

Building a Battery Pack for Your Go-Box

Jim Lavin / K5VZ

Overview

- How to determine battery requirements
- Planning the Battery Pack
- Connector Options
- Charging Solutions
- How to build a 18650 battery pack

Determining Battery Requirements

- Decide on the modes you will be using
 - CW
 - SSB
 - Digital
 - AM
 - FM
- Decide on usage style
 - Contesting
 - Casual Use
- Decide on output wattage
 - QRP
 - QRO
 - Combination of both
- Decide how long you want to be operating before having to charge

Determining Battery Requirements

- Determine the power usage of your rig
 - Use a good power source like a standard 30A power supply
 - Connect an ammeter inline between the power source and your rig
 - Record the amperage usage while receiving
 - Record the amperage usage while transmitting at your intended power output
 - If you have tuners, lights, etc make sure they hooked up as well and turned on while recording your measurements
- Calculate battery requirements
 - W1PNS / WAØITP / AB8XA Battery Life Estimator - http://www.4sqrp.com/Battery_Capacity/index.php

Determining Battery Requirements

W1PNS / WAØITP / AB8XA Battery Life Estimator *

Based on Jim Duffy's (KK6MC) Battery and Charging Systems White Paper **

Revised Aug. 10, 2011

[Batteries and Charging Systems for QRP](#) - Chocked full of facts and well worth reading.

Mode Duty Cycles

SSB - 20% CW - 40% AM/FM - 100% RTTY/Digital - 100%

The entries below are used to calculate the Battery A/H's needed based on your planned operation.

The entries below are used to calculate how long a Battery will deliver the desired A/H's.

Duration needed in Hours -

- Battery Amp/Hour Rating

Mode Duty Cycle -

- Depth of Discharge (%)

Operator Duty Cycle (%) -

Radio's Receive Current in Amps -

Note - All Percentages must be entered as whole numbers without a "%" sign

Radio's Transmit Current in Amps -

Average Current Consumed - 0.736

6 - Usable Battery Amp/Hours

A/H Capacity Needed - 5.888

8.2 - Expected Battery duration in Hours ***

A/H Capacity + Reserve - 11.776

* With WAØITP and AB8XA mods of the original W1PNS Spreadsheet.

** Presented at OzarkCon 2006 and Pacificon 2005.

*** The greater the transmit draw is above the battery Ah Rating divided by 20, the lower the duration will actually be.

- Modified and Uploaded with KK6MC and W1PNS permission - WAØITP - 2 June 2011.
- Corrected and modified - AB8XA - 5 June 2011.
- Adapted for the "Web" - K5DCM - 13 June 2011.

Planning Your Battery Pack

- We can use several sites on-line to determine how many batteries and what configuration we need.
- Cell Savors, <https://cellsaviors.com/pack-planner>, has a pack planner, where you pick a battery and then input what you need.
- There are several sites that sell new 18650 batteries, I use <https://www.18650batterystore.com/>
- Steps to use
 - Select the battery you want to use
 - Select the number of cells in series and in parallel you need based on your requirements
 - Best to use the A/H Capacity + Reserve value to ensure you have a big enough battery

Select a Battery

18650 BATTERIES STORE

18650 BATTERIES ▾ 21700 BATTERIES 12V-72V BATTERY SYSTEMS ▾ ADDITIONAL SIZES ▾ BATTERY CHARGERS ▾ SUPPLIES ▾ LIFEPO4 PRISMATIC CELLS ▾

Home > Panasonic 18650 Batteries

Panasonic 18650 Batteries

Showing 1 - 8 of 8 products Display: 48 per page ▾ Sort By ▾ View [Grid] [List]

Filters

▼ STOCK STATUS

In Stock (1)

Out Of Stock (7)

▼ BRAND

Panasonic (8)

▼ BATTERY TYPE

Fiat Top (6)

Button Top - Unprotected (1)

Button Top - Protected (1)





▼ NOMINAL VOLTAGE

3.6 / 3.7 (NMC) (8)

▼ DISCHARGE CURRENT (AMPS) ?

