DC Power for Amateur Radio

Safely Powering your Station at Home and on the Go.

Steve Jensen • KE7GXC • 16-November-2024
Clackamas ARES Training Program

DC Power for Amateur Radio

Today we will cover

1. Requirements
2. Batteries
3. Power Sources
4. Wiring, Fusing and Safety
5. Power Converters / Inverters
6. Lighting

Powering Amateur Radio Equipment

- In Amateur Radio, we use DC (Direct Current) power, because it is easily, efficiently and safely stored in batteries. In general, voltages lower than 40V DC are safe to touch with one hand.

- Amateur Radio equipment is usually marked as requiring 13.8V DC. HOWEVER, materials used in batteries can be hazardous, and these electrical systems can start fires.

- **Therefore, we need to build our 12 volt systems carefully with maximum durability, safety and interoperability in mind.**

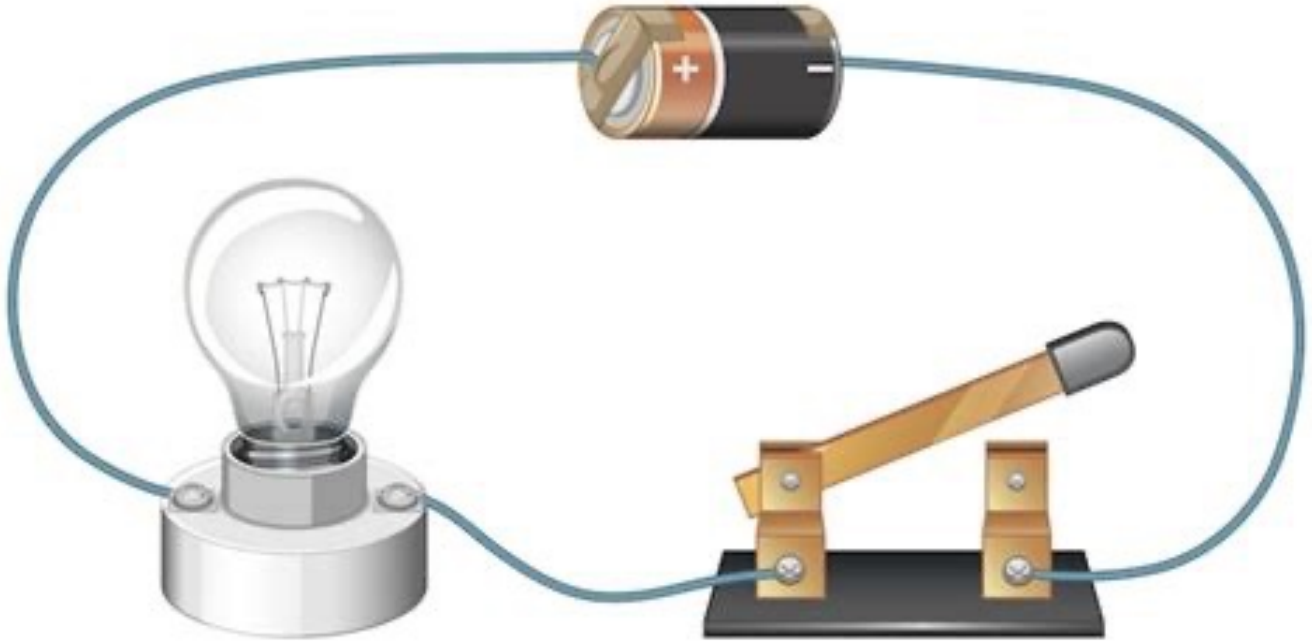
Powering Amateur Radio Equipment

- EMCOMM implies unpredictable power - we store power in batteries to restore predictability.

- We work diligently to keep batteries charged from all available sources:
  - mains (wall socket AC)
  - gas / diesel / propane / natural gas generators
  - cars (which are actually generators)
  - solar
  - wind
  - hydro

Powering Amateur Radio Equipment

- Quick review electric circuit



Powering Amateur Radio Equipment

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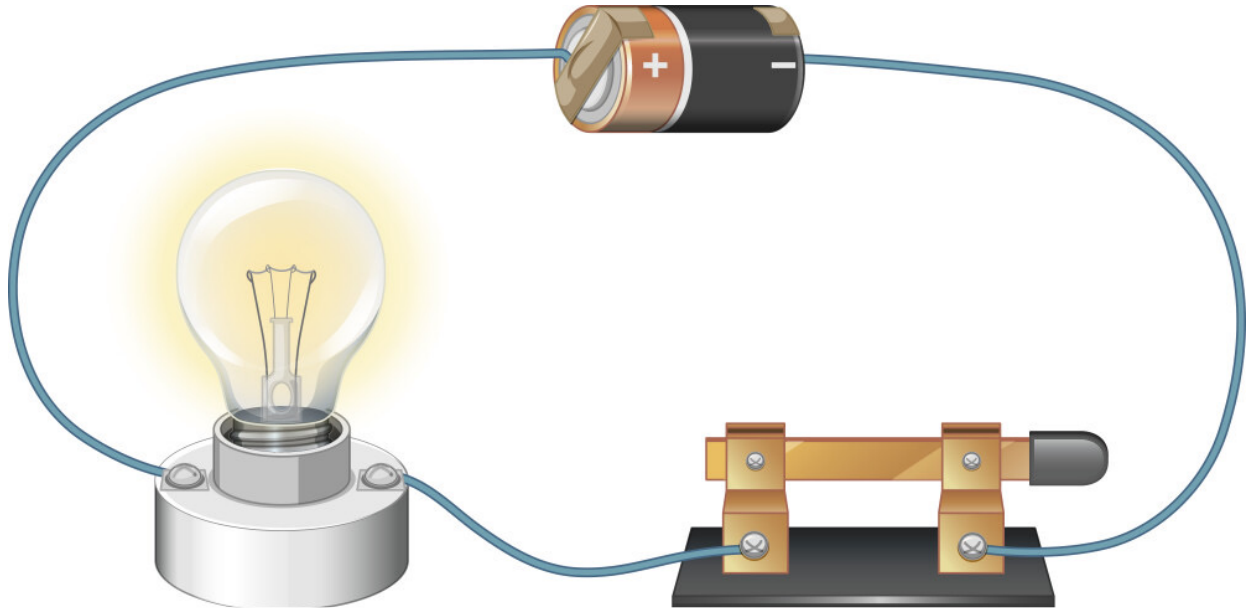


Important Battery Characteristics

- Amperage (current)
- Voltage
- Watts voltage * current = power

- Discharge Rate / Deep Cycle
- Chemistry
- Weight
- Impact resistance/Durability
- Hazardousness

Refer to the manufacturers specifications, data sheet or user guide for the battery!

Important Battery Characteristics

- Lets examine the specification sheet of a Werker 18 Ah AGM

  - Duration of discharge
  - Estimated Capacity
  - Discharge Characteristics
  - Effects of Temperature
  - Battery Life versus discharge cycles

Werker.

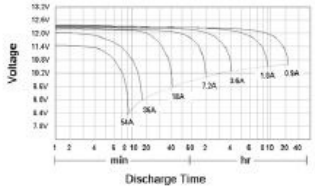
Sealed Lead Acid Absorbed Glass Mat

Technical Specifications

WKA12-18NB

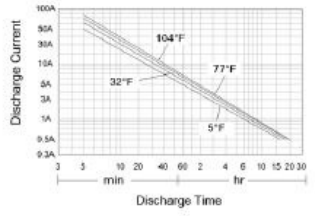
Discharge Characteristics

Duration of Discharge @ 77°F



Discharge Duration vs. Discharge Current

Duration of Discharge @ Various Temperatures



Specifications

All Specifications Are Rated at 77°F Unless Otherwise Noted

Nominal Voltage			12V
Ampere Hour Capacity (20hr Rate to 1.75V/PC)			18Ah
Dimensions		inches	millimeters
	Length	7.13"	181mm
	Width	3.03"	77mm
	Height	6.57"	167mm
	Height w/Term.	6.57"	167mm
Weight		13.89lbs	
Case Plastic		ABS Resin	
Maximum discharge Current 77°F		270A(5s)	
Recommended Charging	Float Use Voltage		2.28V/Cell
	Float Use Current		<2A
	Cycle Use Voltage		2.45V/Cell
	Cycle Use Current		<3.6A
Shelf Life		3 Months	91%
		6 Months	82%
		12 Months	64%
Temperature Range	Charge	32°F to 104°F	
	Discharge	5°F to 122°F	
	Storage	5°F to 104°F	
Capacity Affected by Temperature (20hr rate)		77°F	100%
		32°F	85%
		5°F	65%

Capacity Ratings

Capacity @ 77°F	20 hour rate	18.0Ah
	10 hour rate	16.7Ah
	5 hour rate	15.3Ah
	1 hour rate	10.8Ah

Wattage Ratings

Discharge Rate	End Voltage	
	1.75V/Cell	1.67V/Cell
5 min. rate	135.1	138.6
10 min. rate	87.8	89.7
15 min. rate	68.5	70.0
30 min. rate	39.7	40.9
40 min. rate	35.0	36.1
60 min. rate	25.7	26.7

Ascent Battery Supply LLC
925 Walnut Ridge Drive
Hartland, WI 53029

Ascent

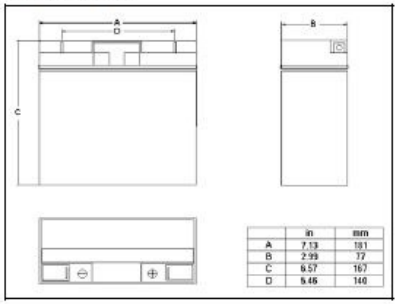
Werker.

Sealed Lead Acid Absorbed Glass Mat

Technical Specifications

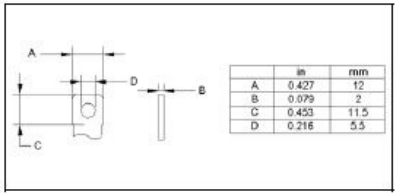
WKA12-18NB

Physical Dimensions



	in	mm
A	7.13	181
B	2.99	77
C	6.57	167
D	5.46	140

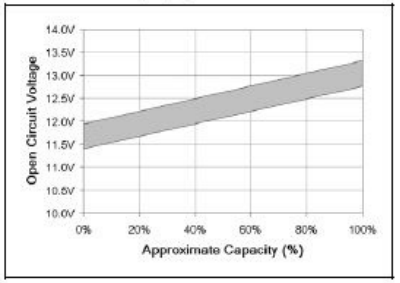
Terminal



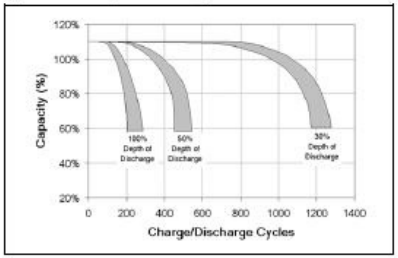
	in	mm
A	0.427	12
B	0.079	2
C	0.453	11.5
D	0.216	5.5

