



DC Power for Amateur Radio

Safely Powering your Station at
Home and on the Go.

Steve Jensen • KE7GXC • 13-April-2023 • Rev 1.0
Clackamas ARES Training Program

DC Power for Amateur Radio

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. This value comes from the terminal voltage of a freshly charged lead-acid battery. Most amateur equipment is marked with a tolerance figure of +/- 15% which means means it is safe to use at any voltage between 13.8 less 15% (12V) and 13.8 plus 15% (15.87V).
 - 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, gas/diesel/propane/natural gas generators, cars (which are actually generators), solar, wind and hydro.
-

Important Battery Characteristics

- Amperage
- Voltage
- Watts
- 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

- The following specification sheet – Werker 18 Ah
 - ❖ Duration of discharge
 - ❖ Estimated Capacity
 - ❖ Discharge Characteristics
 - ❖ Effects of Temperature
 - ❖ Battery Life versus discharge cycles
-



Sealed Lead Acid Absorbed Glass Mat

Technical Specifications

WKA12-18NB



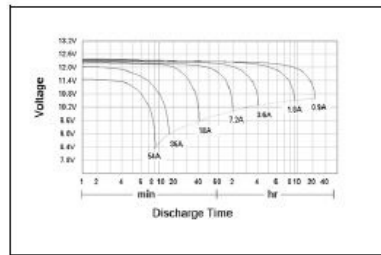
Specifications

All Specifications Are Rated at 77°F Unless Otherwise Noted

Nominal Voltage		12V	
Ampere Hour Capacity (20hr Rate to 1.75VPC)		18Ah	
Dimensions	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%	

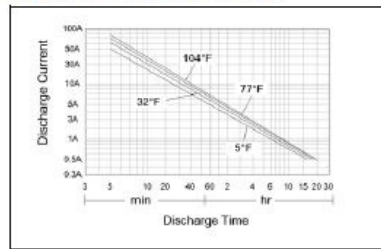
Discharge Characteristics

Duration of Discharge @ 77°F



Discharge Duration vs. Discharge Current

Duration of Discharge @ Various Temperatures



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

The information contained on this specification is generally descriptive only and is not intended to make or imply any representation, guarantee, or warranty with respect to any cells and batteries. Cell and battery design specifications are subject to modification without notice.

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



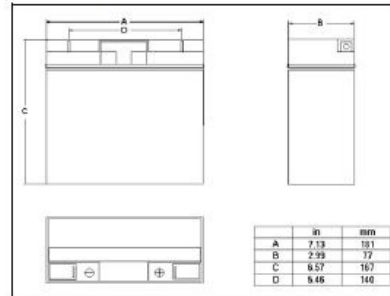


Sealed Lead Acid Absorbed Glass Mat

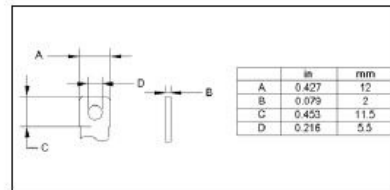
Technical Specifications

WKA12-18NB

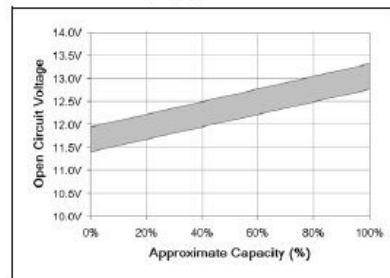
Physical Dimensions



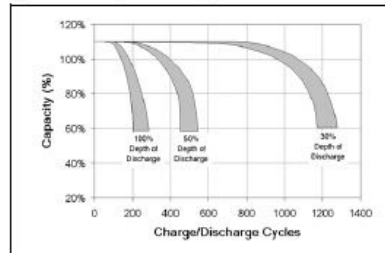
Terminal



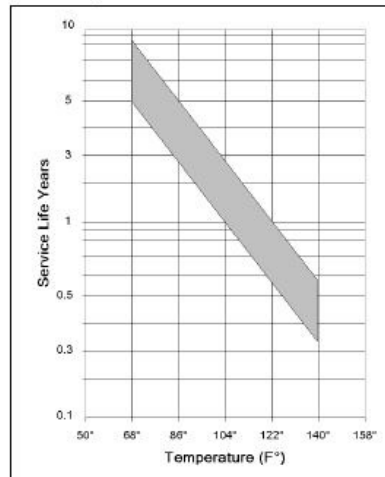
Open Circuit Voltage vs. Capacity Estimated Residual Capacity @ 77°F



