if the V_{oc} exceeds 145 Vdc, the controller will suspend operation to protect the system components.

CAUTION: Equipment Damage

Although the FLEXmax Extreme shuts down when voltage is greater than 145 Vdc, this will not prevent the array from generating voltage. Anything higher than 150 Vdc will damage the controller, whether it has shut down or not. The array should be designed so that voltage never exceeds 145 Vdc in order to prevent equipment damage.

Weather Conditions

Cooler climates can cause the V_{oc} to rise above the array's rated V_{oc}. In climates that observe temperatures less than approximately -15°C (5°F), a V_{oc} greater than 125 Vdc is not recommended.

Hot weather: lower V_{oc} and lower V_{mp}

Cold weather: higher V_{oc} and higher V_{mp}

If the specific voltage temperature correction factor is not known for a particular module, allow for ambient temperature correction using the following information:

25° to 10°C (77° to 50°F)	multiply V_{oc} by 1.06
9° to 0°C (49° to 32°F)	multiply V_{oc} by 1.10
-1° to -10°C (31° to 14°F)	multiply V_{oc} by 1.13
-11° to -20°C (13° to -4°F)	multiply V_{oc} by 1.17
-21° to -40°C (-5° to -40°F)	multiply V_{oc} by 1.25

Maximum Power Point Tracking

Maximum Power Point Tracking (MPPT) is the technology used by FLEXmax charge controllers to optimize the harvest of power from PV arrays.

PV modules do not have a defined operating voltage. Their voltage is defined strictly by the load connected to them. With no load (disconnected), a module displays "open-circuit" voltage (V_{oc}), and delivers no current. At full load (shorted), a module has no voltage, although it delivers the maximum "short-circuit" current (I_{sc}). In neither case does it produce usable wattage.

When partially loaded, a PV module delivers partial current and voltage. These numbers can be multiplied to see the available wattage. However, the delivery of wattage is not linear. The current and voltage delivered at a given load will change with the load, along a curve such as that shown in the drawing to the left in Figure 62. This is known as the V-I curve. The wattage is different at every point along the curve. (The V-I curve also varies with module type and manufacturer.) Only one point on the V-I curve represents the delivery of the module's maximum (rated) wattage. This is known as the maximum power point, or MPP. The current at this point, Imp, is the highest that can be drawn while still maintaining the highest voltage, V_{mp}.

The FLEXmax controller places a variable load on the PV array and tracks the result to determine the maximum power point. This process, MPPT, is maintained so that the FLEXmax can deliver the maximum PV power regardless of any change in conditions. The drawing to the right in Figure 62 shows the MPP and compares the V-I curve against the available wattage.

