Battery Bank Sizing with Magnum Equipment

Please make sure to go through these steps to make sure you have properly sized your system to avoid damaging your battery. There are 4 ways of properly calculating the battery bank size for a given system as outlined below:

1. **Match Overcurrent Protection Device (Breaker Sizes)**
   $\sum_{battery\ bank\ breaker\ rating} \geq \sum_{inverter\ breaker\ rating}$
2. **Match Inverter Surge Rating to Maximum Current Rating of Battery**
   $\sum_{battery\ bank\ cotinuous\ rating} \geq \sum_{inverter\ cotinuous\ rating}$
   &
   $\sum_{battery\ bank\ surge\ rating} \geq \sum_{inverter\ surge\ rating}$
3. **Match Charge Controller to Battery Bank charge capacity**
   $\sum_{battery\ bank} \max charge\ current \geq \sum_{charg\ \ controller} \max output$
4. **Calculate the required battery bank capacity based on actual loads**
   $$\frac{\sum_{total\ energy\ used\ (kwh)}}{\sum_{total\ available\ battery\ capacity\ (kwh)}} x\ 100\% \leq 80\%$$

For the following battery bank size calculations, the below system assumptions apply:

- 1 Magnum MS4448PAE Inverter
  - Recommended External DC Breaker Size: 175A DC
  - Nameplate Capacity: 4300 Watts continuous / 90A DC
  - Surge Capacity: 7500 Watts for 5 seconds / 156A DC
  - Chargers
    - Capacity: 55A DC per Charger
    - 2 parallel chargers: 110A DC

1. Match Overcurrent Protection Device (Breaker Sizes):

- A Magnum MS4448PAE inverter requires externally obtained DC breaker. Magnum recommends (1) 175A DC breaker

- The LFP-5 has a 125A breaker

$$\sum_{(2)\ LFP-5\ battery\ breakers} (125A + 125A) \geq \sum_{inverter\ breakers} (175A)$$ ✓

- The LFP-10 has a 150A breaker

$$\sum_{(2)\ LFP-10\ battery\ breakers} (150A + 150A) \geq \sum_{inverter\ breakers} (175A)$$ ✓

- A single eVault 18.5 has a 250A breaker

$$\sum_{(1)\ eVault\ battery\ breakers} (250A) \geq \sum_{inverter\ breakers} (175A)$$ ✓

2. Match Inverter Surge Rating to Maximum Current Rating of Battery:

- A single Magnum MS4448PAE inverter has a continuous rating of 90A and a surge capacity of 156A.

- The LFP-5 has a continuous rating of 80A with 180A surge capacity

$$\sum_{(2)\ LFP\quad battery\ continuous\ rating} (80A\ + 80A) \geq \sum_{inverter\ continuous\ rating} (90A)$$

$$\sum_{(2)\ LFP-5\ surge\ rating} (180A\ + 180A) \geq \sum_{inverter\ surge\ rating} (156A)$$

- LFP-10's has a continuous rating of 100A each with 180A surge capacity

$$\sum_{(2)\ LFP-10\ battery\ continuous\ rating} (100A\ + 100A) \geq \sum_{inverter\ continuous\ rating} (90A)$$

$$\sum_{(2)\ LFP-10\ surge\ rating} (180A\ + 180A) \geq \sum_{inverter\ surge\ rating} (156A)$$

- The eVault 18.5 has a continuous rating at 180A and surge capacity at 240A.

$$\sum_{(2)\ eVault\ battery\ continuous\ rating} (180A) \geq \sum_{inverter\ continuous\ rating} (90A)$$

$$\sum_{(2)\ eVault\ surge\ rating} (240A) \geq \sum_{inverter\ surge\ rating} (156A)$$

3. Match Charge Controller to Battery Bank charge capacity.

- Each charge controller on the Magnum MS4448PAE inverter has a maximum output current of 55A. The two parallel charge controllers can output 110A.

