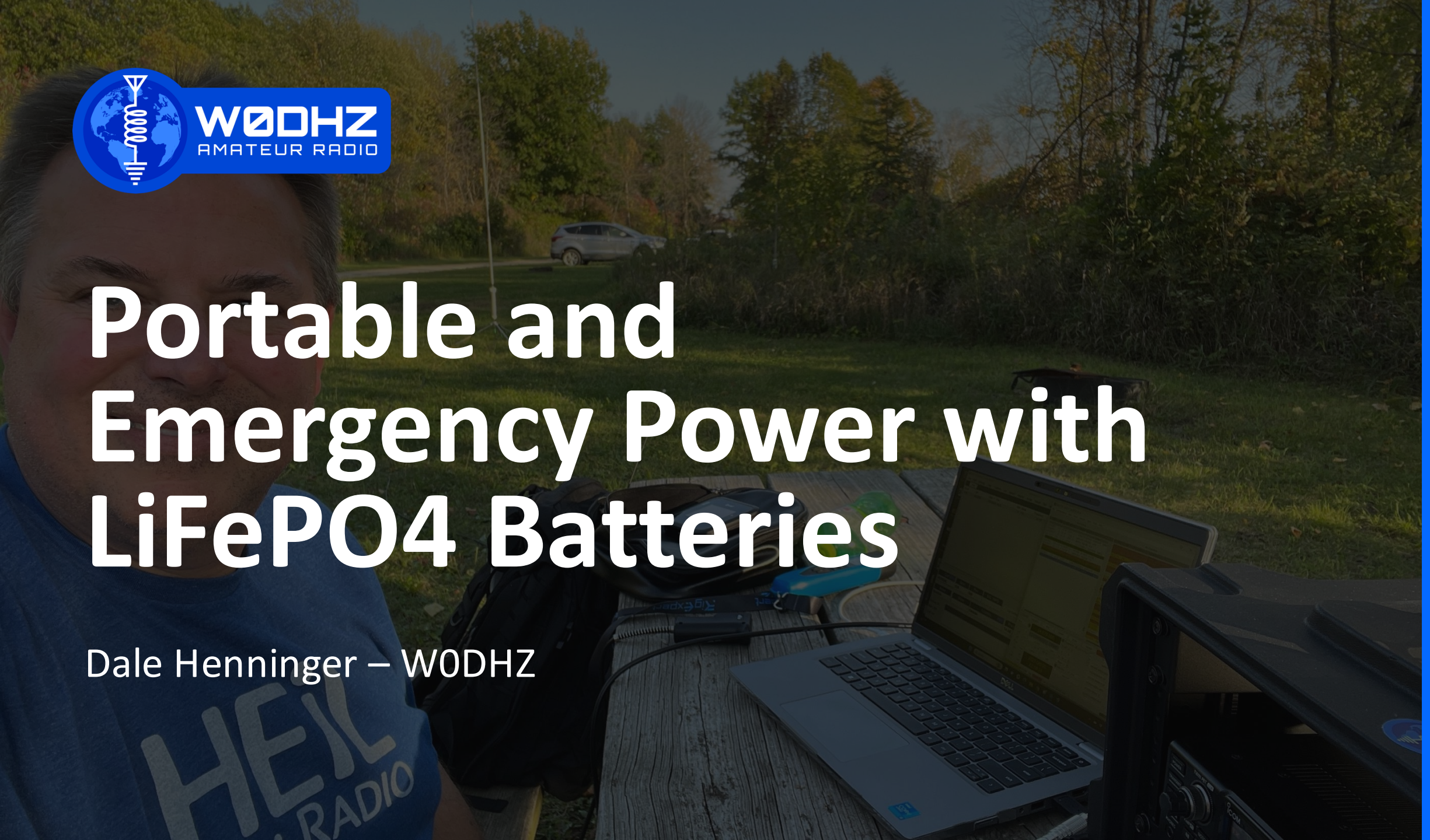


Portable and Emergency Power with LiFePO4 Batteries

Dale Henninger – W0DHZ

Before we start…

I am a hobbyist… Not an electrical engineer.

Be Safe!

- Wear eye protection
- Invest in non-conductive tools
- Use Kapton/Polyimide Insulating Tape

  (heat resistant / non-conductive)

Read manufacturer data sheets!

Use fuses! High quality fuses!

Disclaimer

Bioenno Power has donated batteries to the convention as door prizes.

They did not ask for me to promote their batteries and were not aware that I am doing this presentation.

I personally use Bioenno Power batteries as well as other brands of LiFePO4 batteries.

Bioenno Power has been very gracious to the amateur radio hobby, and I have received excellent customer service, which is why I continue to use their products.

Ham Radio and Batteries

Direct Current!

RF Quiet

Emergency Communications

Off Grid Operations

Great for portable use (POTA/SOTA)

By Towel401 (talk) (Transferred by terraflorin/Originally uploaded by Towel401) - self-made (Originally uploaded on en.wikipedia), Public Domain, https://commons.wikimedia.org/w/index.php?curid=18314016

Ham Radio and Batteries

Your rig is only as good as your power source!

Radios require a 13.8 v power source (+/- 15%)

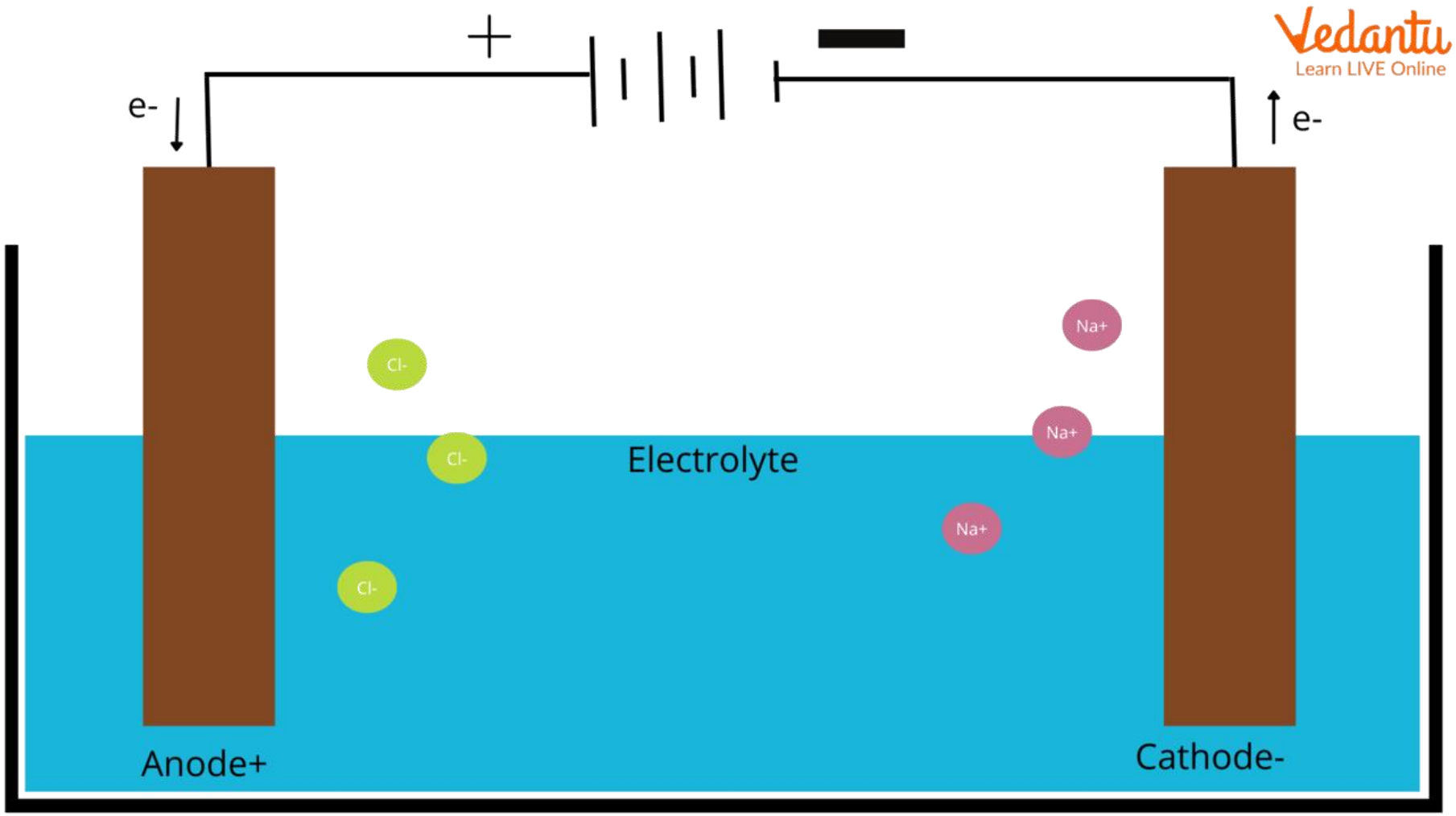
11.73 v - 15.87 v

Battery needs to deliver a current that can sustain the power level you are trying to operate at, with no reduction in voltage.