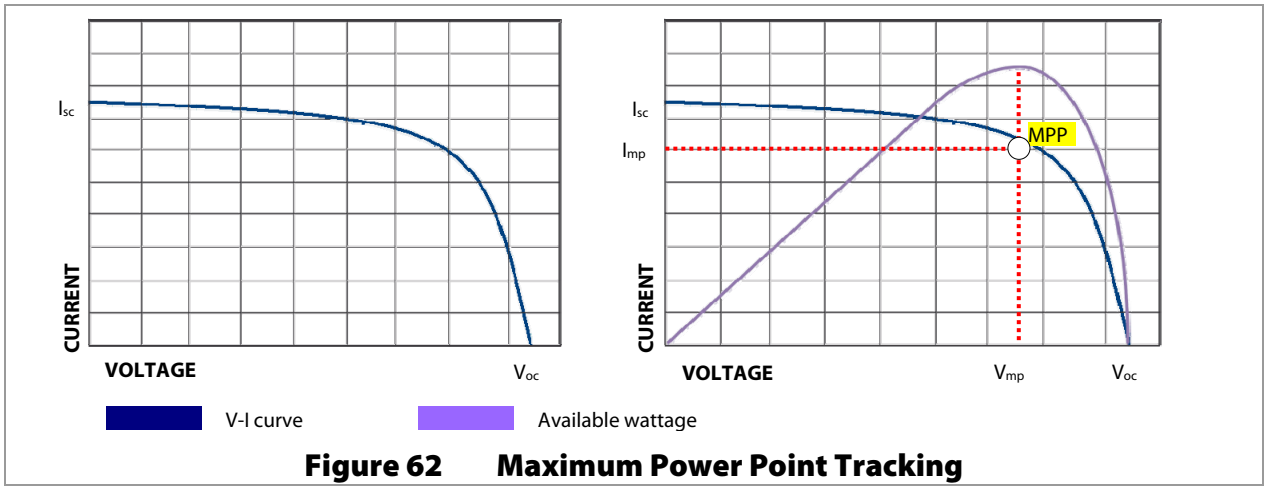


Figure 62 Maximum Power Point Tracking

Three-Stage Battery Charging

The FLEXmax Extreme charge controller is a sophisticated, multi-stage battery charger that uses several regulation stages to allow fast recharging of the battery system while ensuring a long battery life. This process can be used with both sealed and non-sealed batteries. The FLEXmax Extreme is a "buck" converter which turns higher PV voltages into the lower charging voltages used by batteries (with correspondingly higher currents). The chart in Figure 63 shows the voltage levels achieved by the PV array throughout a typical day, and the battery voltages (by stage) during the same times.

The FLEXmax has preset recharging voltage set points (Absorbing and Float voltages); however, OutBack always recommends using the battery manufacturer's recommended charging voltages.

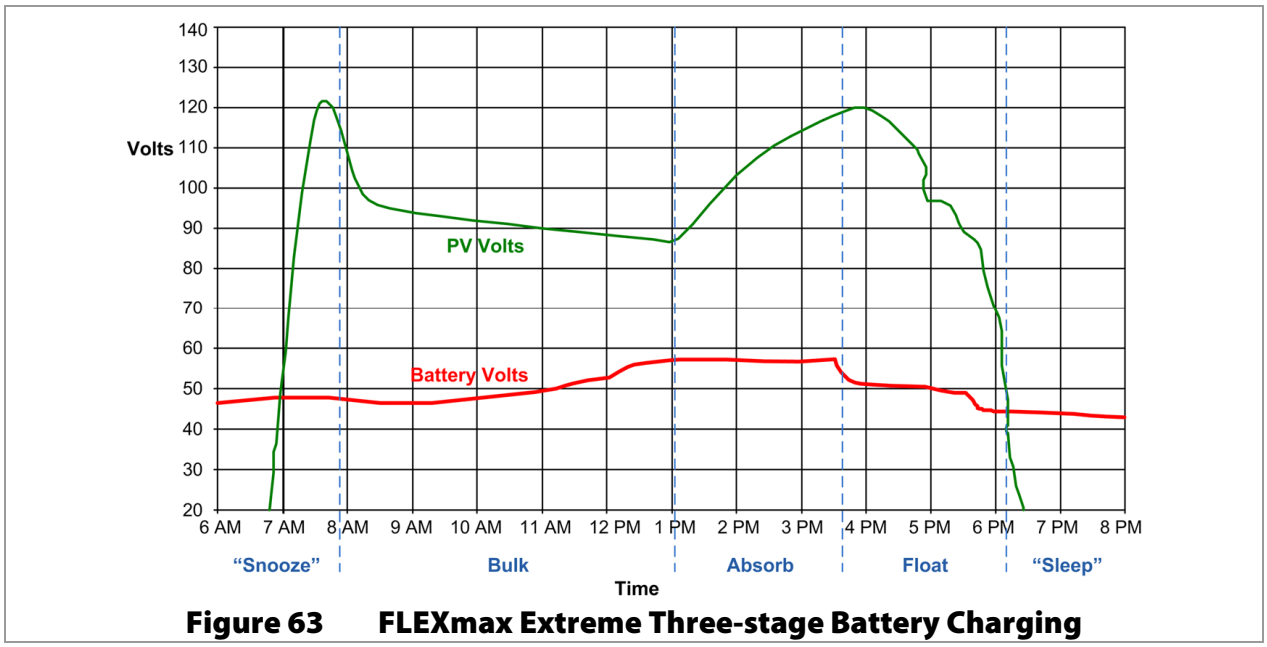


Figure 63 FLEXmax Extreme Three-stage Battery Charging

A new charge cycle is started any time the battery voltage decreases below the ***Rebulk*** set point for 90 seconds or more. (See page 36.) This usually occurs each night unless the batteries were maintained by another means. (If so, they may not need to be recharged).

