

# Battery Safety

(and a few tips on using batteries  
to power your equipment)

Presentation for MCACS

December 29, 2020

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# Agenda

I will focus on safety (and a few operational) issues that arise with three different battery chemistries:


- Lead-acid
- Lithium
- Alkaline

However, a lot of what I have to say about lead-acid batteries also applies to other types, so when we get to lithium and alkaline batteries, I will concentrate on the differences.

I'm not going to talk about nickel-based batteries today, since those are almost always fully integrated with the equipment.

# Speaker Notes

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- Hovering your mouse over the icon should bring the speaker notes into view.
- You might also be able to open the Notes layer in a separate pane depending on which viewer you are using.



# Three safety issues with deep-cycle lead-acid batteries

- Premium deep-cycle batteries are capable of delivering *thousands* of amperes into a short circuit when fully charged
- If the short-circuit is at a distance from the battery, intervening wires can be heated to incandescence, possibly starting a fire, melting insulation from other wires in the bundle
- Principal ingredients, lead and acid, both fall into the category of Very Nasty Stuff. It is important that these remain inside the battery and not be splattered around nearby people, equipment or the environment

# Lead-acid batteries

- Can be connected in series or parallel to increase terminal voltage and/or capacity

---but---

- Parallel connection should only be done with two batteries of the same design, age, and condition. Large currents can flow from one battery to the other if charge level and characteristics are not matched.
- Sooner or later, one of those batteries will fail. And the usual failure mode is a shorted cell. At this point, you will have a 12-V battery in parallel with a 10-V battery.
- So, fuse each battery separately, or buy a bigger battery!

# Lead-acid batteries

- Lead-acid batteries may release explosive hydrogen during charging or rapid discharge so adequate ventilation is required.
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**WRONG!**



# Lead-acid batteries

Two situations commonly occur that result in overcharging.

- First, the float voltage of a lead-acid battery is temperature-dependent. The voltage needs to be decreased by  $3 \text{ mV}/^{\circ}\text{C}$  per cell above  $25^{\circ}\text{C}$  and reduced when the temperature is below  $25^{\circ}\text{C}$ .

*Note: Manufacturers have different specifications. Concorde recommends compensation of  $4 \text{ mV}/^{\circ}\text{C}$ .*

- 3 or 4 mV doesn't sound like a lot, but a 12V lead-acid battery has six cells, so we are really looking at a change of 18 to 24 mV/ $^{\circ}\text{C}$ .



# Example

12V SunXtender AGM battery (made by Concorde)  
with rated charging (float) voltage of 13.3 V (specified  
at 77 °F)

Temp (°F)	Temp (°C)	$\Delta T$ (°C)	$\Delta V$ (mV)	$V_{\text{Float}}$ (V)	Result (when charged at 13.5 V)
77	25	--	--	13.3	battery fully charged as specified in data sheet
95	35	10	-240	13.06	overcharged – outgassing
32	0	-25	600	13.9	undercharged

# Lead-acid batteries

The second issue is the shorted cell failure at the battery's end of life. Now the charger is applying 13.5 V to a 10-V battery instead of a 12-V battery. That is guaranteed to cause outgassing even in an air-conditioned room.

So, you need a battery charger that has two specific features:

- Temperature-compensated charging voltage
- Shorted-cell detection and shut-off



# Lead-acid batteries

Two chargers I recommend are:

- BatteryMinder Model 12248 for 12V lead-acid batteries from 7 to 30 Ah  
---and---
- ProMariner Model 63120, also known as the ProNautic 1220P for powering a 100W HF station from a 80- to 100-Ah lead-acid battery.

Both models have the recommended safety features, and can be adjusted to a range of charging voltages for AGM, gel cell, and flooded lead-acid batteries.

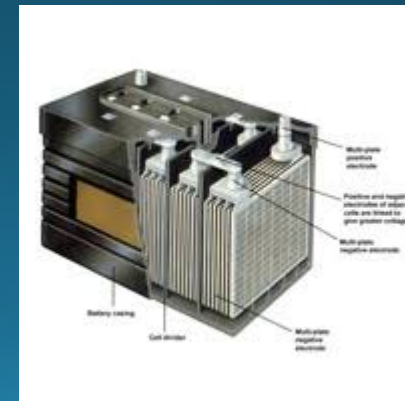
If the battery temperature sensor is an extra-charge option, buy it!

# Improvised power cord for ProNautic charger



# Starting vs. deep-cycle batteries


- Starting batteries
  - Very high current to start engine, but very shallow discharge in normal use
  - Alternator maintains battery fully charged after short recovery period
  - Plates stacked to increase surface area. This lowers internal resistance and enables high current to be delivered
  - Weight is a key factor for vehicular batteries, so plates are thinner than deep-cycle batteries



Source: [batteryuniversity.com](http://batteryuniversity.com)

# Starting vs. deep-cycle batteries

- Deep-cycle batteries
  - Peak current drain much lower in most applications
  - Battery is often the primary source of power to equipment, so battery may routinely experience deep discharge between charges
  - Thicker plates to maintain their geometry during deep discharge



# Starting vs. deep-cycle batteries

- Plate thickness is the primary difference between starting and deep-cycle batteries
- Two plates, separated by a porous glass mat that is suffused with electrolyte,  $\text{H}_2\text{SO}_4$
- During discharge, lead dioxide in the positive plate reacts with the sulfuric acid to produce lead sulfate.



- At the same time, pure lead in the negative plate reacts with sulfate ions in the electrolyte to produce lead sulfate.



