AOESS48V-LFP4100

INTEGRATION GUIDE

Table of Contents

Content explanation

This integration guide describes the recommended set up and configuration of Outback Power equipment for optimizing performance with AOESS48V-LFP4100 electrical energy storage system. Read this integration guide before you attempt to install the product and follow the instructions throughout the installation process. If you are uncertain about any of the requirements, recommendations, or safety procedures described in this integration guide, contact AOE immediately for advice and clarification. The information included in this integration guide is accurate at the time of publication. However, the product specifications are subject to change without prior notice. In addition, the illustrations in this manual are meant to help explain system configuration concepts and installation instructions. The illustrated items may differ from the actual items at the installation location.

Alpha and Outback Energy offers many products which are too numerous to be covered here. This Guide does not substitute literature from Alpha and Outback Energy. The Outback products covered in this guide include, but are not limited to:

- Radian Series Inverter/Chargers & Radian Series GS Load Centers
- FXR/VFXR Series Inverter/Chargers
- FM 60/80
- FLEXmax 100 / AFCI Charge Controllers

OutBack Power has instructional videos showing various steps of the battery commissioning and system programming process: https://www.outbackpower.com/resources/technical-support/videos.

AOE technical support (RE.Support@alphatechnologies.de) is available to take any questions regarding this manual or general installation questions. For assistance with battery system commissioning, AOE asks that a commissioning call be scheduled ahead of time with Technical Support.

! *CAUTION* – Although each AOESS48V-LFP4100 battery contains an internal BMS with circuitry that protects the battery cells from over-charge, over-discharge and extreme load amperage, the AOESS48V-LFP4100 batteries must always be installed with appropriate inverter and/or charge controller settings to protect the battery from high voltage charging sources. Exposure to higher voltage than the AOESS48V-LFP4100 battery rating will destroy the batteries and Void the Warranty.

According to the AOESS48V-LFP4100 battery Warranty, AOE does not warrant AOESS48V-LFP4100 batteries damaged by “Incidental or Consequential Damage Caused by Other Components of the Power System Including but not Limited to Inverters, Charge Controllers, Breakers, Bypass Switches, Fuses, etc.”. The AOESS48V-LFP4100 battery models include built-in over-current protection, but to mitigate risk of potential over-voltage damage from Balance of System equipment it is recommended to install additional over-voltage protections between the system’s charge controller(s) and the battery bank.

1. Battery bank sizing

AOESS48V-LFP4100 batteries are designed to operate at the continuous ratings listed on the relevant AOESS48V-LFP4100 battery model's specification sheet. Therefore, a properly sized AOESS48V-LFP4100 battery bank must be able to handle both the inverter's "load rate" as well as the maximum potential charge rate from the solar photovoltaic (PV) array. Take care to consider not only the energy (kWh) requirement of the battery bank, but also all other power-related sizing parameters, as outlined in the following sections. Failure to do so will void the Warranty.

! *CAUTION* – AOESS48V-LFP4100 battery bank sizing not in accordance with the following sections will damage the AOESS48V-LFP4100 batteries and Void the Warranty.

1.1. Sizing for maximum instantaneous discharge (Load rate)

The load rate is the amount of power that is discharged from the battery bank to the loads. This may include both alternating current (AC) and/or direct current (DC) loads. AOESS48V-LFP4100 battery banks are sized so that the batteries' combined maximum continuous discharge rate meets or exceeds the load rate.

AOESS48V-LFP4100 *battery bank max continuous discharge rate kW DC ≥*
(Inverter DC load rate) + (DC loads, if any)

Because most loads are AC loads, the load rate is typically represented by the inverter's AC Power Output rating. Convert the inverter's maximum potential AC power draw to the maximum potential DC power draw from the battery bank by factoring in the inverter's efficiency rating.

Inverter DC load rate = (Inverter power rating kW AC) ÷ (Inverter efficiency)

Example: An inverter rated at 3.5 kW AC and 93% efficiency potentially draws 3.7 kW DC from the battery bank.