Bulk

This is the first stage in the three-stage charge cycle. It is a constant-current stage which drives the battery voltage up. The DC current is the maximum current the charger can deliver. This stage typically leaves the batteries at 75% to 90% of their capacity, depending on conditions.

In Bulk, the controller will charge the batteries to the ***Absorbing*** voltage setting (see page 36). This stage is not timed. It will charge as long as necessary, regardless of any timer set points. If little PV energy is available, it may take a long time for Bulk to complete. If the FLEXmax is in a different charging stage and little PV energy is available, it may return to Bulk. (See page 25.) This stage is temperature-compensated. (See page 72.)

Absorption

This is the second stage of charging. It is a constant-voltage stage. Current varies as needed to maintain the ***Absorbing*** voltage setting, but will typically decrease to a very low number over time. This "tops off the tank", leaving the batteries at essentially 100% of capacity.

The duration of the Absorption stage is the user-defined ***Absorb Time Limit***. Once in Absorbing, the internal counter will count until it reaches this limit. (See page 26.) The controller will then exit Absorbing and enter the

Float stage. The charger will also also exit Absorbing if the ***Absorb End Amps*** setting is reached, regardless of the timer. This resets the timer to zero. (See page 36.) This stage is temperature compensated.

Float

This is the third stage of charging. It is a constant-voltage stage. The batteries are maintained at the ***Float*** set point. This stage is not timed. The FLEXmax Extreme will continue to maintain ***Float*** as long as PV energy is available. Current varies as needed to maintain the voltage, but typically drops to a low number.

If the PV cannot supply enough power to maintain the ***Float*** set point, the FLEXmax Extreme will not immediately initiate a new charge cycle. It will attempt to draw more PV energy and recharge the battery until the Float voltage set point is reached. This stage is temperature compensated. (See page 72.)

A new charge cycle can be initiated if the voltage falls below the ***ReBulk*** set point for 90 seconds or more (see page 36).

Equalize

Equalization is a controlled overcharge that is part of regular battery maintenance. Equalization follows the same pattern as standard three-stage charging. However, it brings the batteries to a much higher voltage and maintains this voltage for a period of time. This has the result of removing inert compounds from the battery plates and reducing stratification in the electrolyte.

The set points for equalization are adjustable with the MATE3 system display. See page 38.

CAUTION: Battery Damage

- Do not equalize any sealed battery types (VRLA, AGM, Gel, or other) unless approved by the manufacturer. Some batteries may suffer severe damage from equalization.
- Contact the battery manufacturer for recommendations on equalization voltage, duration, schedule, and/or advisability. Always follow manufacturer recommendations for equalization.

Equalization is normally performed only on flooded lead-acid batteries. The schedule for equalization varies with battery use and type, but it is usually performed every few months. If performed correctly, this process can extend battery life by a considerable amount.

Equalization can be triggered manually. To trigger equalization, press the EQ button located on the front of the charge controller. (See page 6.) Hold this button for 5 to 10 seconds, then release. Once triggered, the Status indicator begins alternating amber and green once per second. If the batteries are below 1.75 Vpc, the Status indicator will alternate amber and red. (See page 23.)

Equalization can also be triggered on an automatic schedule. The settings for this schedule are adjustable with the MATE3 system display. See page 38.

Battery Temperature Compensation

Battery performance changes when the temperature varies above or below room temperature (77°F or 25°C). Temperature compensation is a process that adjusts charging to correct for these changes.

When a battery is cooler than room temperature, its internal resistance goes up and the battery voltage changes more quickly. This makes it easier for the charger to reach its voltage set points. However, while accomplishing this process, the charger will not deliver all the current that the battery requires. As a result, the battery will tend to be undercharged.

Conversely, when a battery is warmer than room temperature, its internal resistance goes down and the voltage changes more slowly. This makes it harder for the charger to reach its voltage set points. It will continue to deliver energy as time passes until the charging set points are reached. However, this tends to be far more than the battery requires, meaning it will tend to be overcharged.

