LiFEPO4 Battery Building

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Agenda

- Introduction
- Safety
- Tools / Supplies / Parts
- Construction
- Battery Boxes
- Vendors

Introduction

Key Terms

- **Cell** - single anode and cathode separated by electrolyte
- **BMS - Battery Management System** - circuitry designed to manage a protect a battery pack. A BMS can protect from
  - Overcharging
  - Temperature Limits
  - Over Discharging
  - Current Limits
- **Battery Pack** - a collection of cells wired together in serial, parallel, or a combination of both to produce a desired voltage and/or capacity and a BMS
- **Nominal Voltage** - the voltage produced by a cell when charged
- **C-Rate** - often seen as `C`, this is a multiplier of the batteries capacity usually used in terms of discharge and charge rate
  - If a 100 ah cell can charge at 1 C, it can charged at 100 amps

Data Sheets

- Data sheets give critical information about the performance of your batteries including
  - Continuous charge and discharge rates
  - Max / peak charge and discharge rates
  - Cutoff voltages
  - Temperature ranges
  - Compression requirements

No.	Item		Parameter	Remark
1	Nominal capacity		105Ah	(25±2)°C, Standard charge/discharge.
2	Nominal voltage		3.2V	
3	AC Impedance resistance (1KHz)		≤0.5mΩ	
4	Standard charge/discharge	Current of charge/discharge	0.5C/0.5C	(25±2)°C
		Cut-off voltage of charge/discharge	3.65V/2.5V	
5	Maximum current of charge/discharge	Constant charge/discharge	1C/1C	Refer to constant/pulse charge or discharge MAP
		Pulse charge/discharge (30s)	1C/3C	
6	Recommend SOC window		10%～90%	N.A.
7	Charge temperature		0°C～55°C	Refer to constant/pulse charge or discharge MAP
8	Discharge temperature		-20°C～55°C	
9	Storage temperature	1 month	-20°C～45°C	N.A.
		1 year	0°C～35°C	

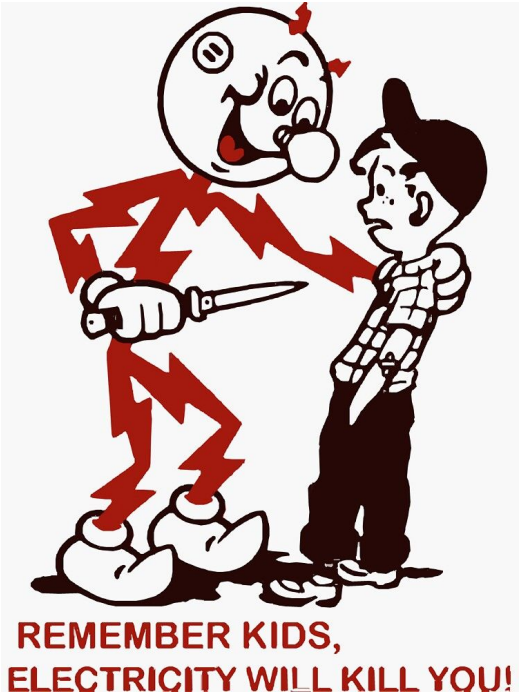
LiFePO4

- Lithium Iron Phosphate
- Nominal Voltage - 3.2v
- More chemically stable than Lithium Ion
- Usually available in either prismatic or cylindrical cells

