

# Dual Battery Systems

Revision 2016.0

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# Usual Disclaimers

- This information is correct to the best of my knowledge and belief. The ideas in this presentation have been tested by field use on my personal 4x4 camper. They may or may not work with your vehicle or any other vehicle. ***Specifically, this information may NOT be correct for Lithium batteries.***
- Products and specifications may change, specific products mentioned are only some of many which may perform the required purpose and may not be the ones actually used on my vehicle.
- Get professional assistance if you are not comfortable working with high amperage circuits.
- When in doubt, follow the instructions of your battery manufacturer over the instructions of your charger manufacturer, this paper, or any other source. Do not undertake any modifications which may void your vehicle's warranty.
- Pay careful attention to fusing - at both ends - and protection of wiring from physical damage.
- YMMV, etc.
- Remember: FUSE IT!

# **At the End of this Presentation You Should be Able to:**

Determine if you really need a dual battery system and, if so, have the information you need to set up a system that works well for your vehicle. Specifics include:

- Proper charging voltage for your batteries.
- Proper wire gauge to assure the fastest possible charging rate.
- Best connection technique between your batteries.
- How to avoid many of the common pitfalls.

# Battery Types:

## The really basic, basics.

***There are several different types of battery construction:***

- **Open Lead Acid Batteries** - Open vents to gas escape. Venting can lead to corrosion of terminals and require topping up with water. Less expensive, need the highest charging voltages. (Flooded Lead Acid - FLA)
- **Absorbed Glass Mat** - Sealed, does not need topping up. (Indeed, cannot be topped up in the event of overcharge.) “Maintenance Free” in that, as there is no venting of fumes, terminals are less subject to corrosion. More resistant to vibration, can be mounted on side. Slightly lower charge voltage, may take higher amperage charge. (AGM) (Valve Regulated Lead Acid - VRLA)
- **Gel** - Older form of sealed battery. Lowest charge voltage. (VRLA)
- **Lithium Iron** - Newest, very, very expensive. Great potential for lower weight and higher performance - deeper discharge. Faster and easier to charge, but some challenges in matching to high voltage vehicle alternators. Rumors of temperature sensitivity, i.e. cannot be charged below freezing.

For most, the easiest options are FLA and AGM. Lithium has tremendous potential, but there is not much proven data in the field yet.

***Lead acid batteries fall into three categories:***

- **Starting Batteries** - These have lots of thin plates to produce a lot of current, but only for a short time. Easily damaged if subjected to a deep discharge.
- **Deep Cycle Batteries** - Also known as forklift or golf cart batteries, these have fewer, heavier plates. They produce less current, but for a much longer time. This is what you want for most camper installations. Can generally tolerate up to a 50% discharge without excessive loss of life.
- **Marine Batteries** - A hybrid battery, half way between the two. Not a good idea for most campers, but a possible option on Jeep sized vehicles, especially if you don't want to use an isolation system.