Cycle Life vs. Depth of Discharge



Effect of Temperature on Float Life



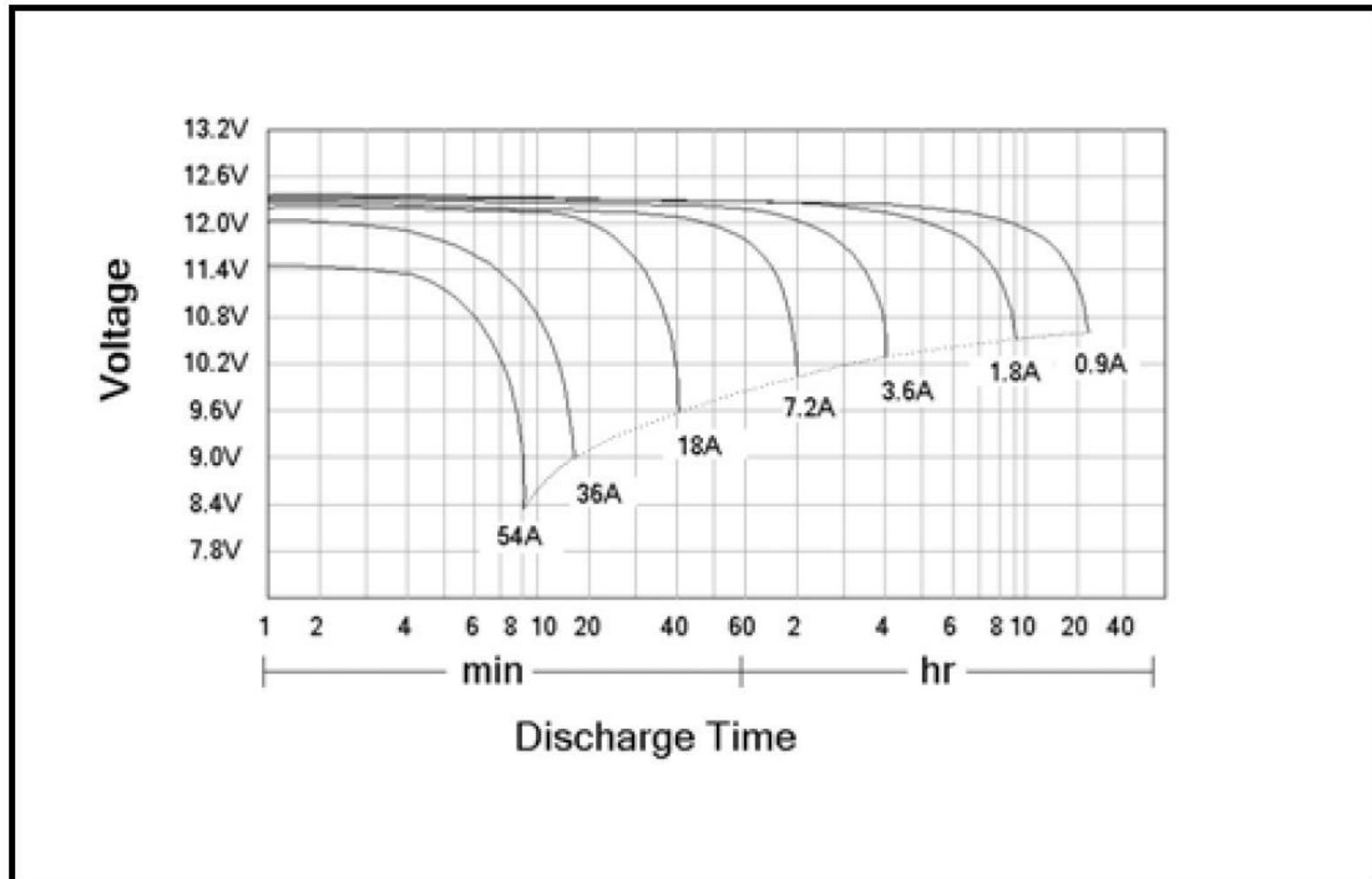
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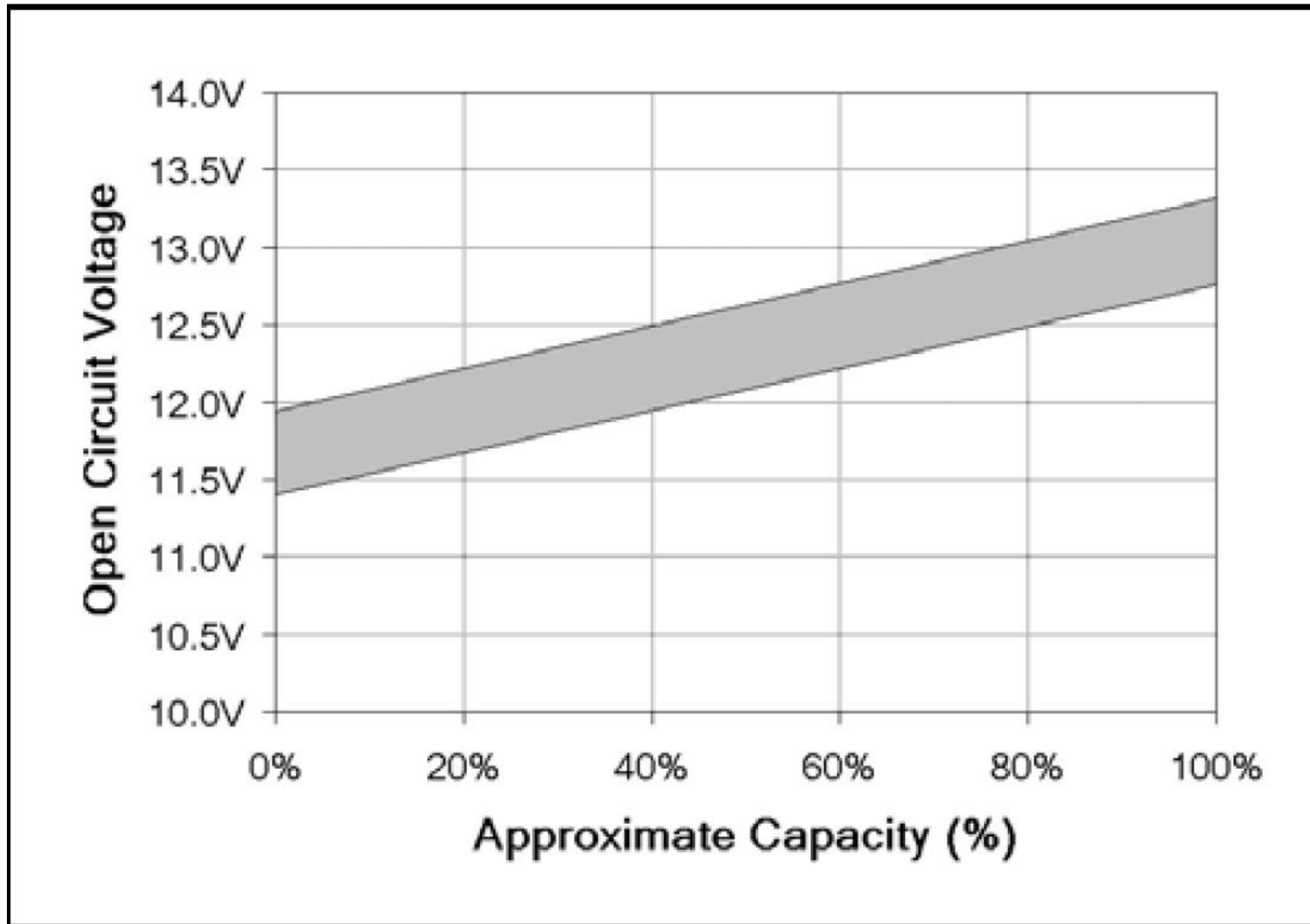