Inverter DC load rate = (3.5 kW AC) ÷ (0.93) = 3.7 kW DC

The inverter can however draw a peak power equal to double its nominal rated power from the battery bank if it is connected to a load that can draw that power on a peak. To ensure the battery bank is not over-discharged, the calculation should be done using the inverter peak power:

Inverter peak DC load rate = (7 kW AC) ÷ (0.93) = 7.5 kW DC

If the system includes DC Loads, no AC-to-DC conversion is necessary. Calculate the minimum quantity of AOESS48V-LFP4100 batteries needed to ensure that the battery bank does not over-discharge by dividing the load rate by the MAX Continuous Discharge Rate per AOESS48V-LFP4100 Battery.

(Load rate) ÷ (Max continuous discharge rate per battery) =
Minimum battery quantity to prevent over-discharge

Example: Two AOESSP48V-LFP4100 (5.12kWh – 51.2$V_{nominal}$) batteries must be paired with an inverter rated at 7kW peak and 93% efficiency to ensure the AOESS48V-LFP4100 battery bank does not over-discharge to power the loads.

(7.5 kW DC) ÷ (5.12kW DC) = 1.46 -> round to 2

Refer to the Battery Bank Sizing for Maximum Instantaneous Discharge (Load Rate) tables on the following page of this Integration Guide for a complete list of common OutBack inverters and the minimum quantity of AOESS48V-LFP4100 batteries those inverters need to be paired with to ensure that the AOESS48V-LFP4100 battery bank does not over-discharge. Over-discharging the AOESS48V-LFP4100 batteries will destroy them and Void the Warranty.

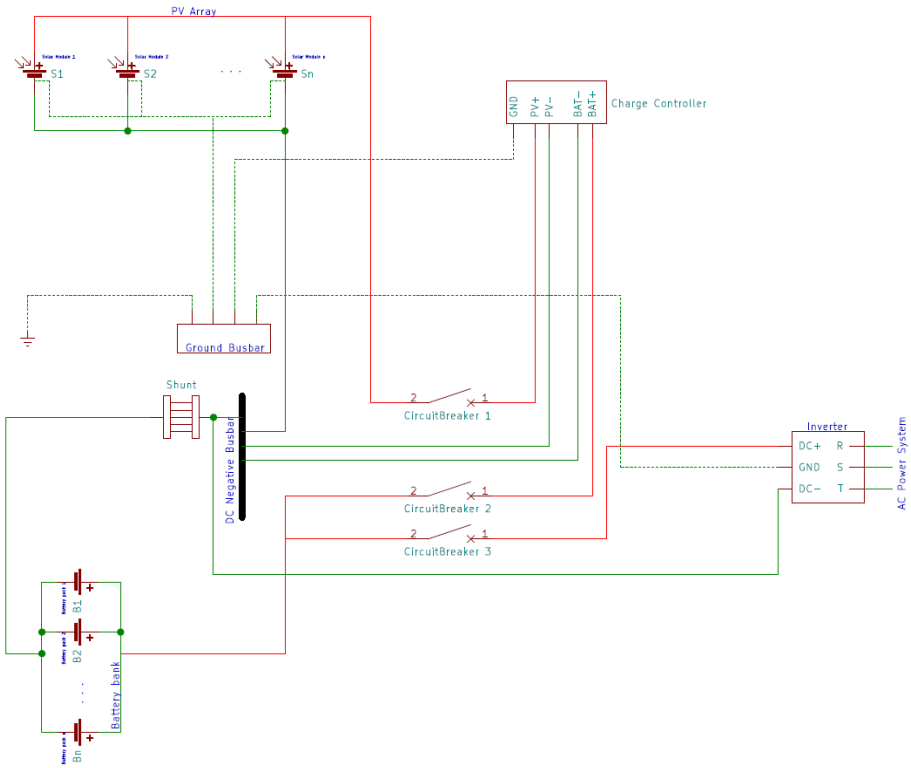
In the case where the inverter's AC Power Output rating exceeds the connected loads' actual power draw (i.e. the inverter is rated at 3.5 kW but all loads amount to 3 kW of maximum instantaneous power draw), AOE still expects that the proper additional precautions be made to ensure that the AOESS48V-LFP4100 battery bank is not over-discharged. This typically involves the installation of an additional overcurrent protection device between the AOESS48V-LFP4100 battery bank and the inverter to ensure that the AOESS48V-LFP4100 battery bank does not discharge beyond its maximum instantaneous power rating. Failure to do so will destroy the AOESS48V-LFP4100 batteries and Void the Warranty.