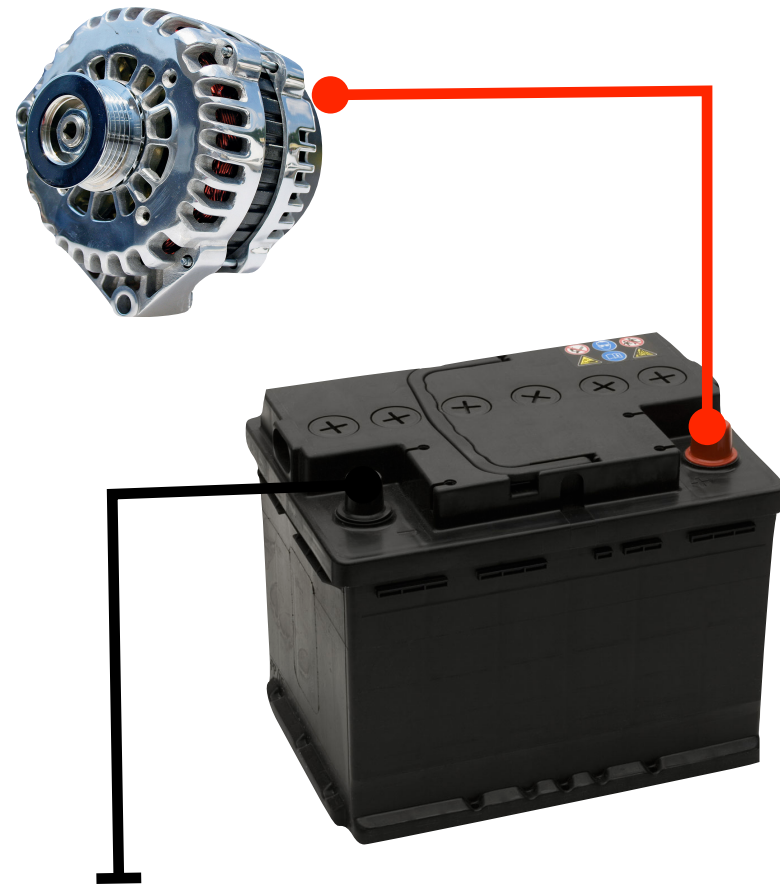


# The “Magic” Number

## 14.4v

- Most Lead Acid batteries call for a charging voltage of around 14.4v **at 70F/20C**. (Actual charging voltages increase as temperature drops and decrease as temperature rises.)
- Most modern vehicles easily meet this voltage, but some, most notably some Toyotas and Mercedes Benz, do not.
- The first step in any dual/auxiliary battery installation is to measure the voltage of your charging system.
- Your charging voltage **MUST** meet the requirements of your battery(s).

# Basic Alternator/Battery Set up



- Alternator charges battery when engine is running.
- Regulation provided by the vehicle's charging system.
- Modern charging systems are increasingly sophisticated, allowing them to respond to things like headlights, temperature, equalization.
- Challenge is to connect this to additional battery(s).

# **Why Are We Doing This?**

**Or, do you REALLY need isolated batteries?**

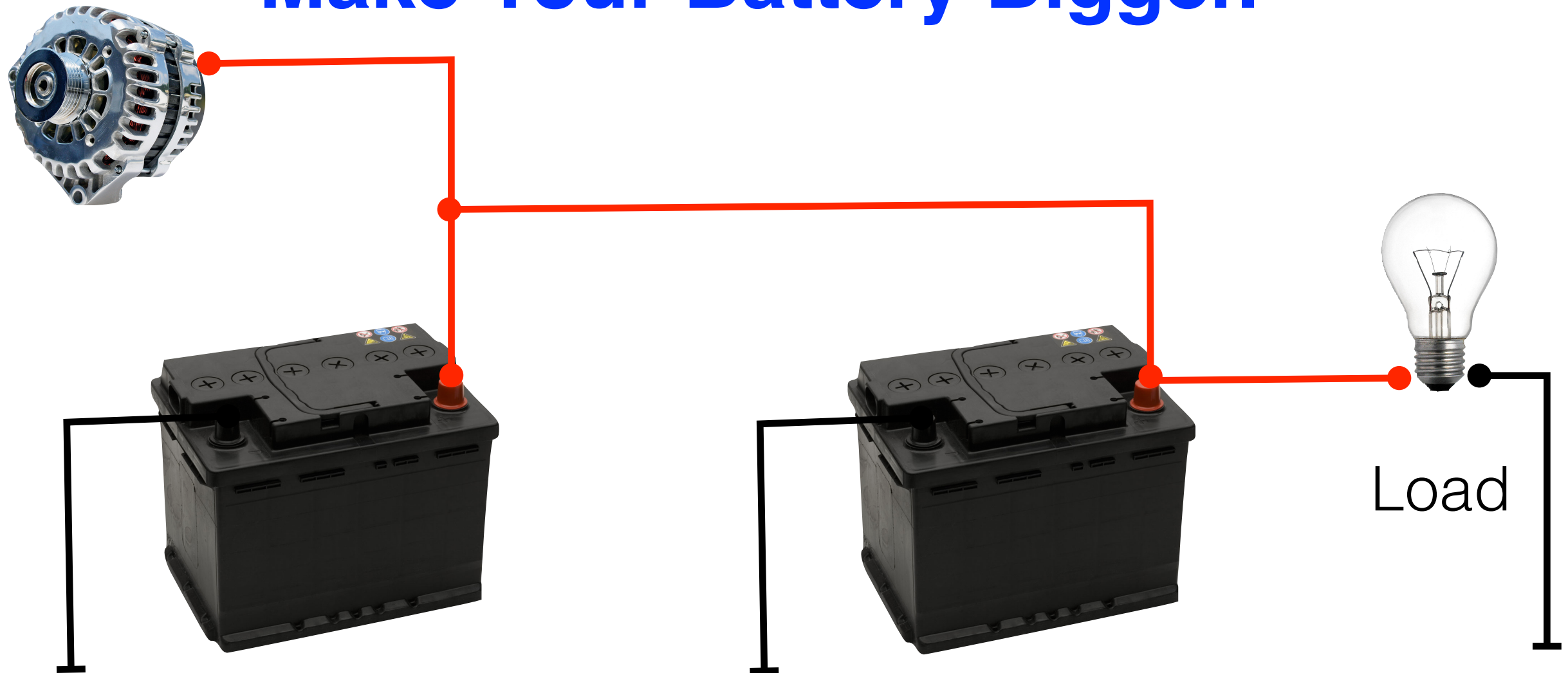
# No.