Open Circuit Voltage vs. Capacity

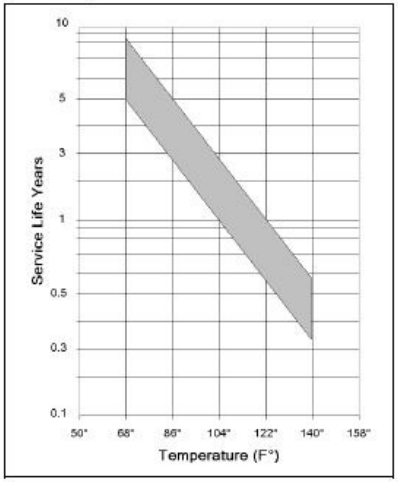
Estimated Residual Capacity @ 77°F



Cycle Life vs. Depth of Discharge



Effect of Temperature on Float Life



ISO 9001

MH 20720

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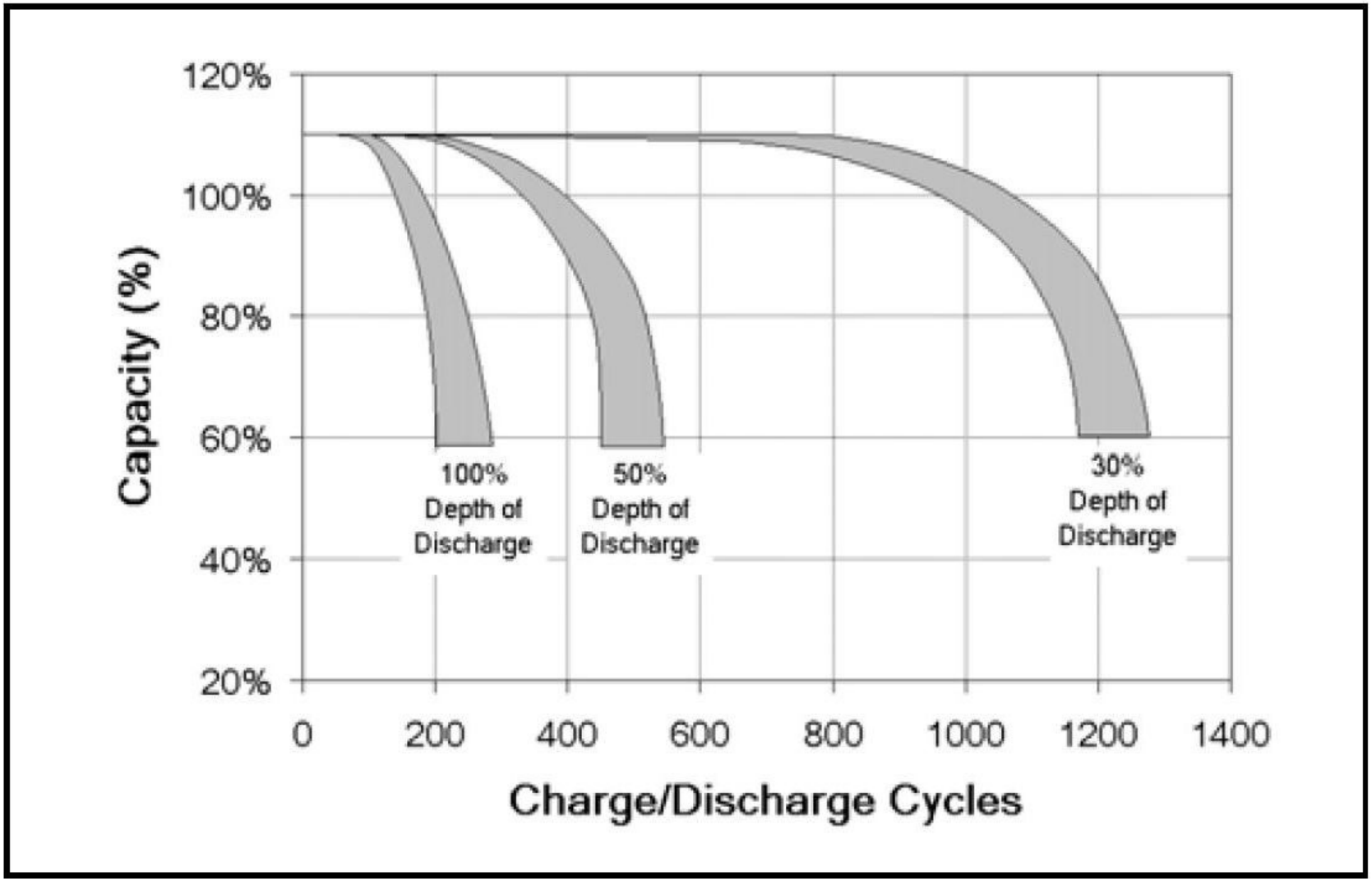
Ascent

Cycle Life vs. Depth of Discharge



** BREAK **

Estimating Power Requirements

- How do you measure your radios power consumption?
- Read your radio manual
- In the *specification section* the radio manufacturer will list the receive and transmit input power, voltage and amperage.
- Power input is radio Amps X radio Volts = Watts

Estimating Power Requirements

- Typical receive estimate is 1 Amp
- Typical transmit power is many times larger
- How many hours of operation?
- Duty cycle is the amount of “on” time vs. “off time”
- Operate net on the 1/4 hour for 5 minutes?
- Factor in other power draws: LED lighting? Laptop?

Estimating Power Requirements

- Alternatively, use a device such as:

Power Conservation

- Batteries have a typical “use time” which predicts how long they will be usable.
- When we have a major event or are practicing for one we practice **power conservation:**

  Focus on minimal power usage, minimized operation, “power on” radio time. Biggest power draw by far is transmit time.
- Label your batteries with “last charged date” and “last tested date”.

Examples of Radio power requirements

- Yaesu FT-1500M:
- 0.6 Amps receive (8 watts input)
- 3 Amps transmit: 10 watts RF power (41 watts input)
- 8 Amps transmit: 50 watts RF power (109 watts input)

- Yaesu FT-8800
- 0.5 Amps receive (7 watts input)
- 8.5 Amps transmit: 50 watts RF power (116 watts input)

- Yaesu VX-170 2 meter HT
- 250mA receive (3.4 watts input)
- 1.5 Amps transmit: 5 watts RF power (20.4 watts input)

- Duty cycle 10% transmit 90% receive ?

- **Get to know your radio's requirements before the event**

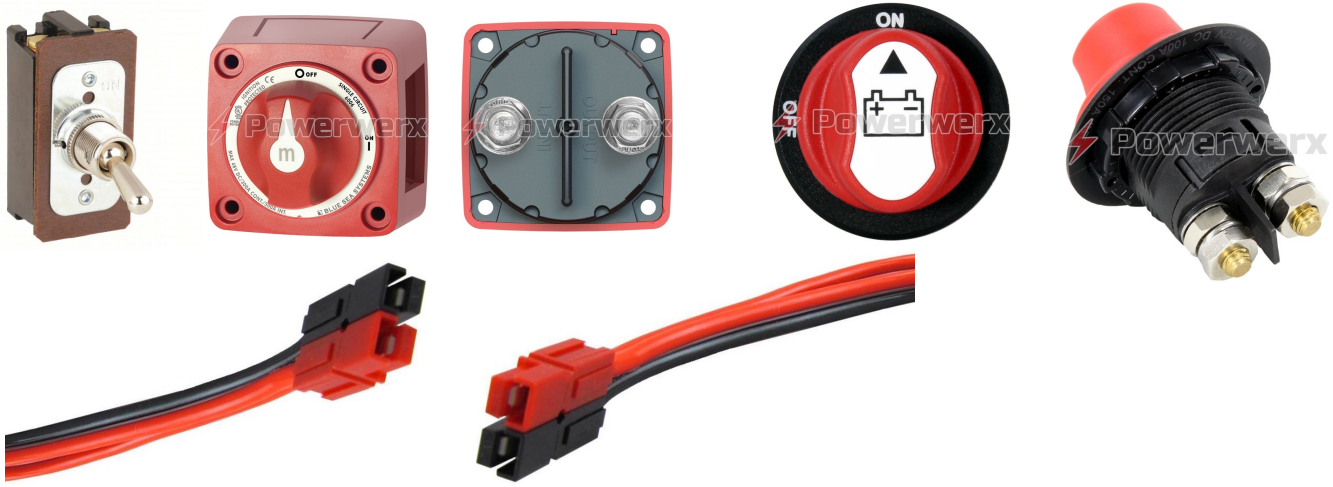
Radio Vampire Power?

- **Most radios have “soft” power switches (they consume power just checking whether you are turning them on)**
  - **Yaesu FT-1500M 2 mA OFF** 
  - **Yaesu FT-8800 4 mA OFF** 
  - **ICom IC-7300 5 mA OFF** 
  - **ICom IC-2200H 4 mA OFF** 

Radio Vampire Power -- CURE

- **Most radios have “soft” power switches (they consume power just checking whether you are turning them on)**

- **Disconnection with a firm mechanical switch**



Or disconnection via unplugging the equipment

DC Power - Battery Types

- Lead Acid
  - Acid Spill Hazard – *Do not use*

- Gel Cell
  - Sealed. Can be mounted in any orientation
  - Have emergency vents
- AGM
  - Can be mounted in any orientation
  - Have emergency vents
  - Some are safe for air transportation as per IATA/ICAO A67
  - Some are classified as non-hazardous, non-restricted for surface transport materials
- Lithium and Lithium Hybrids
  - Expensive
  - Efficient and long life
  - New variations hold tremendous promise for very long life

All of these batteries will be damaged if discharged below recommended voltage (check battery user information!)

DC Power – Battery Types

- Nickel Cadmium (Ni-Cd) -- OBSOLETE
  - Low Cell voltage (1.2V)
  - Environmentally dangerous – dispose of responsibly
  - No longer used - banned in the European Union.
- Nickel Metal Hydride (Ni-MH) -- OBSOLETE
  - 3x capacity of Ni-CD
  - Damaged if overcharged or completely discharged – use the correct charger
  - Fading from favor
- Alkaline “Dry” cells – remove when not in use
  - Low capacity
  - AA and AAA Batteries are supplied by Red Cross – good to have a 12v battery holder for a “MacGyver” emergency backup (enough to make a few transmissions?)
  - Will leak and damage equipment – check installed batteries frequently