AOESS48V-LFP4100 battery bank max continuous discharge rate =
(Battery quantity) x (max continuous discharge rate per battery)

Example: Two AOESS48V-LFP4100 (5.12kWh – 51.2$V_{nominal}$) batteries must be installed with an additional 200 A DC-rated breaker between the battery bank and the inverter. It should not be omitted that a DC-breaker should also be installed between the battery bank and the DC bus-bar.

(AOESS48V-LFP4100 battery bank max continuous discharge rate) = 2 x 100 A DC = 200 A DC

The schematics below presents how the circuit breakers should be connected between the battery system and any other nearby equipment: inverter, charger or bus-bar.



Power circuit breakers locations - Electrical schematics

Minimum Battery Quantity per inverter calculation results are listed below. When using more than one inverter in a system, AOESS48V-LFP4100 battery bank sizing is more precise when the calculations described above are used instead of the following tables.

48V sizing for nominal discharge (load rate)

48V Inverter Model	*Inverter NPR/ PPR (kW AC)[1]*	*Inverter Efficiency*	*Load NPR/ PPR (kW DC)*	*AOESS48V-LFP4100 (5.12 kW/ 10.24 kWp)[2]*
OutBack Radian 7048E	7/14	93%	7.5/15	2
OutBack Radian 3548E	3.5/7	93%	3.8/7.5	1
OutBack VFXR 3048E	3/6	93%	3.2/6.5	1
OutBack FXR 2348E	2.3/4.6	93%	2.5/5	1

Notes: 1. NPR = Nominal Power Rating; PPR = Peak Power Rating

2. kW – at NPR; kWp (kW_peak) – at PPR

→The inverter & batteries can be used at peak power for only 5 seconds.

1.2. Sizing for maximum instantaneous charge rate (DC Coupled)

In a DC Coupled system, the solar PV array output can be curtailed using charge controllers. However, reducing the solar array's power output using charge controller programming implies that the PV array's output is also reduced for the entire remainder of the system, including the solar power available for powering loads and for exporting to the grid. Furthermore, greatly reducing the PV array's output via the charge controllers effectively wastes the solar PV array's power and puts strain on the charge controllers.

Calculate the minimum quantity of AOESS48V-LFP4100 batteries needed to prevent over-charge from the solar PV array by considering both the solar array size and the charge controller's potential output. Whichever value is less should be used to size the AOESS48V-LFP4100 battery bank. If the solar array's maximum potential current output is less than the paired charge controller's Output Amps rating, then the solar array's maximum potential current output can be used to size the AOESS48V-LFP4100 battery bank. If the charge controller's Amp rating is less than the solar array's maximum potential current output, then the charge controller's rating is used to size the AOESS48V-LFP4100 battery bank.

Divide the system's potential charging current by the MAX Continuous Charge Rate per AOESS48V-LFP4100 battery to calculate the minimum quantity of AOESS48V-LFP4100 batteries needed to ensure that the solar PV array does not over-charge the battery bank. A FLEXnet DC (FNDC) controller can be used to control the system charge current in order to prevent over-charging of all the battery packs, by reducing the maximum current of the system.

Example A: 4 x AOESS48V-LFP4100 (5.12 kWh – 51.2$V_{nominal}$) batteries must be paired with a 14,000-Watt solar PV array wired to two 100 Amp-rated FM100 charge controller[1]. In this case, the 200-Amp charge controller is used to determine the minimum AOESS48V-LFP4100 battery quantity needed to prevent over-charging from the solar PV.