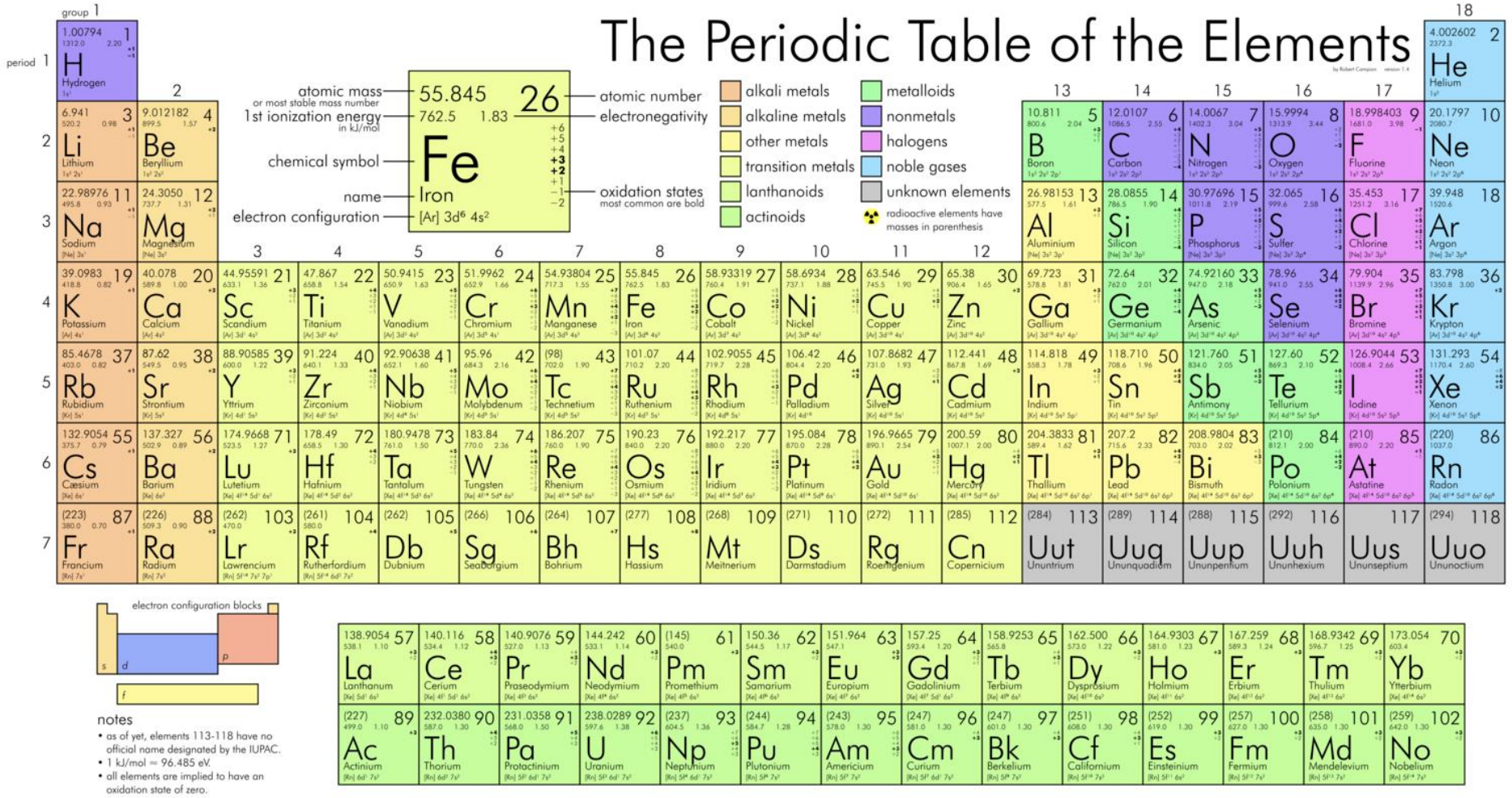
100w = ~ 17 Amps

By Towel401 (talk) (Transferred by terraflorin/Originally uploaded by Towel401) - self-made (Originally uploaded on en.wikipedia), Public Domain, https://commons.wikimedia.org/w/index.php?curid=18314016

Battery Review



Battery Chemistries

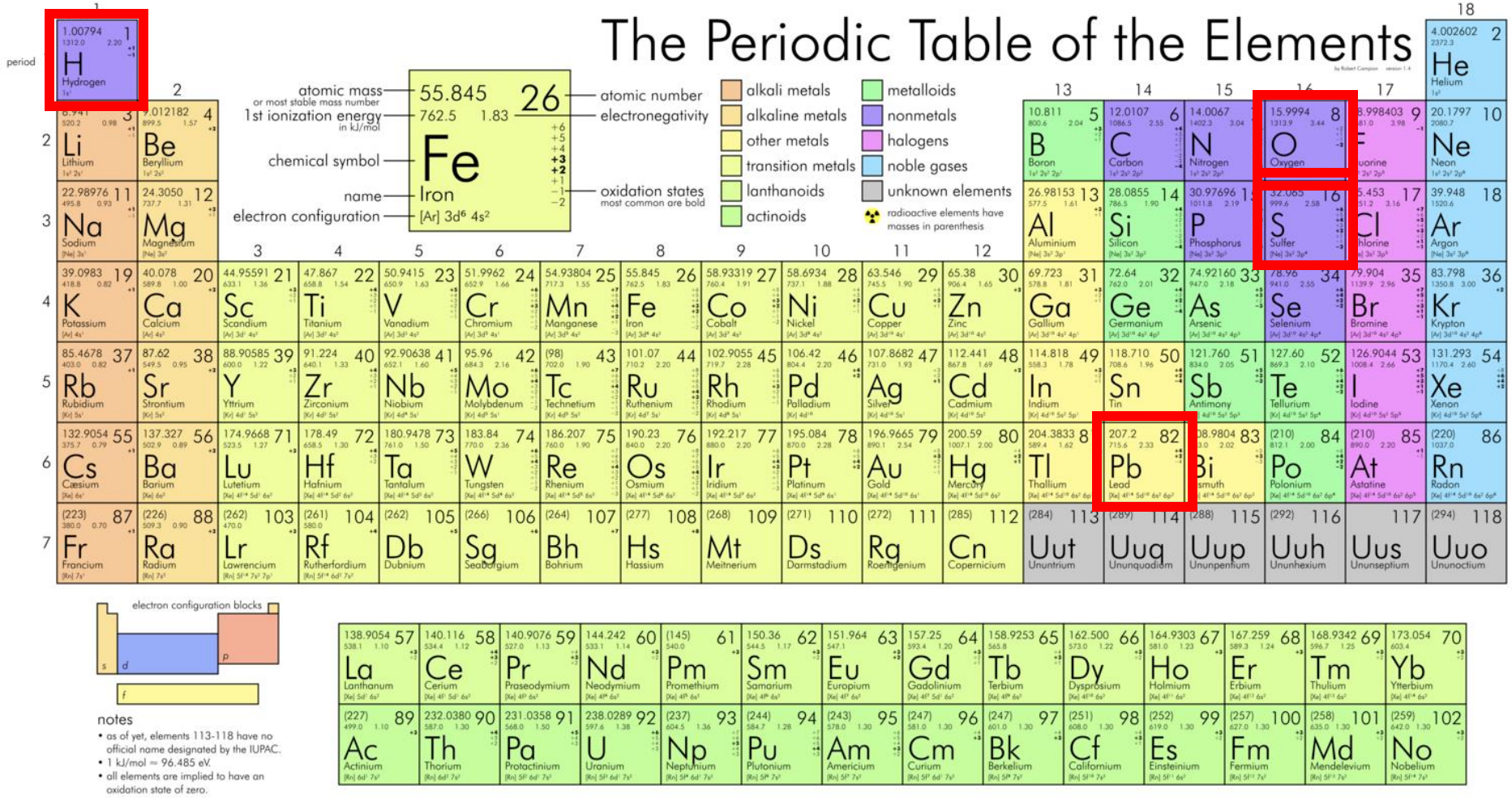


Battery Chemistries – Lead Acid

Lead (Pb)

Sulfuric Acid (H / S / O)