Fire Hazard – Li-Ion batteries

Flaming Dell in 2006

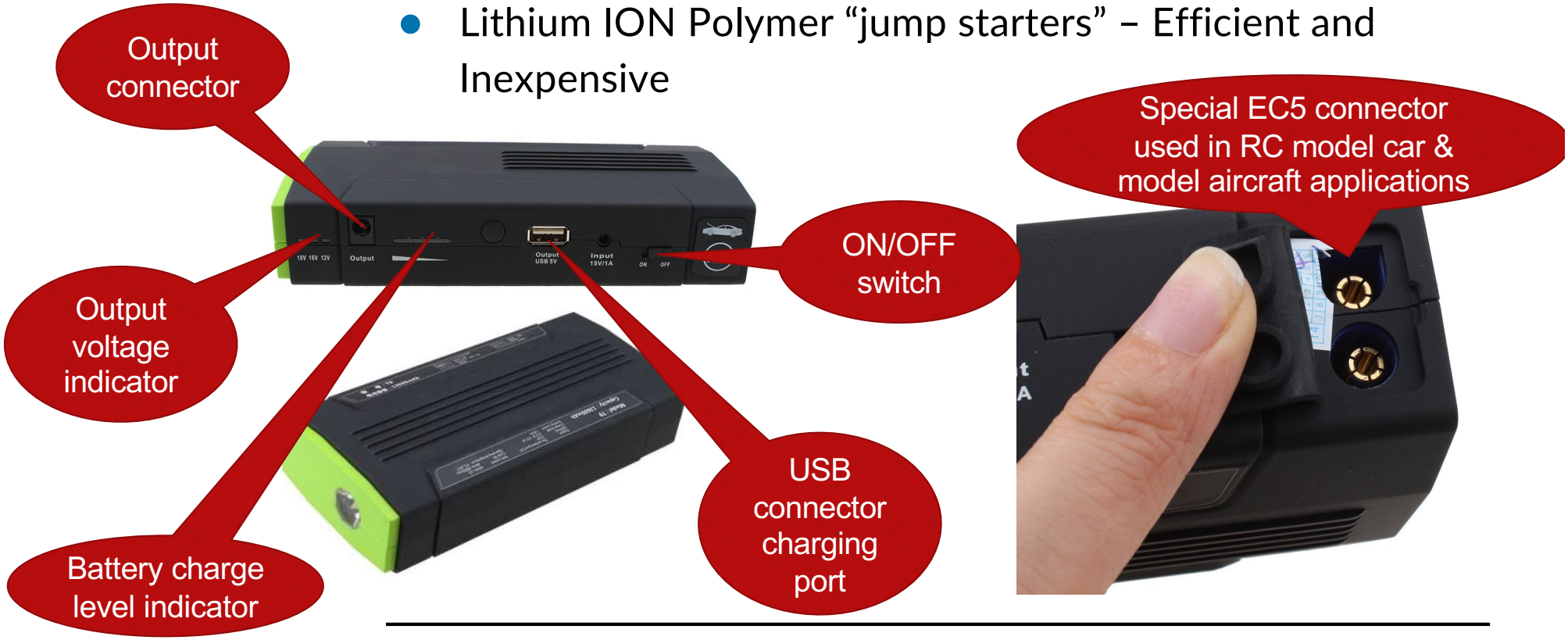
LiFePO4 and LiFeMnPO4 are safer chemistries!

DC Power - Rechargables

- Lithium Ion “laptop” & “flashlight” batteries
- 18650, 26650

DC Power – Jump Starters

- Lithium ION Polymer “jump starters” – Efficient and Inexpensive



DC Power - Batteries

Bioenno: Lithium Iron Phosphate (Li-ION LiFePO4)

Anderson PP-30 red/black for Ham use

EXTERNAL charger input. Use proper charger! **Connector: DCPlug (5.5/2.1mm)**

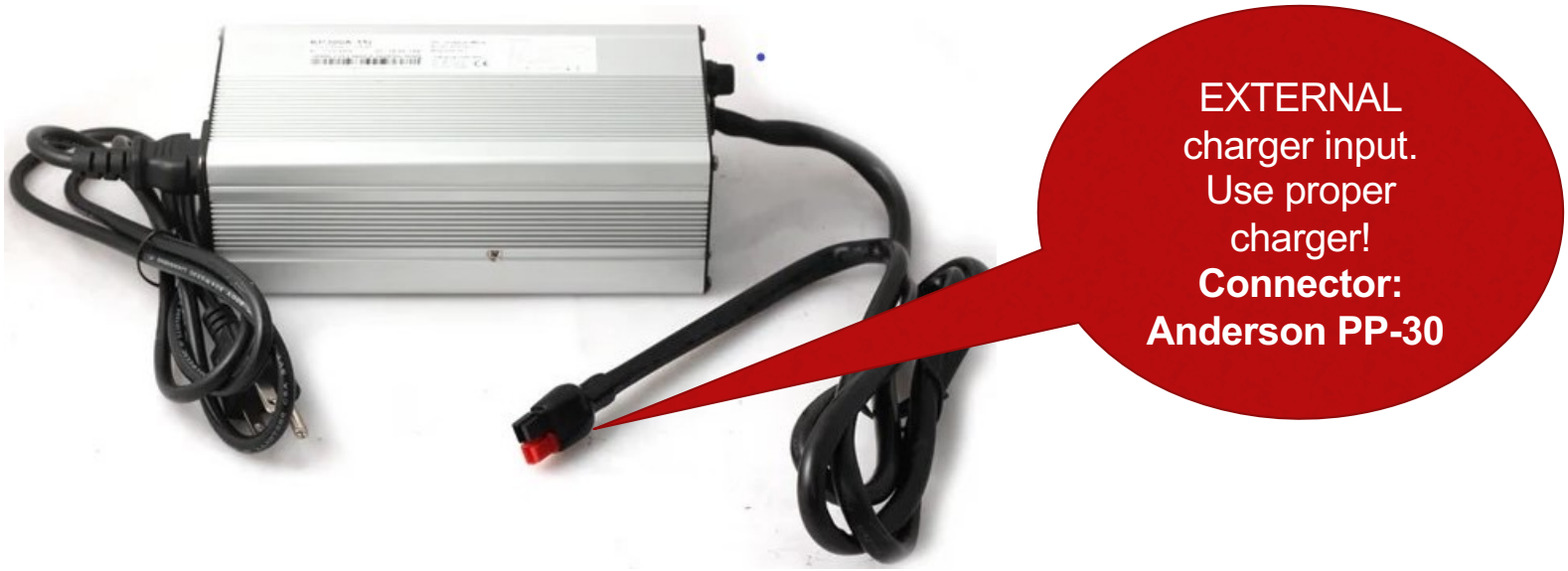
Includes built-in PCM (protection circuit module) which provides internal cell balancing and management, protection from overcurrent, overdischarge, overvoltage and short circuiting, and has integrated charging circuitry.

DC Power - Batteries

Bioenno: Lithium Iron Phosphate (Li-ION LiFePO4)

DC Power - Batteries

Bioenno: Lithium Iron Phosphate battery charger



DC Power - Lithium Batteries

Lithium Iron Phosphate (Li-ION LiFePO4)

Includes built-in BMS (Battery Monitoring System) ??

NO protection circuit module
NO internal cell balancing
NO protection from over-current, over-discharge, over-voltage and short circuiting,

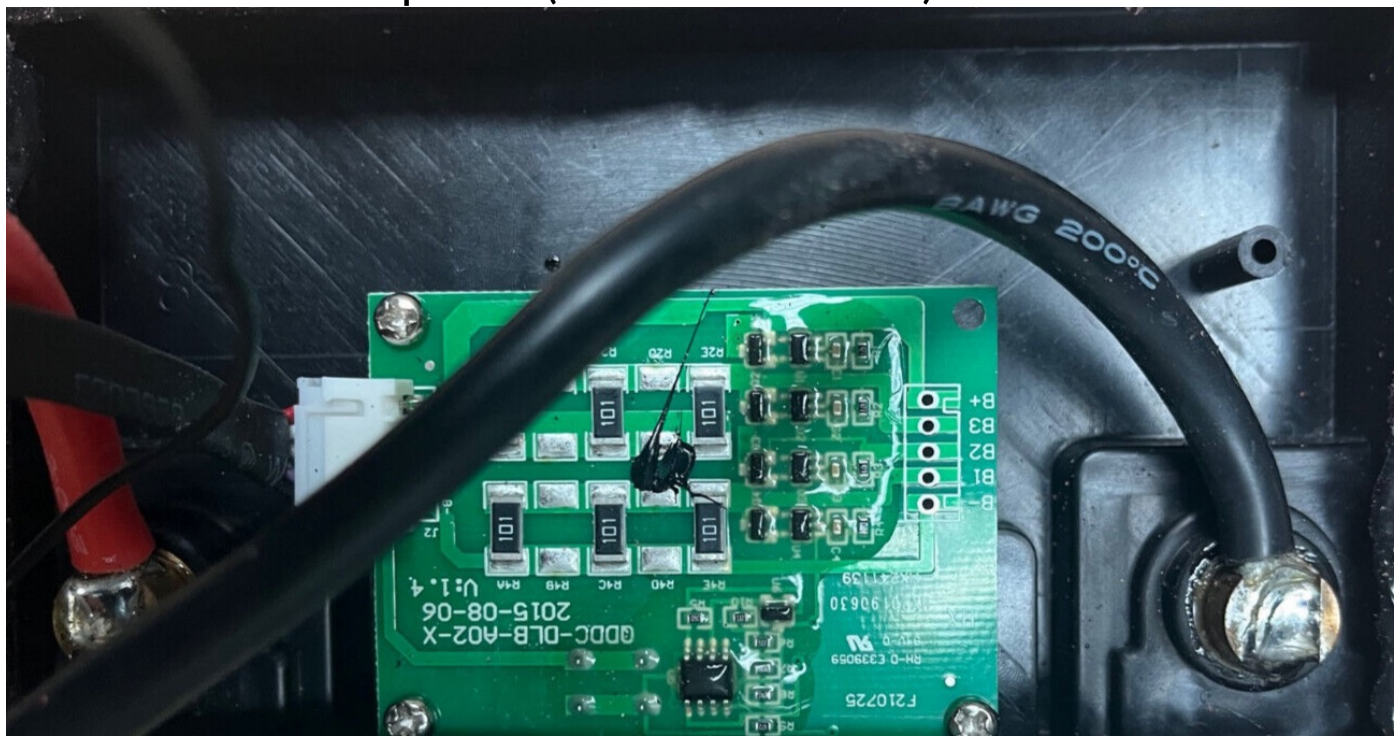
Only quick check on voltage

DC Power - Lithium Batteries

Lithium Iron Phosphate (Li-ION LiFePO4)

DC Power - Lithium Batteries

Lithium Iron Phosphate (Li-ION LiFePO4)



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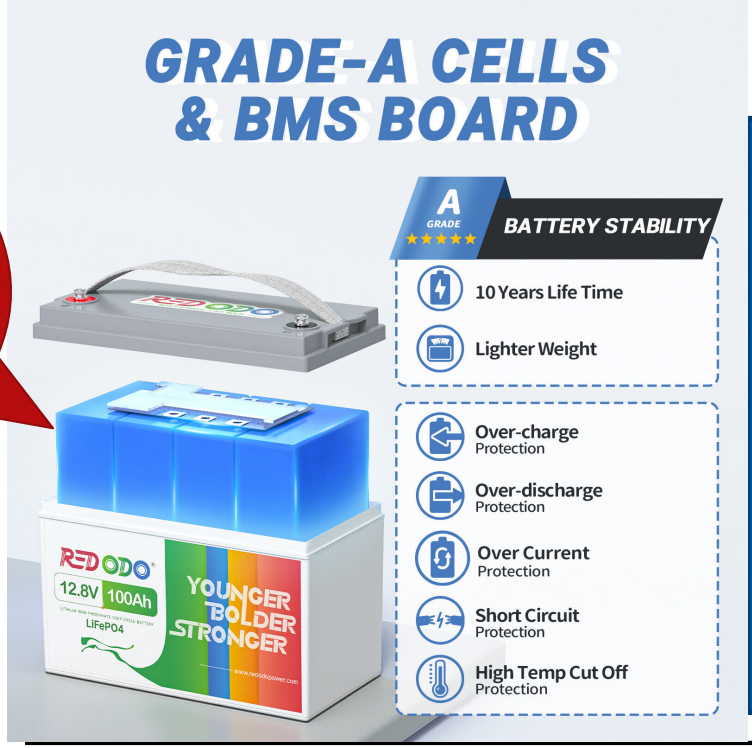
DC Power - Lithium Batteries

Lithium Iron Phosphate (Li-ION LiFePO4)