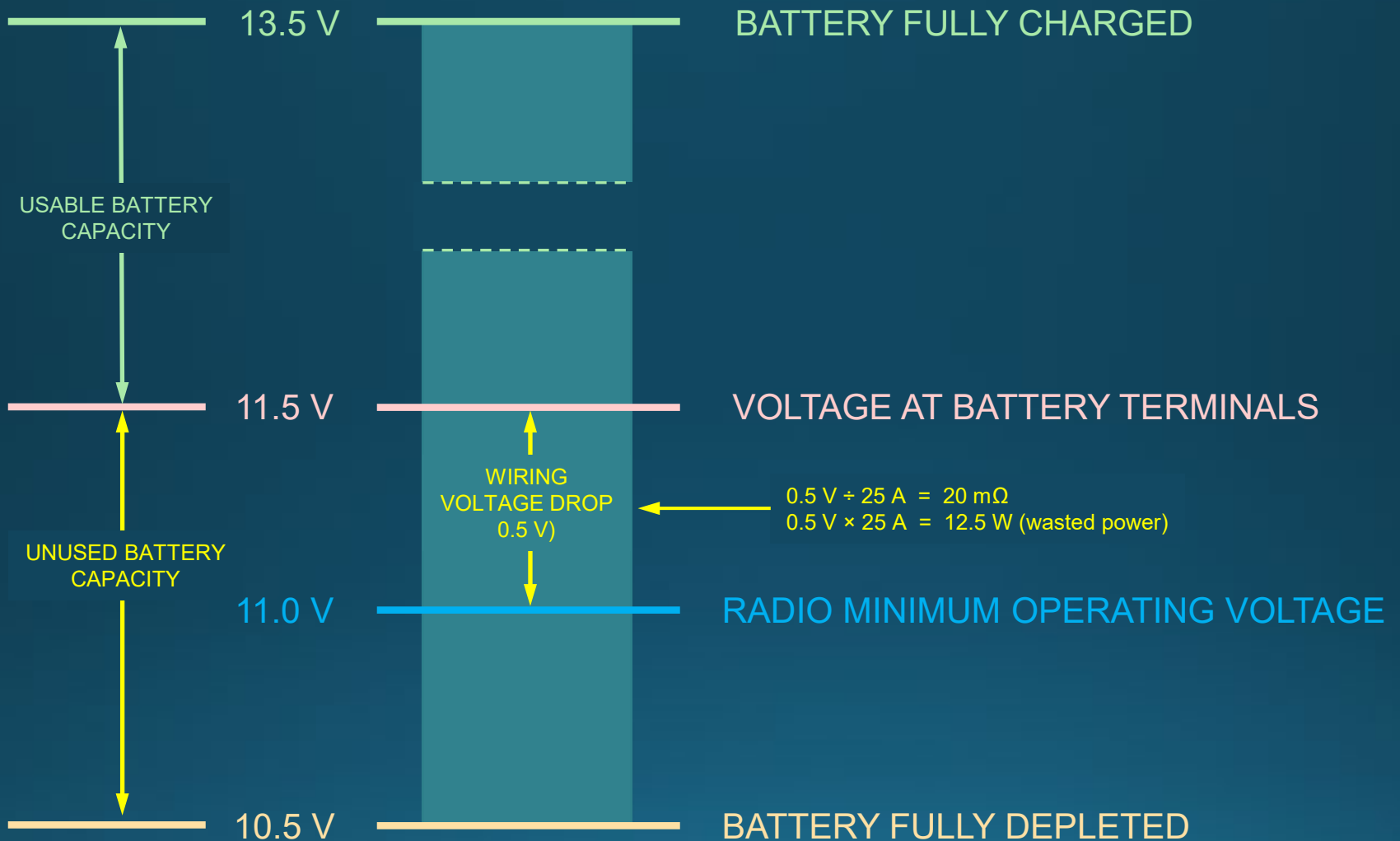
# Voltage drop

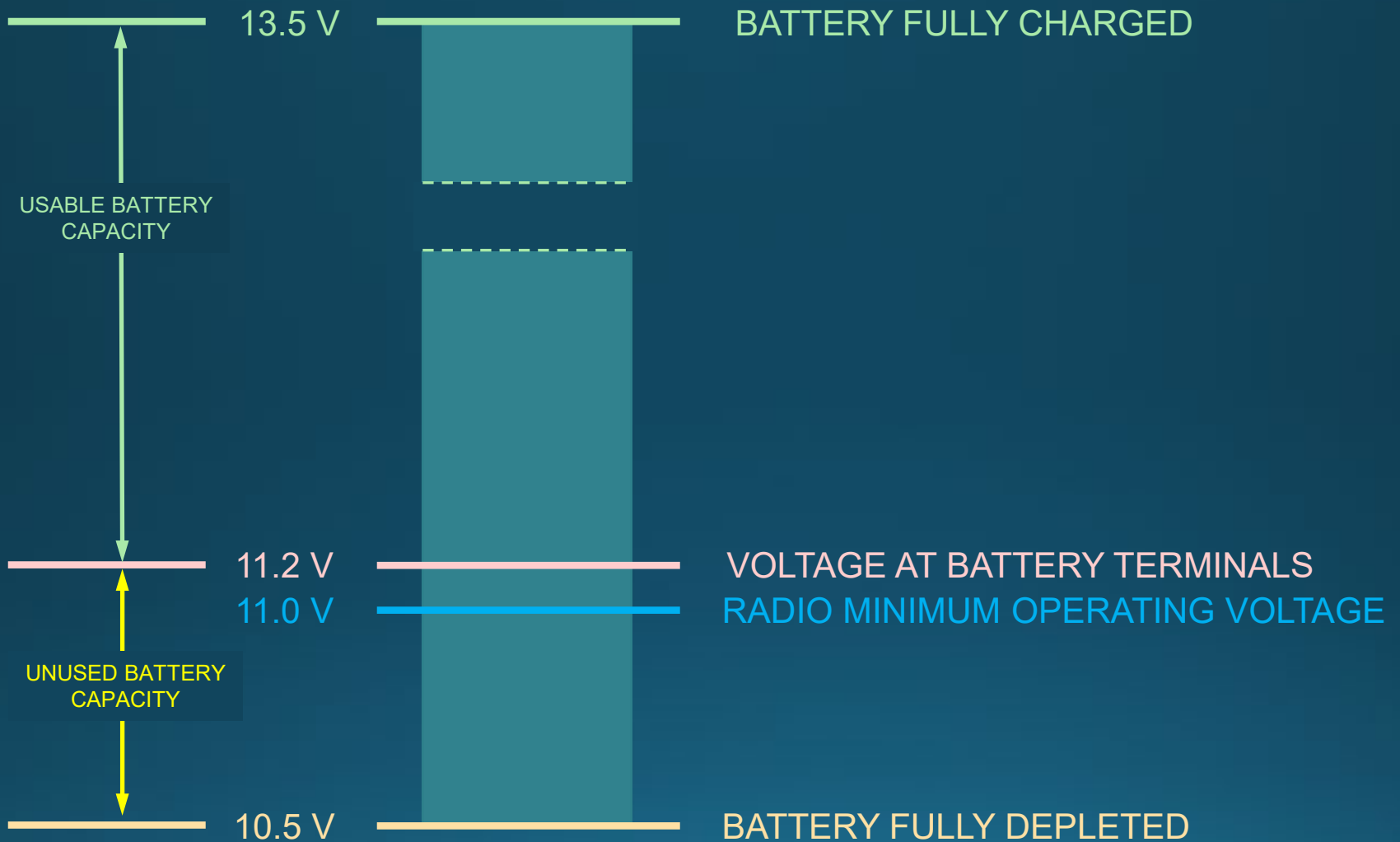
- Use heavy gauge wire from the battery to the radio, and keep the wires as short as possible to minimize voltage drop.
- In most radios, the output power drops with the supply voltage. So you may not get full power when the battery is substantially discharged. In addition, most radios will stop operating well before the battery reaches its terminal voltage of 10.5 V (beyond which it might be damaged.)
- If you are losing a half of a volt at the radio due to resistive loss in the battery cable, not only are you losing output power, but you are also losing run time (because the radio's minimum operating voltage is reached while the battery still has plenty of charge remaining).