AGM – Improves the design – increases the costs



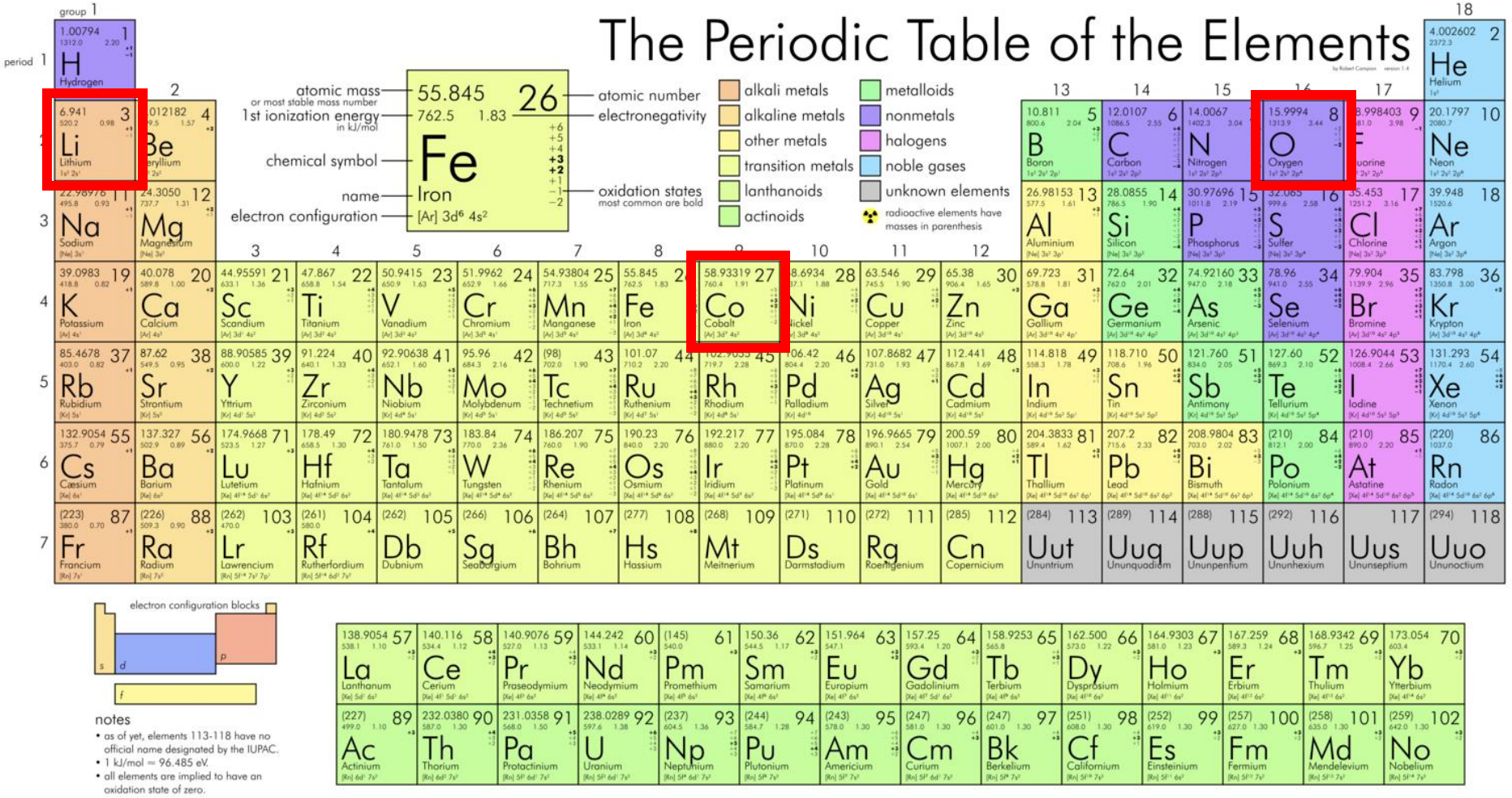
Battery Chemistries – Lithium Ion / Lithium Polymer

Lithium Ion ($LiCoO_2$)

Cobalt

Lithium Polymer (LiPo)

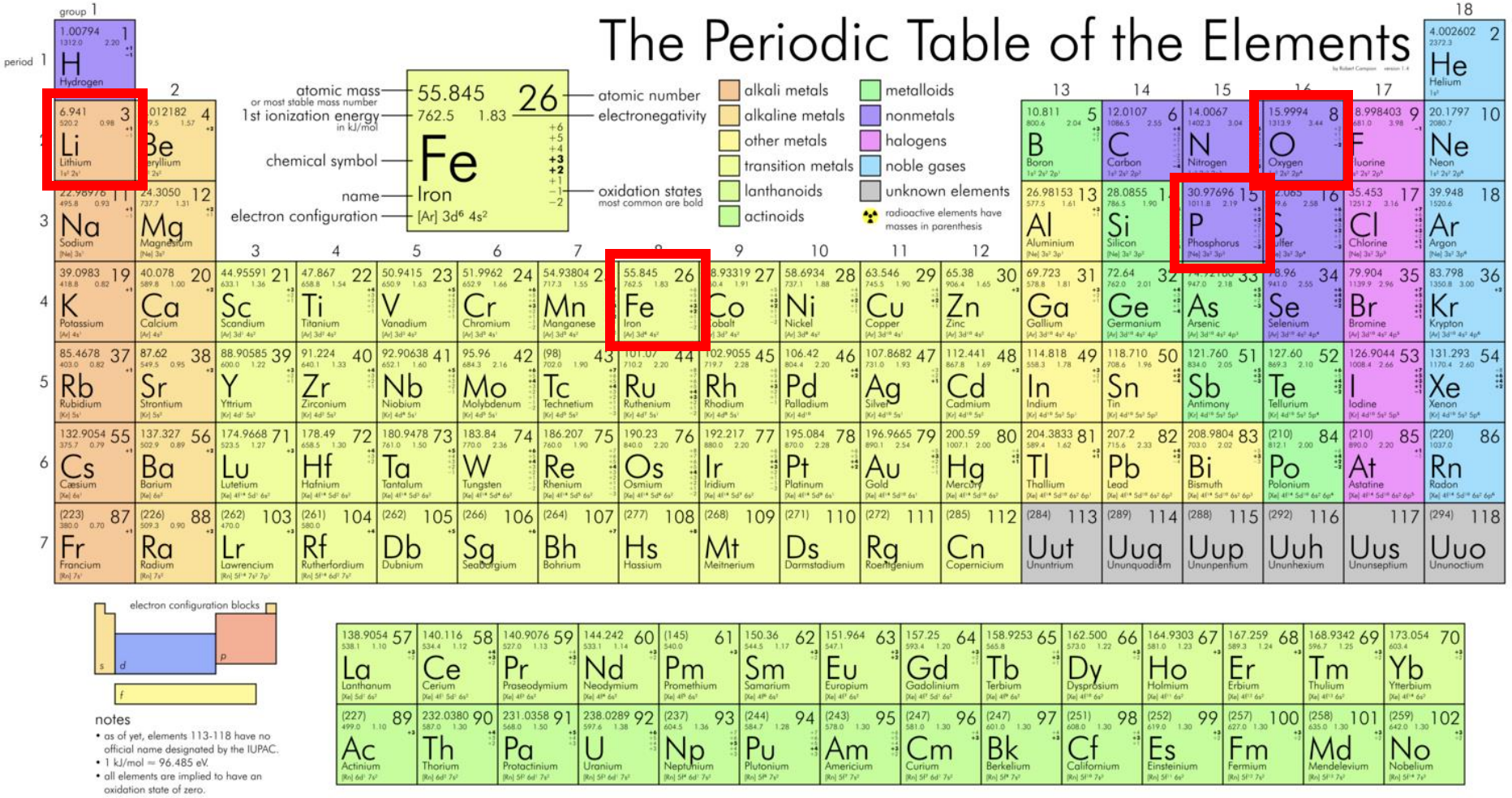
(Lithium Ion variant)



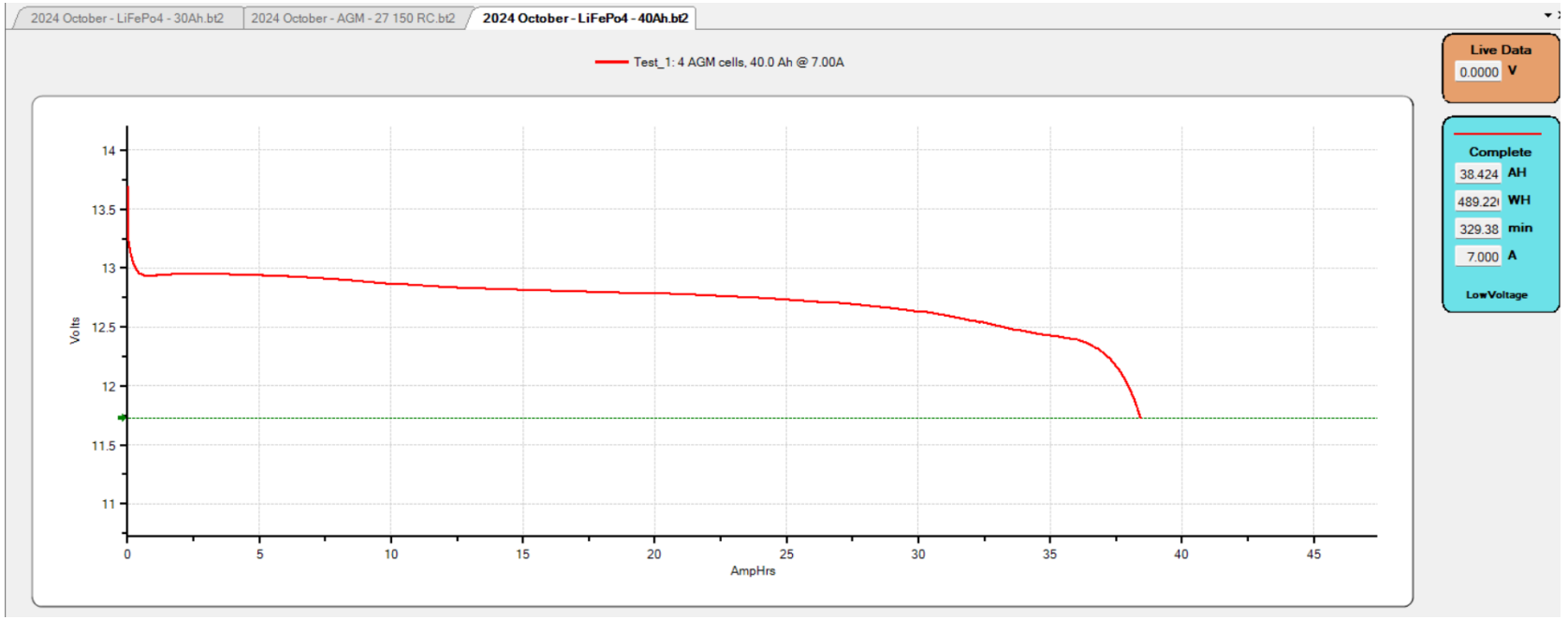
Battery Chemistries – Lithium Iron Phosphate