Typically FOUR Lithium power “cells”



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DC Power - Lithium Batteries

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DC Power - Lithium Batteries

RV's use. Vehicle charger ---

Includes built-in BMS (Battery Monitoring System - protection circuit module) which provides internal cell balancing and management, protection from over-current, over-discharge, over-voltage and short circuiting, and has integrated charging circuitry

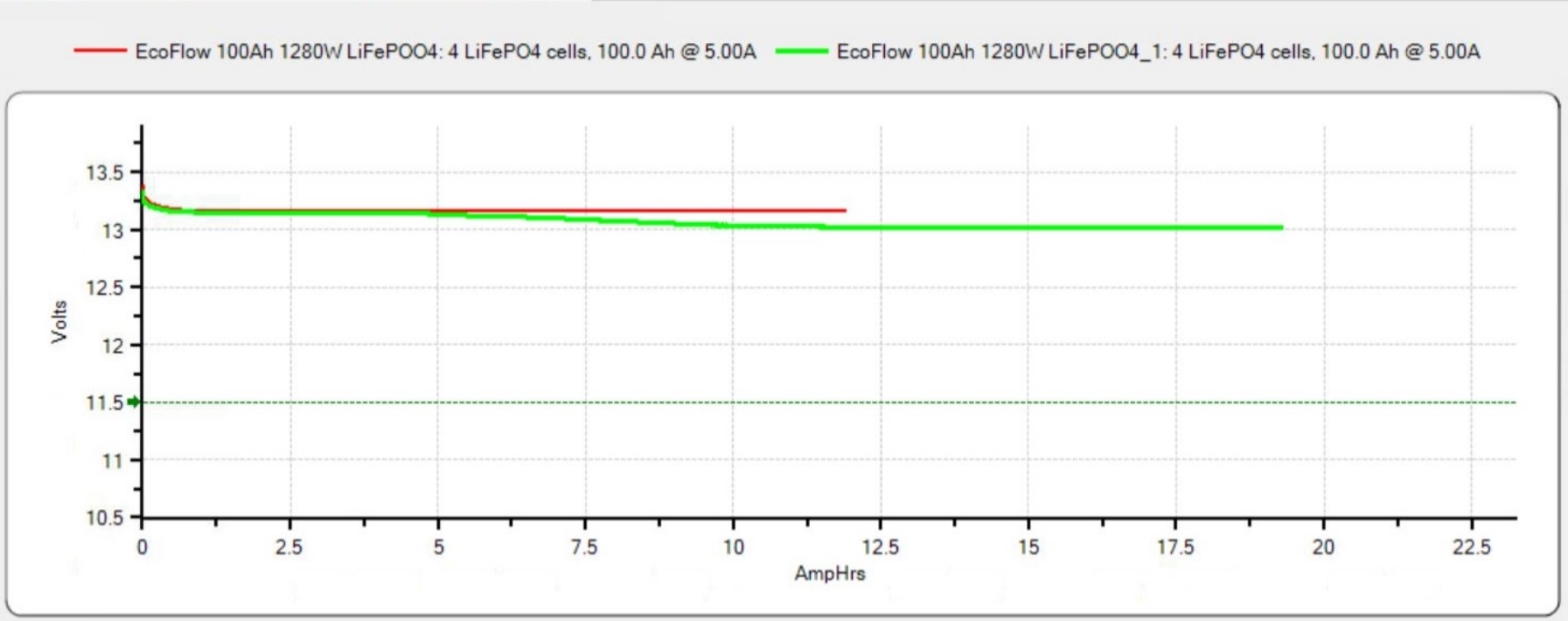
West Mountain Radio CBA

File Test View Chart Tools Web

New Test | Append Test | Quick Load Test | Test Properties | Pause Test | Stop Test | Print Labels | Export Test | Contents | Index | About

Test Load | Test Control | Help

241112_Discharge_EcoFlow 100Ah 1280W LiFePO4_1.bt2



Live Data

13.01 V

Running

19.323 AH

252.51 WH

231.90 min

5.000 A

65.055 W

CBA #42061 - Running

DC Power - Batteries

Lithium Iron Phosphate (LiFePO4)

Special charger "Lithium" (LiFePo4) battery mode required. Note: Battery charger is not included

- Lithium Iron Phosphate Rechargeable
- Amazon $99.99 (was), $129 (now)
- https://www.youtube.com/watch?v=MH4NqoyLGPo KM6ACK

DC Power - Batteries

What's inside?

What if they are dropped?

What if they are smashed?

Considerations – how much trouble are you in?

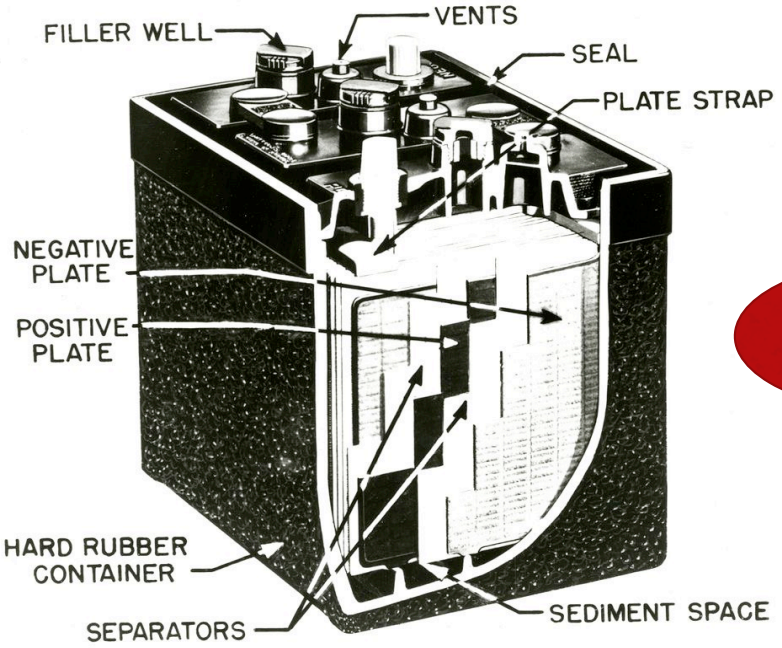
DC Power - Batteries

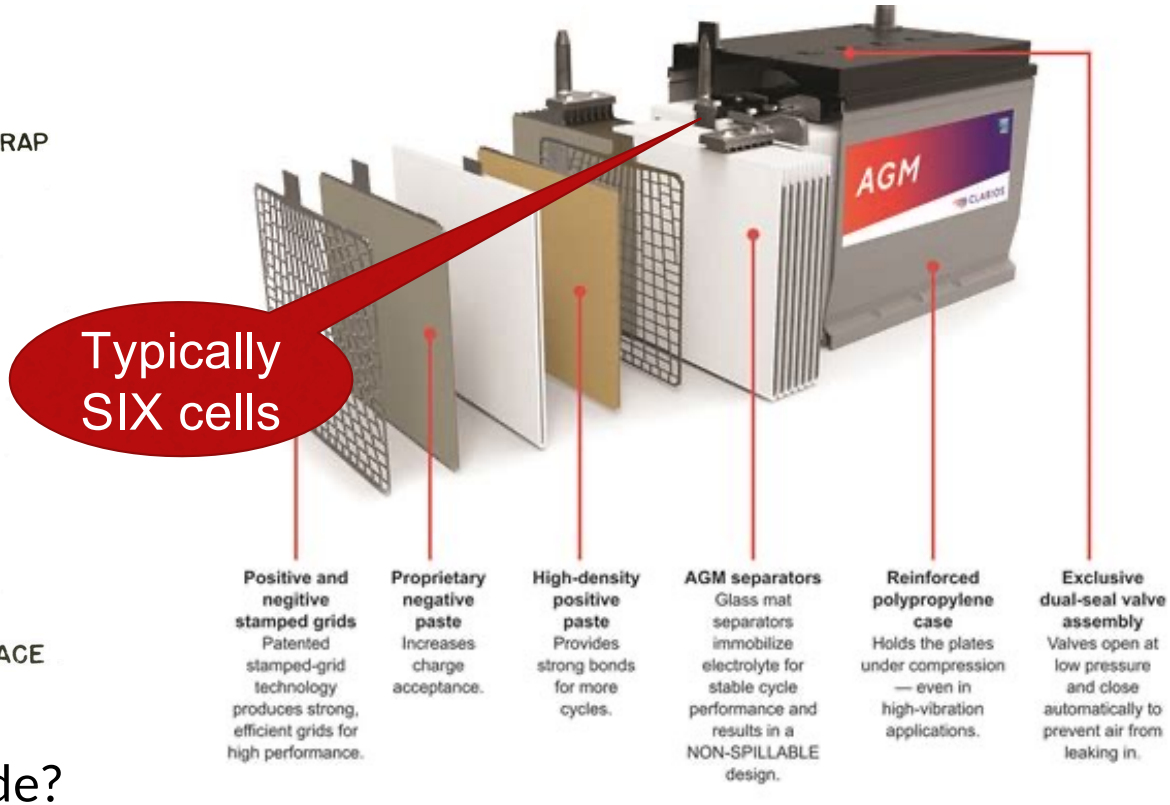
Same ? AGM: 2 amps

DC Power - Batteries

Same ? AGM: 2 amps

DC Power - Batteries





What's inside?

DC Power - Batteries

Lithium Iron “nano” Phosphate (LiFePO4)

Special charger required ?????

The targeted market was direct replacement

DELL
12V7
FH_-1811614-AA05679
FH_-1811614-AC03484
FH_-1811614-AA05536

Summary

- What are you looking for ??
- AGM – is a really good choice currently for stationary batteries
- Lithium Ion -- Includes built-in BMS (Battery Monitoring System - protection circuit module) – are great for portable
- Be sure the Lithium has
  - Protection circuit module
  - Internal cell balancing
  - Protection from over-current, over-discharge, over-voltage and short circuiting

Integrated Portable Batteries

- High end units: Lithium Iron Phosphate (LFP) and Li-ION based auxiliary power units
- Bluetti AC200 1700 Wh Pure Sine Wave Li-ION
- Bluetti AC200P 1700 Wh Pure Sine Wave LiFePo4
-
- Goal Zero Yeti 150 $200 – Lead Acid AGM
- Various Goal Zero & Bluetti, etc. -- $200 - $2,000

Power Tool Batteries

Lithium Iron Phosphate (LFP) – common

Battery Unit

Insert here

Insert here

Special charger! Simplified for consumer use

Some lanterns have a USB for charging phones

Power Tool Batteries

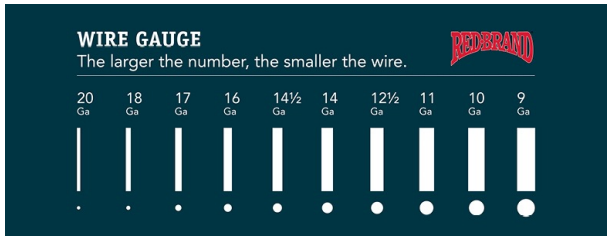
Lithium Iron Phosphate (LFP) – common

Very hand to have USB and lighting powered by your household drill motor battery !