The FLEXmax Extreme controller, when equipped with the Remote Temperature Sensor (RTS), will compensate for temperature. The RTS is attached to a single battery near the center of the bank. When charging, the RTS will increase or decrease the charge voltage by 5 mV per degree Celsius per battery cell. This setting affects the ***Absorbing*** and ***Float*** set points. Equalization is not compensated in the FLEXmax Extreme.

There can be side effects to temperature compensation. During cold weather, a battery often requires a higher charging voltage. Some inverters might not accommodate these higher voltages and can shut down during charging, cutting off power to their loads. In addition, some battery manufacturers specify not to exceed a certain voltage due to the risk of battery damage.

To accommodate these problems, the FLEXmax Extreme has adjustable compensation limits. It also has an adjustable rate of compensation ("slope") to meet the requirements of certain batteries. The default slope value is 5 mV per degree C.

When the system includes an OutBack HUB Communications Manager and a system display, only one RTS is needed for multiple inverters and charge controllers.

See page 38 for more information on these items.

Table 12 Examples of Compensation

Cells (volts)	Slope Value	Temp	25° ±	Calculation	Total Compensation
6 (12V)	5 mV	8°C	-17	6 x 0.005 x 17	+0.5 Vdc
12 (24V)	3 mV	36°C	+11	12 x 0.003 x 11	-0.4 Vdc
18 (36V)	5 mV	26°C	+1	18 x 0.005 x 1	-0.1 Vdc
24 (48V)	6 mV	0°C	-25	24 x 0.006 x 25	+3.6 Vdc
30 (60V)	2 mV	37°C	+12	30 x 0.002 x 12	-0.7 Vdc

FLEXnet DC Battery Monitor (FN-DC)

The OutBack FLEXnet DC will work normally if it is networked with the FLEXmax Extreme and OutBack inverters. This requires a HUB Communications Manager.

If the FN-DC is networked exclusively with FLEXmax Extreme charge controllers and a HUB product, the FLEXmax Extreme AUX– terminal must be connected to the battery negative conductor. (This item is terminal ⑤ on the Accessory Terminal Block.) The FN-DC will not function until this is done.

Any devices connected to the AUX+ and AUX– terminals should be electrically isolated. (Examples include, but are not limited to, coil relays, optical isolators, or fans.)

CAUTION: Equipment Damage

Using non-isolated devices in this application can damage the controller and other devices. This damage is not covered under warranty.

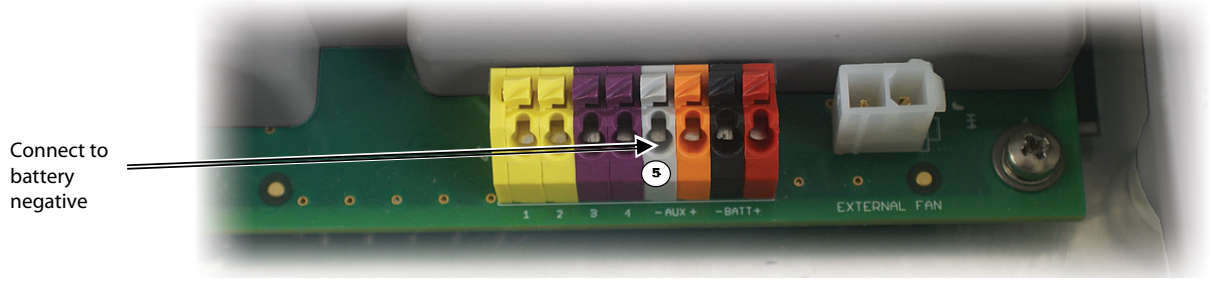


Figure 64 Adapting for the FN-DC

Positive-Ground Systems

The FLEXmax Extreme can be used in a positive-ground system. However, due to internal grounding paths between the controller and other devices, positive grounding allows only certain combinations of devices in the configuration. These combinations are dependent upon whether or not the system is networked together or the devices stand alone.

CAUTION: Equipment Damage

A system requiring positive grounding should only use the configurations specified in this section. Connecting the FLEXmax Extreme in other positive-ground configurations can damage the controller and other devices. This damage is not covered under warranty.