Lithium Iron Phosphate

($LiFePO_4$)



My Test Suite



Battery Measurement/Testing Terms

Amateur Radio Effective Voltages – 11.73v minimum (-15% of 13.8v)

All my tests are conducted with a shut off voltage of 11.73v

Amp Hours (Ah) – Battery capacity measurement

Amps * Hours = Ah (30 Ah battery could deliver 1A for 30 hours or 30A for 1 Hour)

State of Charge – Measurement of hour much capacity is left in the battery

0-100%

Battery Technologies

Lead Acid

Pros

- Cheap / Durable (abuse may shorten life span)

Cons

- Heavy (lowest energy density)
- Can only be discharged to about 50% of their rated capacity for peak life span (life span not that long)
- Voltage drops as you discharge
- Messy / Dangerous (AGM solves some of this)

Lead Acid / AGM Batteries

Group 27 AGM Deep Cycle

Specs

- 65 Pounds / 11” x 7.3” x 9.3”
- 150 Minutes of Reserve Capacity
- $249.99

- Max/Peak Discharge: Hundreds of Amps

Power Density

51.5 Ah of Capacity > 11.73 volts

.79 Ah / Pound Power Density

$4.85 / Ah

Deep Cycle Lead Acid / AGM Batteries

Reserve Capacity vs Amp Hour

Reserve capacity (RC)

Measures how long a battery can run before its voltage drops to a certain level. For example, a battery with a reserve capacity of 150 minutes can supply 25 amps for 150 minutes before the voltage drops to 10.5 volts. RC is a good indicator of how long a battery can power essential accessories if a vehicle's alternator fails.

Amp hours (Ah)

Measures how many amps a battery can produce in one hour. One ampere-hour is the amount of electric charge transferred by a steady current of one ampere for one hour

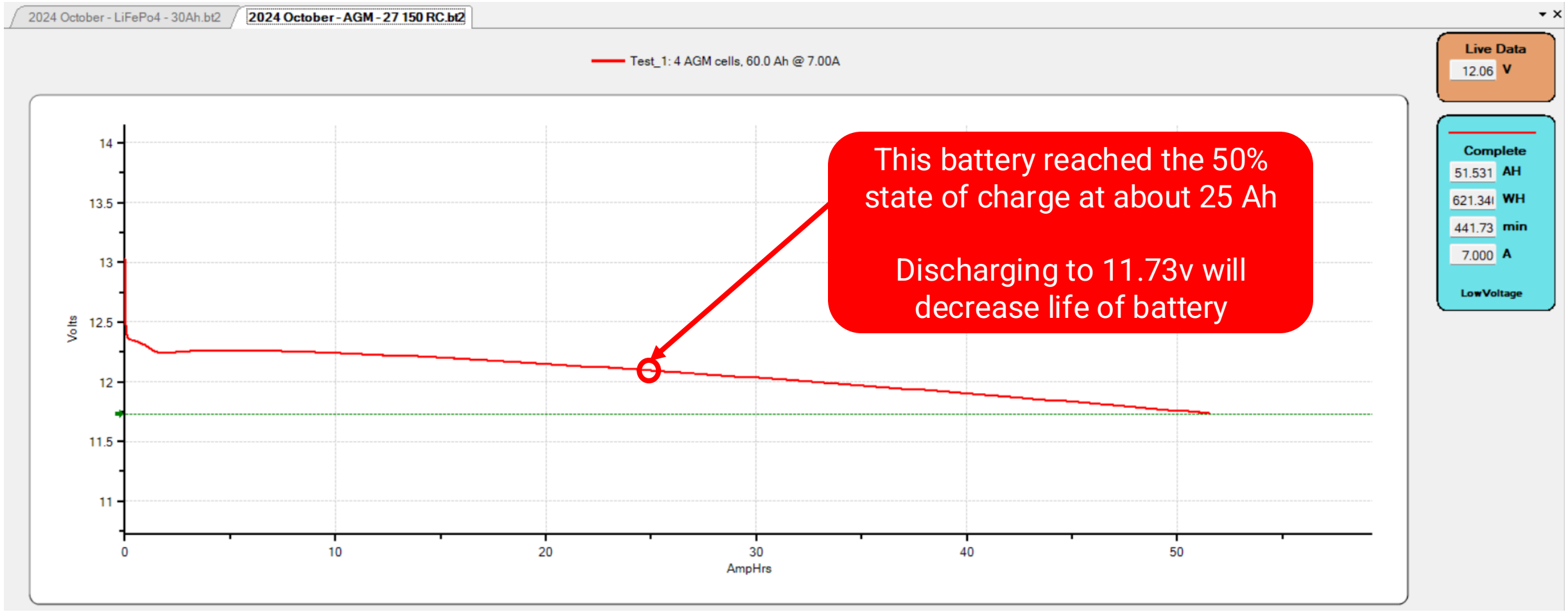
12V Sealed Lead Acid Battery Voltage Chart		12V Flooded Lead Acid Battery Voltage Chart	
Voltage	Capacity	Voltage	Capacity
12.89V	100%	12.64V	100%
12.78V	90%	12.53V	90%
12.65V	80%	12.41V	80%
12.51V	70%	12.29V	70%
12.41V	60%	12.18V	60%
12.23V	50%	12.07V	50%
12.11V	40%	11.97V	40%
11.96V	30%	11.87V	30%
11.81V	20%	11.76V	20%
11.70V	10%	11.63V	10%
11.63V	0%	11.59V	0%

$$Ah = \frac{RC}{60} \times 25$$

$$62.5\ Ah = \frac{150}{60} \times 25$$

I only measure 51.5 Ah as I cutoff testing when I pass below 11.73v

Group 27 Discharge Curve = 7A Load



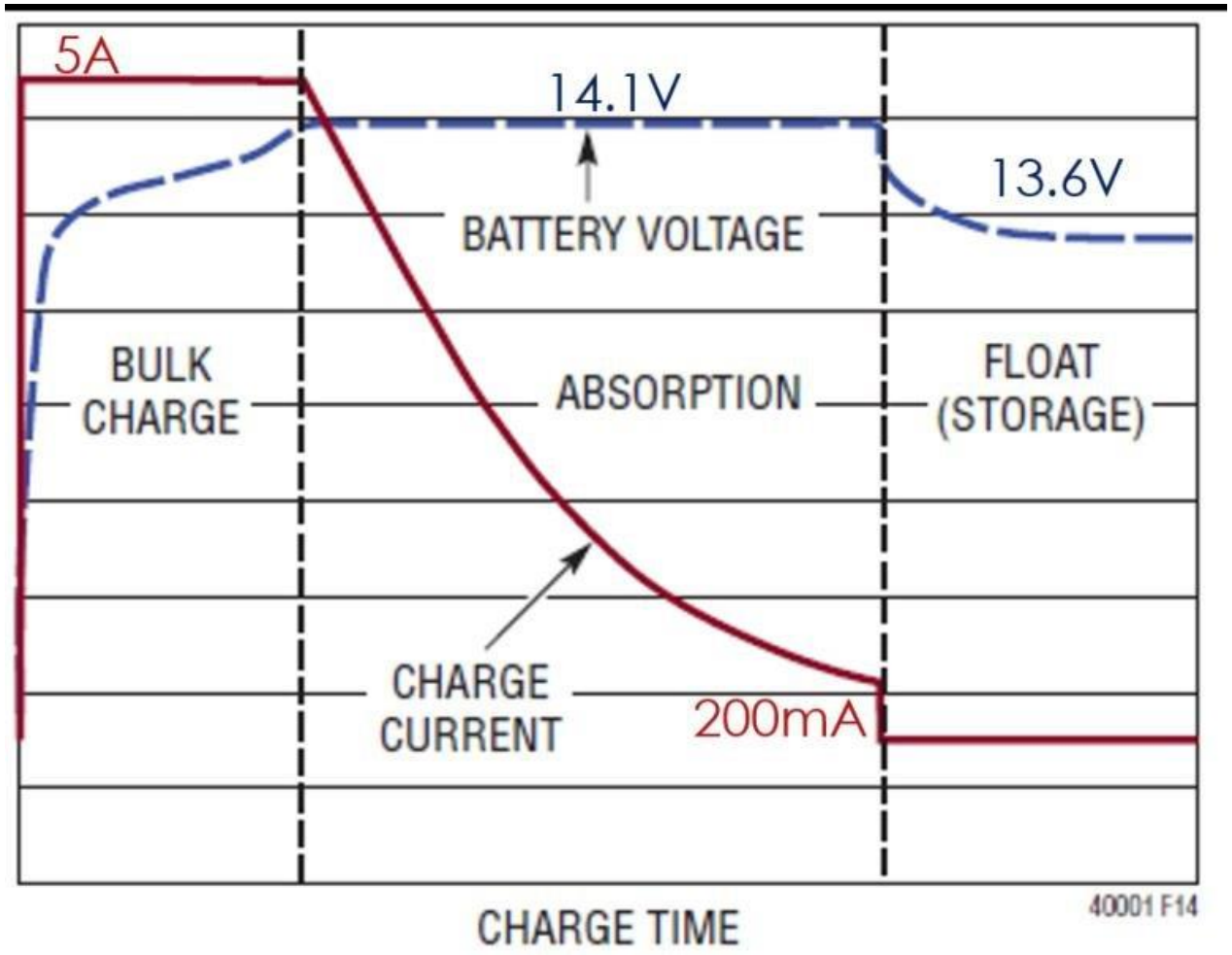
Lead Acid Battery – Complex Charging Profile