** BREAK **

DC Power - Safety

- Fuses
  - What is a fuse?
  - Why are they so important? What will happen if I don't use them?
  - Where should they be installed?
  - Why do some people use fuses on both the red and black wires?
  - How do I choose the correct fuse amperage?
- Sizing Wires
  - What is AWG and why is it important?
  - Why is it important to use the right gauge wire?
  - How do we estimate what gauge wire to use?
  - Solid vs. Stranded Wire?
  - What wire coating in which application?



DC Power - Wiring Sizing

- A length (8 to 10 ft) of **stranded copper** wire that comes with amateur radios are designed to be connected to a power supply/battery

- AWG calculations are for a radio operating at full power

Here are some handy wire sizing calculator:

- https://www.powerstream.com/Wire_Size.htm
- https://www.fabhabs.com/dc-cable-sizing-calculator
- http://www.ayixa.com/dc-wire-size-calculator-awg-and-sq-mm/

DC Power - Wiring Sizing

- **Example:** 2 meter transceiver operating at 50 watts RF output requires 11 amps

- Recommended Wire: #14, 10 feet long, @ 11 Amps, 0.571 VDC drop, for positive/RED and negative/BLACK runs = 1.142 VDC drop total (between the power source and the radio). That's pretty much the acceptable limit in my opinion

- #10, 10 feet long, @ 11 Amps, 0.226 VDC drop, for positive/RED and negative/BLACK runs = 0.452 VDC drop total. A **much better** power loss situation

DC Power - Wiring Sizing

In summary:

- For a 10 ft long run, #14 AWG is adequate.
- If you need to lengthen the wire run -- move to #10 AWG in order to reduce the voltage drop losses to the radio.
- If you need to run two or more radios off of such a run (only one transmitting at a time) a run of #10 AWG would be advised.

DC Power - Wiring, Fusing, etc.

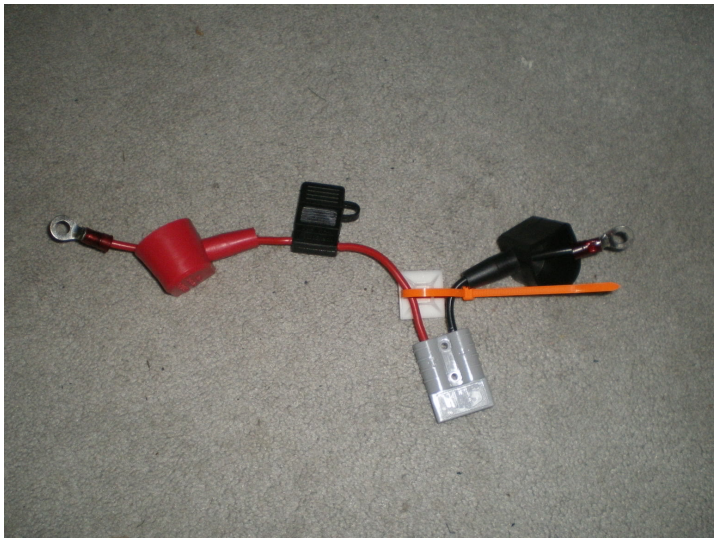
- Anderson PowerPole connectors
- PP-30 (30 amps rated). Use the PP-30 connector on radios & equipment.
- SB-50 (50 amp rated). Use SB-50 connector on batteries and heavy power cable interconnects.

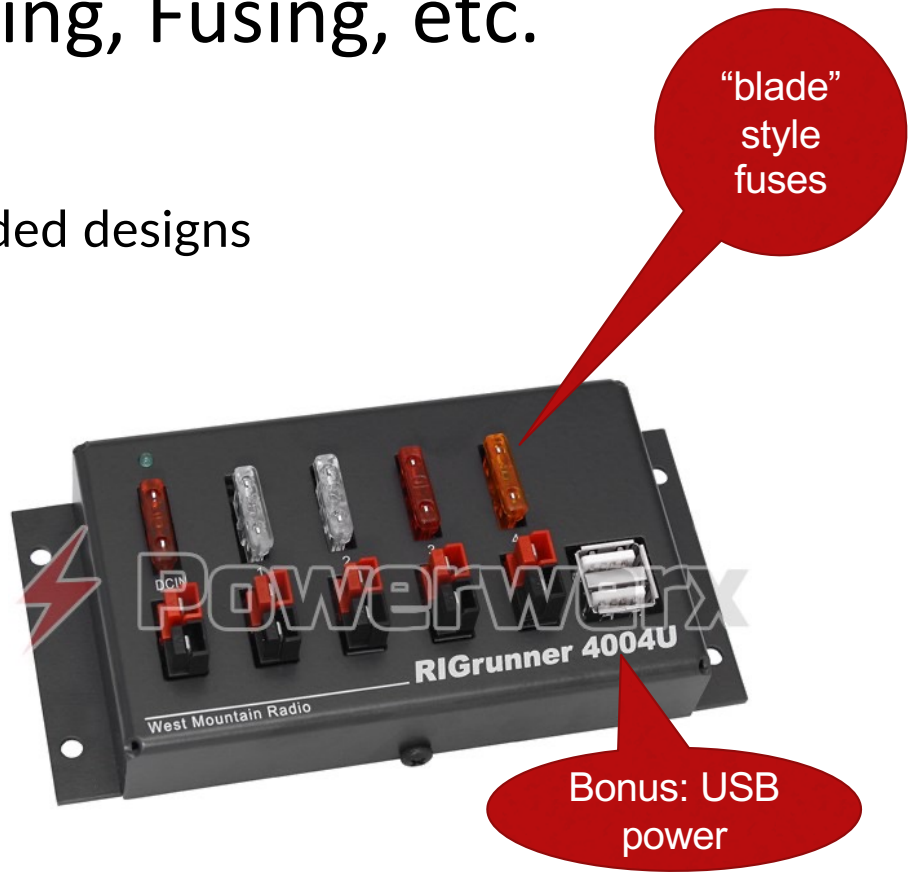
DC Power - Wiring, Fusing, etc.

- Anderson PP-30 PowerPole connectors alignment orientation for ham radio use:
  - interlock raised side up, viewed from the front is RED on the left, BLACK on the right.

DC Power - Wiring, Fusing, etc.

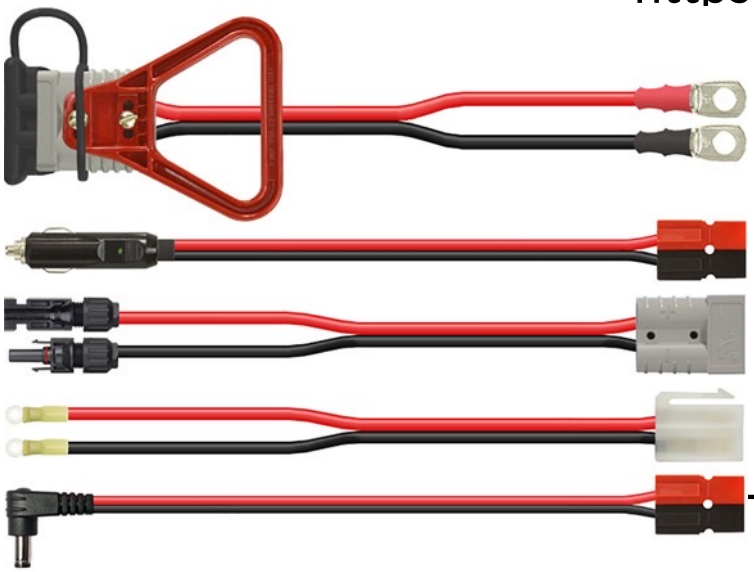
- CARES recommended designs





DC Power – Pre-built cables

- CARES recommended designs – alternate supplier: PowerWerx
- https://powerwerx.com/dual-conductor-custom-cable



But…
NO PROVISION FOR:
fuse in their design tool….. But you can add an external fuse assembly

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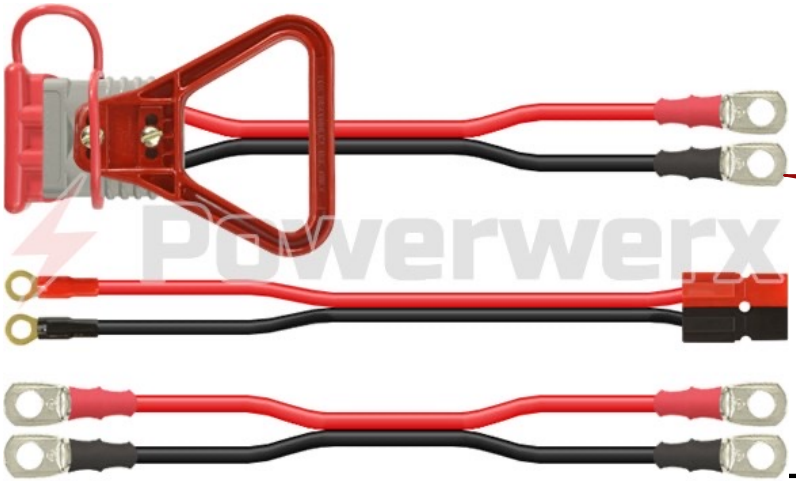


But…
NO PROVISION FOR:
fuse in their design tool….. But you can add an external fuse assembly

DC Power - Safety

- Batteries and Power Supplies – Ensure proper fuses, wiring, connections
- Get a mentor to check your work
- Charging Batteries – ventilate & monitor
- Power supply / battery isolation units – West Mountain Radio make a good one
- Power distribution blocks – suppliers: Rig Runner, PowerWerx.com, HRO, Auto Parts stores

** BREAK **

DC Power - How big a battery ?

- Charging: Charge the battery after every use. Running a battery down completely rapidly decreases battery life.
- Use the charger specifically designed for your type of battery.
- **Do not use an old-style automotive or liquid acid type charger on sealed batteries.**
- Maintaining -- Always store your battery fully charged. A topping charge should be applied every six months to help keep the voltage from dropping. It is best to store the battery in a cool, dry place and disconnected when not in use. Avoid extreme hot or cold temperatures when storing.
- Example: Werker WKA12-80C/FR 12V 80AH SLA AGM battery recommended float: 2.28 volts per cell * 6 = 13.68 volts with max. 200mv P-P ripple.

DC Power - Charging Batteries

- Batteries have specification sheets - check the manufacturer's web site.
- Must supply the battery with 13.5Vdc to 13.7Vdc with VERY low AC ripple (200mv P-P max). Use a recommended charger.
- Must limit charge current (some big AGM's only: 5A)
- Use newer *multi*-mode chargers in the correct mode for your battery.