Safety

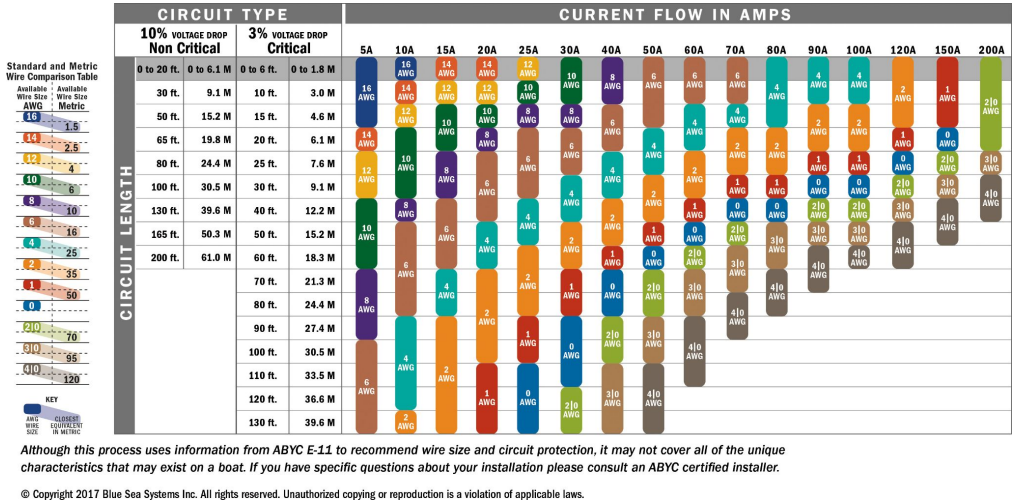
Be nice to your batteries

- Don’t overheat
- Don’t puncture
- Don’t charge while close or below freezing
- You are working with voltage and current



Wire Gauge

- Remember to choose the right size wire for the current and distance you will be using



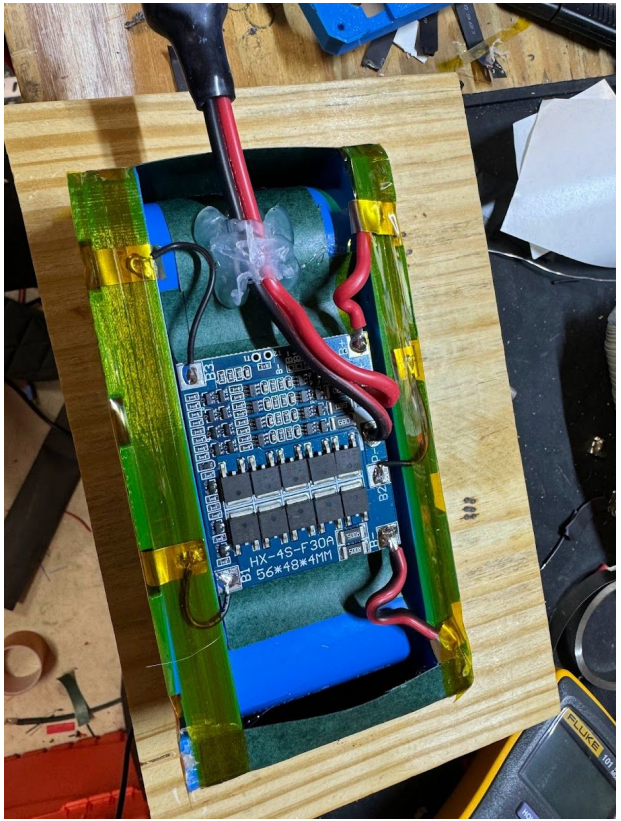
Although this process uses information from ABYC E-11 to recommend wire size and circuit protection, it may not cover all of the unique characteristics that may exist on a boat. If you have specific questions about your installation please consult an ABYC certified installer.

Source: http://assets.bluesea.com/files/resources/newsletter/images/DC_wire_selection_chartlg.jpg

The Build

High Level

- We will be taking four identical cells and wiring them into a 4S1P battery pack
  - Four cells in series
  - 3.2v x4 = 12.8v
- Attaching a BMS and programming a BMS for our battery pack (remember that data sheet)
- Connecting the battery pack to either a distribution block or Power Poles



Tools / Parts / Supplies

Workbench Tools

- Multimeter
- Wire cutters
- Wire strippers
- Crimpers
- Soldering iron / Solder / Flux / Fume extractor
- Anderson Pole Power crimpers
- Wrench set or Socket set
- Heat gun

Workbench Tools (recommended)

- Adjustable bench top power supply
  - Allows you to balance your cells as well as charge them

Tools you will need access to

- Spotter Welder (if building cylindrical cell packs)
- Cylindrical cell battery charger (if building cylindrical cell packs)
- (optional) Capacity Tester