5 - 10

5 6 7 8 9 10

 <p>Panasonic Panasonic NCR18650GA 3450mAh 10A Battery</p> <p>★★★★★ (52)</p> <p>\$7.29</p> <p><input checked="" type="checkbox"/> In stock</p> <p>ADD TO CART</p>	 <p>Panasonic Panasonic NCR18650PF 2900mAh 10A Battery</p> <p>★★★★★ (10)</p> <p>\$6.99</p> <p><input checked="" type="checkbox"/> Out Of Stock</p> <p>SOLD OUT</p>	 <p>Panasonic Panasonic NCR18650A 3100mAh 6.2A Battery</p> <p>★★★★★ (24)</p> <p>\$7.99</p> <p><input checked="" type="checkbox"/> Out Of Stock</p> <p>SOLD OUT</p>	 <p>Panasonic Panasonic NCR18650BD 3180mAh 10A Battery</p> <p>★★★★★ (22)</p> <p>\$7.99</p> <p><input checked="" type="checkbox"/> Out Of Stock</p> <p>SOLD OUT</p>
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[Help](#)

Record the Battery Characteristics

Panasonic NCR18650GA 3450mAh 10A Battery

Specifications:

Manufacturer	Panasonic
Model	GA
Size	18650
Positive Terminal	Flat Top
Nominal Capacity	3450mAh
Continuous Discharge Rating (max)	10A
Nominal Voltage	3.6V
Maximum Voltage	4.2V
Discharge cut-off Voltage	2.5V
Protected	No
Rechargeable	Yes
Approx. Dimensions	18.33mm x 65.08mm
Approx. Weight	46.5g
Country of Origin	Japan
Associated Names	NCR18650GA, GA6
Data Specification Sheet	Panasonic NCR18650GA Datasheet

Pick the Battery in the Planner

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18650 Battery Pack Calculator and Planner

Get 5% off your entire order at Battery Clearing House with discount code: CSS

Select a cell from the cell database

Use this autocomplete search functionality to find your specific cell in order to pre-populate the values that we have for that cell.

This list is by no means exhaustive. If you have cells that you would like added or find that we are missing data for some of the cells that we do have, [please email us](#), or [fill out a contact form](#).

Cell database made possible and initially compiled by Wolf @ the [SLS.com forums](#)

Enter your cell manufacturer or model number to search for your cell. Results will appear automatically as you type.

Cell Manufacturer or Model Number

NCR18650GA

Manufacturer: Sanyo
Part Number: NCR18650GA
Cell Format: 18650

mAh Rating: 3300mAh
Nominal Voltage: 3.6V
Cell Wrap Color: Red

Single cell information

Enter information on a single cell into the input fields to receive results for a single cell. Results will automatically generate every time a value changes and there is enough information to calculate results.

The C-rate will be used down below at pack level calculations, so make sure you fill this section out.

Enter the voltage of a single cell in your planned pack and the rated & tested capacity of one cell.

Nominal voltage of one cell

Rated capacity of one cell in Ah

Minimum voltage of one cell (optional)

Maximum voltage of one cell (optional)

Enter the C-rate & the charge/discharge current.

C-rate

Charge or discharge current in amps



Join the Community

You Can Also Manually Enter Values

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Nominal voltage of one cell

Rated capacity of one cell in Ah

Minimum voltage of one cell (optional)

Maximum voltage of one cell (optional)

Enter the C-rate & the charge/discharge current.

C-rate

Charge or discharge current in amps

Results

Watt Hours (Wh)

12.42 Wh

Time to charge / discharge one cell

0 hours and 21 minutes

Pack level information

Enter information related to your up-and-coming pack to get all kinds of information on the pack.

The C-rate, voltage, and capacities from the single-cell step will be used to calculate information in this step. Make sure that you fill out the fields above to get accurate results in this section.

Enter the intended series and parallel cell numbers of the pack you are going to be building.

Cells in series

Cells in parallel

Results



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Select the Configuration - 4S (14.4V) 3P (10.35 Ah)

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Pack level information

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The C-rate, voltage, and capacities from the single-cell step will be used to calculate information in this step. Make sure that you fill out the fields above to get accurate results in this section.

Virtual battery life estimator

This section allows you to get an idea of approximately how long the pack you are building will be able to run.

If you plan on running something that consumes 1000W, you can now figure out how long the pack will last while providing that power.

Enter the intended series and parallel cell numbers of the pack you are going to be building.

Cells in series

Cells in parallel

Results

Number of cells in the pack	12 cells
Nominal voltage of pack	14.40V
Minimum pack voltage	10.00V
Maximum pack voltage	16.80V
Max discharge current	30.00A
Estimated capacity of pack (Ah)	10.35 Ah
Estimated capacity of pack (Wh)	149.04 Wh










Enter the amount of watts you expect to be drawing off of the pack to figure out how long that pack would last before needing a recharge.