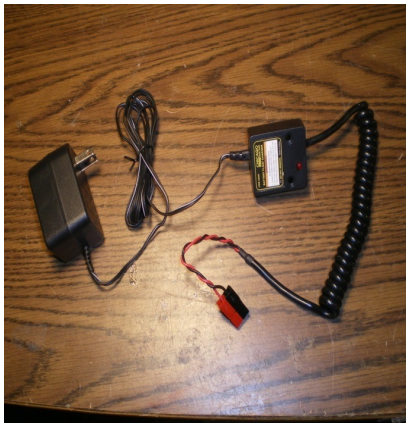
DC Power - Charging Batteries

- CARES recommended chargers:
  - Noco Genius 12v 5 Amp Charger, Model: Genius5
  - Multi-step charging: Analyze, Diagnose, Recovery, Initialize, Bulk, Absorption, Optimization, Maintenance

Note: Some units can be a radio interference generator

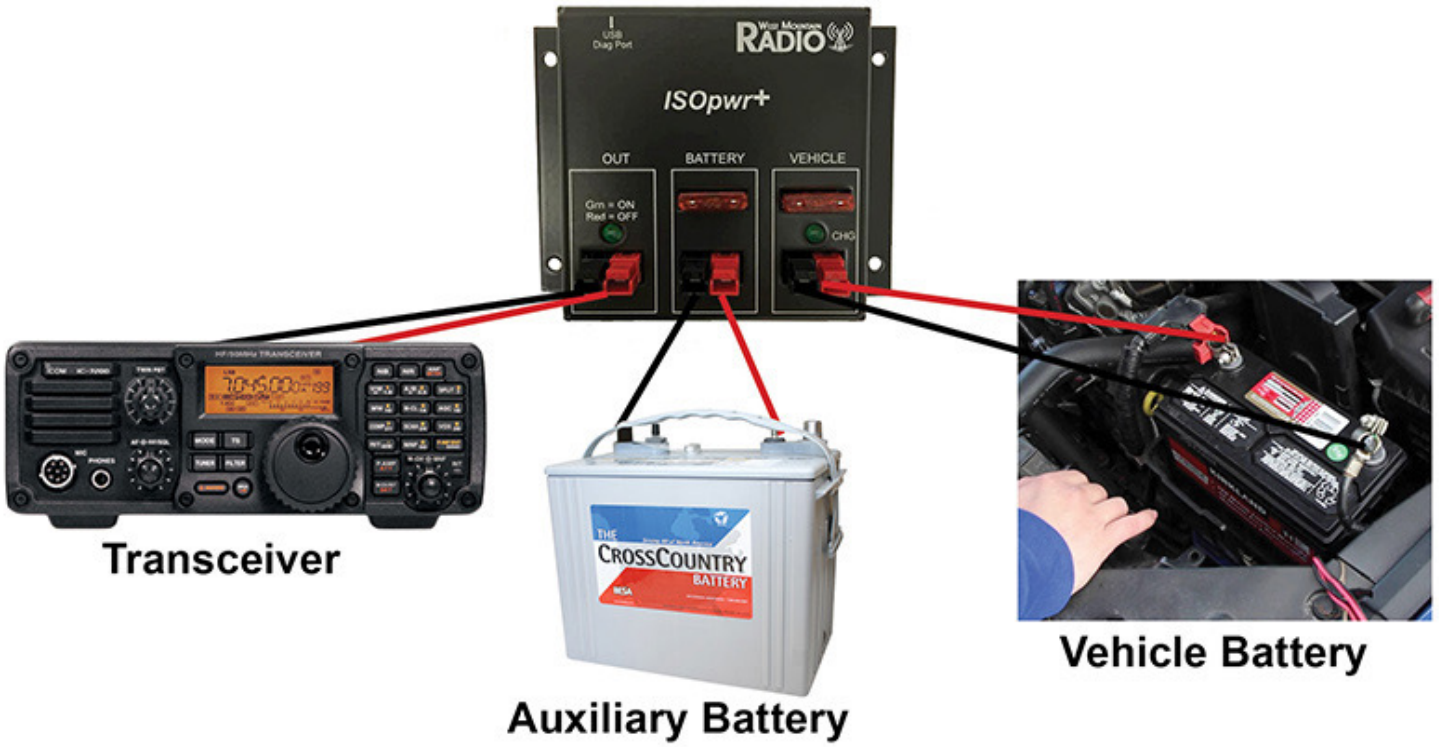
DC Power - Charging Batteries

- ***CARES DOES NOT RECOMMEND THESE***
    - Cheap float chargers: $10 (Note: we've seen a number of failures)



DC Power - Charging Batteries

- West Mountain **ISOpwr+**



DC Power - Discharging Batteries

- Need to limit discharge to the voltage specified by the manufacturer to avoid damaging the battery.
- Monitor the voltage frequently with a voltmeter
- In an *emergency* you might decide to sacrifice the battery to get the last bit of power
- Batteries that are sitting idle will discharge – if they are not recharged, they will be damaged
- **READ THE BATTERY DOCUMENTATION!**

DC Power - Testing Batteries

- One of the best tools on the market for the ham is the West Mountain Radio battery automated tester
- Must limit discharge to voltage specified by battery manufacturer
- Or… use cheaper electronic loads or build your own load cells from light bulbs and monitor voltage and time with a voltmeter

DC Power – Monitoring Battery Voltage (for both Charging and Discharging)

- Get multiple Digital Voltmeters (for your go-kit, car, garage, etc.)
- Price range from $15-$50 is good for this purpose.
- Build a voltmeter/ammeter into your battery box or connected via Anderson Powerpole connectors

- Harbor Freight voltmeters are inexpensive and pretty accurate – however, should verify with DVM workshop.

DC Power - Power Meters

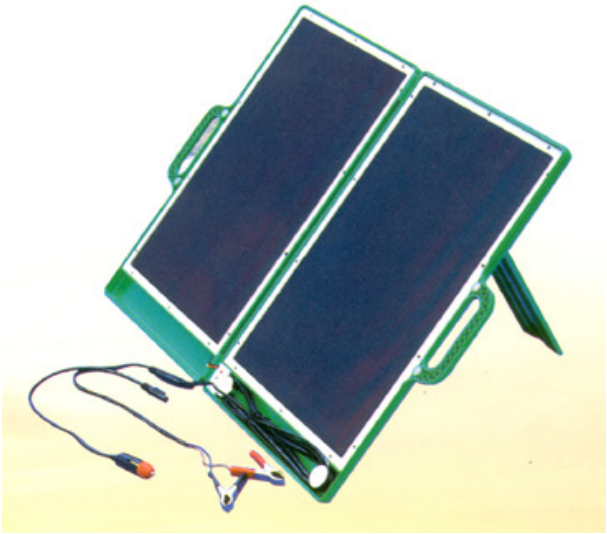
- West Mountain Radio PWRcheck+
- Turnigy 130A
- Buddipole POWERmini

DC Power - Generators

- Look for 3 fuel generators – Propane does not expire or corrode parts
- For gas, use non-ethanol fuel – less corrosive - often available at farm stores, marinas, stations dealing with motorsports, (often premium fuel at any gas station is ethanol free - ask at your station or check pump labels)
- Use a gas stabilizer (will extend life from 6 months to one year)
- Avoid diesel as diesel generators are very heavy
- Check for portability
- Test annually
- Test for RFI – may need to distance from the radio

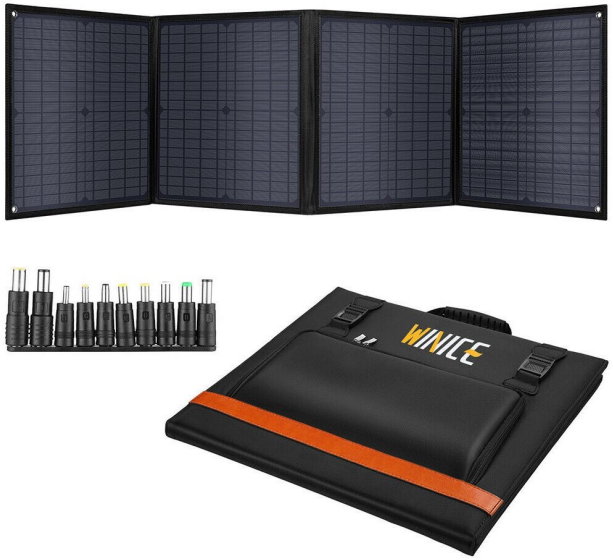
DC Power - Solar panels

Briefcase 13 watt



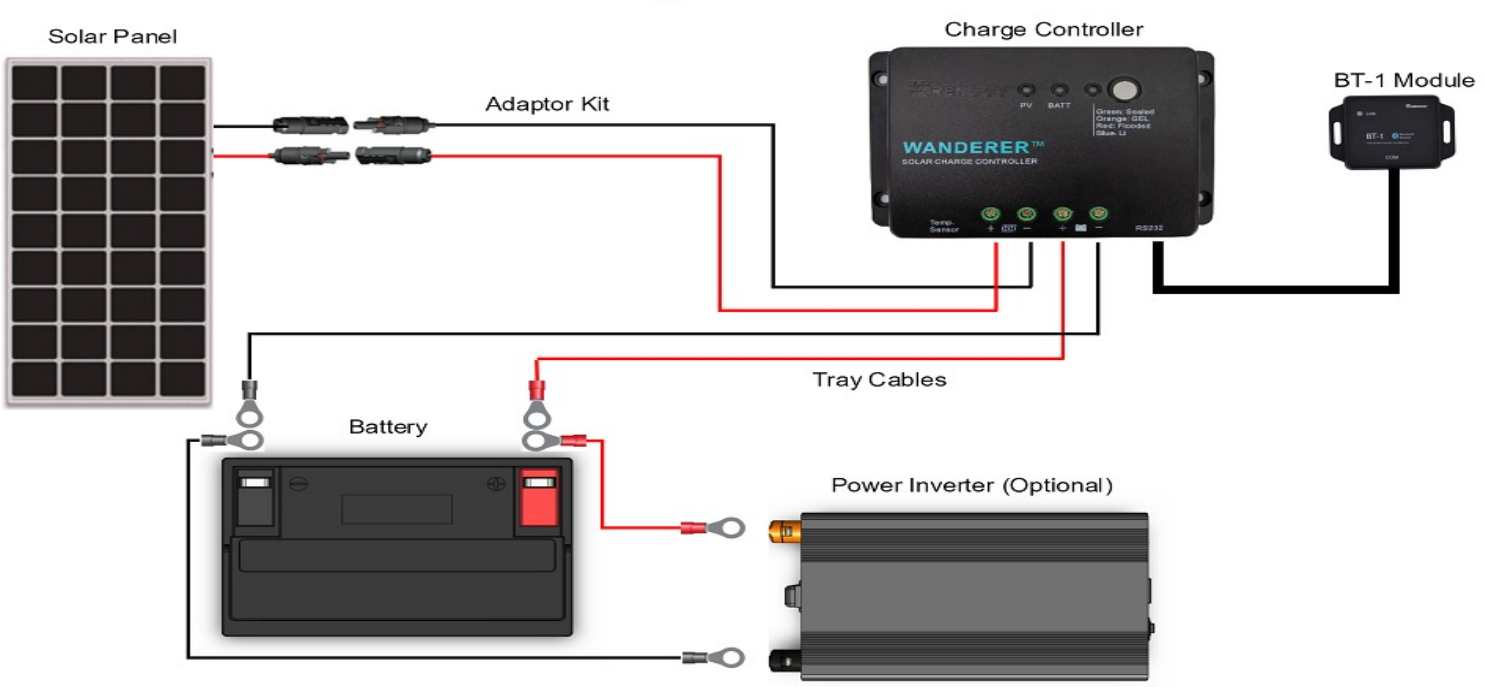
Roll-Up 13 watt

Fold-up 50 watt



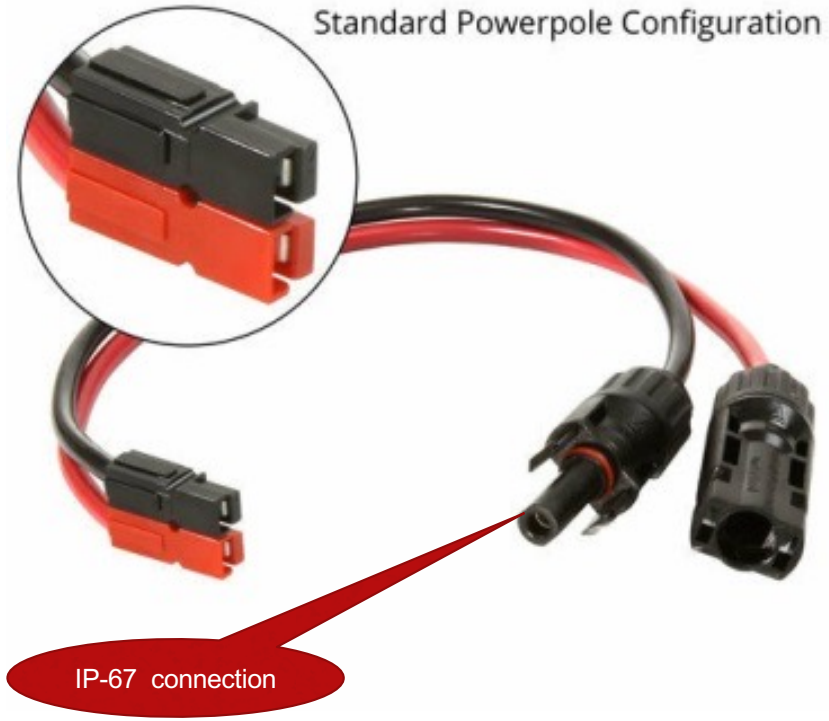
DC Power - Solar

How a Solar System Works



DC Power - Solar

IP-67 solar connectors
to Anderson PP-30



DC Power – Oregon sunlight expectations

- 100% solar rated output at high Noon in July / August
- Expect 10-20% at High Noon December
- Expect 20% cloud covered days