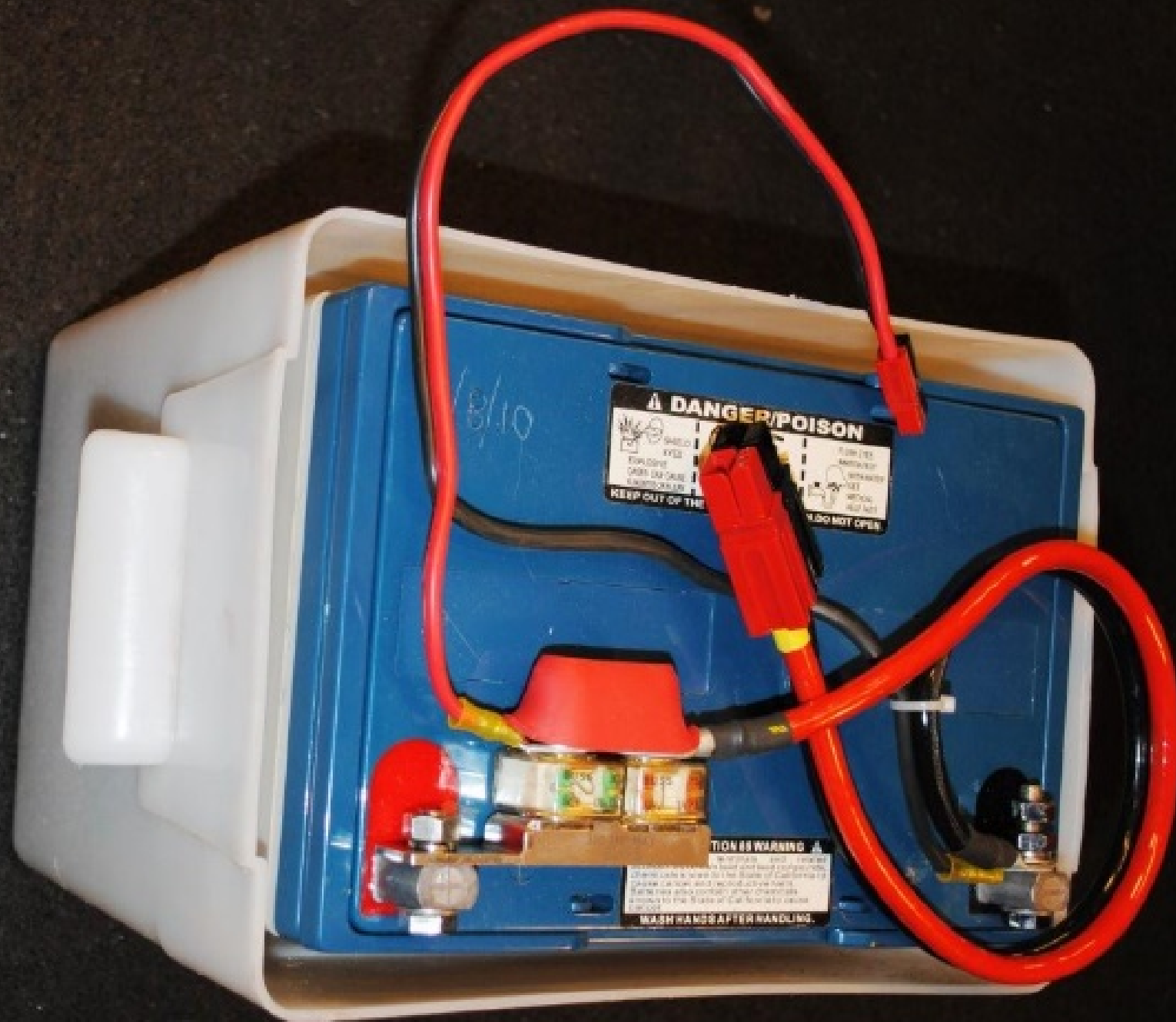


# Voltage drop

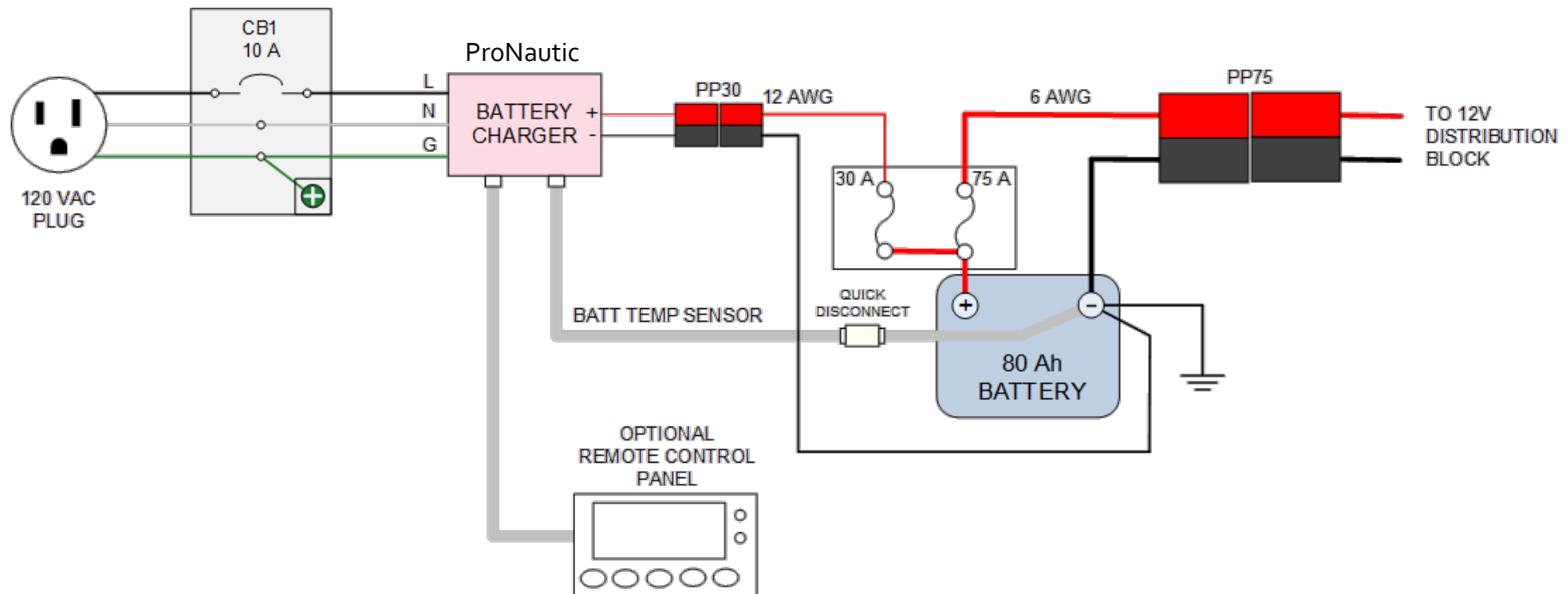
- If you are losing a half of a volt at the radio due to resistive loss in the battery cable, not only are you losing output power, but you are also losing run time.
- In house wiring, the maximum current for a given wire gauge is based on heat buildup due to the wire's resistance. Most hams know that 12 AWG house wire is good for 20 A.
- But when the wire is used to power a 12V DC radio, the voltage drop of a 12 AWG wire may preclude its use, and you probably need a larger wire size if you are going more than a few feet.







# Block diagram of power supply for 100-W HF station



# Lithium batteries

All the same hazards as lead-acid batteries, plus:

- Thermal runaway in li-ion batteries. No li-ion battery should be considered immune to this failure mode.
- Ingredients are very, very nasty stuff. If the battery case is compromised, water ingress may cause an explosion.
- Lithium primary batteries behave badly when current flows into the battery instead of out of it. High pressure may cause the battery to rupture. Reverse current flow can occur if a battery in a string is installed backwards, or if two batteries of unequal charge are connected in parallel.

