How To Set Up SimpliPhi™ Batteries Using OutBack Chargers

Introduction

The main focus of this application note will be on setting up OutBack charging sources for best operational performance for SimpliPhi™ lithium ferro phosphate (LFP) batteries: model 3.4 which is currently obsoleted and replaced by model 3.5. Basic specifications for both models are in Table 1 with program settings for both in Table 2.

Table 1 SimpliPhi Model 3.4 (3.5) Specifications

PHI 3.4	24V	48V
Nominal DC Voltages	25.6	51.2
Amp Hours	134 (138)	67 (69)
Rated kWh Capacity @ C2	3.4 (3.5) kWh	
Max Output Capacity	60 Adc (10 mins)	
Max Charge Current	45 Adc	33 (34) Adc
DC Voltage Range	20 to 28.8	40 to 57.6
Depth of Discharge	Up to 100%	
Operating Efficiency	98%	
Operating Temp	–20° to 60°C	
Charging Temp	0° to 49°C	
Self-Discharge Rate	<1% loss per month	
Cycle Life	10,000+ (@ 80% DOD)	
Memory Effect	None	
Warranty Period	10 Years	
Dimensions	13.5 x 14 x 8 inches / 0.88 cu. ft.	
Weight	75.5 (77.5) lbs	

Table 2 Program Settings for SimpliPhi Model 3.4 (3.5), 24V / 48V

INVERTER	80% DoD, 10k cycles	90% DoD, 5k cycles	100% DoD, 3.5k
Absorb Voltage and Time	27.8 / 55.4, 0.1 hour	28.4 / 57.2, 0.1 hour	
Float Voltage and Time	27 / 54 (default), Time = 0 = Disable		
Re-Float Voltage	25 / 50 (Disabled, leave at default)		
Re-Bulk Voltage	25.3 / 50.6		
AC Input Mode	Grid Tied (default, adjust as needed)		
SellRE (Offset) Voltage	26 / 52 (default)		
AC Charger Limit in AC	24V = 5A @ 240V, or 10A @ 120V 48V = 7A @ 240V, or 14A @ 120V		
Low Battery Cut-Out Voltage	25.1 / 50.2	24.8 / 49.6	24 / 48
Low Battery Cut-In Voltage	26 / 52		
CHARGE CONTROLLER			
Absorb Voltage and Time	28 / 56, 0.1 hour	28.8 / 57.6, 0.1 hour	
Float Voltage	27 / 54 (Default)		
Rebulk Voltage	25.3 / 50.6		
DC Current Limit	45 / 33 (34) Use full 80A only for multiple batteries – see Tips and Precautions		
Absorb End Amps	0		
FLEXnet DC (FN-DC)			
FN-DC Battery Ah	140 / 70 (see Tips & Precautions)		
FN-DC Charge Voltage	27.6 / 55.2	28.2 / 57.0	
FN-DC Charged Return	8A / 4A		
FN-DC Battery Charge	98%		
FN-DC Relay Invert Logic	No (see Tips & Precautions for applications requiring FN-DC Relay)		
FN-DC Relay Voltage	High = 53 (26.5 for 24V system) Low = 49.6 (28.8 for 24V system)		
FN-DC Relay SOC High/Low	SOC High = 0% SOC Low = 0%		
FN-DC Relay Delay	High = 1, Low = 0		
MATE3 / MATE3s			
FLEXnet DC Advanced	Low SOC Warning = 20%		
FLEXnet DC Advanced	Critical SOC Warning = 10%		

OutBack Inverter and Charge Controller Charging Setup Procedure

The SimpliPhi batteries have a very fast current dropoff when the ***Absorb*** voltage target is met. This can be problematic, as when the SimipliPhi batteries are full, the current drops to nearly zero. This is unlike a lead-acid battery where the end amps are typically 2-3% of the battery Ah rating and never drop to zero. Under these lightly loaded conditions, the OutBack charging devices cannot regulate as well, causing voltage fluctuations that may rise above the limit of the SimpliPhi input overvoltage protection circuit. This may cause the OutBack inverter system to shut down. The minimum Absorb time is 0.1 hour, or six minutes. If the charge voltage creeps up to the SimpliPhi input protection voltage (~60-62 volts), then the ***Charge Termination Control*** function can be implemented. (Settings are listed under FN-DC setup on page 5). These settings can be used to detect the current dropoff to end the charge cycle.