Watts = Amps x Volts

14,000 Watt Solar PV array = Amps x 48 volts

$\frac{14{,}000\,Watts}{48\,Volts}$ *= 291.7 Amps = max potential solar PV array output*

291.7 Amps > 200 Amps -> max potential solar PV array output through the charge controller

(Max potential charging current) ÷ (Max charge rate per battery) =

Minimum battery quantity to prevent overcharge

(200A) ÷ (50A) = 4

Note 1: The 100 A current limit is not valid for FM60/FM80.

Example B: 6x AOESS48V-LFP4100 (5.12 kWh – 51.2$V_{nominal}$) batteries must be paired with a 14,000-Watt solar PV array wired to four 80 Amp-rated FM80 charge controller. In this case, the 14,000-Watt solar array is used to determine the minimum AOESS48V-LFP4100 battery quantity needed to prevent over-charging from the solar PV.

Watts = Amps x Volts

14,000 Watt Solar PV array = Amps x 48 volts

$\frac{14{,}000\,Watts}{48\,Volts}$ *= 291.7 Amps = max potential solar PV array output*

291.7 Amps < 320 Amps -> max potential solar PV array output through the charge controller

(Max potential charging current) ÷ (Max charge rate per battery) =

Minimum battery quantity to prevent overcharge

(291.7A) ÷ (50) = 6

Refer to the Battery Bank Sizing for Maximum Instantaneous Charge Rate table below for a complete list of OutBack charge controllers and the minimum quantity of AOESS48V-LFP4100 batteries those controllers need to be paired with to ensure that the AOESS48V-LFP4100 battery bank does not over-charge (assuming that the charge controllers' full current output rating is utilized). Failing to do so will destroy the AOESS48V-LFP4100 batteries and Void the Warranty.

1.3. Overall battery system sizing

Size the AOESS48V-LFP4100 battery bank so that the minimum number of batteries in the bank is the greater of the two figures obtained from the Discharge and Charge calculations. For example, a system that requires 5 AOESS48V-LFP4100 batteries to ensure that the battery bank does not over-discharge and 3 AOESS48V-LFP4100 batteries to ensure that the battery bank does not over-charge, should include a final minimum quantity of 5 batteries. Failure to do so will destroy the AOESS48V-LFP4100 batteries and will void the Warranty.

Note that these sizing guidelines and program settings outlined in Section 2.0 – Program Settings for AOESS48V-LFP4100 batteries assume that solar PV charging and charging via the inverter/charger do not occur simultaneously. If there is a possibility that these two charging sources might be active at the same time in your system, it is recommended to use a FNDC controller to limit the maximum system charge current. A second option would be to size the number of batteries used for overall charging (simultaneously from solar PV and grind).

Note also that the quantity of AOESS48V-LFP4100 batteries calculated from this sizing guide is the minimum requirement to prevent over-discharge and over-charge from an instantaneous power perspective. The system may need more AOESS48V-LFP4100 batteries in the battery bank in order to meet the system's energy requirement (the amount of power the batteries must supply to the loads over time).

! *CAUTION* – Not all system discharge or charge characteristics can be mitigated via programming. Under-sizing an AOESS48V-LFP4100 battery bank relative to the system's maximum discharge or charge rate will destroy the AOESS48V-LFP4100 batteries and Void the Warranty.

2. Program settings

2.1. Inverter settings

In order to maintain the AOESS48V-LFP4100 Battery Warranty, it is critical to ensure that the appropriate settings are programmed in all system components. The settings outlined in the following table maintain a maximum 80% Depth of Discharge (DoD) for the AOESS48V-LFP4100 batteries, thereby optimizing the performance and life of the AOESS48V-LFP4100 batteries.

Not all equipment includes all the listed settings. Settings that are not explicitly listed above do not directly pertain to the AOESS48V-LFP4100 batteries. Refer to the relevant OutBack manual for more detailed information on any one of the listed settings.