- The LFP-5 batteries have a maximum charge current of 80A.

$$\sum_{(2)\ LFP-5\ battery\ \max\ charge\ rating} (80A + 80A) \geq \sum_{inverter\ \max\ char\quad rating} (55A + 55A)$$

- and 10 batteries have a maximum charge current of 100A.

$$\sum_{(2)\ LFP-10\ battery\ \max\ c\qquad rating} (100A + 100A) \geq \sum_{inverter\ \max\ char\quad rating} (55A + 55A)$$

- The eVault has a maximum charge current of 170A.

$$\sum_{(1)\ eVault\ battery\ \max\ c\qquad rating} (170A) \geq \sum_{inverter\ \max\ charge\ rating} (55A + 55A)$$

4. Calculate the required battery bank capacity based on actual loads.

Every load on the Back-Up Panel will need to be analyzed (load power and duration). All total energy is calculated by summing the individual energies for each load. Assume the following loads and a customer who wants to run 24 hours off batteries only:

1	Appliance	Running wattage	Operating hours/day	Daily Consumption
2	Refrigerator	250 W	12 hrs/day	3 kWh
3	Lights:	100 W	6 hrs/day	0.6 kWh
4	Well Pump	3000 W	1 hr/day	3.0 kWh
5	Internet and continuous Phantom Loads	100 W	24 hrs/day	2.4 kWh
6	TV	200 W	4 hrs/day	0.8 kWh
			Sum	**9.8 kWh**

REMINDER! Always try to maintain the recommended Depth of Discharge (%DOD) of 80%, for healthy battery life and performance.

1. 2 LFP-5's = 10.24kwh. Compared to the required hypothetical sum, this roughly yields a 97% DOD. Therefore, not acceptable.
2. 1 LFP-10 = 10.2kwh. Offering 2 LFP-10's at 20.4 kwh yields approx. 48% DOD. Acceptable, but oversized.
3. 1 eVault at 18.5kwh however, would be the better option.

$$\frac{\sum_{total\ energy\ used\ (kwh)}(9.8kWh)}{\sum_{total\ available\ battery\ capacity\ (kw\ )}(18.5kWh)} x\ 100\% = 53\% \leq 80\%$$

If the customer cannot supply the load information, or assumptions cannot be made, the rule of thumb as an absolute minimum battery size is to match the power rating of the inverter in kW to the energy rating of the battery in kWh. A single Schneider inverter is rated at 6.8 kW meaning a minimum battery size of 6.8 kWh would be required. In that case an LFP-10, with an 80% discharge capacity of 8 kWh would be enough to meet the minimum battery size by this very basic calculation method.

Setting up a Fortress Power Lithium Battery using Magnum Inverter/Charger

Magnum MS4448PAE Inverter Battery Turn On/Off Levels Setting

	80% DoD, 6000 cycles	90% DoD, 3000 cycles
Low Battery Cut In Voltage	51.5V	51V
Low Battery Cut Out Voltage (1 Minute Delay)	48.8V	48.8V
LBCO Voltage (No Delay)	48V	
High Battery Cut Out Voltage	LFP-10 & LFP-15: 63 V eVault: 61 V	
High Battery Cut In Voltage	LFP-10 & LFP-15: 61.8V eVault: 59.8 V	

- **Low Battery** - The inverter will shut off whenever the battery voltage falls to the LBCO (Low Battery Cut Out) level to protect the batteries from being over-discharged. After the inverter has reached the LBCO level and turned off, the inverter will automatically restart after one of the following conditions:
  - AC Power is applied and the inverter begins operating as a battery charger.
  - Battery voltage rises to the LBCI (Low Battery Cut In) level.

- **High Battery** - In the event the battery voltage approaches the HBCO (High Battery Cut Out) level, the inverter will automatically shut down to prevent the inverter from supplying unregulated AC output voltage. The inverter's status LED turns off when a high battery fault condition occurs. The inverter will automatically restart when the battery falls to the HBCI (High Battery Cut In) level.