Discharge Characteristics

Duration of Discharge @ 77°F

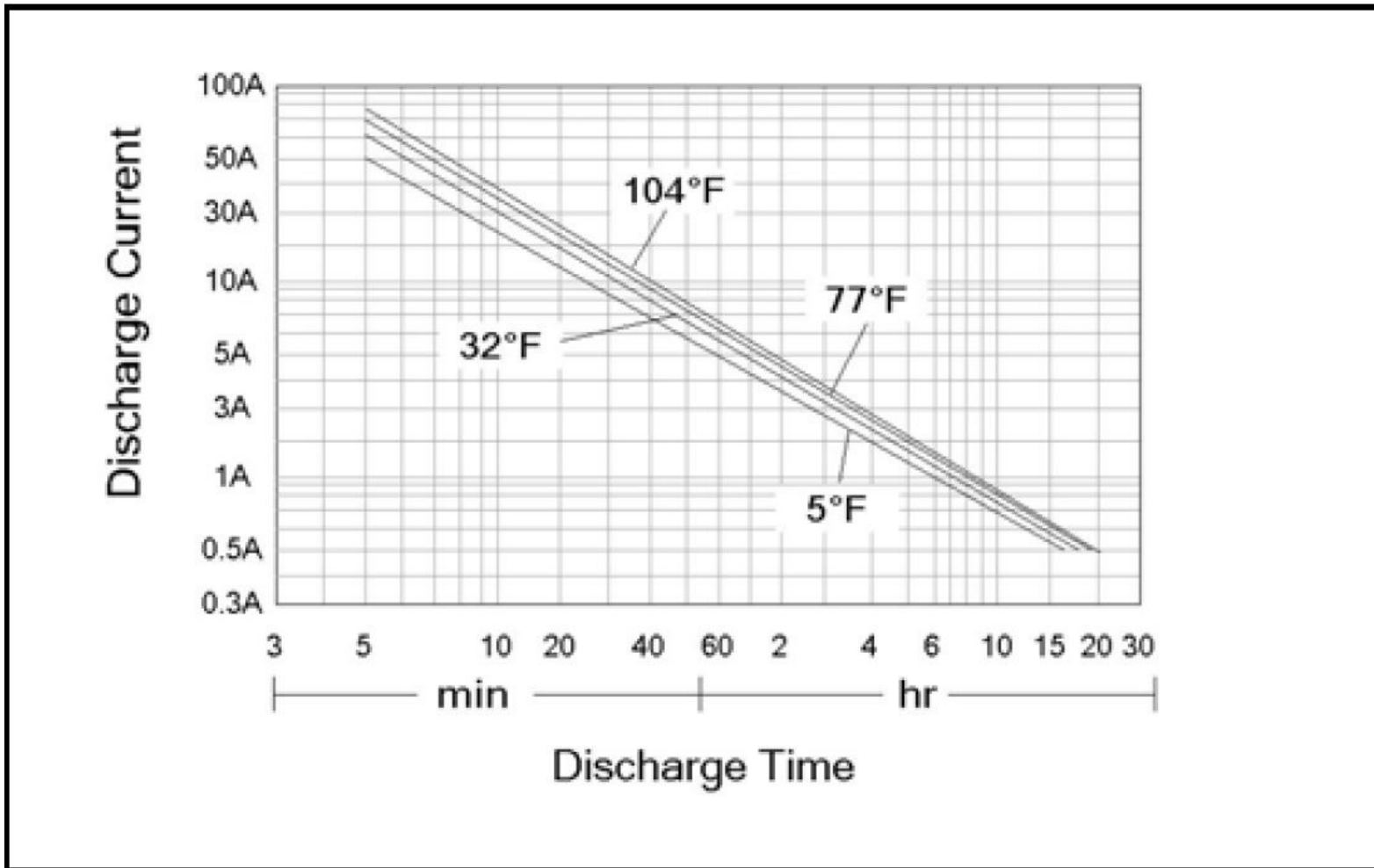


Estimated Residual Capacity @ 77°F

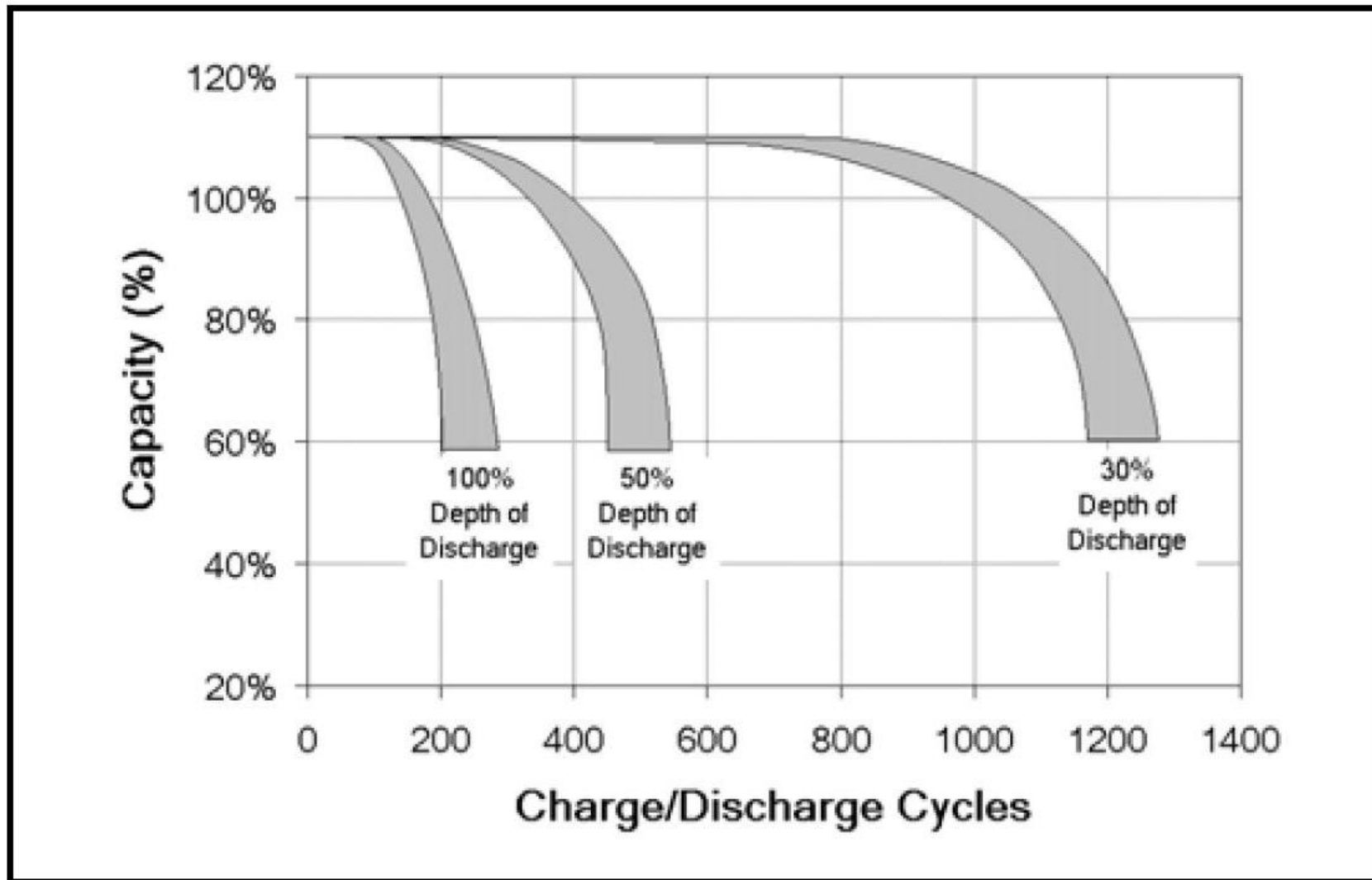


Discharge Duration vs. Discharge Current

Duration of Discharge @ Various Temperatures



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. Monitor battery voltage as you use them, and get to know how your batteries act. As batteries age, a rechargeable battery will hold less energy.
- 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
- 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