Networked Devices

A networked system includes the HUB Communications Manager and the MATE3 or MATE System Display in the configuration. The following conditions apply for all positive-ground devices communicating in a networked system. The conditions do not apply to non-communicating devices. (See Non-Networked Devices.)

- Multiple FLEXmax Extreme controllers can be networked.
- Multiple OutBack inverters cannot be networked with this charge controller.
- One OutBack inverter or one previous-model OutBack controller (FLEXmax or MX Series) can be networked with one or more FLEXmax Extreme controllers if the following conditions are true:
  - ~ The FLEXnet DC Battery Monitor (FN-DC) is not present on the network
  - ~ No devices are connected to the Ethernet port on the MATE3

  This configuration is depicted on page 14 (using one inverter and one FLEXmax Extreme)
- The FN-DC can be networked with one or more FLEXmax Extreme charge controllers if the following conditions are true:
  - ~ No OutBack inverters are on the network
  - ~ No previous-model OutBack charge controllers are on the network
  - ~ No devices are connected to the Ethernet port on the MATE3.
- The Ethernet port on the MATE3 can be used if the network is limited to one or more FLEXmax Extreme controllers. No other OutBack devices can be present.
- Any devices connected to the AUX+ and AUX– terminals should be electrically isolated. (Examples include, but are not limited to, coil relays, optical isolators, or fans.) This can be ignored if no devices are connected to the HUB/Display port.

Non-Networked Devices

Non-networked devices provide information individually instead of using a communications manager or a single system display. This definition also applies to devices which work in common with a networked system but do not communicate with it.

The restrictions under “Networked Devices” do not apply when using the FLEXmax Extreme in a positive-ground system with non-networked devices. For example:

- The MATE3 Ethernet port can be used with both the FLEXmax Extreme and an inverter if the MATE3 is plugged directly into the FLEXmax Extreme.
- Multiple inverters can be used if they are not connected to the communications manager.

NOTE: Other, non-OutBack devices may have their own restrictions.

Grid-Interactive Settings

When using an OutBack inverter, FLEXmax Extreme, HUB Communications Manager, and system display, set the Grid-Tie Mode menu to ***Y*** in the system display. This mode allows the inverter to manage the charge controller's Float setting. It ensures the controller always keeps the battery above the sell voltage of the inverter. (See page 39.)

When using a FLEXmax Extreme charge controller with an inverter without the use of a HUB, GT mode will not work because the charge controller cannot communicate with the inverter. In this situation, when selling electricity back to the grid, keep the inverter's "sell" voltage setting below the charge controller's Float setting. In a 24-volt battery system, the difference should be at least 0.5 Vdc. In a 48-volt system, the difference should be at least 1.0 Vdc.

Hydroelectric and Fuel Cell Applications Performance Optimization

The FLEXmax Extreme charge controller is designed to work with PV arrays. Although it will work with hydroelectric turbines and fuel cells, OutBack Power Technologies can only offer limited technical support for these applications due to variance in turbine and fuel cell specifications.

IMPORTANT:

The FLEXmax Charge Controller is not usable for direct regulation of wind turbine input and OutBack cannot warranty its use in these applications. In wind turbine applications, the FLEXmax is recommended as a diversion controller.

Using the MATE3 system display, the maximum power point tracking (MPPT) function can be set to ***Auto*** or ***U-Pick VOC*** mode. (See page 37.) The MPPT function is based on the open-circuit voltage (V_{oc}) of the DC source. This is the unloaded voltage displayed by the source when it is disconnected. MPPT values are expressed as a percentage of V_{oc}. ***Auto*** mode allows the FLEXmax Extreme to sweep the range of percentages. The ***Auto*** mode begins at the maximum value and loads the array, working its way through lower voltages, until it locates the input voltage that yields maximum wattage.