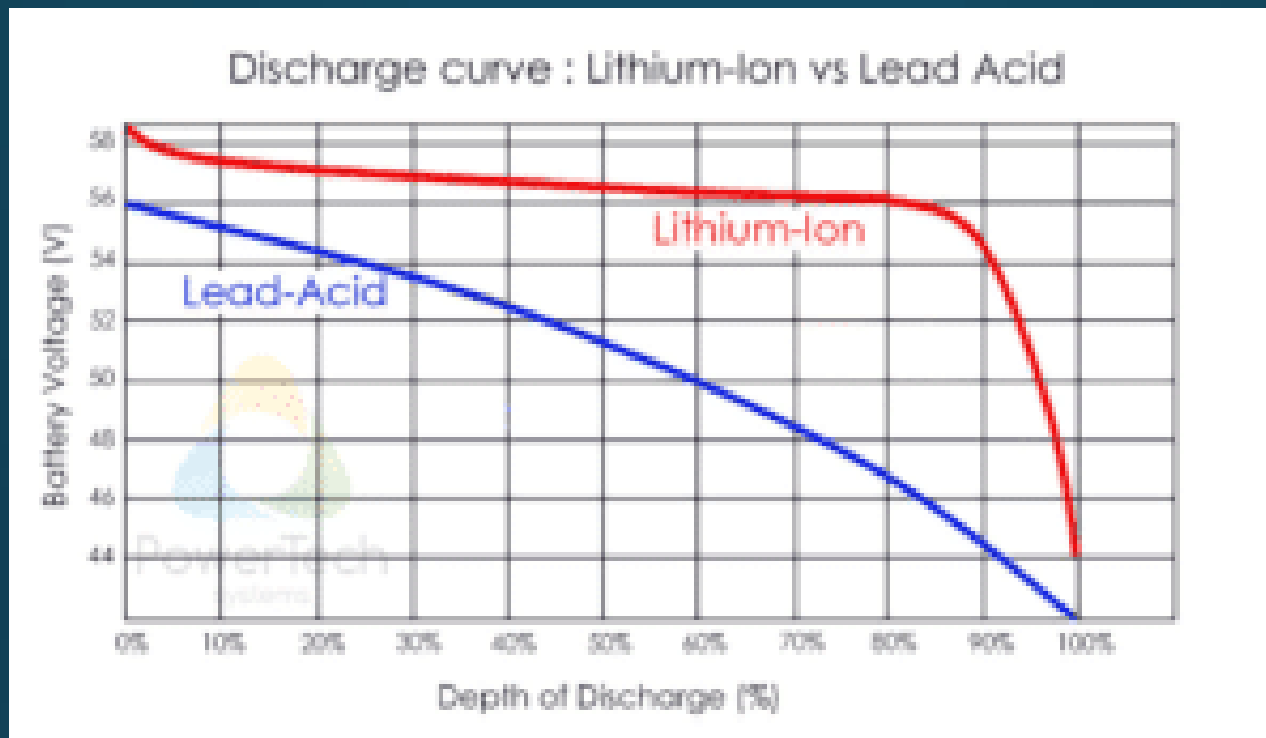
# LiFePo Batteries ...

- Are very popular as lead-acid battery substitutes.
- Are not subject to thermal runaway that plagues Li-ion batteries.  
---but---
- Vulnerable to same hazardous situations as lead-acid batteries – with a vengeance
- Extremely sensitive to reverse current and overcharging. Always use the recommended charger.

# LiFePo Batteries

- Never parallel LiFePo batteries to get increased capacity. Most manufacturers recommend not to place LiFePo batteries in series, either, because they accept charge unequally, and the first battery in the string will be overcharged while the charger continues to deliver charging current to bring the rest of the string up to terminal voltage.
- LiFePo batteries have a higher terminal voltage (14.6 vs. 13.5 V) when fully charged than the corresponding lead acid battery, and they hold their terminal voltage through most of the discharge cycle. The voltage drops off sharply when the battery approaches the end of its useful capacity. That can be useful in some applications, but it may place additional stress on your equipment.





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# Drugstore alkaline batteries

- Even a alkaline battery stores enough energy to cause a second-degree burn if short-circuited.
- The design of the two exposed terminals of a 9V battery in proximity to one another can easily be short-circuited by coming into contact with any conductive material
- Materials are not particularly harmful. Spent batteries should be placed in regular trash. But put tape over the terminals to be safe. Trash fires have been started by alkaline batteries.



## NEWS

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### Colgate recalls Motion electric toothbrush after nine reports of the product exploding

**NP** POSTMEDIA NEWS | November 3, 2011 | Last Updated: Nov 3 10:35 AM ET  
More from Postmedia News

The advertisement features a blue Colgate Motion electric toothbrush with a white head and a blue handle. The text 'Colgate Motion' is prominently displayed at the top, followed by 'The Power to CLEAN Better'. Below this, it says 'Colgate Motion Battery-Powered Toothbrush For a Superior Clean and Healthier Teeth!'. A list of benefits includes: 'Proven to clean better than a manual toothbrush', 'Rotating bristles sweep plaque away and gently remove food particles', 'Ergonomic curved neck to reach those hard to reach places', 'Easy to hold handle with non-slip grip', and 'Easy to replace refill heads'. A section titled 'Colgate Motion Whitening' lists: 'Dual action head with rotating bristles for cleaner, whiter teeth' and 'Soft rubber polishers help remove stains and whiten teeth'. The advertisement also mentions 'Available in: Blue, Purple, Fuchsia, Dark Green' and includes a small image of a woman smiling. At the bottom, there is a social media sharing bar with options for Facebook, Twitter, Google+, LinkedIn, Email, and Comments.

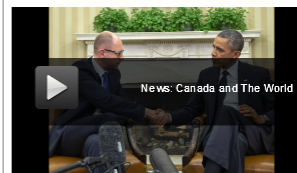
Health Canada is warning Canadians to stop using a model of electric toothbrush after several were reported to have "exploded."

Colgate-Palmolive is recalling the Colgate Motion Electric Toothbrush after Health Canada issued a warning.

**POST POINTS** Earn rewards for being a loyal National Post Reader

The advertisement for element14 features a search bar at the top. Below it, the text 'Find millions of products from 500+ world-class manufacturers.' is displayed. A 'Learn More' button is located at the bottom. The background shows various electronic components and tools.