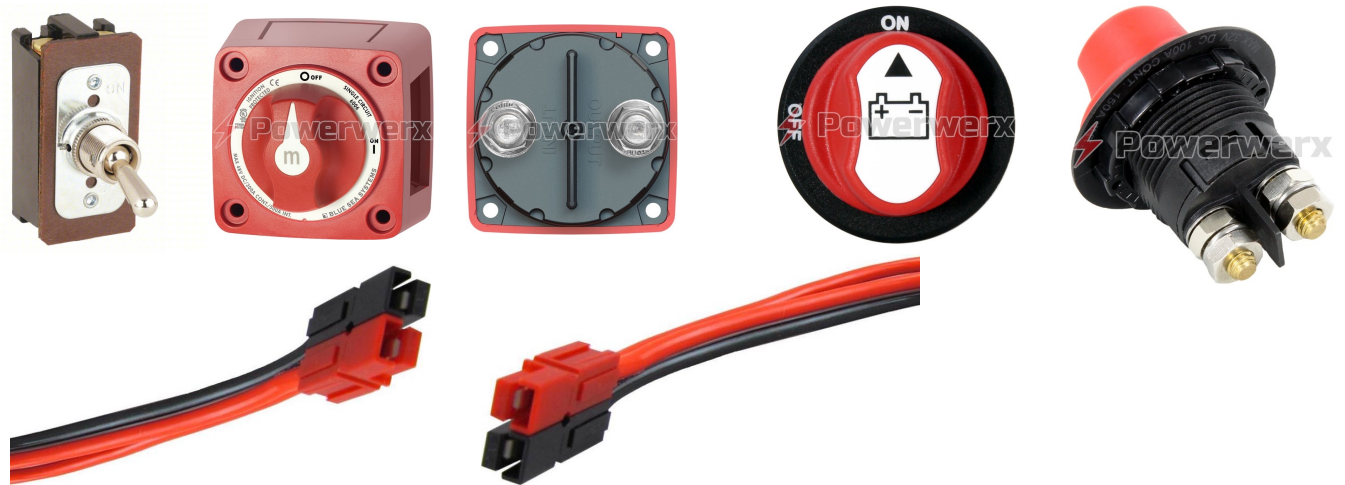
- ICom IC-2200H 4 mA OFF






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

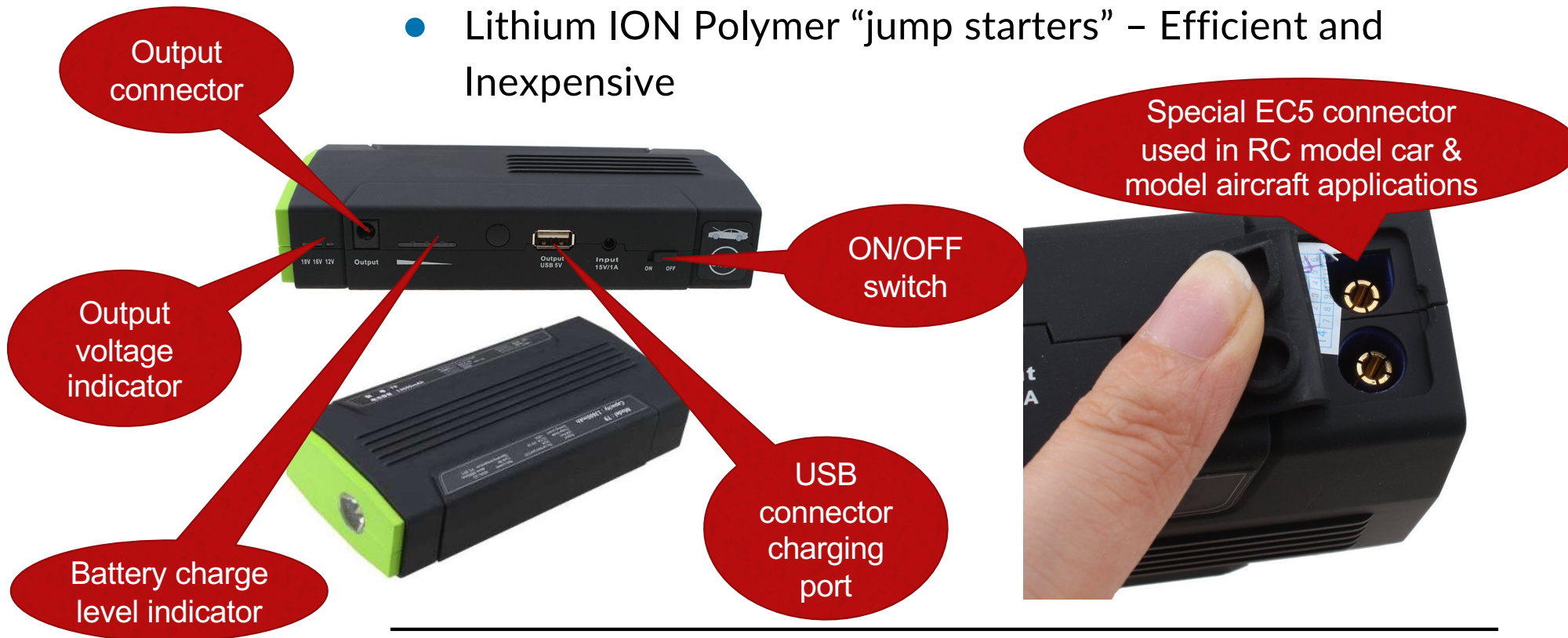
All of these batteries will be damaged if discharged below recommended voltage (check battery user information!)

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)
 - 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
-

DC Power – Jump Starters

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



DC Power - Rechargeables

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





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



Special charger! Simplified for consumer use



Insert here



Some lanterns have a USB for charging phones

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

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=MH4NgoyLGPo> KM6ACK
-

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

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.



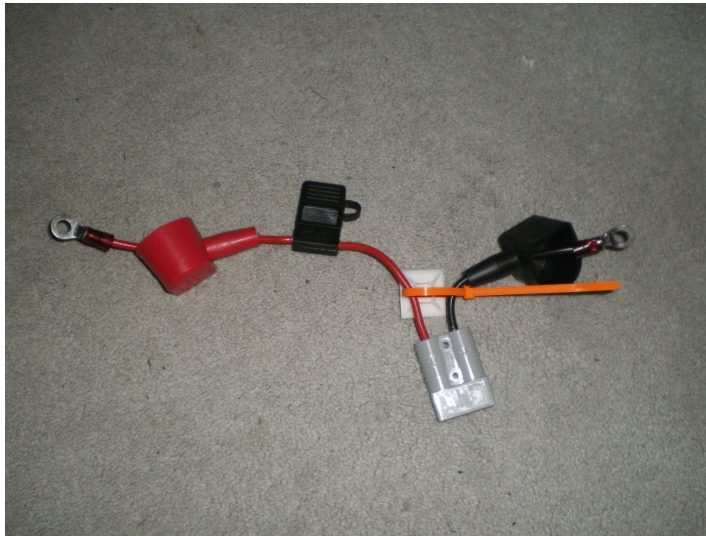