Parts

- Four (4) identically sized LiFePO4 cells
  - Ideally these would be from the same batch or similar time frame
  - Select cells based upon your capacity and current needs
- 4S LiFePO4 BMS
  - Select based upon your current needs
- Bus bars / screws / nuts if using prismatic cells
- .15 x 8 mm nickel strip is using cylindrical cells
- 22 mm ring terminals for BMS wiring if using prismatic cells

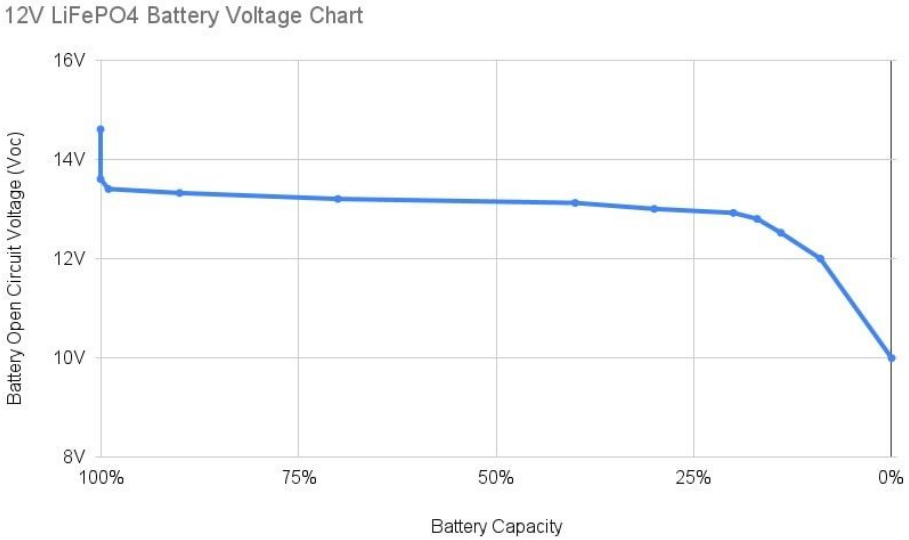
Supplies

- Appropriate sized wire for wiring pack to termination
- 22/26 awg wiring to connect BMS to cell (if your BMS doesn't include it)
- Fish paper / insulation paper for cylindrical cells
- Heat shrink for cylindrical cells
- (optional) Cell spacers for cylindrical cells
- Epoxy sheets for spacing for prismatic cells
- Reinforced tape for compressing prismatic cells
- Double sided tape to hold BMS to battery pack
- Powerpole connectors