If your battery is large enough to handle any load you give it and still start your vehicle. For example, running the radio for thirty minutes.

If your starter battery is too small you may simply need a bigger battery(s). This could be as simple as buying a bigger battery or wiring in a second battery.

Don't make things more complicated than they need to be.

# Make Your Battery Bigger.



- Alternator charges both batteries when engine is running. Many vehicles, especially diesels, are set up this way from the factory.
- As both batteries are in parallel, they will discharge together and equally - they should be of the same type and age. If they are to be deeply discharged, then they should be deep cycle or marine types.
- ***Danger Will Robinson!*** It is possible to run down the batteries to the point that you cannot start your vehicle.

***This creates one big battery.***

# Yes.

- **You are going to abuse a camper battery that is too small** - And you do not want to abuse/damage your starting battery as well. There may be some justification for this; no room for an adequate camper battery bank, more economical to simply use up and replace batteries.
- **You want to use two different types of batteries** - This is the best reason. Your starter battery will be damaged if subjected to the kind of deep discharge that proper camper batteries can support and true, deep cycle batteries will give much better performance.

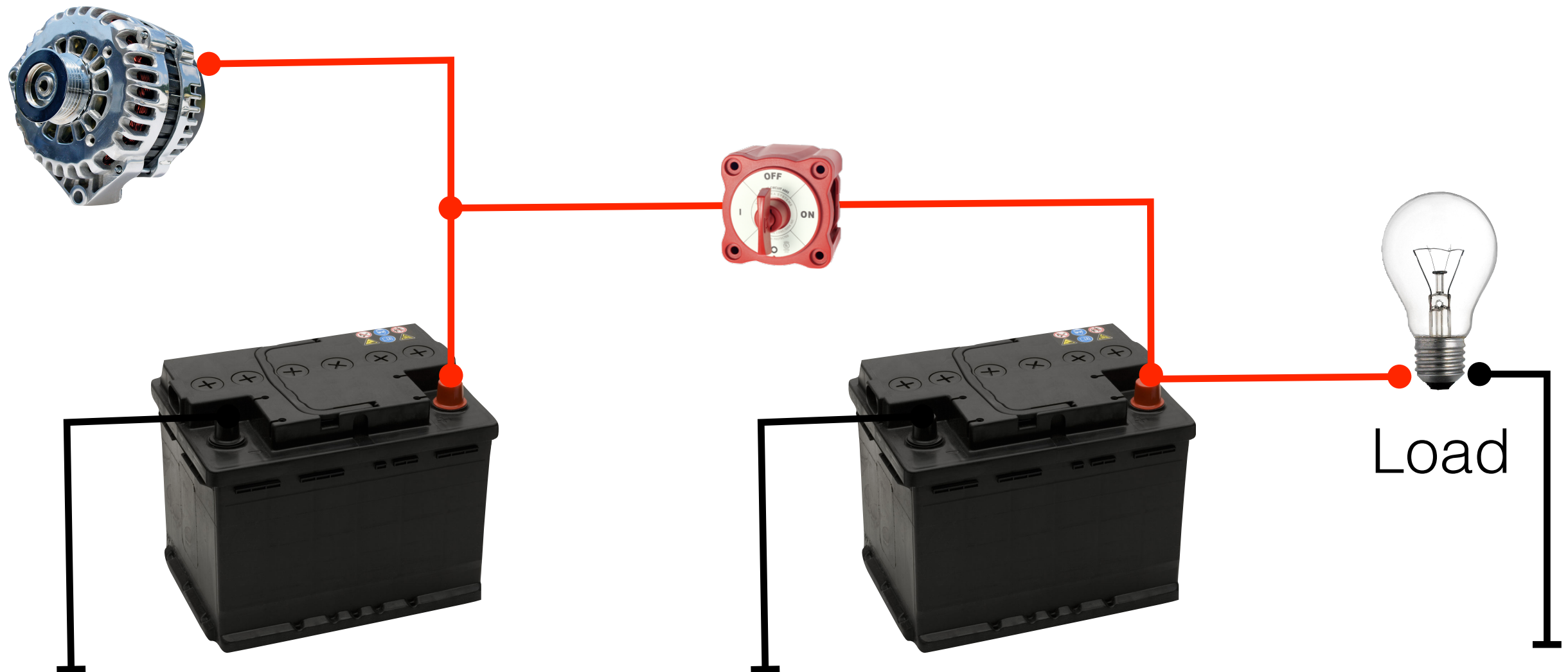
# My Truck Charges at 14.4v!