Steve's 8.5 KW Solar System – SW & West Facing

DC Power - Wind

- Physical Safety Issues
- Dangerous rotating blades

DC Power - Review

- Safety First
- Determine storage needs and types
- Anticipate/calculate needs
- Budget power
- Take appropriate care of your batteries
- Obtain alternate energy sources

DC Power - Power Supplies

- ARE NOT designed for charging batteries.
- ARE designed to power equipment.
- Can be adapted to maintain charge on batteries (float).
- But .....

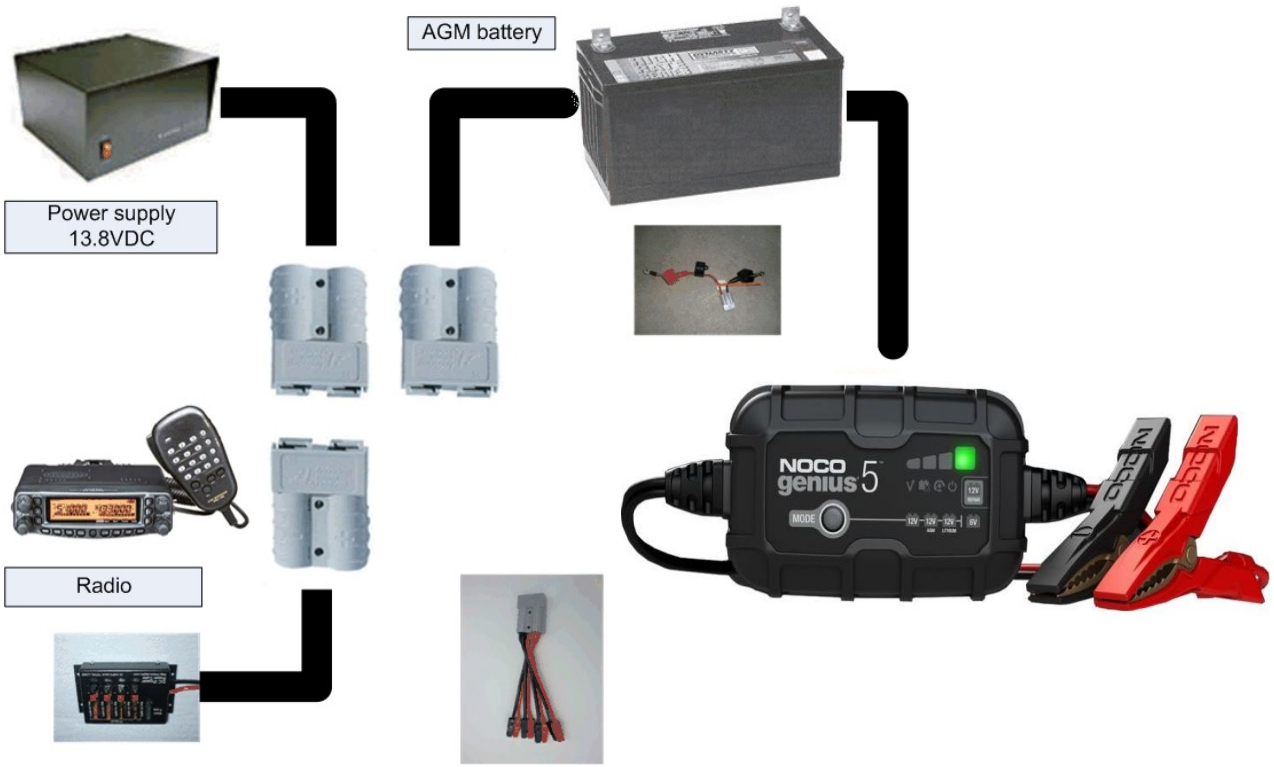
DC Power - Power Supplies

Can be used to slowly recharge batteries** – West Mountain Super PWRgate

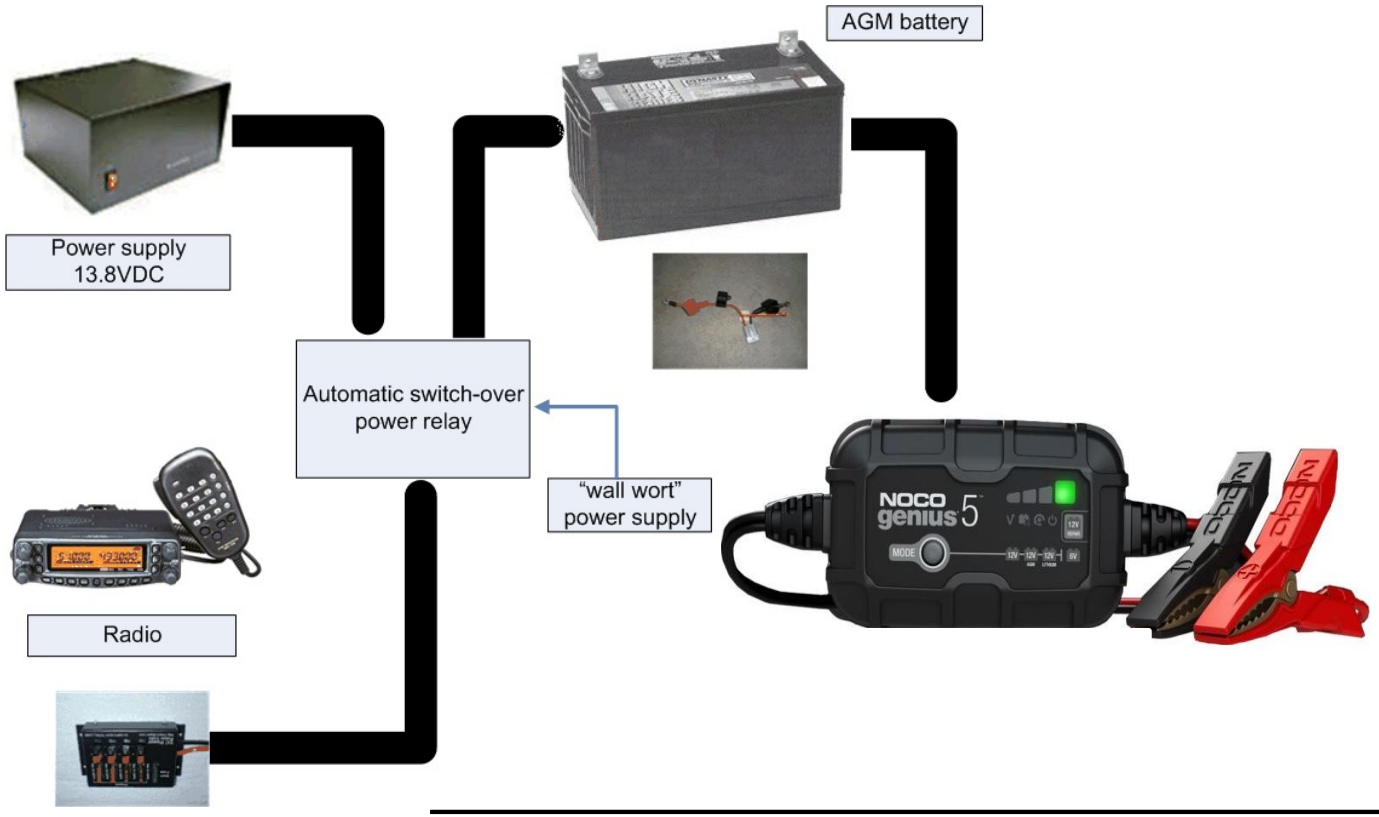
- ** To be used with Gel or AGM batteries. Not compatible with Li-ION.