Construction

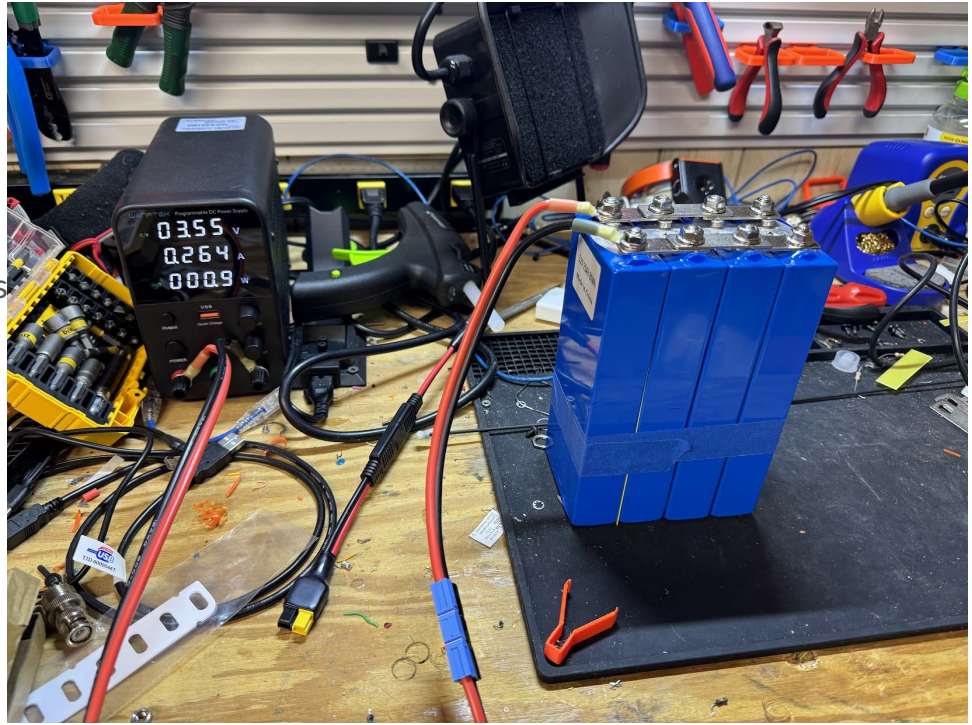
Balancing

- To achieve the best capacity, your cells should be at the same level of charge
- Most BMSs do not actively balance cells.
- Top balancing - bringing the cells to their max charge before connecting them
  - Top balancing to allows for max capacity
- Bottom balancing - bringing the cell to their lowest charge level before connecting them
  - Bottom balancing allows for max power delivery



Top Balancing

- Connect all the cells in parallel using the bus bar, screws, and nuts pending on your cells
- Connect your power supply and bring all the cells to 3.6v
    - We aren't taking them to max charge but close enough to get our desired result
- Once desired voltage is reach, disconnect the power supply and allow the batteries to set still connected for 24-48 hrs
- If using cylindrical cells, use a battery cell charger to fully charge each cell

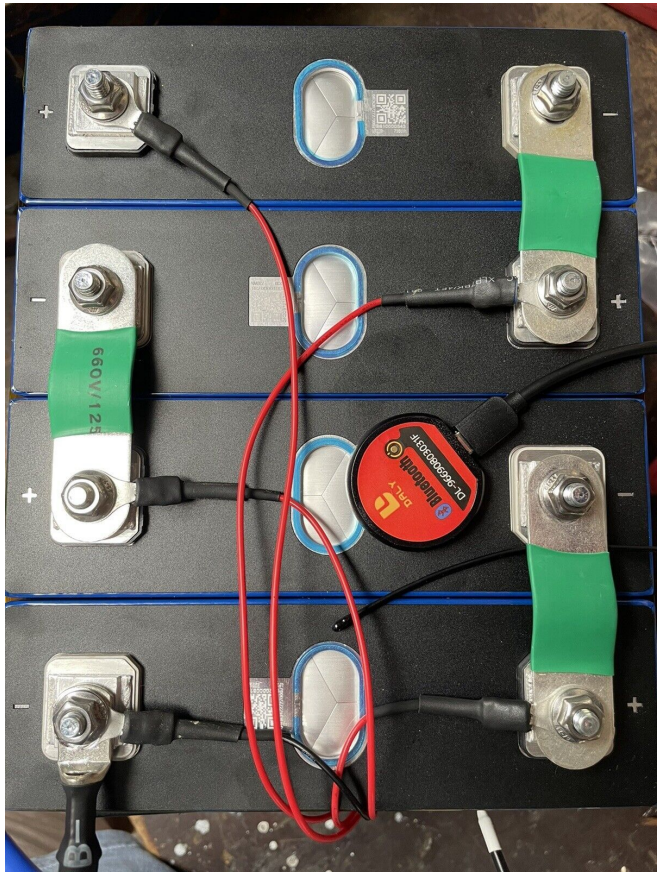


Prepping Prismatic Cells

- Remove the bus bars from the cells (you did top balance didn't you??)
- Position a pair in series
- Insert epoxy sheet between them
- Wrap those two cells with reinforced packing tape
- Positing the remaining two cells on either side of the two you just wrapped and add the epoxy sheet and tape together to make your final pack