SMILE! You should probably use a switch based system:



The good news is that this is the least expensive approach.

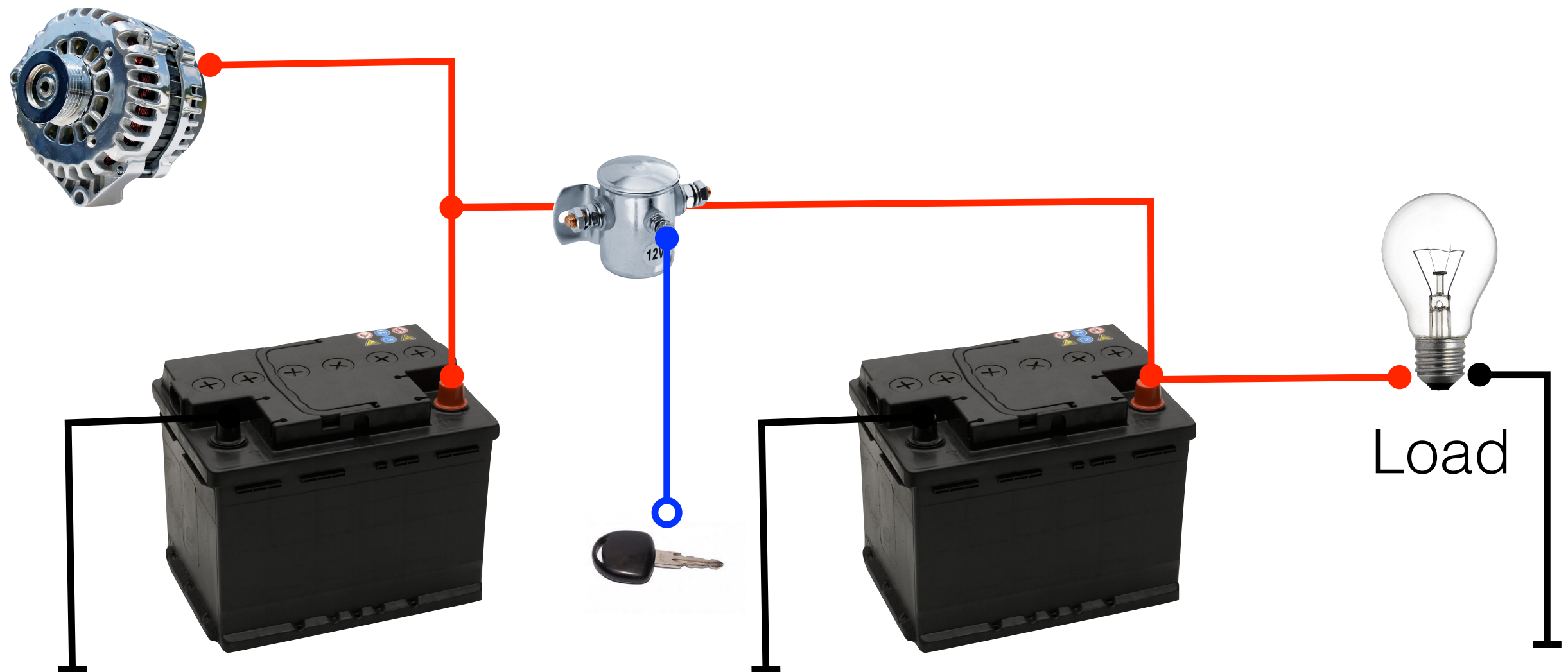
# Dual Battery With Manual Switch



- Second battery can be disconnected when discharging to keep it from drawing down the starting battery.
- Makes it easy to mix battery types.
- No automation, so the potential for human error, as in forgetting to separate or combine, is high.