The following steps are performed in the MATE3 or MATE3s system display's ***Main Menu***. Bring up the ***Enter Password*** screen using the LOCK navigation key. Enter the password **141** for the ***Main Menu***.

1. Enter the inverter charger settings.
    a. From the ***Main Menu***, select the ***Settings*** menu.
    b. From the ***Settings*** menu, select the ***Inverter*** menu.
    c. From the ***Inverter*** menu, select the ***Battery Charging*** screen. Enter the ***Absorb*** charging settings listed in Table 2. Set the ***Float*** charging time to zero to disable it (as the SimpliPhi battery only requires a single charging source voltage).
    d. Press the UP navigation key and select the ***AC Input and Current Limit*** screen. Enter the charger settings listed in Table 2. **NOTE**: the values listed are for maximum charge current.
    e. Press the UP navigation key and select the ***Low Battery*** screen. Enter the ***Low Battery Cut-Out*** and ***Cut-In*** voltages listed in Table 2.
2. Enter the inverter settings for operating modes.
    a. From the ***Main Menu***, select the ***Settings*** menu.
    b. From the ***Settings*** menu, select the ***Inverter*** menu.
    c. From the ***Inverter*** menu, select the ***AC Input Mode and Limits*** screen for the appropriate input. Set ***Input Mode*** for desired operating mode.
        - Grid Connected Offset (AC “blending”) modes: Grid Tied, Grid Zero, Support or Mini Grid
        - Off-Grid modes: Backup or Generator

        NOTE: More information on input modes can be found in the Radian or FXR *Operator Manuals* and the application notes on Offset and AC Input Modes, located at **www.outbackpower.com**.
3. Enter the charge controller charger settings.
    a. From the ***Main Menu***, select the ***Settings*** menu.
    b. From the ***Settings*** menu, select the ***Charge Controller*** menu.
    c. From the ***Charge Controller*** menu, select the ***Charger*** screen. Enter the ***Absorb*** and ***Float*** settings listed in Table 2. **NOTE**: The table shows settings for Model 3.4. For other models, set the Absorb and Float voltages 0.4 Vdc higher than the inverter settings (0.2 Vdc for 24V systems) to give priority charging to the charge controller.

4. Enter the charge controller current limits.

    a. Each charge controller has its own current limit from the maximum setting down to five amps. Typically the charge controller is left to the maximum setting so all available RE is accessible at all times. If for some reason the maximum current from the charge controller output needs to be limited, it can be changed from the default maximum setting on the MATE3 using the following steps.

        i. From the ***Main Menu***, select the ***Settings*** menu.

        ii. From the ***Settings*** menu, select the ***Charge Controller*** menu.

        iii. From the ***Charge Controller*** menu, select the ***Charger*** screen. Scroll to ***Current Limit*** and enter the setting ***Leave Absorb End Amps*** at 0.

    b. Global Charge Control (GCC) is a MATE3 function that limits the total charge controller current to prevent overcharging of the batteries. For example, if the maximum charging current for a battery bank is 100 Adc, then the maximum current setting for GCC is also set to 100 Adc. If the inverter contributes 50 Adc, then the GCC function in the MATE3 will then limit the total charge controller output to 50 Adc so the total net current to the batteries will be 100 Adc. It is important to note that GCC does not regulate or affect inverter charging at all. It simply factors the inverter current into the equation for the total net current to the battery bank. Also, the GCC uses the charge controller's ***Grid Tie Mode*** to implement the global current control.

        Use the following steps to program the MATE3 for Global Charge Control.

        i. From the ***Main Menu***, select the ***Settings*** menu.

        ii. From the Settings menu, select the ***MATE3*** menu.

        iii. From the ***MATE3*** menu, select the ***Global Charger Output Control*** screen. Change the ***Enable*** setting to ***Y***(es). Enter the desired ***Maximum Battery Charge*** amps.

        iv. Press the UP navigation key to return to the ***MATE3*** menu.

        v. From the ***MATE3*** menu, select the ***Grid-Tie Sell*** screen. Change the ***Enable*** setting to ***Y***(es).