#### Today's Top News Videos



1-5 of 53



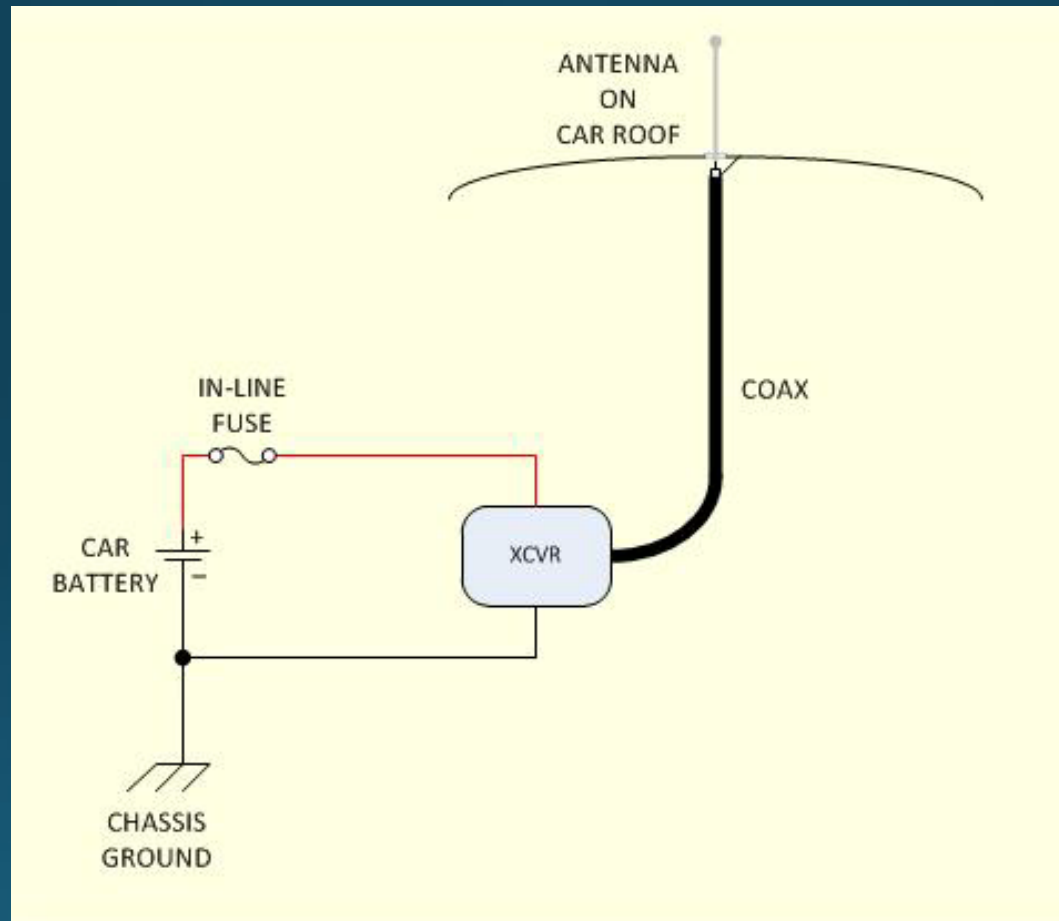
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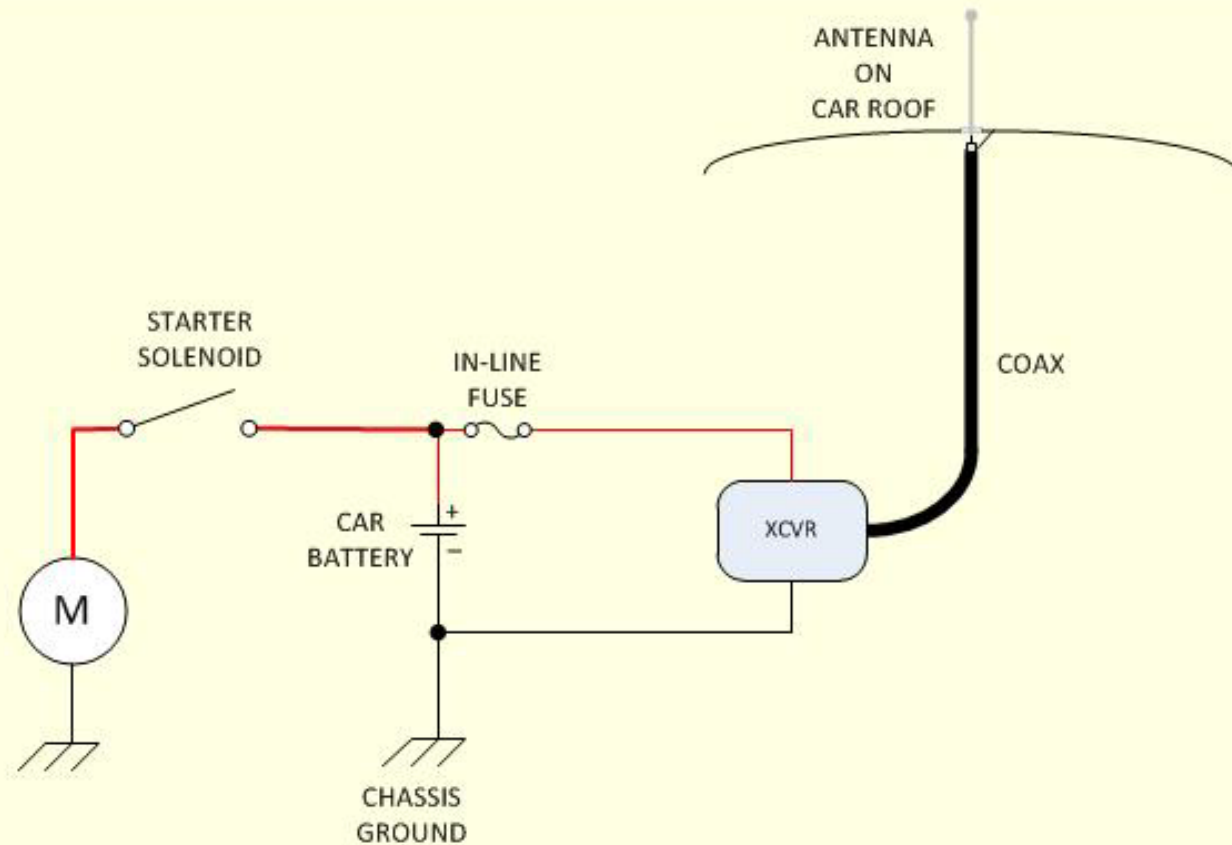
# Mobile Power Wiring Safety

- Car batteries hold lots of energy – shorting a battery could cause a fire.
- Special requirements for safe car wiring:
  - Fuse both positive and negative leads.
  - Connect radio's negative lead to negative terminal or engine block ground strap.
  - Use grommets or protective sleeves to protect wires.
  - Don't assume all metal in the car is grounded; modern cars are as much plastic as metal.