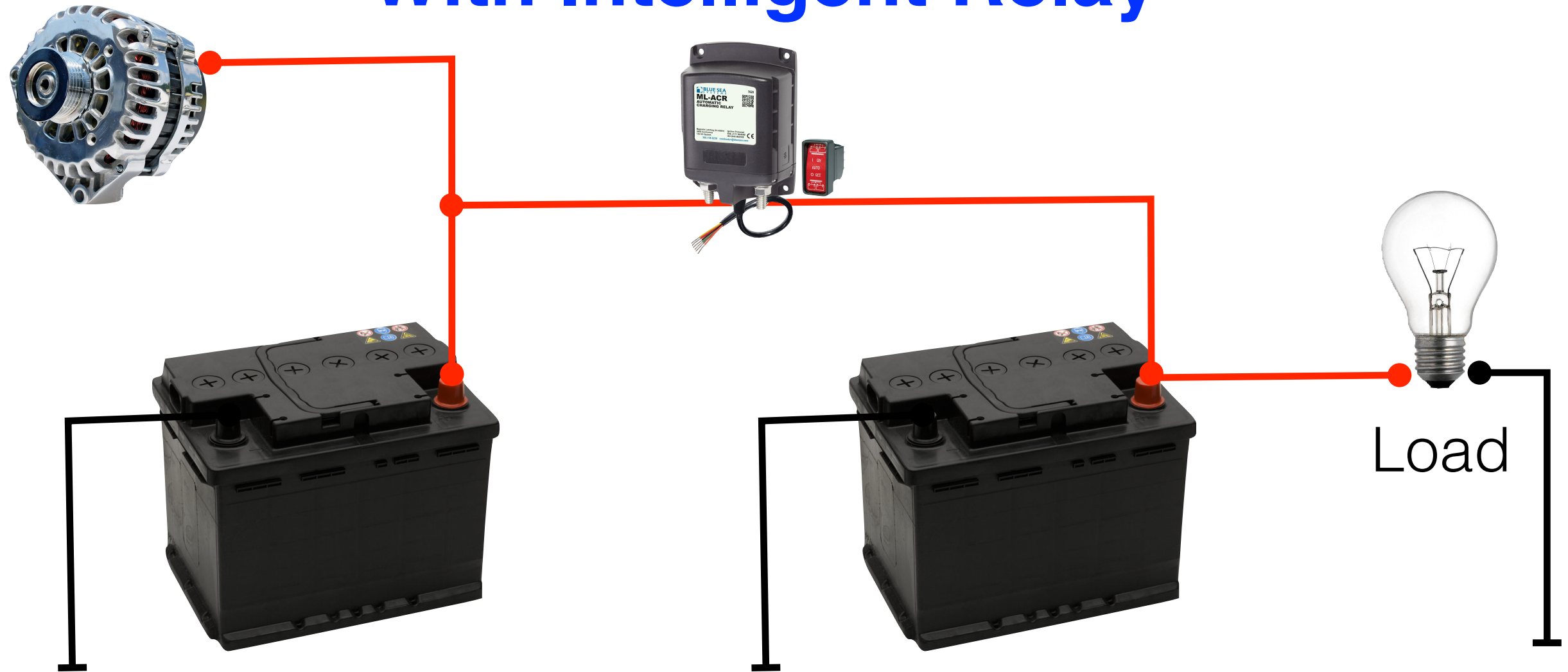
# Dual Battery With Key Controlled Relay



- Replacing the manual switch with an ignition controlled switch means that the batteries are in parallel only when the engine is running.
- The degree of isolation is as before, but the chances of error are much smaller.