DC Power - Wiring, Fusing, etc.

- 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

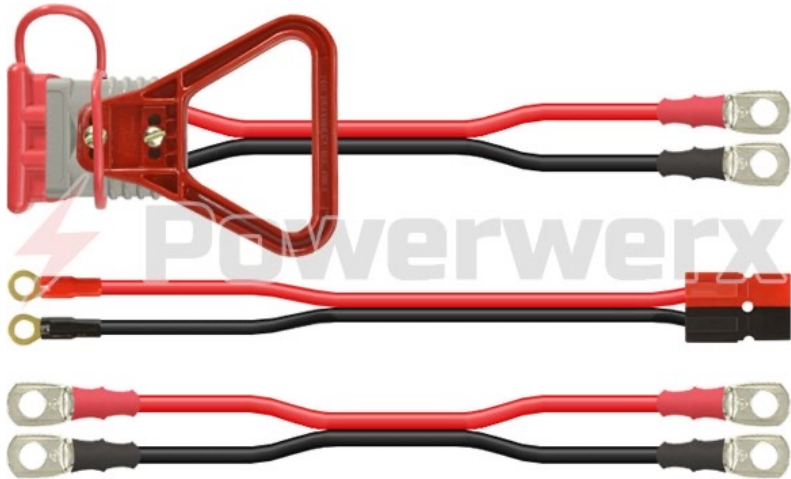


“blade”
style
fuses

Bonus: USB
power

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.....

DC Power - Safety

- Batteries and Power Supplies – Ensure proper fuses, wiring, connections (shrink wrap). 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



Fire Hazard – Li-Ion batteries

Flaming Dell in 2006



LiFePO_4 and LiFeMnPO_4 are safer chemistries!

**** 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 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: $2.28 \text{ volts per cell} \times 6 = 13.68$ 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: less than \$10 (Note: we've seen a number of failures)



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 – 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
- Do not recommend the Harbor Freight voltmeters (often free) as some tested are very inaccurate.