OutBack FLEXnet DC Setup Procedure

The FLEXnet DC Battery Monitor (FN-DC) provides three main functions: 1) data logging of shunt information (including daily kWh), 2) charge termination control, and 3) state of charge (SoC). Charge termination control will terminate charging from all OutBack chargers (including inverters and charge controllers) when the FN-DC ***Battery Setup*** settings of ***Charged Voltage*** and ***Time***, plus the ***Charged Return Amps*** are all met. Meeting these charge parameters is an indication that the battery is full and charging should stop. This can save wear and tear on the batteries if (for some reason) multiple absorption cycles are initiated with minimal battery discharge. In this case, the charge parameters will probably be met more quickly than the ***Absorb*** time and can terminate the cycle so the batteries do not become overcharged. Meeting the charge parameters will also set the SoC to 100%.

The ***Charged Voltage*** setting is typically 0.2 Vdc lower than the lowest charger's Absorb voltage setting. This ensures the parameter is met in case there is a discrepancy between the voltmeters of the charging device and the FN-DC. The time setting is typically about 3-10 minutes depending on the battery.

Return Amps is typically 2-3% of the battery amp-hours, but should use the settings in Table 2 with the SimpliPhi batteries. The charging current drops off more dramatically when the charging voltage is met.

The FN-DC battery function that measures amps in and out of the battery can only determine SoC after measuring against other factors. These include the ***Battery Ah*** and the battery ***Charge Factor*** (BCF) settings. This allows the FN-DC to determine when the battery bank is full. For example, if the batteries are 90% efficient then it would take 100 Ah plus another 10% (10 Ah) to fully recharge a 200 Ah battery bank that had been discharged 50%. In this case, the FN-DC would measure 100 Adc on the discharge, then 110 Adc on the recharge before indicating the batteries are at the point of 100% SoC.

However, a single SimpliPhi 3.4 battery only has 67 Ah. The lowest setting in the FN-DC is 100 Ah. One possibility is to double the apparent battery size to exceed the 100 Ah lower limit. The doubled setting will also prevent the low SoC warning light from coming on if the batteries are mostly or fully discharged. (The FN-DC is programmed for batteries that cannot be discharged as low as lithium ferro phosphate batteries.) Note that this will add a 2× error to the SoC% reading, but the SoC% reading would simply be divided by two to get a more approximate value (while keeping the warnings from coming on and causing undue low battery concerns from the site owner). Also, lowering the ***SoC Warning*** and the ***SoC Error*** settings will also keep the SOC warning lights from coming on. These settings are listed in Table 2 and are also discussed on the next page.

In the example of the SimpliPhi 3.4 battery above, the ***Battery Ah*** would be set at 134, doubling the battery size. The user would need to divide all percentage and amp-hour readings by two.

More information can be found in the FN-DC manual on the OutBack website under **Products/Communications/FLEXnet DC**, as well as an FN-DC application note under **Support/Documents/Tech Notes**.

1. Enter the FN-DC ***Battery Setup*** settings in the MATE3.
    a. Bring up the ***Enter Password*** screen using the LOCK navigation key. Enter the password **141** for the ***Main Menu***. Press the ***Settings*** selection from the ***Main Menu***.
    b. From the ***Settings*** menu, select the ***Battery Monitor*** menu.
    c. From the ***Battery Monitor*** menu, select ***Battery Setup***.
    d. On the ***Battery Setup*** screen, enter the TOTAL battery bank amp-hours in ***Battery Ah***.
    e. Set ***Charged Voltage*** to 0.2 Vdc lower than the lowest ***Absorb*** volts setting in Table 2.
    f. Set ***Charged Return Amps*** to the value in Table 2.
    g. Set ***Time*** to 1 minute.
2. Enter the Charge Factor as the battery efficiency. This will be 98% for the SimpliPhi batteries. **NOTE**: Charge Termination Control is enabled by default in the ***FLEXnet DC Advanced Control*** menu. There is no need to change the setting unless for some reason it needs to be disabled.
3. If the ***Grid Tied*** function is being used to sell back to the grid, it is possible the battery bank may never see an absorption cycle completed. This is because the inverter's ***Sell RE*** set point is never exceeded when the charge controller is on during the day. For applications utilizing offset and the ***Sell RE*** set point, there is a function under the ***FLEXnet DC Advanced Control*** settings called ***Enable Auto Grid-Tie Control***. Changing from the default of ***N***(o) to ***Y***(es) will disable the ***Grid Tied*** mode at midnight and not re-enable it until the batteries have been allowed to go through an absorption cycle if necessary.