Charging the battery to 80% happens quickly

The last 20% of the charge has to be done at a much slower rate to top off the battery

Specialized chargers are needed to effectively charge these batteries

Charging incorrectly will cause heat and you will boil your battery



Battery Technologies

Lithium Ion / Polymer

Pros

- ~500 Discharge Cycle Lifespan
- Lightweight (high energy density)

Cons

- Higher Cost
- Risk of Thermal Runaway / Swelling

Battery Technologies

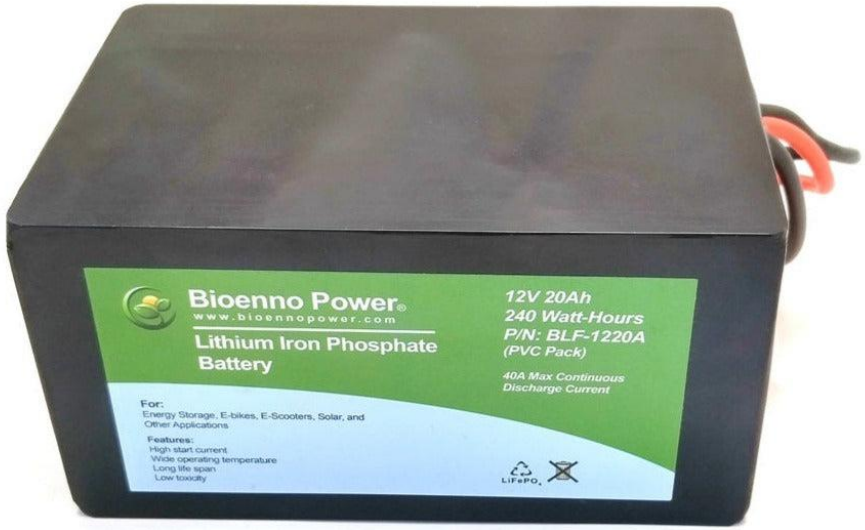
Lithium Iron Phosphate

Pros

- ~3000+ Discharge Cycle Lifespan
- Lightweight (high energy density)
- Able to utilize +90% of the stored energy
- Very Safe / Stable / Durable

Cons

- Higher Cost



LiFePO4 Batteries

Bioenno 40 Ah LiFePO4

Specs

- 10.4 Pounds / 8.4” x 6.3” / 3.2”
- $359.99
- 40A Max Continuous Discharge
- Peak Discharge 80A (5 seconds)