Watts drawn from pack (W)



Select the Configuration - 4S (14.4V) 4P (13.80 Ah)

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Pack level information

Enter information related to your up-and-coming pack to get all kinds of information on the pack.

The C-rate, voltage, and capacities from the single-cell step will be used to calculate information in this step. Make sure that you fill out the fields above to get accurate results in this section.

Enter the intended series and parallel cell numbers of the pack you are going to be building.

Cells in series

Cells in parallel

Results

Number of cells in the pack 16 cells

Nominal voltage of pack 14.40V

Minimum pack voltage 10.00V

Maximum pack voltage 16.80V

Max discharge current 40.00A

Estimated capacity of pack (Ah) 13.80 Ah

Estimated capacity of pack (Wh) 198.72 Wh

Virtual battery life estimator

This section allows you to get an idea of approximately how long the pack you are building will be able to run.

If you plan on running something that consumes 1000W, you can now figure out how long the pack will last while providing that power.

Enter the amount of watts you expect to be drawing off of the pack to figure out how long that pack would last before needing a recharge.

Watts drawn from pack (W)



Calculate Life Time, Cost and Weight

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Virtual battery life estimator

This section allows you to get an idea of approximately how long the pack you are building will be able to run. If you plan on running something that consumes 1000W, you can now figure out how long the pack will last while providing that power.

Enter the amount of watts you expect to be drawing off of the pack to figure out how long that pack would last before needing a recharge.

Watts drawn from pack (W)

Results

Estimated run time	21 hours and 7 minutes
Pack discharge rate	0.63A

Pack weight and cell cost

This section estimates the cost and weight of the pack based on cell count, single cell weight, and cost per cell. The series and parallel information from the above step are used to calculate this information, so make sure you fill out the above step first.

Enter the weight per cell, in grams, and the cost per cell to calculate overall pack weight and cell cost.

Cost per cell (\$)

Weight in grams

Results

Cell cost of pack	\$116.64
Weight of pack (g)	744 grams
Weight of pack (lbs)	1.64 lbs



Building out

1. Get parts
2. Test cells to get actual capacity per cell
3. Plan cell placement based on actual values
4. Assemble the pack

Parts and Links

Parts and Links will be provided in a separate hand out along with all resource links so you can build your own pack.

- 18650, 21700, or other Battery Cells
- BMS 4S rated at 2x Amperage you will be pulling
- Wire rated at 2x Amperage you will be pulling 14ga - 24A, 12ga - 34A
https://www.engineeringtoolbox.com/wire-gauges-d_419.html
- Cell Holders
- Kapton Tape
- Felt Insulator Stickers

Test Cells for Actual Capacity

Use a battery tester like the Opus BT - C3100 to measure each cell's current capacity via a discharge test

Annotate the capacity on each cell

Depending on the number of cells you will be using this could take a couple of days

Plan The Cell Placement

1. To plan on where each cell goes in your pack, use the Pack Builder web site at <https://www.repackr.com/#/pack-builder>
2. Enter in the capacity of each cell you will be using in Step 1
3. Enter the Pack Dimensions 4S or 3S and 1P, 2P, 3P, 4P, etc.
4. Generate the Pack assembly configuration

Enter Cell Capacities in Step 1

Pack Builder

1 Provide a list of cells

2 Specify pack dimensions

Comma separated list of cell capacities in mAH to be added to the packs

3410,3416,3343,3347,3344,33433471,3416

Add Cells

Specify Pack Dimensions in Step 2

Pack Builder

1 Provide a list of cells — 2 Specify pack dimensions — 3 Generated

Number of cells in series

Capacity

or

Nominal Cell Voltage

Choose between a fixed number or variable number of cells to achieve a target capacity

Generate packs

Back

Generate Pack Details

Pack Builder

1 Provide a list of cells — 2 Specify pack dimensions — 3 Generated pack

[Start again](#) [Export CSV](#) [Copy to Clipboard](#) Compact

Summary

Each parallel pack once connected together will create a battery with these characteristics.

Voltage (3.6 nominal)	14.4V	Amp Hours	6.757 Ah	Watt Hours	97.3008 Wh
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Clicking on a capacity will highlight it in green to help you check off cells you've found.