DC Power - Power Meters

- West Mountain Radio PWRcheck+

- Turnigy 130A

- Buddipole POWERmini



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 - Charging Batteries

- West Mountain ISOpwr+



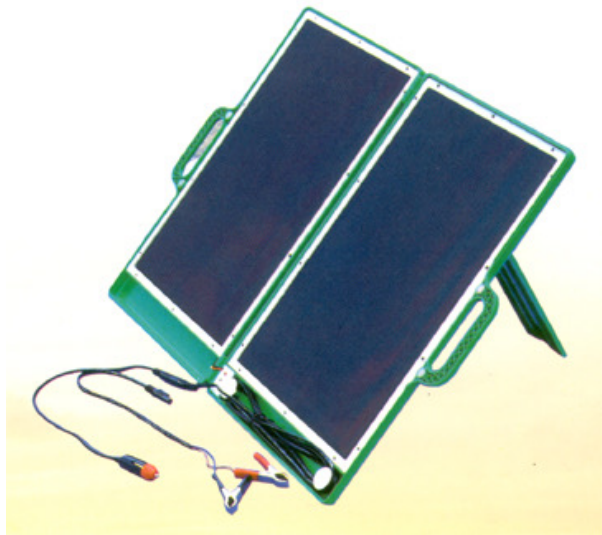


DC Power - Generators

- 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 radio distance
-

DC Power - Solar panels

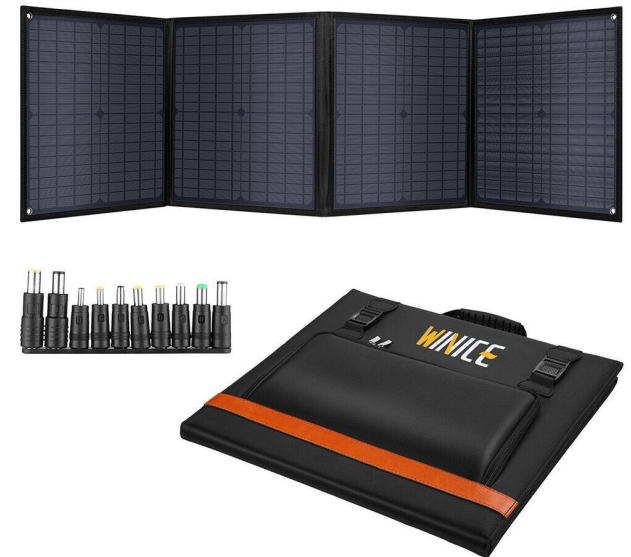
Briefcase 13 watt



Roll-Up 13 watt

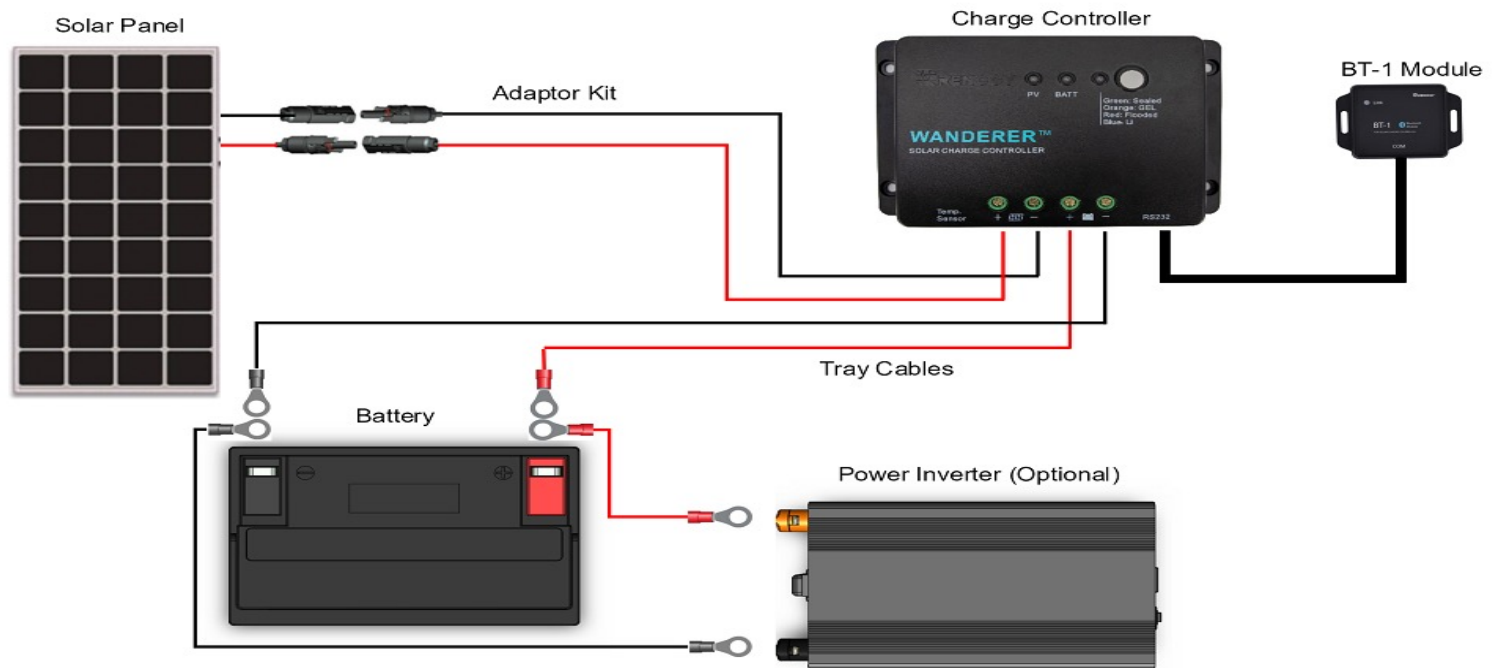


Fold-up 50 watt



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 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

**** BREAK ****

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.