MATE3 Setup Procedure

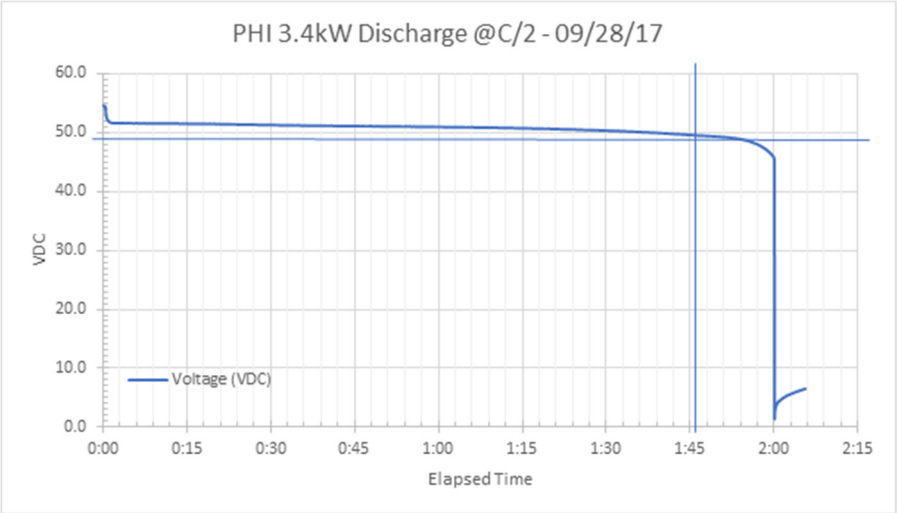
The MATE3 monitors the FN-DC for low battery bank SoC and will report a ***Low SOC Warning*** when the setting is reached. The same is true for the ***Critical SOC Warning*** when its setting is reached. The default settings of 50% and 60% respectively, are more for lead-acid batteries which are rarely discharged more than 50%. As the SimpliPhi batteries are typically discharged 80% to 100%, these default settings will cause the warning lights and events to activate prematurely. Follow the steps below to reduce the number of warnings and events for the times that the bank is discharged more than 50%.

1. Entering SoC warning settings in the MATE3.
    a. Bring up the ***Enter Password*** screen using the LOCK navigation key. Enter the password **141** for the ***Main Menu***. Press the ***Settings*** selection from the ***Main Menu***.
    b. From the ***Settings*** menu, select the ***MATE3*** menu.
    c. From the ***MATE3*** menu, select the ***FLEXnet DC Advanced Control*** screen. For the ***Low SOC Warning***, enter 20% (lowest setting). For the ***Critical SOC Warning***, enter 10% (lowest setting).

Tips and Precautions

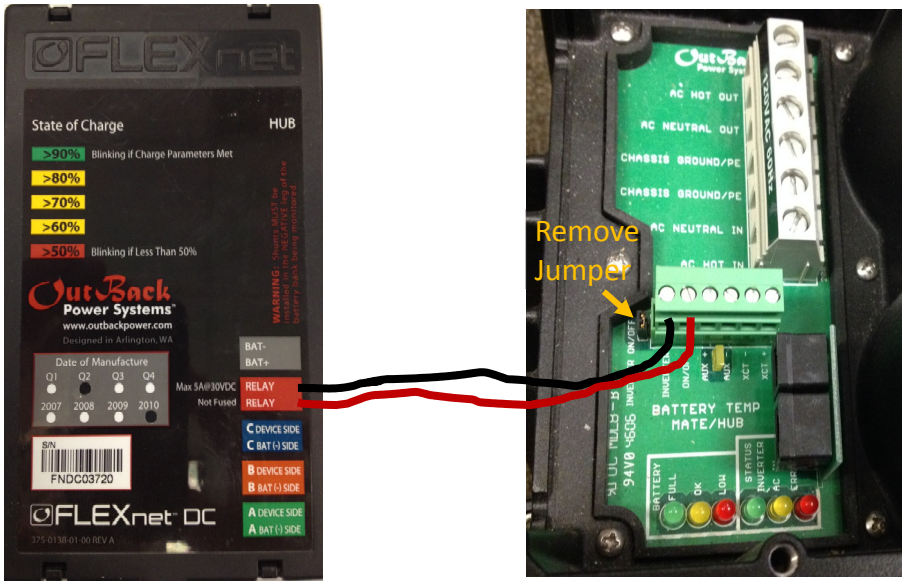
If the SimpliPhi batteries are discharged at a fast enough rate, then it is possible to completely discharge the battery before the low battery cut-out (LBCO) is able to stop the inverter from powering loads. If the inverter does not stop drawing power from the battery before LBCO is activated and the battery is fully discharged, then the whole inverter system can shut down.