Table 2.1 Part 1 – Settings for AOESS48V-LFP4100 Batteries with OutBack Inverters Based on 80% DoD Levels

Inverter Settings - Battery Charging	**51.2 V_{nom} AOESS48V-LFP4100 Battery**
Absorb Voltage when *Generator Charging* or *AC Coupled PV Charging*	57.6 V
Absorb Voltage when *Grid Charging*	57.6 V
Absorb Time when *Generator Charging* or *AC Coupled PV Charging*	0.1 hours
Absorb Time when *Grid Charging*	0,1 hours
Float Voltage	54.6 V
Re-Bulk Voltage	50.0 V
Float Time	0 hours
Re-Float Voltage	N/A (52 V may be used as a placeholder value; Float is disabled by setting Float Time to 0)
EQ Voltage	N/A (57.6 V may be used as a placeholder value; EQ is disabled by setting EQ Time to 0)
EQ Time	0 hours
- Battery Protection	
Low Battery Cut-Out Voltage[1]	42.0 V
Low Battery Cut-Out Delay[2]	10 seconds
Low Battery Cut-In Voltage	50.0V
High Battery Cut-Out Voltage[2]	58.4 V
High Battery Cut-Out Delay[2]	1 second
High Battery Cut-In Voltage[2]	58.0 V
- Mini Grid	
Mini Grid Connect to Grid	48
Mini Grid Delay	10
- Grid Zero	
Grid Zero DOD Volts	50
Grid Zero DOD Amps	5
Inverter Settings - AC Input	
AC Input Select Priority	According to the homeowner's system preference.
Charger Operating Mode	According to the homeowner's system preference.

Table 2.1 – Part 2

Charger AC Limit	Refer to Section 2.2.
- Grid	
Grid Input Mode	According to the homeowner's system preference.
Grid-Tie	According to the system's setup.

Notes:

[1] It is recommended to program equipment as outlined in above Table 2.1 in order to maintain 80% DoD levels.

[2] Not available for FXR/VFXR series.

• Levels are typical at 25°C and may need adjusting at temperature extremes.

• When performing rapid deep charge/discharge cycles the battery needs a resting time 15 minutes in between.

! CAUTION: When AOESS48V-LFP4100 Battery quantities change the capacity and charge/discharge current settings must be reassessed. Failure to do so will void the Warranty.

2.2. Charger AC Limit Calculation

The OutBack inverter/charger's Charger Limit setting is regulated on the AC input side of the charger (not the DC side of the charger). Convert the AOESS48V-LFP4100 Battery bank's maximum* continuous DC charging current to the charger's AC current limit by following these steps:

1. Convert the AOESS48V-LFP4100 Battery bank's maximum continuous DC charging current to DC watts.

2. Apply the charger efficiency.

3. Convert AC watts to AC current.

*When Grid charging specifically, it is permissible to charge the battery bank according to its maximum continuous DC charging current, but it is recommended to charge at less than the maximum current. In a Grid charging scenario, it is recommended to multiply the Charging Amps found according to this section by 40% or less, as long as the value obtained is higher than the maximum AC Input Charge Current of the charger.

Example: 3x AOESSP48V-LFP4100 (5.12 kWh - 51.2 V) nominal batteries (used in a 48-Volt system) are paired with an OutBack Radian GS7048E model inverter/charger.

1. Each AOESS48V-LFP4100 (5.12 kWh - 51.2 V) battery has a maximum continuous DC charging current of 50 Amps DC, or 2.56 kW DC at the battery's 51.2 V nominal voltage. The Three-battery bank has a combined maximum continuous DC charging current of 150 Amps DC, or 7.68 kW DC.

   kW DC = Amps DC x Volts DC / 1000
   2.56 *kW DC = 50 Amps DC x 51.2 Volts DC*
   7.68 kW DC = 3 x 50 Amps DC x 51.2 Volts DC

2. Apply the charger efficiency. If the charger converts AC Input power to DC Charging power at an 85% efficiency rate, then over 6.02 kW AC can be used as the charger's maximum AC Input.

$$\frac{7.68\ kW\ DC}{0.85} = 9.03\ kW\ AC$$

3. Convert AC power to AC current by dividing AC kiloWatts by the inverter's AC Voltage rating and multiplying by 1000. The EU OutBack inverters have a 230V AC output rating, but some other models are rated at 120 or 240 AC voltages.

$$\frac{9.03\ kW\ AC}{230\ V\ AC} \times 1000 = 39.26\ A\ AC$$

The OutBack Radian GS7048E has a maximum AC Input Charge Current of 30 A AC, lower than the calculated 39.26 A AC maximum for the two-battery bank. Therefore, it can operate at its full 30 A AC-rated charger output without over-charging the AOESS48V-LFP4100 battery bank.