***This is the classic, dual battery setup.***

# Dual Battery With Intelligent Relay



- The intelligent charging relay connects the batteries when it detects that **either** battery is being charged.
- The remote switch allows you to force connect (start boost/winch use) or disconnect (maintenance) the batteries as you wish.
- The intelligent relay also eliminates any chance of interaction of the key controlled relay with the vehicle's electrical system. (An issue with Chevrolet products.)

# My Truck Only Charges at 13.9v! What should I do?

There are two approaches:

- Raise the charging voltage of the entire system.
- Raise the charging voltage fed to the auxiliary battery(s) only.

# Raise the Overall Voltage (And then build a Switch based system.)

There are several ways to do this.

- Splice some diodes into your alternator wiring.  
Details here: [http://www.smartgauge.co.uk/alt\\_mod.html](http://www.smartgauge.co.uk/alt_mod.html)
- Do the same thing at higher cost/but plug and play.
- Do the same thing with a dash panel.

Available from: <http://www.mechman.com>



# Raise the Voltage to the Auxiliary Battery(s) ONLY.

This requires the use of a Battery to Battery charger, sometimes known as a DC-DC Charger or a “B2B”.

- These devices draw the voltage of the starter battery down to 13v, causing the alternator to respond by producing more amperage.
- The B2B then boosts the voltage and sends this to the auxiliary battery.
- Most B2B have multistage chargers

The good news is that a B2B will assure that the auxiliary battery can be fully charged, the the actual charge rate may be reduced as the amperage is much reduced. (Most only output 20-40A.)

# Battery to Battery Chargers



Sterling Power, CTEK, REDARC, and others make several models.

- <https://sterling-power.com>
- <http://smartercharger.com/battery-chargers/>
- <https://www.redarc.com.au/battery-chargers>

CTEK make an interesting product, called a Smart Pass that is basically a relay controlled by their B2B. This produces a rather unique, hybrid system.



# Dual Battery With Battery to Battery Charger



- The B2B isolates the two batteries.
- The B2B draws down the voltage of the starter battery and then draws off the extra current to charge the camper battery.
- The B2B boosts (and, in some cases, cuts) the voltage on the circuit to the camper battery.
- The diodes in the B2B prevent a charge at the camper battery from reaching the starter battery. This can be an issue for systems that include solar.