Inverters with “SA” firmware versions 001.001.006x or higher (that also incorporate enhanced grid protection settings) have an extended LBCO range to 54 Vdc. This is unlike older inverter firmware revisions that have a maximum LBCO setting of 48V. In many cases, the 48 Vdc setting will not be high enough in a fast discharge application.



In the discharge curve above, the drop-off below 49 Vdc is very fast. Even with an increased LBCO setting between 49-50 Vdc, it may still not prevent a dead battery condition. The LBCO function only shuts down after a delay of approximately five minutes.

For fast discharge applications that don't have the extended LBCO range, or where even the extended LBCO range is not enough due to the five minute delay, there is another solution. The FN-DC relay can be used to detect the voltage drop-off with little or no delay. The relay contacts can then be connected to the **INVERTER ON/OFF** terminals to turn the inverter off and prevent the batteries from being completely discharged. The settings that have worked under test conditions in the OutBack test lab are listed in Table 2. These can be tailored for the best results for a given application. Connection points are identified in the figure below.



Guidelines for Sizing the Inverter and Charging Sources

SimpliPhi states in their warranty that a C2 charge/discharge rate should not be exceeded, with a recommendation that the battery bank be greater than twice the kW load. This is illustrated in the examples below.

The calculations assuming:
Battery rated power = Bat_{kWh}
Inverter power full load = Inv_{kW}
Maximum battery charge current = $I_{BatChrgMax}$
PV charge controller maximum = $I_{PVChrgMax}$
Recommended minimum number of batteries to optimize solar harvesting = $B_{\#}$
Discharge equation: $B_{\#Inv} \geq Inv_{kW} / Bat_{kWh}$
Charge equation: $B_{\#PV} \geq I_{PVChrgMax} / I_{BatChrgMax}$

Inverter Power Battery Bank Sizing

To optimize the battery bank and protect against over-discharge (voiding the battery warranty) the battery bank should be sized at least 2x the kW rating of the inverter.

If:
- Inverter is rated at 8kW
- Battery is rated at 3.5kWh
- Therefore, C/2 load is 1.75kW

$B_{\#Inv} \geq$ 8kW/1.75kW = 4.5

So a properly sized battery bank would have a minimum of 4 batteries. This insures no greater than C/2 battery load.

PV / Charge Controller Battery Bank Sizing

To optimize solar harvesting a properly sized battery bank should be able to accept the maximum PV charge current.

Refer to the PHI battery max continuous charge current specification which may differ from C/2 depending on model. Then divide the max charge controller output by the maximum battery charge current to determine the minimum number of batteries required to optimize PV.

Example: $B_{\#PV} \geq IPV_{ChrgMax} / I_{BatChrgMax}$

If:
- Maximum battery charge current = 34A
- PV Charge controller max = 80A

$B_{\#PV} \geq$ 80A/34A = 2.35

So a properly sized system would have a minimum of 3 batteries. This maximizes the use of available PV while insuring the batteries are never stressed by overcharging.

Additional Warning: Both the SimpliPhi model 3.4 and 3.5, 24V and 48V batteries ***must not*** be connected in series under any circumstance, or the BMS may be damaged. SimpliPhi has a different BMS for series connected batteries.

NOTE: The OutBack Remote Temperature Sensor (RTS) should never be used with SimpliPhi LFP Batteries. Temperature compensation will exceed the battery charging parameters.

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.

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