Typically, a properly sized AOESS48V-LFP4100 Battery bank will have a maximum charging current greater than the paired inverter/charger's maximum potential charging output. If a AOESS48V-LFP4100 Battery bank is under-sized relative to its paired inverter, in addition to programming a lower inverter/charger charge limit, other additional precautions must also be taken to protect the battery from over-discharge (refer to Section 1.1 – Sizing for Maximum Instantaneous Discharge (Load Rate)).

AOESS48V-LFP4100 Batteries' Maximum Charge Rates Table

Refer to the "Amps AC at 230VAC" or the "Amps AC at 120VAC" column depending on the AC Output rating of the inverter in use. Values are per battery; calculate the Charger AC Limit by multiplying the per-battery value by the number of batteries. If necessary, round figures *down* to the closest integer for the 120VAC or half Amp for the 230VAC inverters.

Table 2.1.3 – AOESS48V-LFP4100 Batteries' Maximum Charge Rates

Battery Model	MAX Continuous Charge Rate per Battery (A DC)	MAX Continuous Charge Rate per Battery (Watts DC)	Watts AC (assume 85% charger efficiency)	Amps AC Charge Limit per Battery at 230 V AC	Amps AC Charge Limit per Battery at 120 V AC
AOESS48V-LFP4100	50	2560	3012	13	25

! **CAUTION:** When AOESS48V-LFP4100 Battery quantities change the capacity and charge/discharge current settings must be reassessed. Failure to do so will void the Warranty.

2.3. FM100 / AFCI Charge Controller Wiring & Settings

The FM100 and FM100 AFCI charge controller's Aux terminals 7 and 8 must be utilized for the Battery Sense to function. Refer to page 21 of the FM100 charge controller manual for additional information regarding the device's Battery Sense terminals and Battery Sense function:

http://www.outbackpower.com/downloads/documents/charge_controllers/flexmax_100/flexmax100_manual.pdf

A twisted-pair cable can be wired from Aux terminal 7 (negative) and 8 (positive) to any of the (respective) negative and positive battery terminals in the AOESS48V-LFP4100 Battery bank. If the

system includes more than one charge controller, daisy chain the wiring from Aux terminals 7 and 8 in the multiple charge controllers.