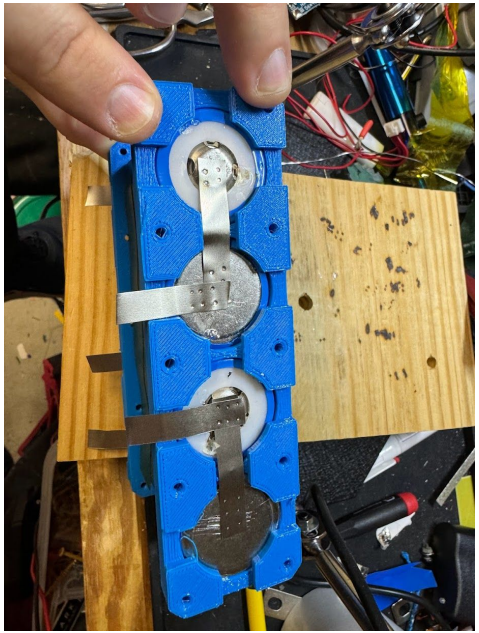
Wiring Prismatic Cells

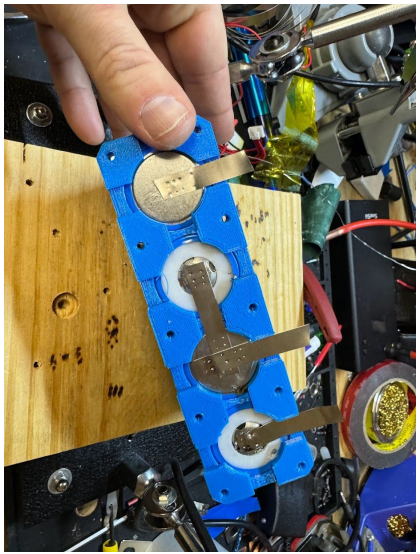
- Confirm the polarity of your cells and attach the bus bars to the top of each cell in series (positive to negative
  - At the end, you should have one positive post and one negative post for the pack
- Using your multimeter, check that you have the correct voltage (approx 12.5~13.8v)
- Loosely tighten the screws or nuts as we will need to remove some later to attach the BMS



Wiring Cylindrical Cells

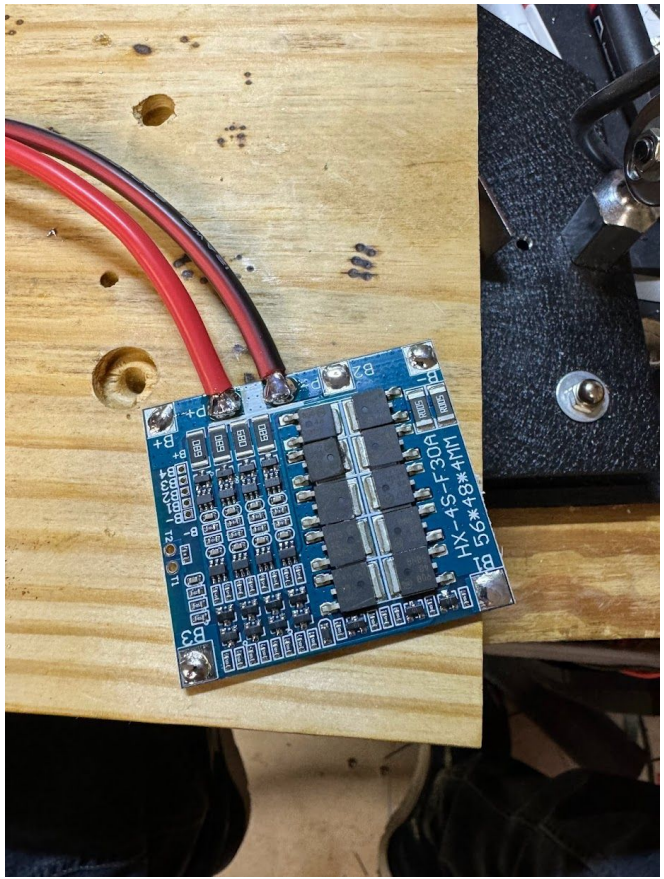
- If using cell spacers, insert the cells into them in a series configuration (alternative positive and negative ends). If not using spacers, lay out your cells in the same configuration as above
- On one side, spot weld the two outer pairs to each other (this creates two 2S batteries). Flip the pack over and spot weld the two packs together using the center two cells to create a 4S pack
- Using your multimeter, check that you have the correct voltage (approx 12.5~13.8v)