Parallel Pack 0

#	Capacity
0	3416
1	3344
Total Capacity	6760 mAh
Divergence (from the average pack capacity)	-13 mAh
Deviation (between the capacity of cells in the pack)	50 mAh

Parallel Pack 1

#	Capacity
0	3471
1	3343
Total Capacity	6814 mAh
Divergence (from the average pack capacity)	41 mAh
Deviation (between the capacity of cells in the pack)	90 mAh

Pack Details Continued

Parallel Pack 2

#	Capacity
0	3410
1	3347
Total Capacity	6757 mAh
Divergence (from the average pack capacity)	-16 mAh
Deviation (between the capacity of cells in the pack)	44 mAh

Parallel Pack 3

#	Capacity
0	3416
1	3343
Total Capacity	6759 mAh
Divergence (from the average pack capacity)	-14 mAh
Deviation (between the capacity of cells in the pack)	51 mAh

Arrange Batteries in Holder



Tape Battery Pack with Kapton Tape



Cut Nickel Strips To Size



Weld Strips To Cells



Weld Cells In Parallel



Weld Cells In Series



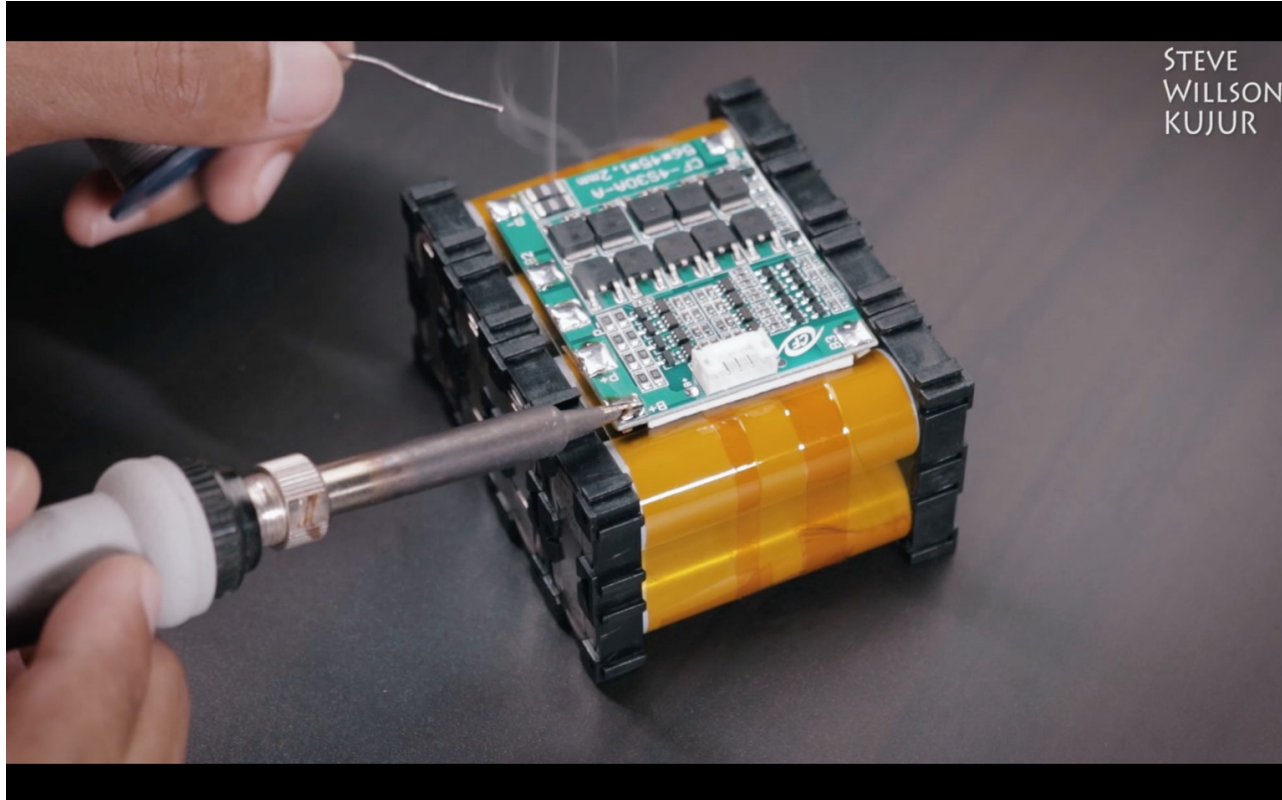
Weld Cells In Series Second Side



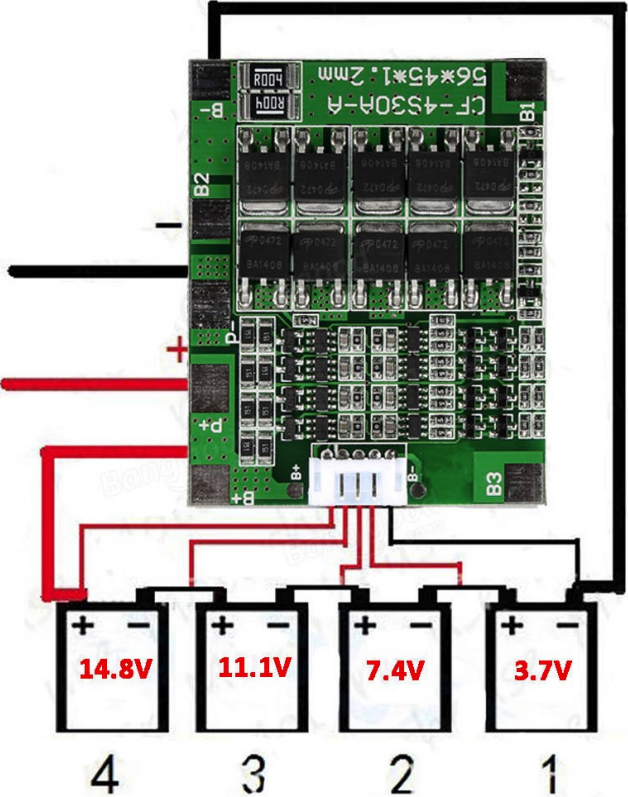
Attach BMS To Battery Pack



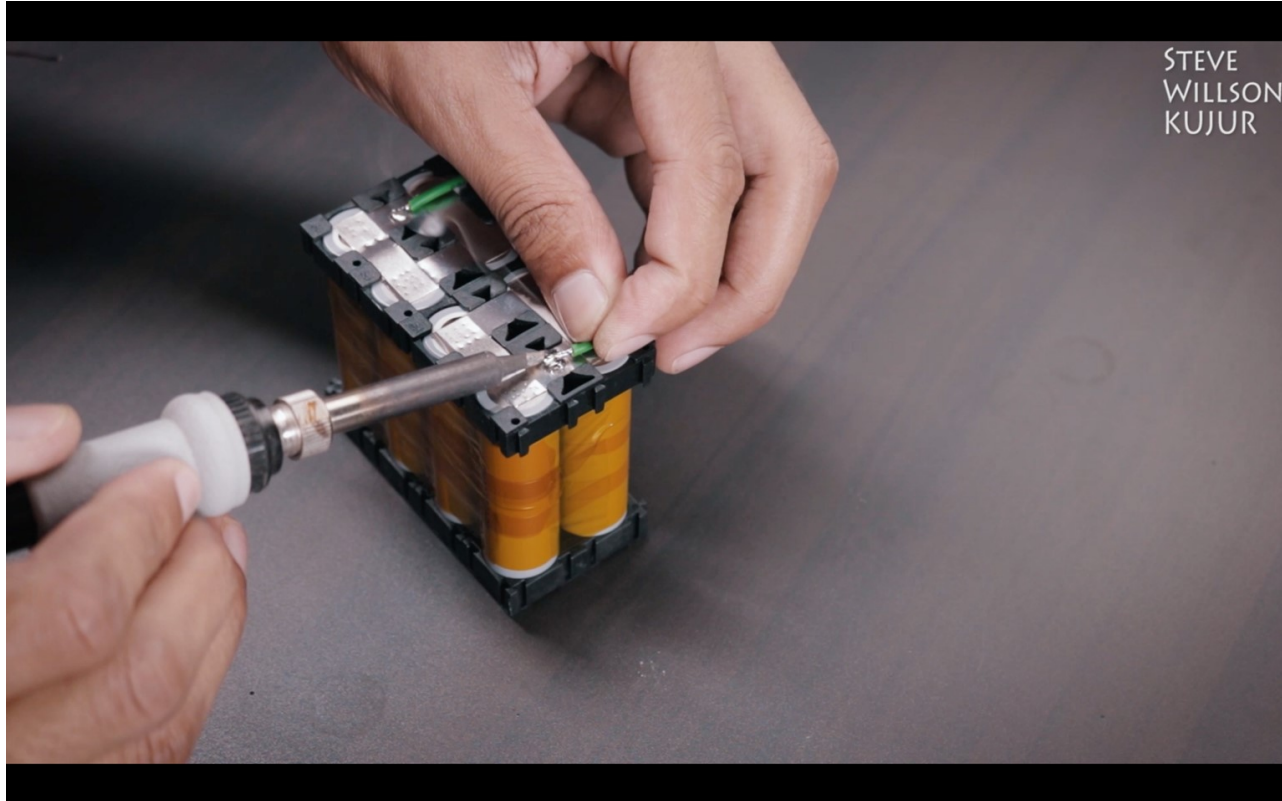
Pre-Tin Connections On BMS