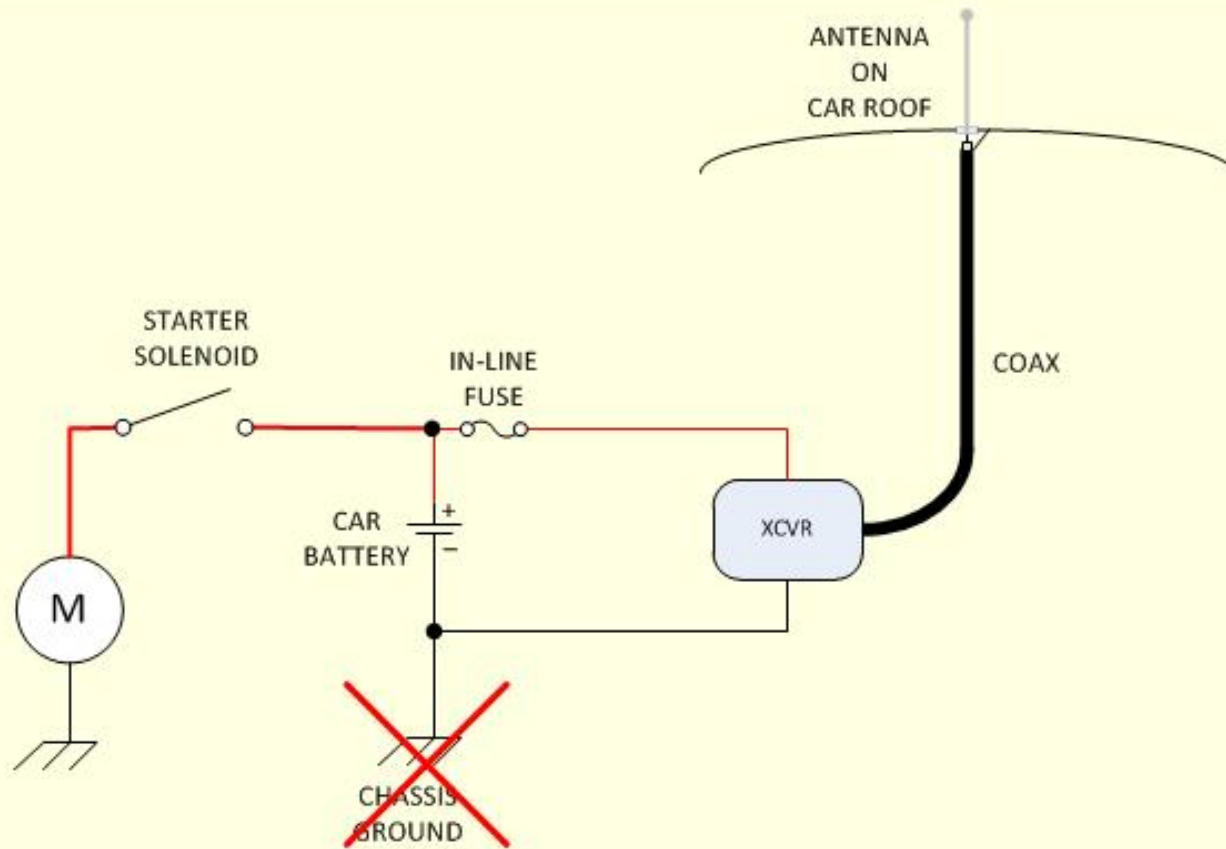
# Mobile Power Wiring Safety



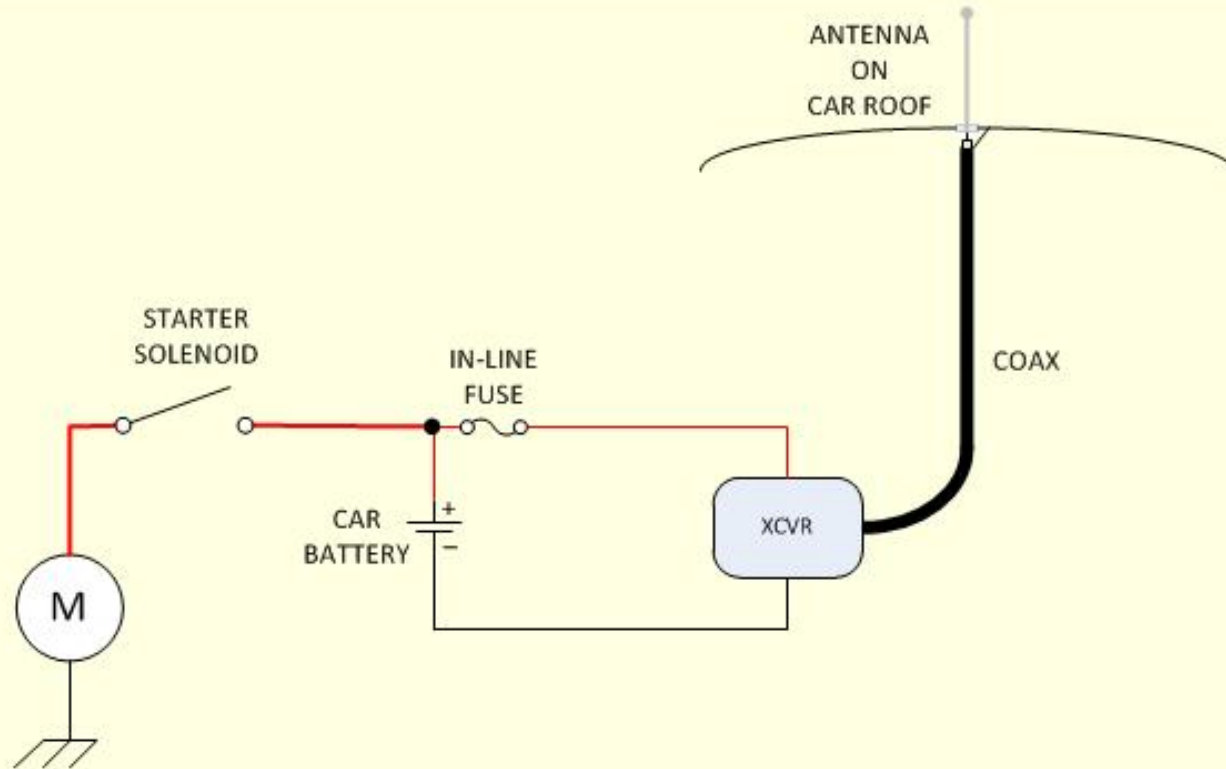
# Mobile Power Wiring Safety



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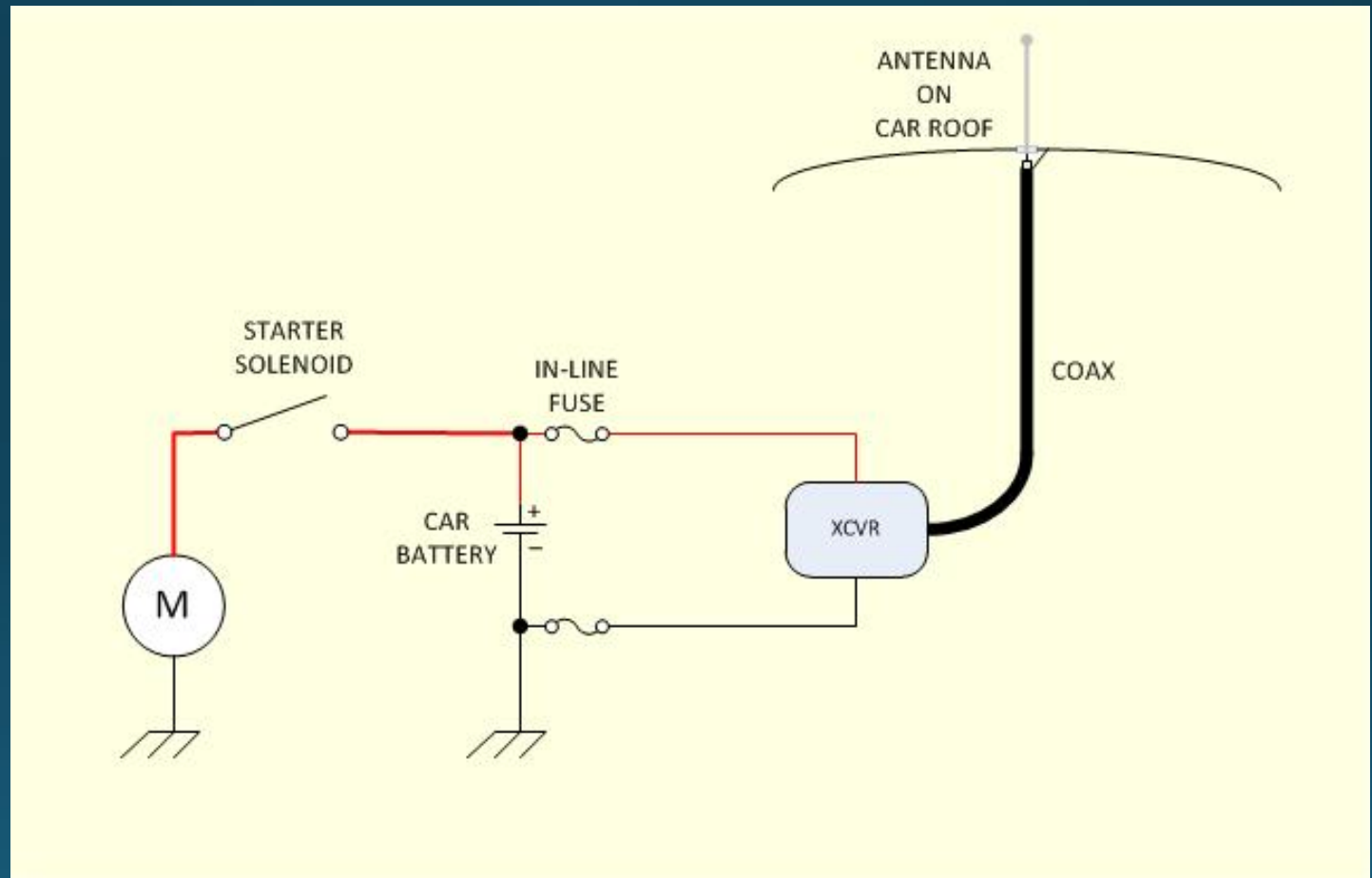


# Mobile Power Wiring Safety





# Mobile Power Wiring Safety



# This is not only an issue in mobile radio installations!

- Any time you have high- and low-current devices sharing a common power supply, this problem can occur if the two devices share a signal ground in common.
- Consider a HF rig with any of the following accessories:
  - External keyer
  - External automatic antenna tuner
  - Signalink or similar sound card interface
- If the high-powered radio loses its 12V power supply negative connection, that 20A transmit current is going to flow back to the battery via the accessory.