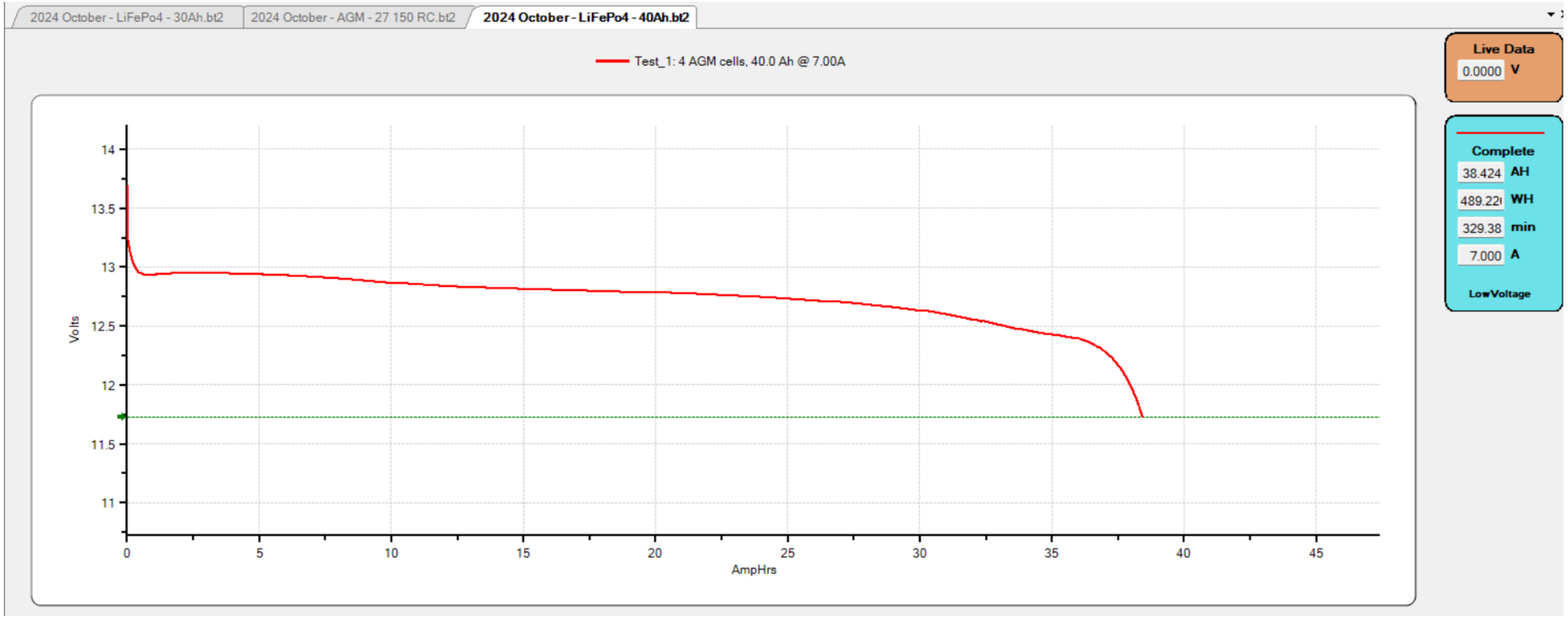
Power Density

38.4 Ah of Capacity > 11.73 volts

3.7 Ah / Pound Power Density

$9.38 / Ah

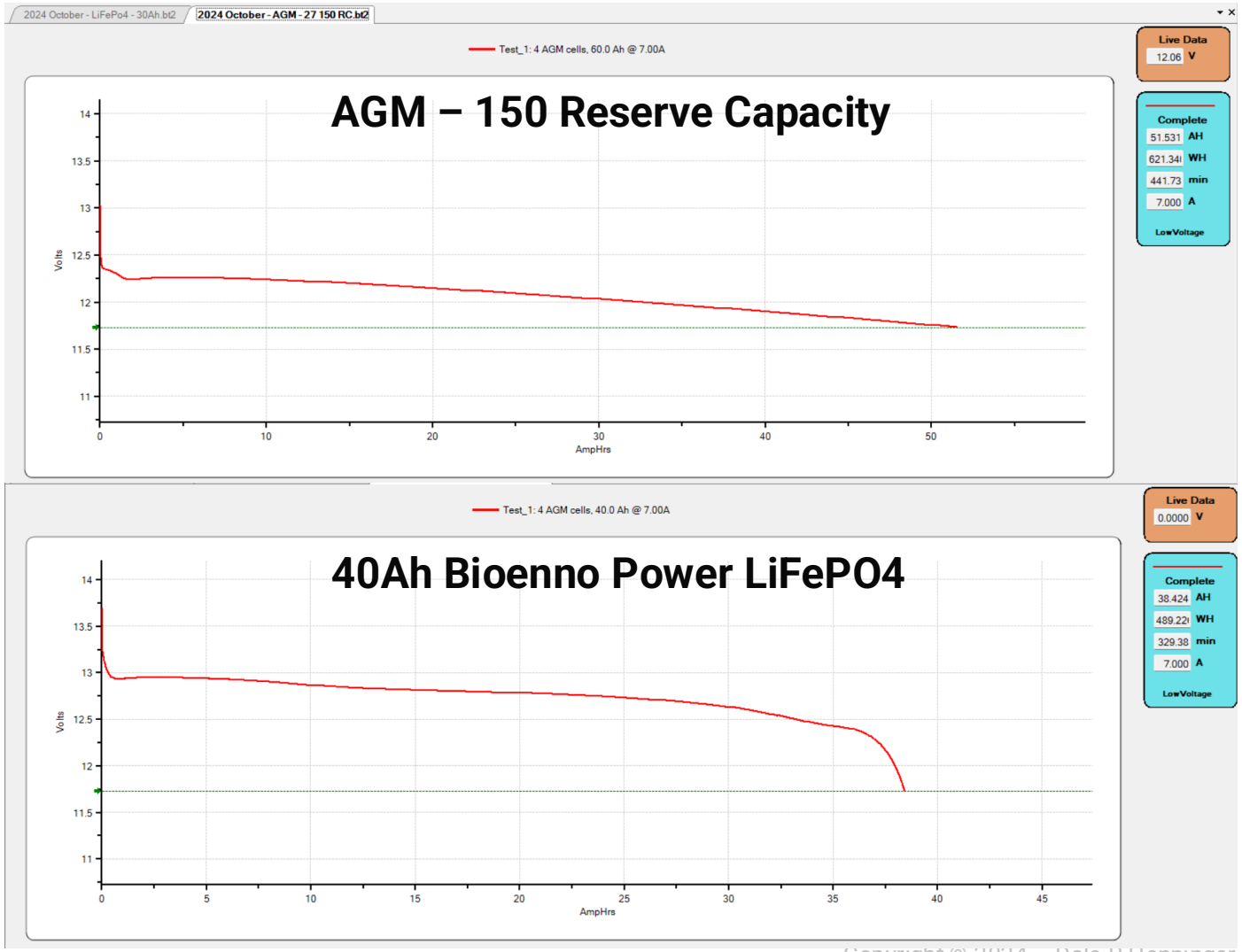
40Ah LiFePO4 = 7A Load



Battery Discharge Curve Comparison

AGM / Lead Acid – Easier to determine State of Charge – Voltage varies throughout the discharge cycle

LiFePO4 – Holds voltage until the end of the capacity

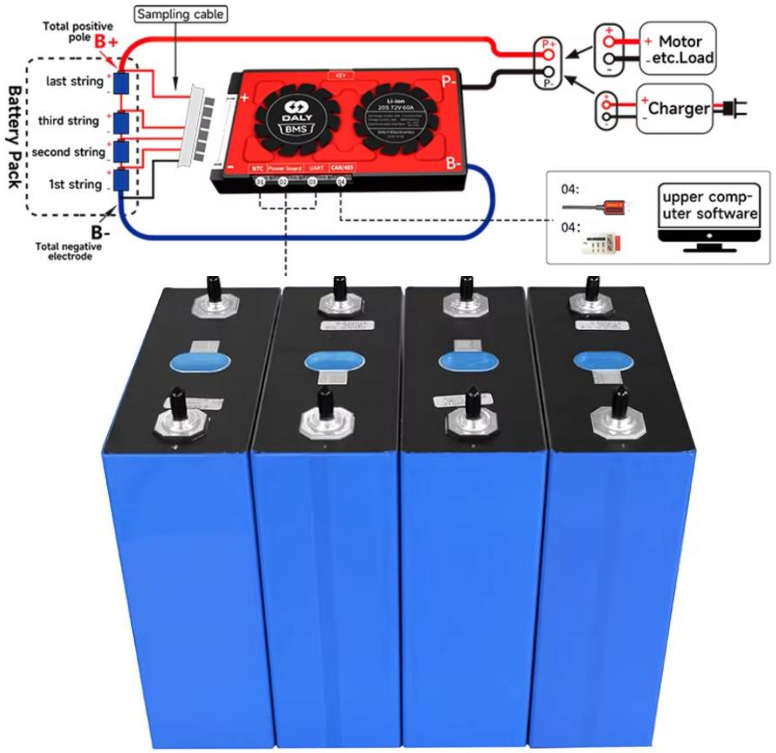


SAFETY / DURABILITY

Performance

Anatomy of a Lithium Iron Phosphate Battery

Battery Management System (BMS)



3.2V Prismatic Cells
4x = 12.8V (Nominal)
(13.6V-14.4V Fully Charged)