*High battery voltage may be caused by excessive or unregulated voltage from the solar panels or other external charging sources

Magnum MS4448PAE Inverter/Charger Values

	80% DoD, 6000 cycles	90% DoD, 3000 cycles
Shore Max	51.5V	51V
01 Search Watts	48.8V	48.8V
02 LowBattCuutOut	48V	
03 Batt AmpHrs	LFP-10 & LFP-15: 63 V eVault: 61 V	
04 Battery Type	LFP-10 & LFP-15: 61.8V eVault: 59.8 V	
05 Charge Rate **	100%	

06 VAC Ropout	80VAC

- **Shore Max** - This setting ensures the inverter AC loads receive the maximum current available from the utility or generator power. When the total current used to power the AC loads and charge the batteries begins to approach the Shore Max setting, the current that was used for charging the batteries will automatically be reduced.
- **01 Search Watts** - This setting allows you to turn off the power-saving Search Mode circuitry or adjust the power level at which the inverter will “wake up” and start inverting.
- **02 Low Battery Cut Out Voltage -** This setting determines when the inverter will turn off based on low battery voltage. The inverter turns off automatically after the battery voltage has been below this setting for more than one minute. This protects the batteries from over-discharge and the AC loads from unregulated power (brown-outs).
- **03 Batt AmpHrs** (see “Max Bulk and/or Discharge Current”) - This setting allows the user to input the battery bank size in amp hours which tells the charger how long to charge the batteries in the Absorb charge stage.
- **04 Battery Type -** Sets the type of batteries being used in the system; this information tells the charger what voltage level to use to charge the batteries.
- **05 Charge Rate -** This setting can be used to turn off the charger, limit the amount of current that the charger can use (leaving more current available to power loads); or to ensure small battery banks are not overheated because of a charge rate that is too high.
- **06 VAC Dropout -** Sets the minimum AC voltage that must be present on the AC input before the unit transfers from Standby Mode to Inverter Mode. This protects the AC loads from utility outages and brown-outs. On MS-PAE models, when two inputs (leg 1 and leg 2) are used, the VAC Dropout voltage is determined by the sum of the two inputs ÷ 2. For example, if input 1 = 120VAC and input 2 = 110 VAC, the sum (230) ÷ 2 = 115. In this example, 115 VAC is what the inverter’s AC input is sensing to determine when to stay connected or disconnect and start inverting.

Charge Controller Settings

In a DC coupled system, solar controller(s) must be used to regulate the PV power and charge the batteries. Please select the Charge controller which are compatible with Fortress Lithium batteries. We use MAGNUM PT-100 MPPT Charge Controller as example here.

Parameter Setting for PT-100 Charge Controller

Battery Type	Custom	
Custom Setting		
	80% DoD, 6000 cycles	90% DoD, 3000 cycles
Eqlz Support	Disable	
Bulk Voltage	54.4 V	54.6 V
Absorb Voltage	54.4 V	54.6 V
Float Voltage	54.4 V	
EQ Volts	Set to the same value as Absorb Volts to prevent Equalization	
EQ Done time	N/A	
Absorb Done Time	1Hr	
Absorb Done Amps	2A	
Battery Capacity	LFP-10: 200Ah per battery LFP-15: 300Ah per battery eVault: 360Ah per battery	
Max Charge Rate **	LFP-10 & LFP-15: 50A per battery eVault: 100A per battery	LFP-10 & LFP-15: 80A per battery eVault: 160A per battery
Max Charge Time	12 Hrs	
Bulk Starts	52.0 V	
Daily/Sunup	YES, to set the PT-100 to start a Bulk charge cycle each new day at sun-up	
Bulk Start Volts	51V	
Bulk Start SOC	50% (ME-BMK is required for this setting)	
Battery Temperature Compensation	0mV/C	
PT Alarm	PT controller can be programmed for a low battery voltage alarm	

⚠Please reassess capacity and charge/discharge current settings, when Fortress battery quantities change.

How to Calculate the Max Charge Rate

RULE: I *Battery Max Charge* > I *Charge Controller Max Charge* + I *Inverter Max Charge*

Example: 1 MAGNUM PT-100 MPPT Charge Controller; 1 MS4448PAE; 2 LFP-10 batteries
Recommend setting: I *Battery Max Charge* = 80A per Battery; Total: 160A for 2 batteries
I *Charge Controller Max Charge* =100A **(100%)** per Charge Controller
I *Inverter Max Charge* must be less than or = 60A (160A-100A=60A)
One MS4448PAE maximum output charge current is 60A
Therefore, the Max Charge Rate of the inverter will be set at 100% (60A / 60A = 100%)

As example:

	PT-100 Charge Rate	**MS4448PAE Charge Rate**
1 LFP-10	60%	33%
2 LFP-10	100%	100%