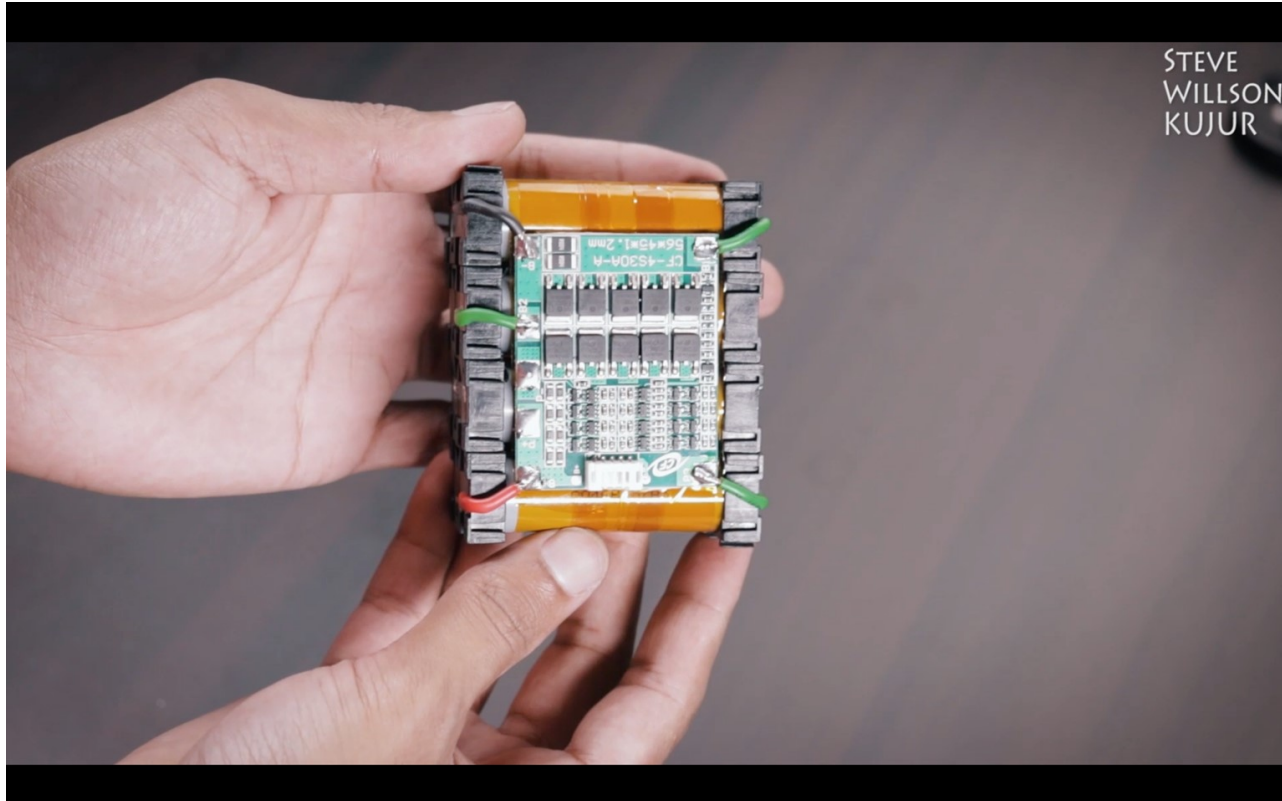
BMS Wiring Diagram



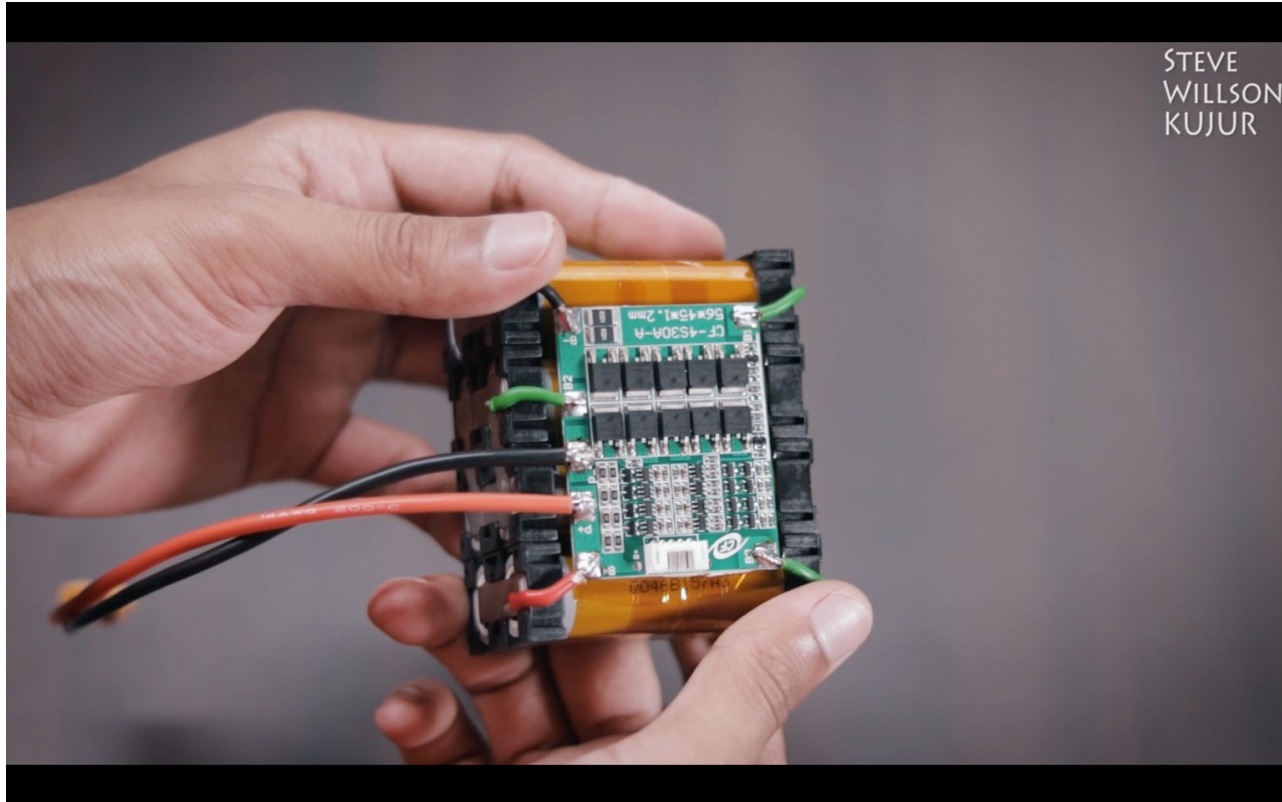
Solder BMS Connections to Cells



Final Wiring Example



Solder Charging/Discharging Connections To BMS



Resources

- Beginner's guide to building 18650 battery packs - https://www.youtube.com/watch?v=tKg-jlrr_JE
- W1PNS / WAØITP / AB8XA Battery Life Estimator - http://www.4sgrp.com/Battery_Capacity/index.php
- Cell Savior Pack Planner - <https://cellsaviors.com/pack-planner>
- rePackr - 18650 pack builder - <https://www.repackr.com/#/pack-builder>

Links to Parts

Batteries - <https://www.18650batterystore.com/> <https://www.batteryspace.com/>

<https://batteryhookup.com/>

Battery Tester - <https://www.amazon.com/gp/product/B01852TBOU> Out of Stock

[Amazon - 4 slot charger/tester](#)

Heat shrink covers - [Amazon 110mm](#)

Kapton Tape - [eBay - 2 x 1" x 36yd rolls](#)

Battery Management Circuits [Amazon 3S 25A](#) [Amazon 4S 30A](#)

Ready built packs - <https://www.batteryspace.com/> https://bmsbattery.com/ebike-battery/652-16350-12v-10ah-38120s-lifepo4-battery-4-cells-ebike-battery-pack-battery.html#/212-discharge_current-20_40a