Auto Track Mode

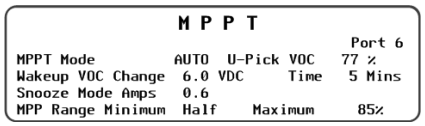
The default minimum value of ***Auto*** is ***Half*** (50% of V_{oc}). The default maximum is 90% of V_{oc}. This is the standard maximum-power range for PV. A hydroelectric or fuel-cell system's operating voltage may operate in a different range and often have a maximum-power voltage close to the battery voltage. The FLEXmax Extreme allows a user to set a sweep range more appropriate for the source. The minimum setting can be changed to ***FULL***, which is 40% of the V_{oc}. The maximum value can be set from 80% to 99% of V_{oc} if necessary.

This adjustment only affects the initial tracking at the beginning of the day and any subsequent trackings caused by ***Auto-Restart*** or any forced restart of the FLEXmax Extreme.

U-Pick Mode

If an optimal voltage is known for a given DC source, then this voltage can be set as a designated V_{oc} percentage in ***U-Pick*** mode. This percentage is assigned in the ***U-Pick VOC*** set point, which allows a range of 40% to 99% of V_{oc}. If ***U-Pick*** is chosen, the FLEXmax Extreme will load the source to operate continuously at the designated voltage. It will not sweep for the maximum power point and will ignore all ***Auto*** values.

MPPT Menu



To adjust the range limits:

1. In the MATE3, navigate to the ***MPPT*** menu. (See page 35. See page 37 for more information about the items on this page.)
2. Select the ***MPPT Mode*** menu item. Set it to ***U-Pick***.
3. Select the ***U-Pick VOC*** menu item. Set it to a percentage value that is appropriate to the charging source.
4. Select the ***MPP Range Minimum*** menu item. Set it to ***Full***.

Figure 65 Adjusting Range Limits for Hydroelectric or Fuel-cell Applications

Definitions

The following is a list of initials, terms, and definitions used with this product.

Table 13 Terms and Definitions

Term	Definition
AC	Alternating Current; refers to voltage produced by the inverter, utility grid, or generator
AGS	Advanced Generator Start
AUX	Inverter's 12-volt auxiliary output
AXS Card	Optional Modbus Ethernet accessory for the FLEXmax Extreme
CE	Conformité Européenne; French for "European Conformity"; a marking on OutBack products indicating that they meet European Union requirements
DC	Direct Current; refers to voltage produced by the batteries or renewable source
Derate	Automatic reduction of the FLEXmax Extreme rated output of 80 Adc; usually performed for temperature reasons
DVM	Digital Voltmeter
EMI	Electromagnetic Interference; a detrimental condition that affects electronic circuits
EPO	Emergency Power Off; a manual switch intended to disconnect power on short notice
FET	Field Effect Transistor; a reference to a temperature reading by the FLEXmax Extreme
FN-DC	FLEXnet DC; the OutBack Battery Monitor
GFDI	Ground Fault Detector/Interruptor; shuts down the system if a ground fault event occurs
Grid-interactive, grid-tie	Utility grid power is available for use and the system is capable of returning (selling) electricity back to the utility grid
Ground Fault	An unsafe condition of current flow to ground, resulting from accidental contact between an electrical source and ground
I_{mp}	Maximum-power current; the current harvested by MPPT when operating at the V_{mp}
I_{sc}	Short-circuit current; the fully-loaded current displayed by a PV module or array
LED	Light-Emitting Diode; refers to indicators used by the FLEXmax Extreme and the system display
MPP, MPPT	Maximum Power Point, Maximum Power Point Tracking
Negative-Ground	A wiring system that bonds the negative conductor to ground for safety
Network	OutBack devices which communicate on a bus established by the HUB Communications Manager
Positive-Ground	A wiring system that bonds the positive conductor to ground for safety

Table 13 Terms and Definitions

Term	Definition
PWM	Pulse-Width Modulation
PV	Photovoltaic
RTS	Remote Temperature Sensor; accessory that measures battery temperature for charging
SK	Soft Key; a key with programming that varies with screen
Slope	A selectable rate of battery temperature compensation
Sweep	Part of the MPPT process; the controller is attempting to locate the V_{mp}
System display	Remote interface device (such as the MATE, MATE2, or MATE3), used for monitoring, programming and communicating with the inverter; also called “remote system display”
V_{mp}	Maximum-power voltage; the voltage sought by MPPT where maximum power is harvested
V_{oc}	Open-circuit voltage; the unloaded voltage displayed by a PV module or array

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