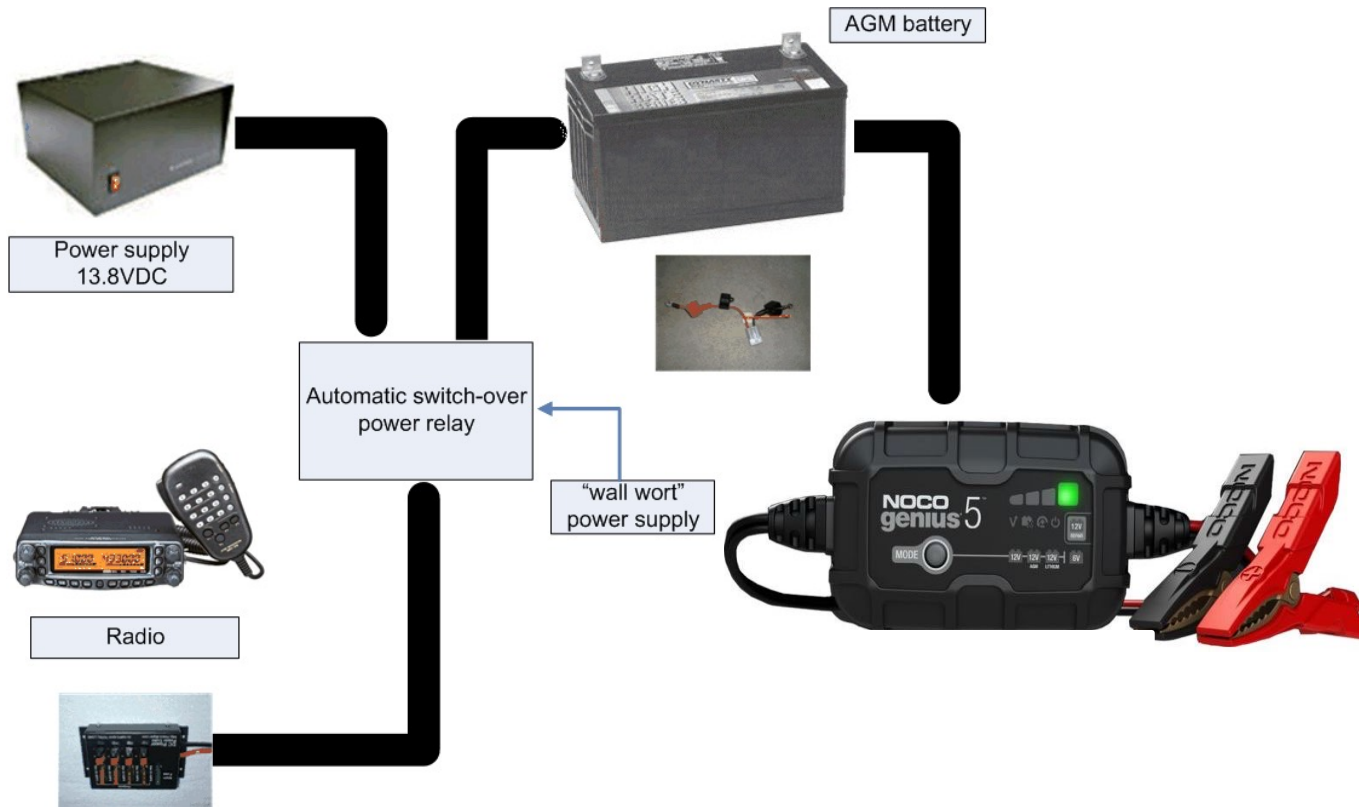
DC Power - Power Supplies



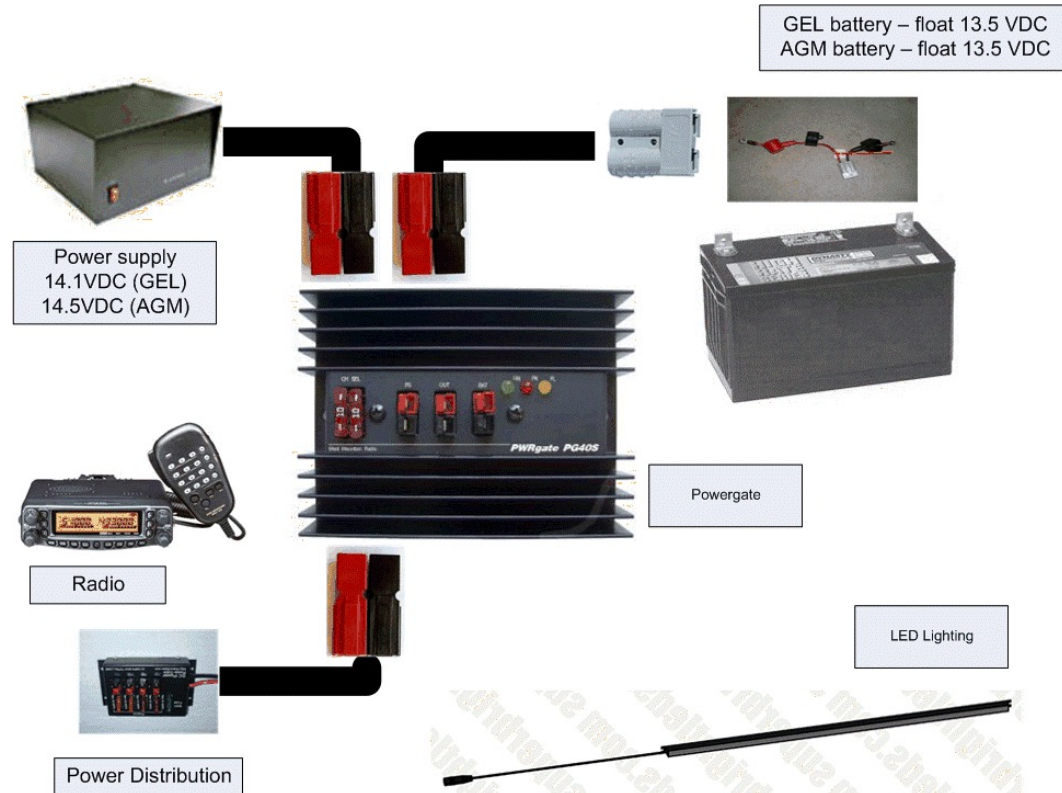
DC Power - connect & disconnect



DC Power - connect & disconnect



DC Power - connect & disconnect



DC Power - LED Lighting

18650 Li-ION battery

Use
adapters
for AAA
batteries



DC Power - LED Lighting

18650 Li-ION Charger

Tenergy model: TN270

120 VAC input

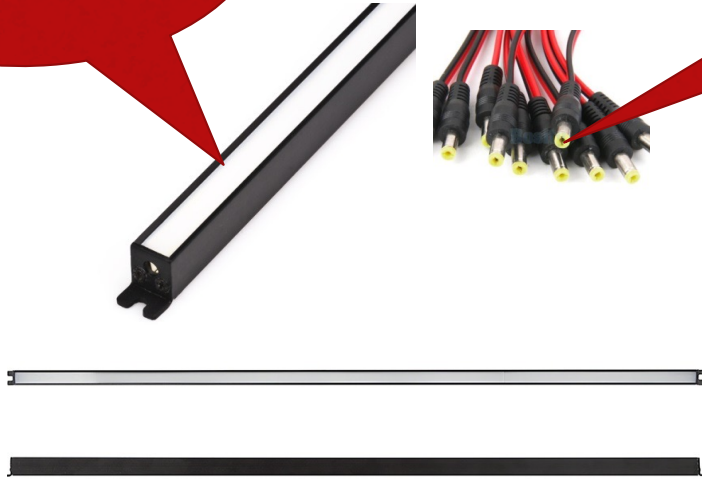
12 VDC cigar plug input



\$17 on Amazon for the Charger only

DC Power - LED Lighting

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

Keep these

**VERY
TIGHT!**

Change to
Anderson
SB-50's