Load

Charger

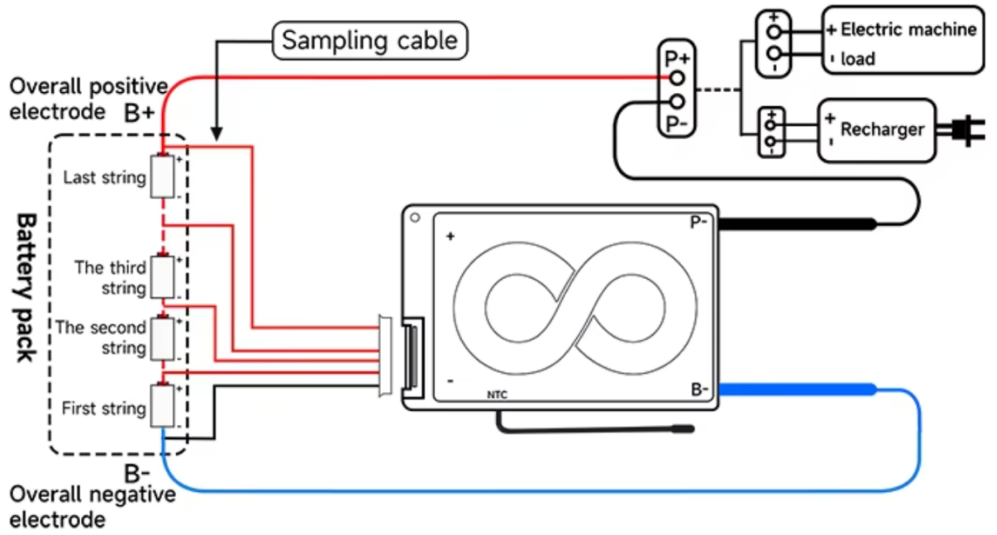
Anatomy of a LiFePO4 Battery

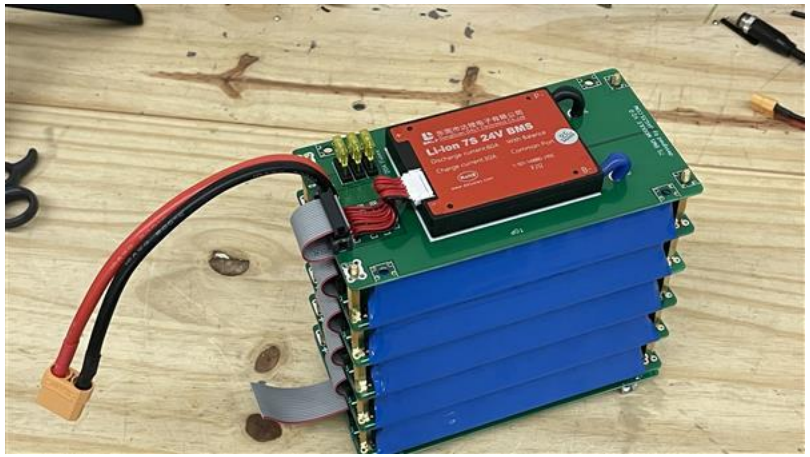
Battery Management System

BMS

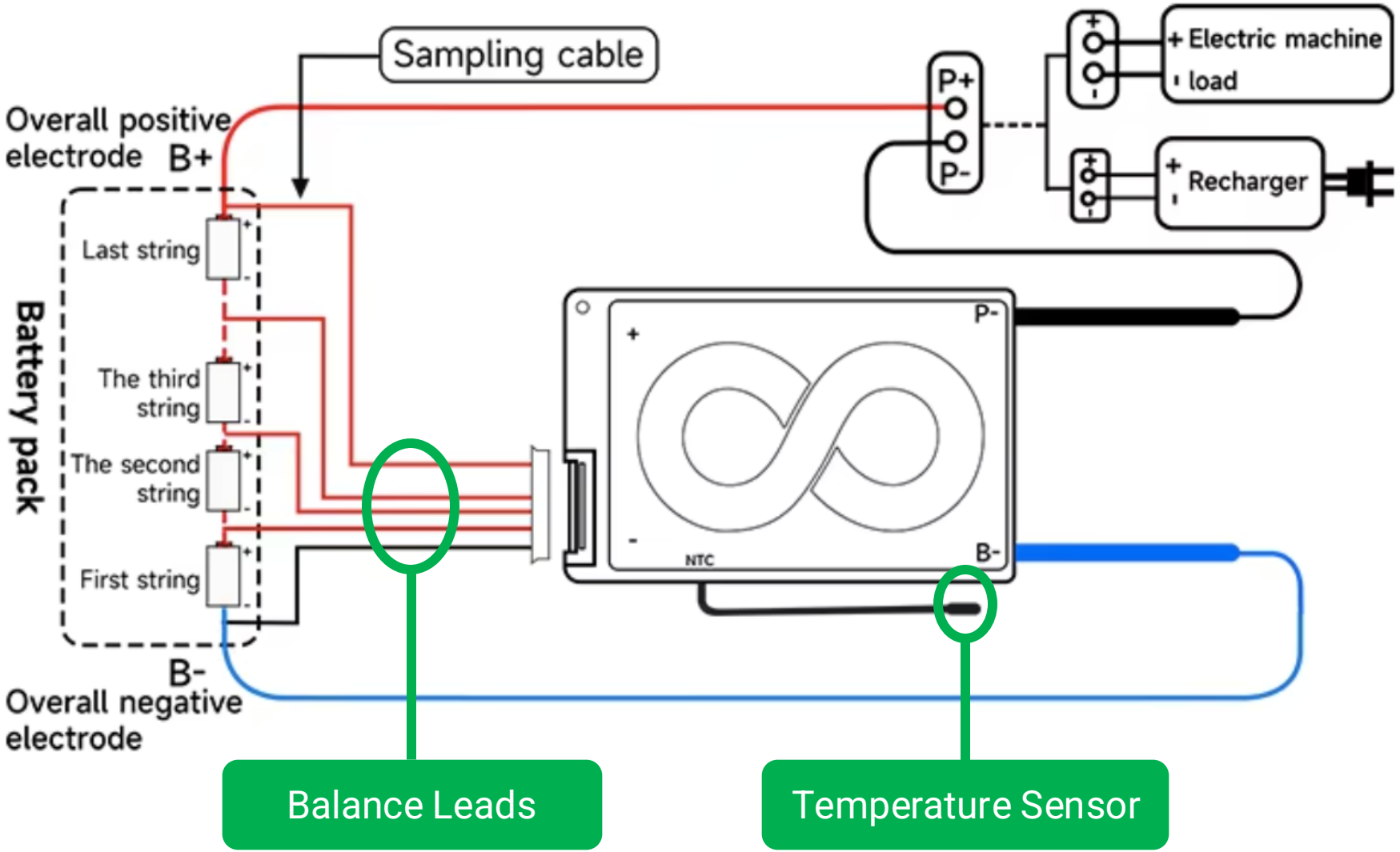
- Protects cells against damage
- Protects against over discharge / over charging
- Provides low/high temperature protection
- Monitors operation of cells – Monitors individual cell voltages to try to protect cells and try to maintain consistent SoC (state of charge between all cells)
- Passive Balancing (most common) vs Active Balancing

DALY BMS





DALY BMS

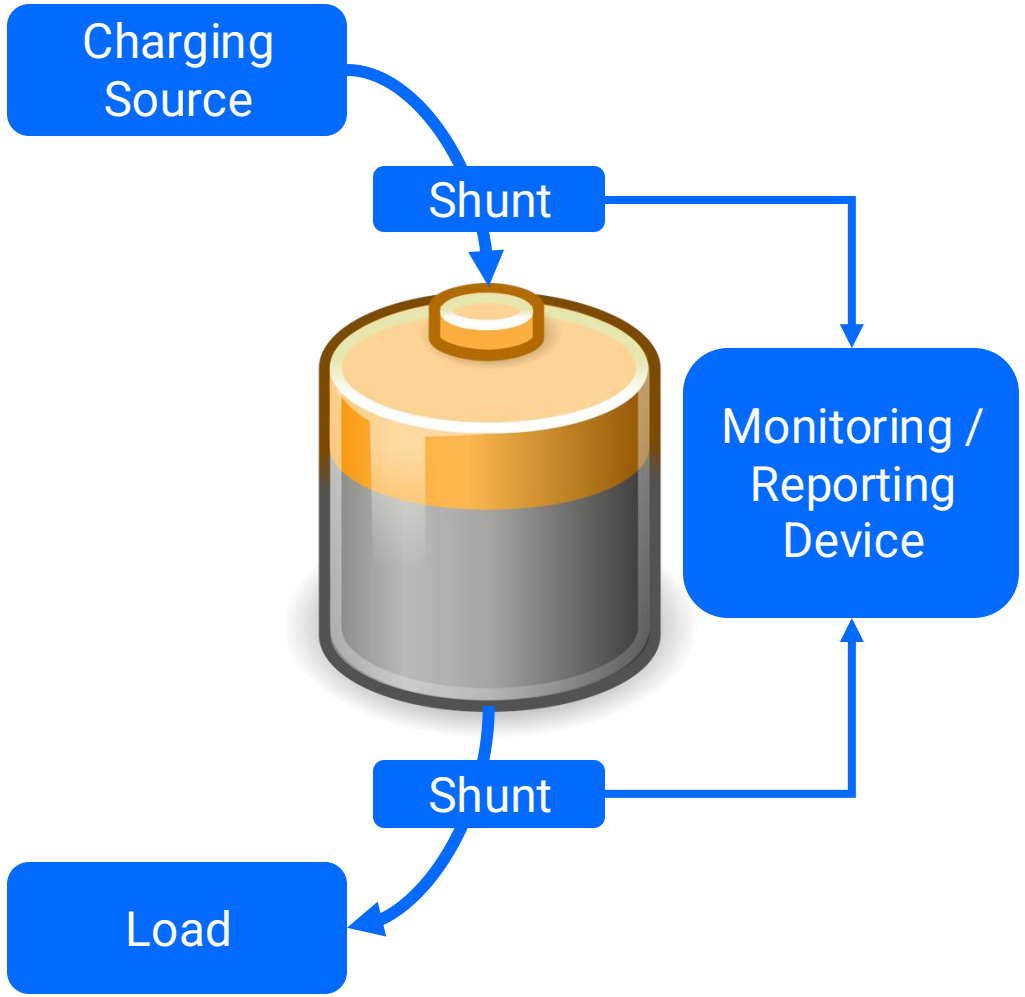


State of Charge (SoC)

Coulomb-Count Method

Coulomb Counting

Provides a relative State of Charge by measuring how much current is put in and taken out of a battery.



LiFePO4 Chargers

How to Charge a LiFePO4

Constant Current / Constant Voltage

LiFePO4 chargers provide a constant voltage of 14.2 to 14.5 volts

Constant current should be regulated based on the size of the battery. Although you can charge at higher rates, to maximize the life span of your battery, it is generally accepted that you should not charge at anything higher the .2C of the batteries rated Ah capacity.

Look for the recommendation of your manufacturer

40 Ah Battery

40 * .2 = 8 A Charging
Recommended @ 14.2 – 14.5v

Bioenno recommends 6 A charger (they do not have an 8 A model)

LiFePO4 Chargers

AC Chargers

Manufacturer

Review the chargers that the manufacturer recommends for your battery and Ah rating.

Desktop Power Supplies

Look for a model that can support constant voltage and constant current settings.

LiFePO4 Chargers

DC-DC Chargers

Charing your LiFePO4 batteries on the go

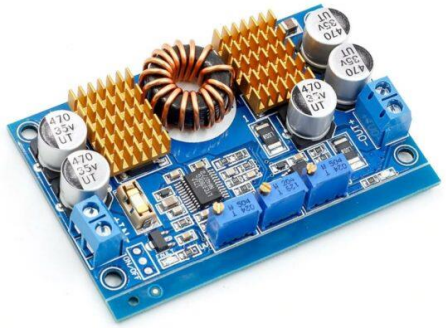
Allows you to charge your battery while in your car

LiFePO4 Chargers

DIY DC-DC Chargers

Buck-Boost Converters

Provides a relative State of Charge by measuring how much current is put in and taken out of a battery.



Buck/Boost
Input Voltage: 5-32V DC
Output Current Continuous: 8A

$15

Buck/Boost
Input Voltage: 10-60V DC
1800 Watts
10A Output easy at 14.2 V

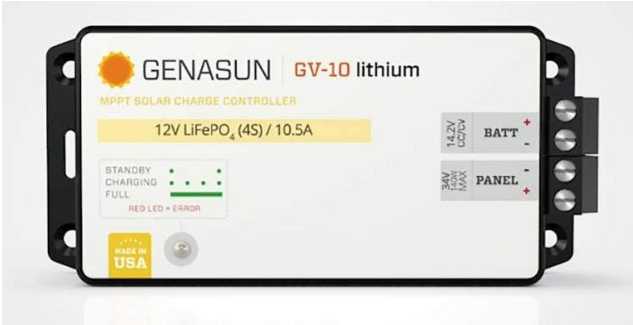
$19

LiFePO4 Chargers

Solar Chargers

Charge your battery for off grid use

Solar charge controllers can convert the power from a solar panel to a constant current/constant voltage that is compatible with your LiFePO4 battery



$135

$70

$70

What Battery is Right for You?