# Dual Battery With Intelligent Relay and Solar

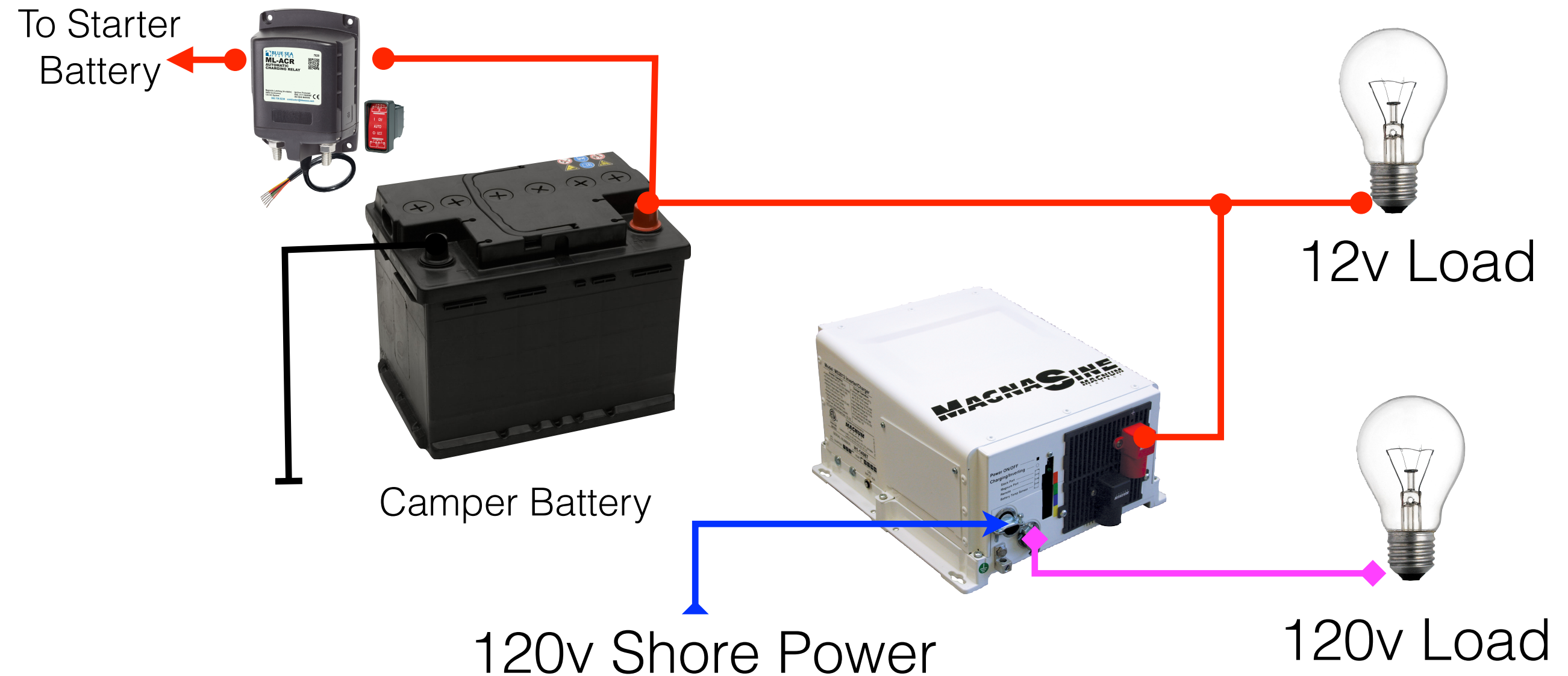


The intelligent charging relay connects the batteries when it detects that **either** battery is being charged. This allows the solar panel to charge the starting battery.

***This is ideal for most overland campers.***



# Adding Shore Power



- The Inverter/Charger takes in 120V, when available, and uses it to charge the battery.
- When 120v is not available, the Inverter/Charger converts 12v to 120v to provide for 120v loads.
- Using the intelligent relay allows the Inverter/Charger to also charge the starter battery.

# How to do it Wrong:

Most dual battery systems perform badly because the wiring is, by an order of magnitude, too small. If your camper batteries are not under the hood, you probably need 1/0 AWG or larger. This is large, heavy, and expensive.

AWG	mm2
10	6.0
8	10.0
6	16.0
4	25
2	35
1	50
1/0	55
2/0	70
3/0	95
4/0	120

# How to do it Right:

- Assure that your system provides the correct voltage for your battery.
- Use properly sized wire to reduce voltage drop at high amperages.
- Use a high quality relay, rated for continuous service at 100A or more. If using a B2B, use one or more to assure adequate amperage.
- Size everything to the rated output of your alternator.

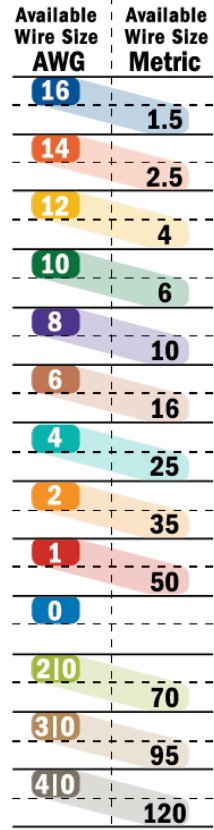
The links below are useful for calculating wire sizes. Size matters, when in doubt, go larger or double up the runs.

<http://circuitwizard.blueseas.com>

<http://www.calculator.net/voltage-drop-calculator.html>

# Size Matters

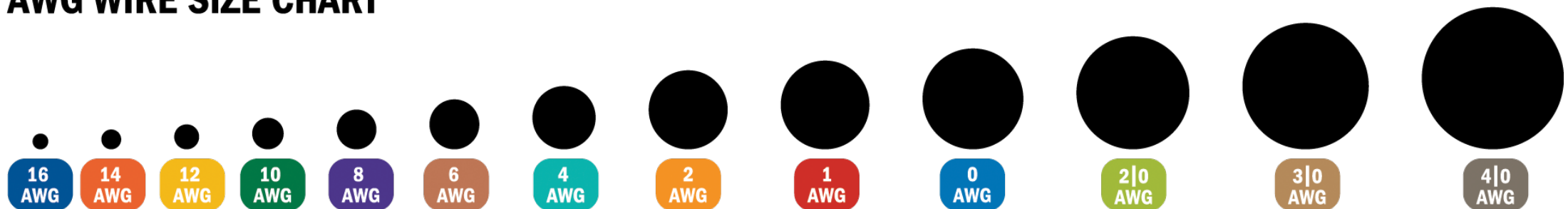
Standard and Metric Wire Comparison Table