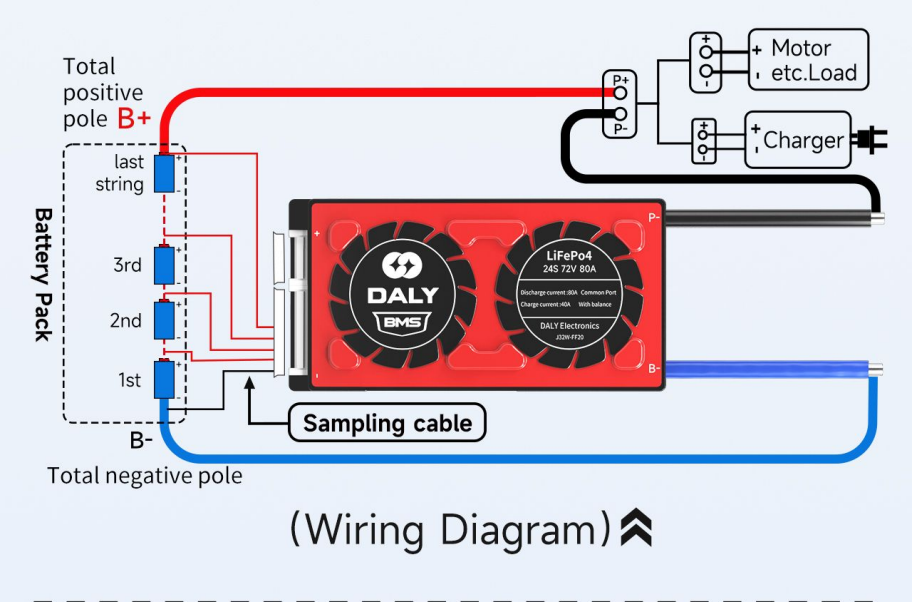
Terminating the Battery

- Follow your BMS's wiring diagram.
- Depending on your BMS, you will either
  - attach both of your positive and negative wires for the pack or
  - attach a pack wire to the negative port of the pack
- Terminate the overall positive and negative wires either with PowerPoles or ferrules for a fuse block (electrical tape until ready to install)
- Remember you have a live battery pack and can easily cause a short. Do not touch the negative and positive wires together



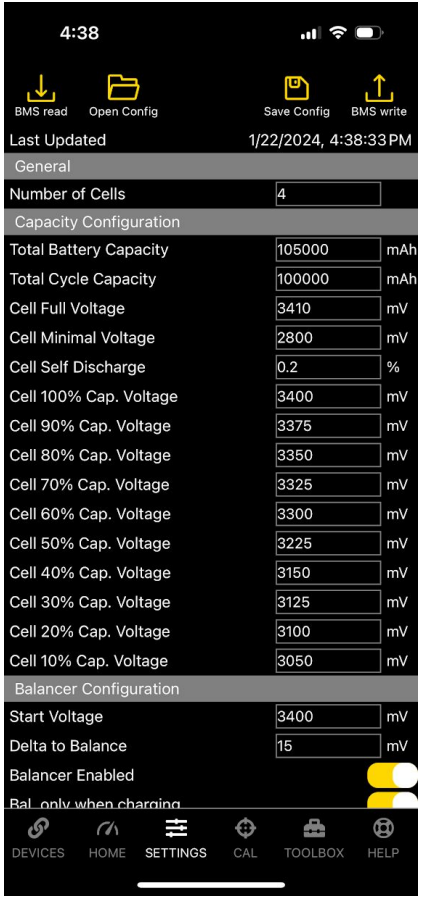
Connecting the BMS

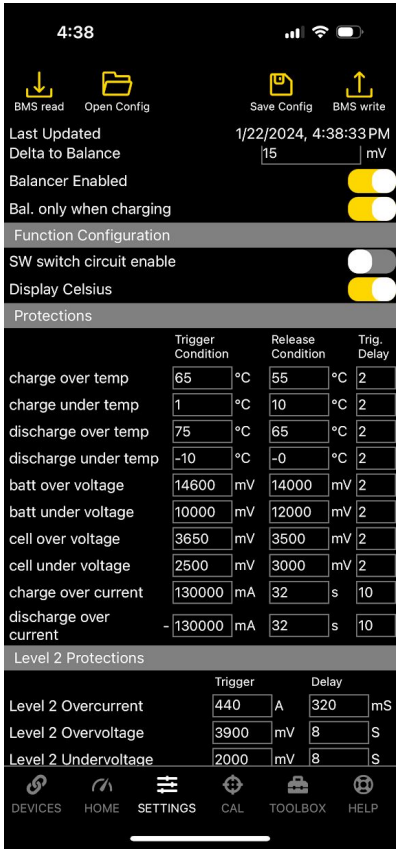
- Follow your BMS's wiring diagram. If your BMS has a detachable wiring harness, leave it detached until we are ready to power on the BMS
- In general, you will connect one wire to the positive terminal for the pack, the next three wires to each of the positive terminals of each cell, and the final wire to the pack negative terminal
- Finally, if using a detachable harness, plug it into the BMS