QRP – 5w/10w

6Ah (3-6 Hours)

$79.99

12Ah (6-12 Hours)

$124.99

QRO – 100w

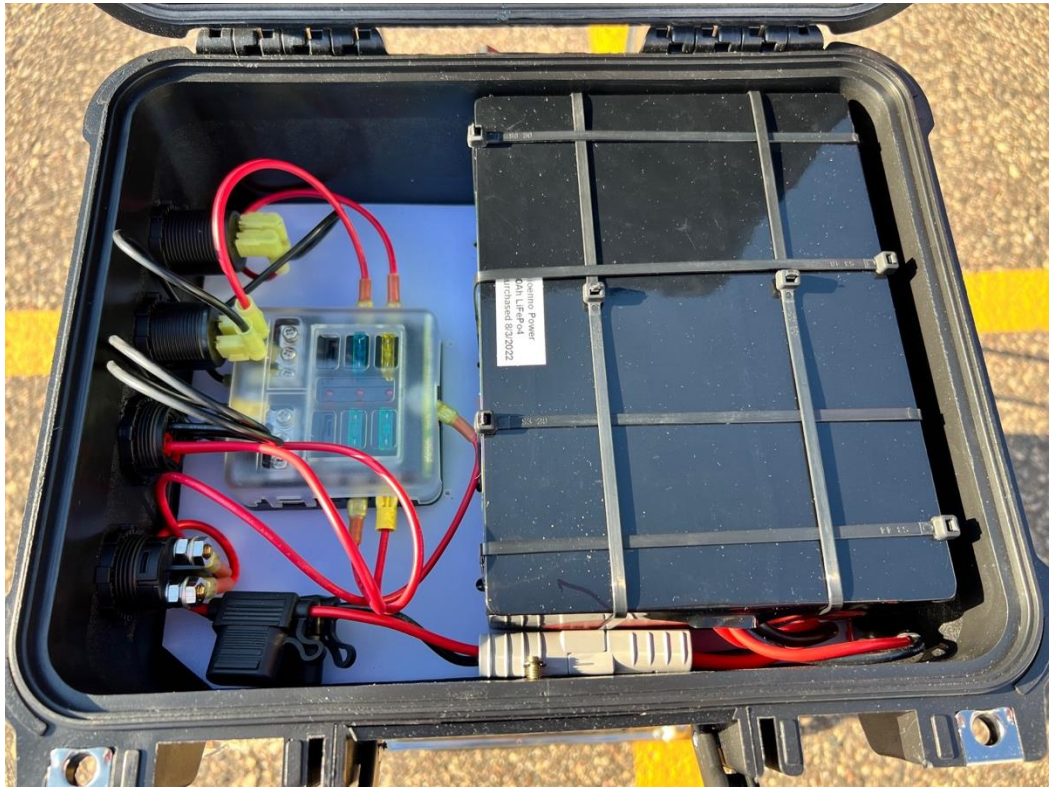
30Ah (3-6 Hours)

$279.99

100Ah (9-20 Hours)

$203.99

Form Factors – Go Boxes



Key Take Aways

Do you research – look for reviews – cheap is not always bad…

Look for a battery with the following features

- Low Temperature Disconnect (if you can't get this, never charge when your battery is below 32F)

Charge your battery at .2c when possible

Store your battery for long periods at around 60% State of Charge

Batteries I have experience with (positive)

Dakota Lithium

https://www.dakotalithium.com

- Made (mostly) in the USA

Bioenno Power

https://www.bioennopower.com

- Best selection of sizes and form factors

Li Time

https://www.litime.com

- Lowest cost by a longshot
- Options for batteries with internal heaters for cold climates

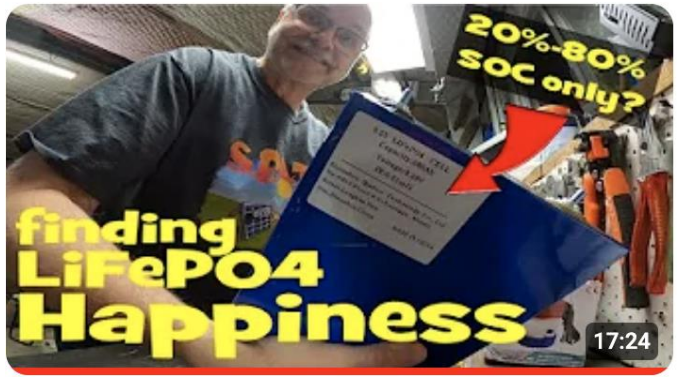
CHINS

Amazon

YouTube Resources

DIY Solar with Will Prowse

https://www.youtube.com/@WillProwse



Off-Grid Garage

https://www.youtube.com/@OffGridGarageAustralia

Ray Builds Cool Stuff

https://www.youtube.com/@RayBuildsCoolStuff

Other Resources

DC-DC Buck/Boost SEPIC Converter

https://universal-solder.ca/automatic-dc-dc-sepic-converter-10a/

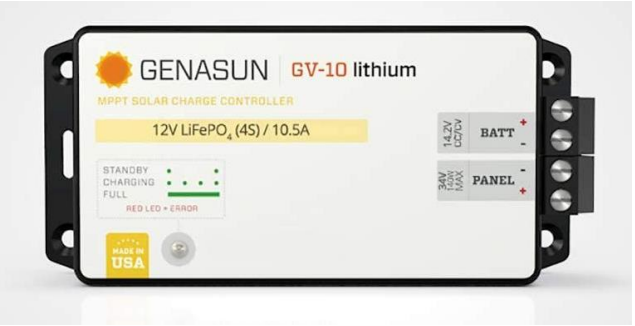
DC-DC Buck/Boost Converter – 1800w

https://www.qskj.cc/shop/1941708-dc-dc-converter-1800w-30a-cc-cv-step-up-power-supply-module-qs-4884cccv-1800w-6704

Other Companies to Look At

Victron Energy

Renogy



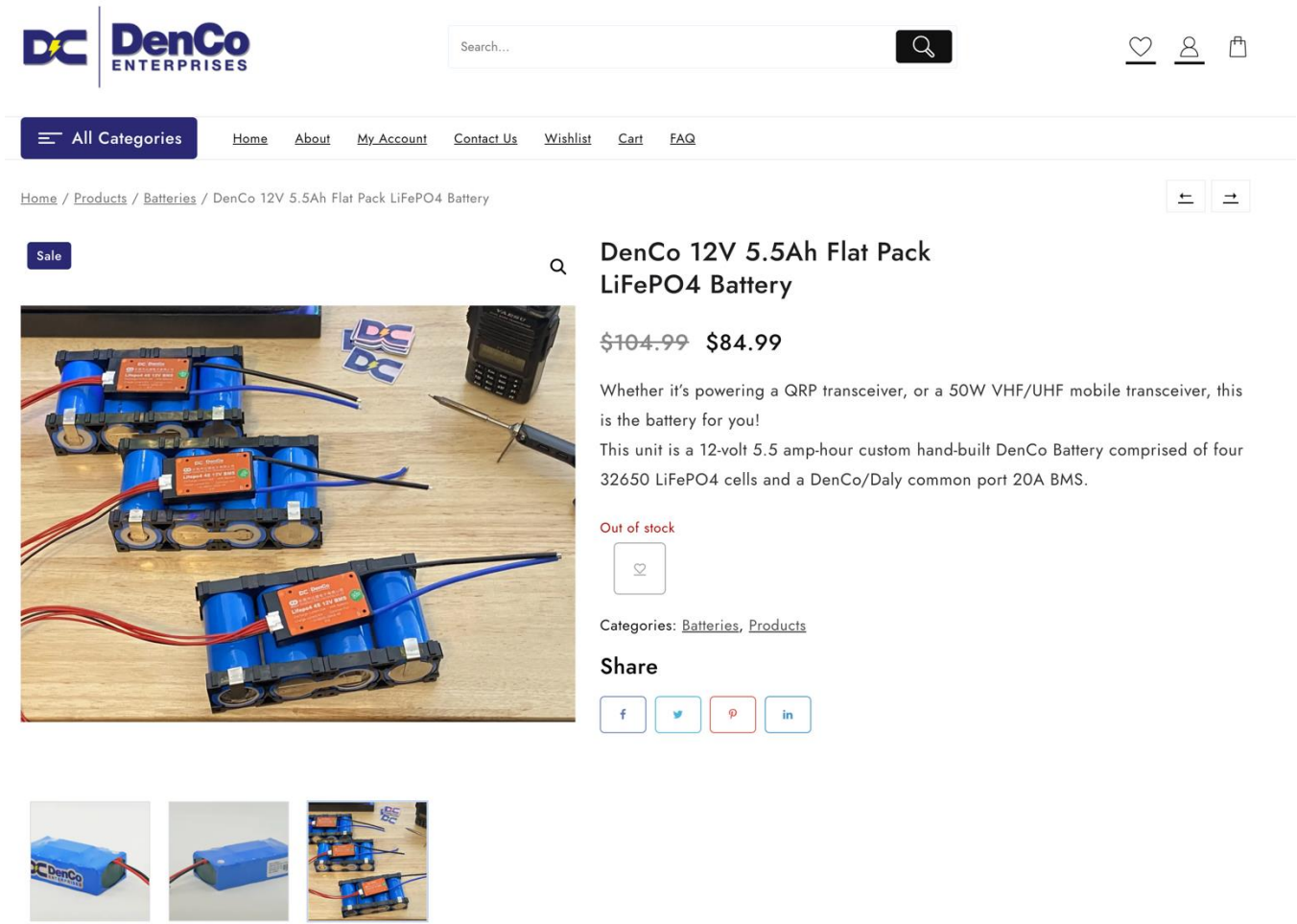
Genasun Solar Charge Controllers

https://sunforgellc.com/product/gv-10/

Other Resources

Want to build your own battery?

https://shop.denco.enterprises/



Thank You!

I hope to see you in my log!

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https://www.youtube.com/@W0DHZ

https://www.w0dhz.com