DC Power - Power Supplies

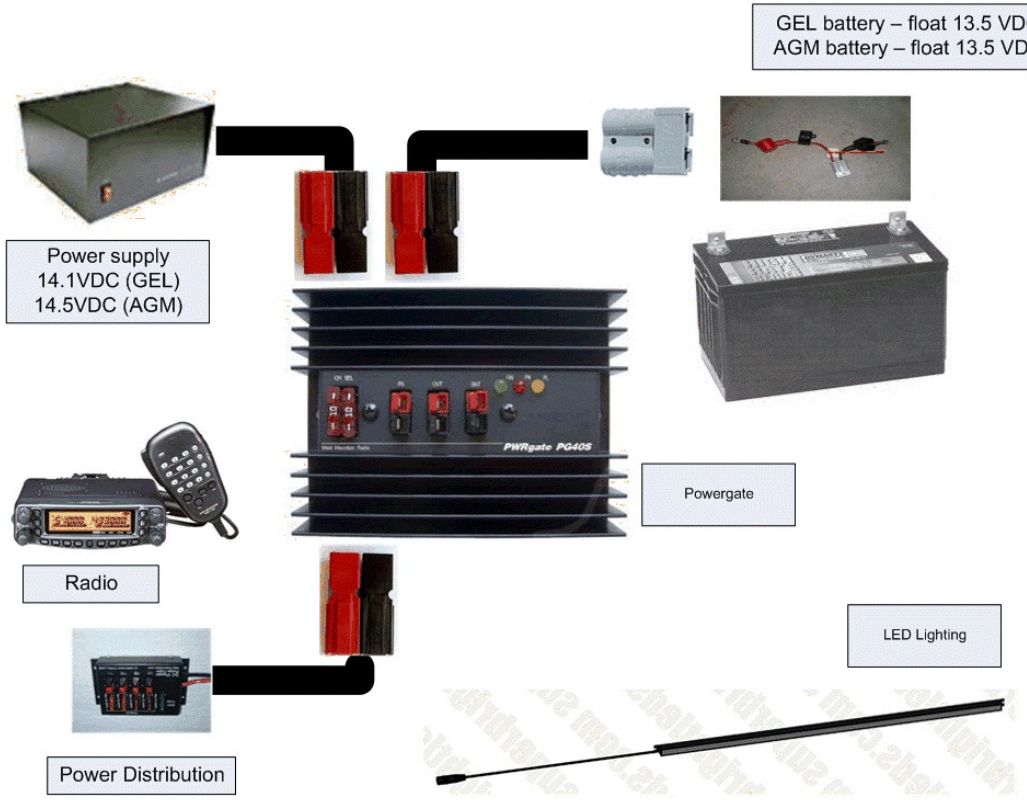
DC Power - connect & disconnect



DC Power - connect & disconnect



DC Power - connect & disconnect



DC Power - LED Lighting

Don’t forget lighting

DC Power - LED Lighting
18650 Li-ION battery

Use adapters for AAA batteries

DC Power - LED Lighting
18650 Li-ION Charger

Tenergy model: TN270

120 VAC input

12 VDC cigar plug input

$17 on Amazon for the Charger only

DC Power - LED Lighting
CR-123 style …

Maglite Mag-Tac LED
2-CR123 Flashlight

CR123 “primary”
battery
7-10 year shelf life

DC Power - LED Lighting

LED 18” strip – natural “warm” white 4100K color temperature

MALE power connector 2.1 mm x 5.5mm

FEMALE power connector 2 .1 x 5.5mm

Early days version

** BREAK **

DC Power Inverter - Sine & modified sine

- Types of Inverters:
  - Sine wave, square wave, modified sine
  - Sine wave is the best / safest for equipment
  - Modified sine wave may be just fine, but..... May damage equipment.
  - Sine wave units produce far less RFI (Radio Frequency Interference)
  - “Modified” sine wave may produce lots of RFI !
  - Sine wave will cost MORE !

DC Power - Inverters, Converters

- Harbor Freight 400 Watt

DC Power - Inverters, Converters

- Xantrex XPower Inverter 1000 sinewave

More Information…

- Other training sessions
- Consulting services, other sources
- ARRL Handbook
- ARRL Emergency Power Handbook
- www.BatteryUniversity.com – recommended by ICom support tech
- www.pcguide.com/ref/power/ext/ups/funcOutput-c.html
- QST articles

Summary

- Safety Safety Safety
- Fuses, heavy wiring, good insulation
- Be especially cautious recharging discharged batteries
- ***NEVER*** bring ***liquid acid*** batteries to any event
- Programmable battery charger

In Closing

- No all batteries are made the same
- Pay for quality engineering and manufacturing
- Get recommendations

In Closing

- Careful power budgeting
- Practical use of batteries
- Practical charging equipment
- Practical LED lighting
- Safe wiring, power distribution, fuses
- This presentation has a bit of information regarding vehicle power systems in the Appendix.
- Questions?

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Thank your for contributions and comments:

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Mitch Bayersdorfer W7MDB
David Warner W7SZS

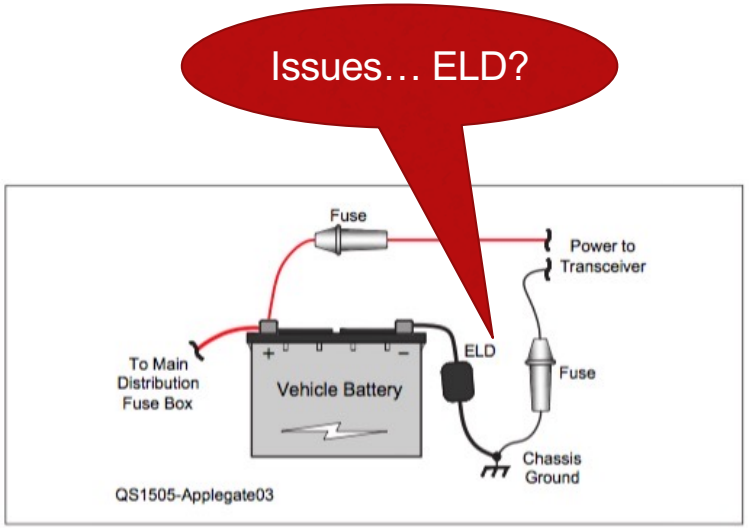
Questions and Answers

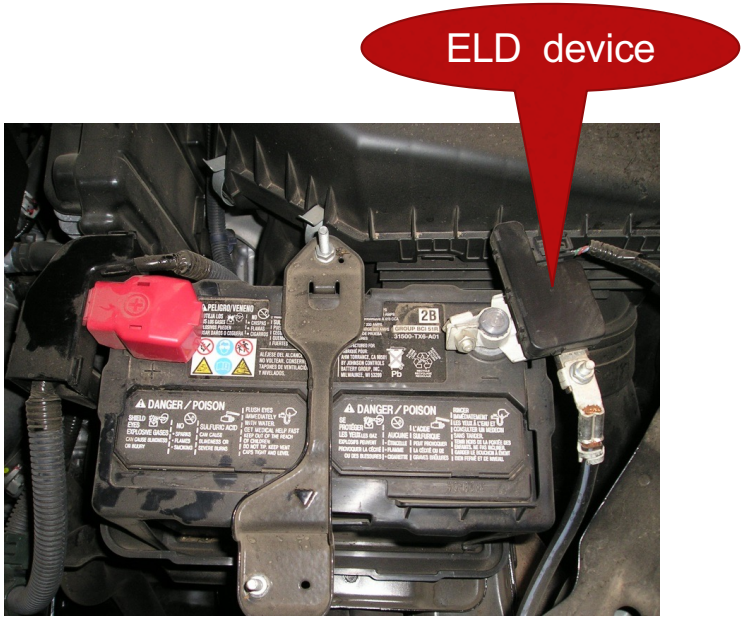
Appendix

1. Automotive DC Wiring

DC Power - Automotive

- Great vehicle wiring page: http://www.k0bg.com/wiring.html
- May 2015, QST, starting on page 35, entitled *The Modern Mobile*

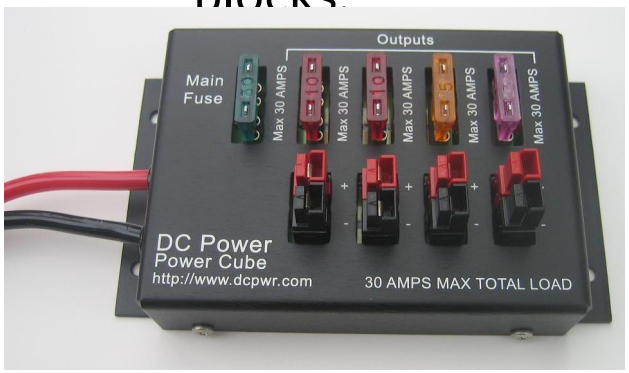




- Steve Jensen (KE7GXC), Asst. Emergency Coordinator, Clackamas County ARES CARES

DC Power - Automotive

- HEAVY extra thick insulated wire #10 AWG or #8 AWG
- Suggest using circuit breakers and Power Distribution blocks:



- Do not use “speaker“ wire.

Steve Jensen (KE7GXC), Asst. Emergency Coordinator, Clackamas County ARES CARES

DC Power - Automotive

- Abrasion resistance:
- Cover the wiring to maintain long term safety

- Steve Jensen (KE7GXC), Asst. Emergency Coordinator, Clackamas County ARES CARES

DC Power - Lithium Batteries

Valence 40Ah Lithium Iron Magnesium Phosphate Battery (LiFeMgPO4) $1000 originally pallet quantity, alt. replacements $900

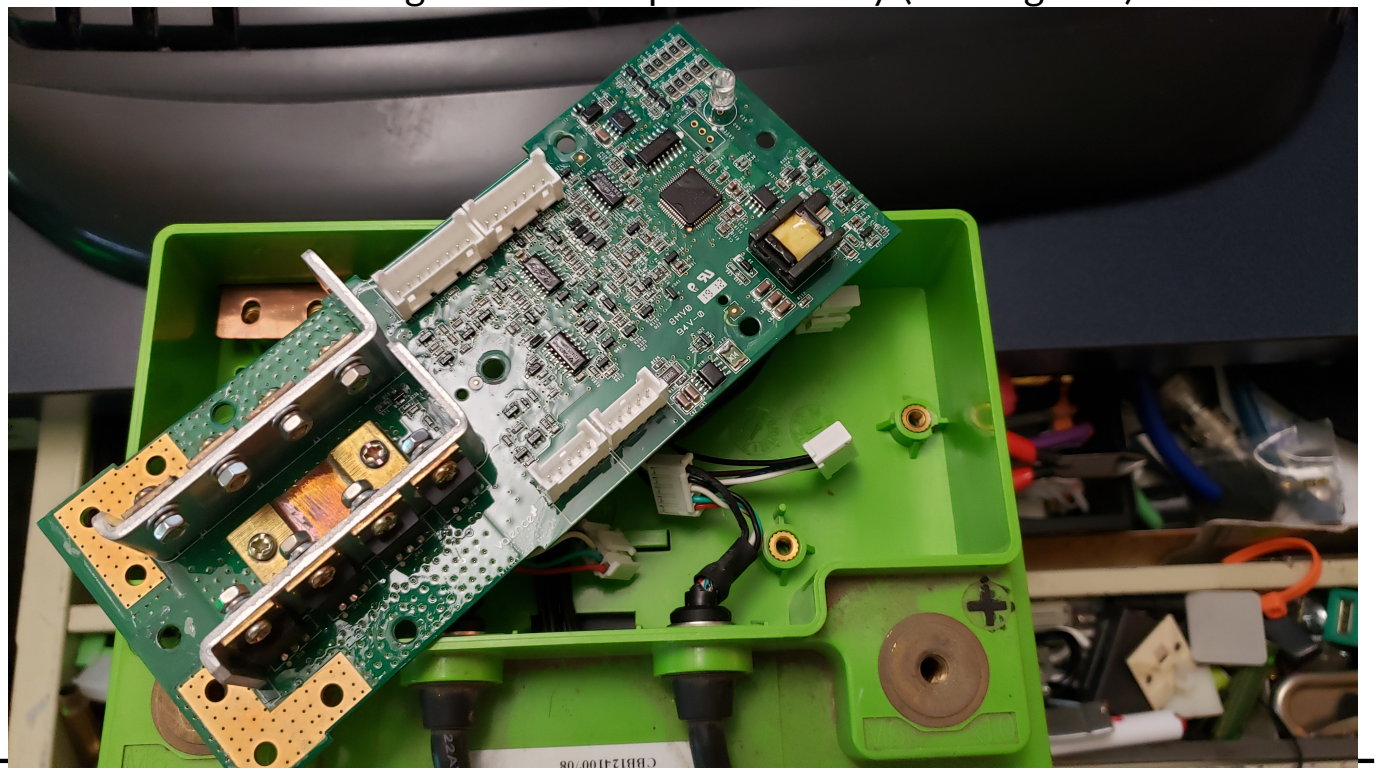
Includes built-in BMS (Battery Monitoring System - protection circuit module) which provides internal cell balancing and management, protection from over-current, over-discharge, over-voltage and short circuiting, and has integrated charging circuitry

DC Power - Lithium Batteries

Valence: Lithium Iron Magnesium Phosphate Battery (LiFeMgPO4)

DC Power - Lithium Batteries

Valence: Lithium Iron Magnesium Phosphate Battery (LiFeMgPO4)



DC Power – End of Life Batteries