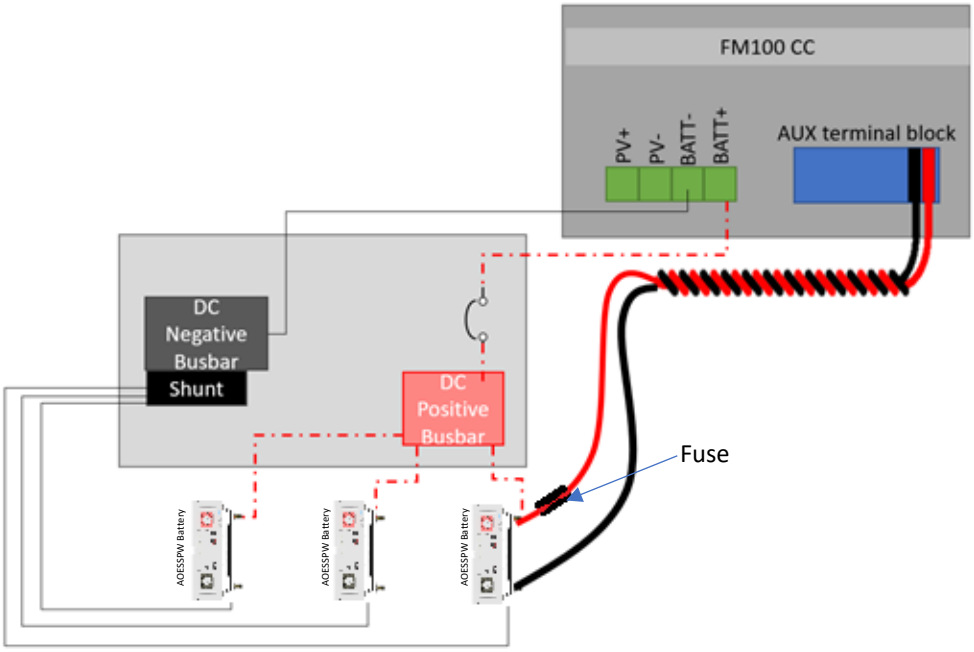


Table 2.2 – Settings for AOESS48V-LFP4100 Battery w/ OutBack Charge Controller – Part 1

Charger	**51.2 V_{nom} AOESS48V-LFP4100 Battery**
Absorb Voltage[1]	57.6 V
Absorb Time	0.1 hours
Float Voltage	55.6 V
ReBulk Voltage	50 V
DC Current Limit	AOESS48V-LFP4100 battery banks sized according to *Section 1.2. Sizing for Maximum Instantaneous Charge Rate (DC Coupled)* do not require any limitation of the charge controller's DC Current output.
Absorb End Amps[2]	0A
MPPT	Refer to page 44 of the *FM100 Manual*
Battery Equalize	
Equalization Voltage	Although Equalize is Disabled, the below value may be used as placeholder.
	57 V

Table 2.2 – Part 2

Equalization Time	Although Equalize is Disabled, 0-1 Hours may be used as a placeholder value.
Automatic Battery Equalization	0 Days (disables Equalization)
Grid-Tie Mode	
Enable	N (No) when the system does not export energy onto the grid, and/or when the entire system is not composed of all OutBack devices networked to each other via the HUB.

Grid-Tie Mode	Y (Yes) when the system exports energy onto the grid and the entire system is composed of OutBack devices (including a grid-interactive OutBack inverter) networked to each other via the HUB.

Notes:

[1] Setting the charge controller's Absorb Voltage higher than inverter's Absorb Voltage prioritizes charge controller charging over inverter charging. Even if the system does not utilize an inverter/charger for battery charging from an AC power source, the Absorb Voltage in the charge controller can still be programmed to this value as this is the maximum charging voltage of the AOESS48V-LFP4100battery.

• Levels are typical at 25°C and may need adjusting at temperature extremes.

• When performing rapid deep charge/discharge cycles the battery should be allowed a resting period of 15 minutes in between.

2.3. FLEXnet DC Settings

While the FLEXnet DC (FNDC) provides data logging of shunt information, it does not provide reliable State of Charge (SOC) measurements of the AOESS48V-LFP4100 Batteries when successive partial charging takes place at variable charge and discharge rates over many cycles. For this reason, using an FNDC in conjunction with AOESS48V-LFP4100 Batteries can frequently be misleading.

Table 2.3.1. Settings for AOESS48VLFP4100 Battery w/ OutBack FLEXnet DC

FLEXnet DC Settings	**51.2 V_{nom} AOESS48V-LFP4100 Battery**
Battery Ah[1]	Batteries' Capacity Rating
Charged Voltage (V)	57.2 V when *Generator Charging* or *AC Coupled PV Charging*
	57.2 V when *Grid Charging*
Charged Time	1 Minutes
Charged Return Amps	2A
Battery Charge Factor	95%
Relay Invert Logic	No
AUX Relay Set Points	All Relay Set Points remain as the Default settings because the AOESS48V-LFP4100 Battery does not require that the relay be utilized.

Notes:

[1] Per AOESS48V-LFP4100 Battery – These settings are calculated by multiplying the per-battery Ah value times the number of batteries.

To avoid conflict between the Return Amps parameter programmed in the FNDC and the Absorb End Amps parameter in any connected OutBack charge controller, disable the charge controller's Absorb End Amps parameter by setting it to 0 when a FNDC is included in the OutBack system.

• Levels are typical at 25°C and may need adjusting at temperature extremes.

• When performing rapid deep charge/discharge cycles the battery should be allowed a resting period of 15 minutes in between.