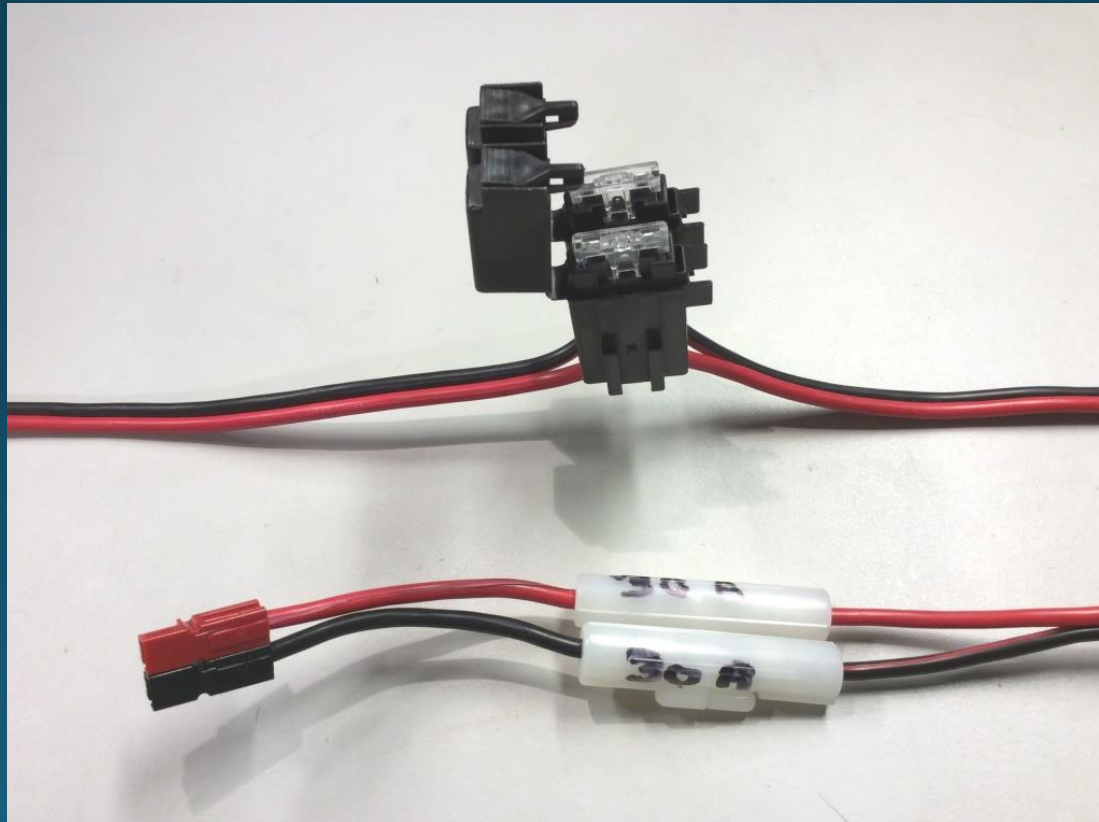
# 12V outlet strips – two design weaknesses to be concerned with



- Can plug a low-current device into a high-current fuse by accident
- Negative leads of low-current devices are not fused!