Programming the BMS

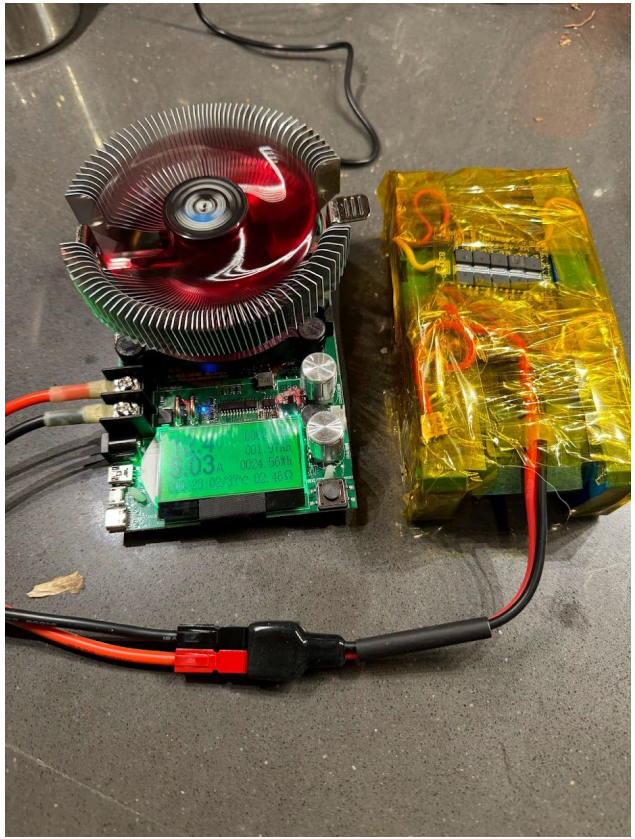
- If your BMS has a bluetooth connection option, it may need to be programmed so it can calculate the correct capacity as well as the shutoff thresholds (remember your data sheet).
- Follow your BMS instructions to get the appropriate application
- Core numbers are
  - Charge cutoff cell voltage - 3.65v
  - Discharge cutoff cell voltage - 2.5v
  - Charge temp range - 0 - 55 C





Capacity Testing

- This step is completely optional - it will allow you to know the overall capacity of your pack
- Expect 90-100% capacity based upon the theoretical max - it is all based upon your balancing



Battery Boxes

Vendors

Battery Cells

- 18650 Battery Store
  - https://www.18650batterystore.com/collections/lifepo4-prismatic-cells
  - Local to Atlanta (Stockbridge)
- Battery Hookup
  - https://batteryhookup.com/
  - New and good condition used cells
- AliExpress
  - LiitoKala Office Store for 32700 cells

BMS

- Battery Hookup
  - https://batteryhookup.com/products/12v-lifepo4-smart-bms-w-low-temp-cutoff
  - Uses the Overkill solar app
- Overkill Solar
  - https://overkillsolar.com/product/4s-bms-120a-lifepo4-threaded/
- Amazon
  - RadioB Tech Smart BMS 4S 12V LiFePO4
  - Uses the Overkill solar app
- Aliexpress
  - Daly BMS Factory Store
  - TZT BMS 30a 4s LiFePO4

Tools

- Spot Welder
  - Look for something around 8000w that says it can do .2 mm nickel strip
- Battery Capacity Tester
  - Amazon
    - MakerHawk Electronic Load Tester
- Bench Adjustable Power supply
  - Amazon
    - 30 v / 10 amp Adjustable Power supply

Questions