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

- 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?

Steve Jensen – KE7GXC@ARRL.NET

**Thank you for contributions and
comments:**

Jeremy Tanzer KI7BDP

Mitch Bayersdorfer W7MDB

David Warner W7SZS

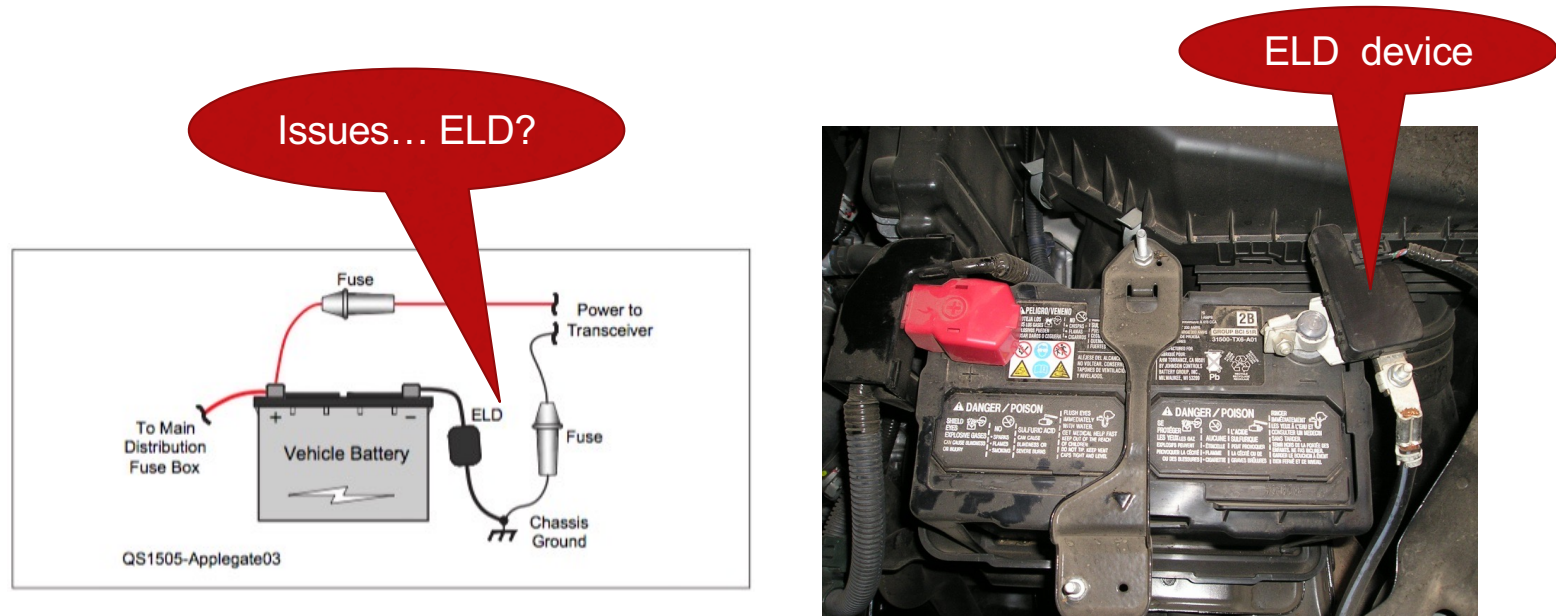
Questions and Answers

Appendix

1. Automotive DC Wiring

DC Power - Automotive

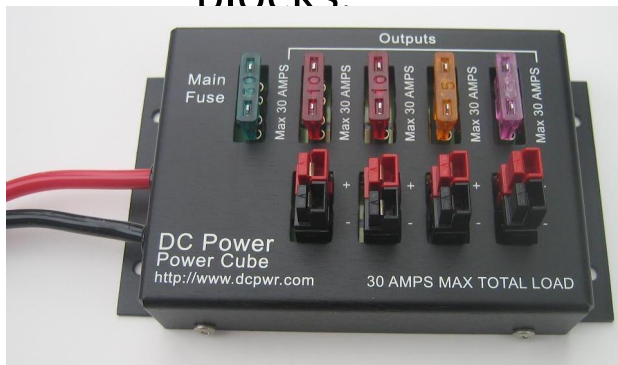
- Great vehicle wiring page: <http://www.k0bg.com/wiring.html>
- May 2015, QST, starting on page 35, entitled *The Modern Mobile*



- 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
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