# A better idea ...

- Inline fuses close to power source connector

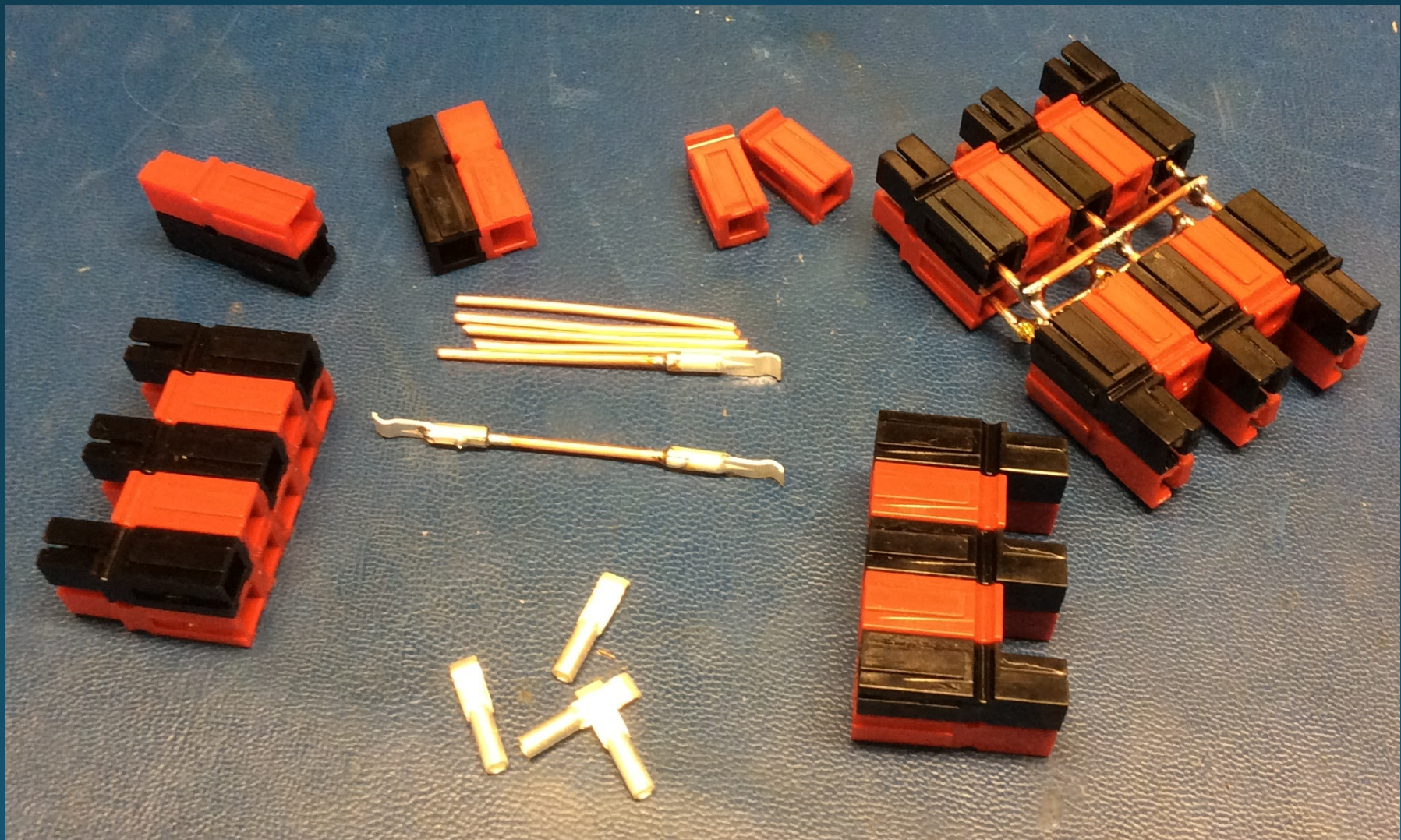


# Powerpole distribution blocks

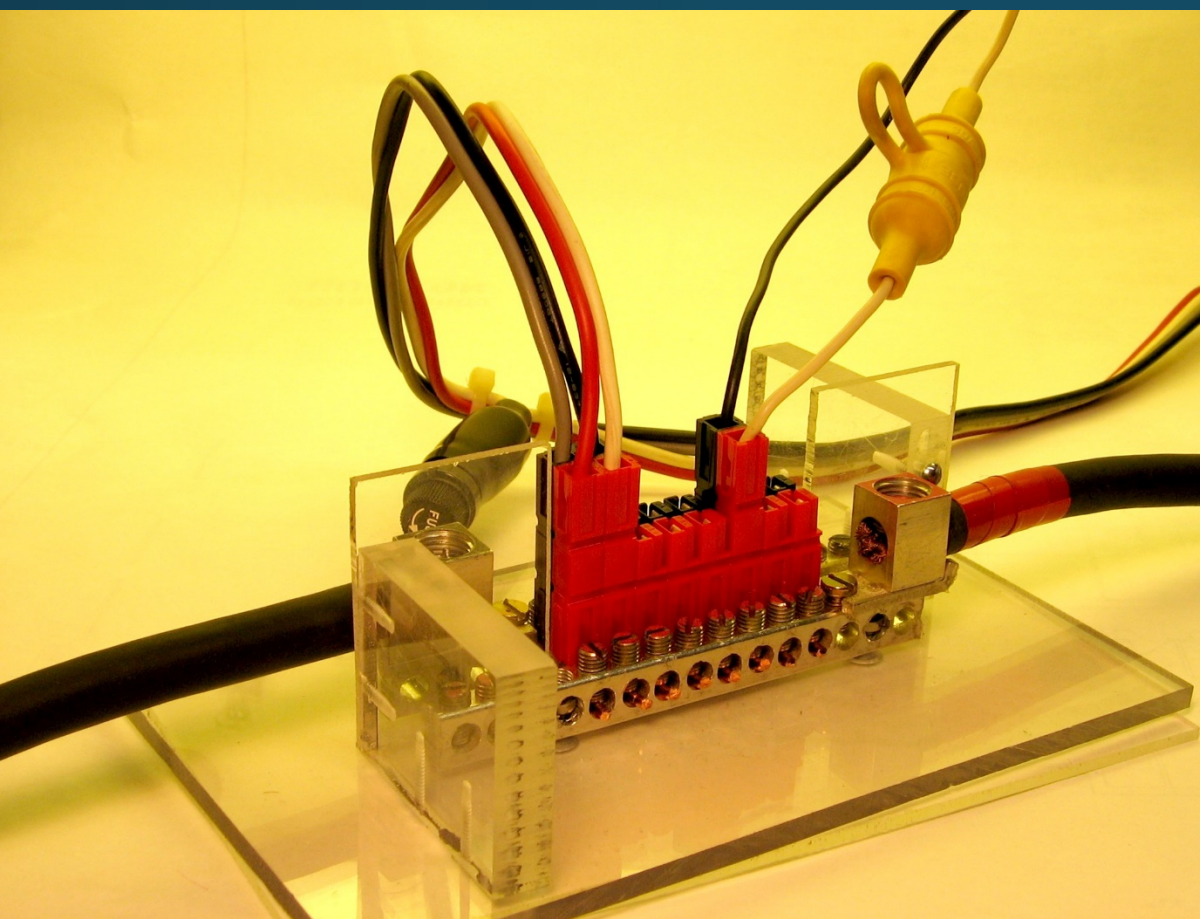




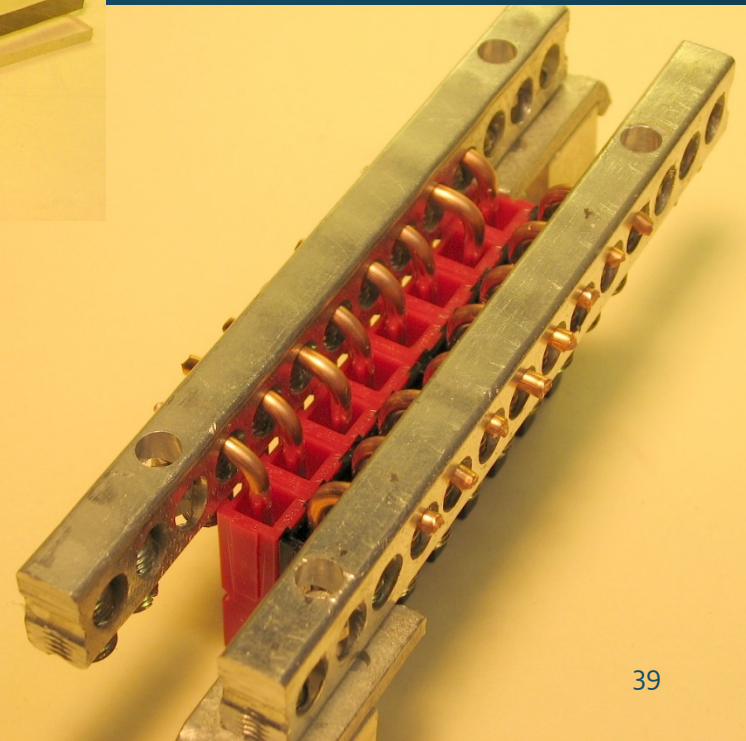
# DIY distribution block # 1







# DIY distribution block # 2



# Jumping batteries safely

- Connect the jumper cables to the weak battery first (keeping the clamps on the other end from shorting together). Always connect the red cable to the positive terminal.
- Then connect the other end of the red jumper cable to the fresh battery – double-check the polarity
- Finally, connect the black (negative) cable to the engine block or vehicle chassis as far away from the battery as possible (in case there is hydrogen gas built up near the battery, which could be ignited by the spark).
- Disconnect the black cable first after the vehicle starts.



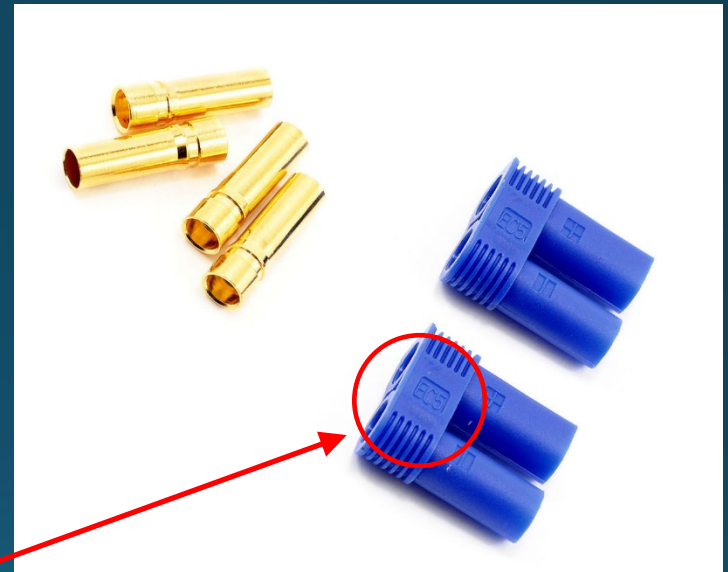
# Self-powered jump-starter

- Jumper cable w/ reverse polarity protection
- 5V USB outlets
- Laptop power supply – 12, 16 or 19V
- Flashlight / strobe
- Wall charger and cig lighter charging cable
- Various models with lithium-ion batteries between 12 and 22 Ah capacity



# Self-powered jump-starter

- Make your own Powerpole adapter
- Most models require a female EC5 battery connector to plug into the main output
- Two-pack of connectors on Amazon for \$11
- Check to see which size fits your unit (connector size is embossed in connector housing)
- Put inline fuse in positive lead



Female connector has straight barrel contacts

# Questions/discussion