**KEY**  
 AWG WIRE SIZE  
 CLOSEST EQUIVALENT IN METRIC

CIRCUIT TYPE		CURRENT FLOW IN AMPS															
Non-Critical 10% VOLTAGE DROP	Critical 3% VOLTAGE DROP	5A	10A	15A	20A	25A	30A	40A	50A	60A	70A	80A	90A	100A	120A	150A	200A
0 to 20 ft	0 to 6 ft	16 AWG	16 AWG	14 AWG	14 AWG	12 AWG	10 AWG	8 AWG	6 AWG	6 AWG	6 AWG	4 AWG	4 AWG	4 AWG	2 AWG	1 AWG	2 0 AWG
30 ft	10 ft	16 AWG	14 AWG	12 AWG	12 AWG	10 AWG	10 AWG	8 AWG	6 AWG	6 AWG	4 AWG	4 AWG	4 AWG	2 AWG	2 AWG	1 AWG	2 0 AWG
50 ft	15 ft	16 AWG	12 AWG	10 AWG	10 AWG	8 AWG	8 AWG	6 AWG	6 AWG	4 AWG	4 AWG	4 AWG	2 AWG	2 AWG	2 AWG	1 AWG	2 0 AWG
65 ft	20 ft	14 AWG	10 AWG	10 AWG	8 AWG	6 AWG	6 AWG	6 AWG	4 AWG	4 AWG	2 AWG	2 AWG	2 AWG	2 AWG	1 AWG	0 AWG	2 0 AWG
80 ft	25 ft	12 AWG	10 AWG	8 AWG	6 AWG	6 AWG	6 AWG	4 AWG	4 AWG	2 AWG	2 AWG	2 AWG	1 AWG	1 AWG	0 AWG	2 0 AWG	3 0 AWG
100 ft	30 ft	12 AWG	10 AWG	8 AWG	6 AWG	6 AWG	4 AWG	4 AWG	2 AWG	2 AWG	1 AWG	1 AWG	0 AWG	0 AWG	2 0 AWG	3 0 AWG	4 0 AWG
130 ft	40 ft	10 AWG	8 AWG	6 AWG	6 AWG	4 AWG	4 AWG	2 AWG	2 AWG	1 AWG	0 AWG	0 AWG	2 0 AWG	2 0 AWG	3 0 AWG	4 0 AWG	4 0 AWG
165 ft	50 ft	10 AWG	6 AWG	6 AWG	4 AWG	4 AWG	2 AWG	2 AWG	1 AWG	0 AWG	2 0 AWG	2 0 AWG	3 0 AWG	3 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG
200 ft	60 ft	8 AWG	6 AWG	4 AWG	4 AWG	2 AWG	2 AWG	1 AWG	0 AWG	2 0 AWG	2 0 AWG	3 0 AWG	3 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG
	70 ft	8 AWG	4 AWG	4 AWG	2 AWG	2 AWG	1 AWG	0 AWG	2 0 AWG	3 0 AWG	3 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG
	80 ft	8 AWG	4 AWG	2 AWG	2 AWG	1 AWG	0 AWG	2 0 AWG	3 0 AWG	3 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG
	90 ft	8 AWG	4 AWG	2 AWG	2 AWG	1 AWG	0 AWG	2 0 AWG	3 0 AWG	3 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG
	100 ft	6 AWG	4 AWG	2 AWG	2 AWG	1 AWG	0 AWG	2 0 AWG	3 0 AWG	3 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG
	110 ft	6 AWG	4 AWG	2 AWG	2 AWG	1 AWG	0 AWG	2 0 AWG	3 0 AWG	3 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG
	120 ft	6 AWG	4 AWG	2 AWG	2 AWG	1 AWG	0 AWG	2 0 AWG	3 0 AWG	3 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG
	130 ft	6 AWG	2 AWG	2 AWG	2 AWG	1 AWG	0 AWG	2 0 AWG	3 0 AWG	3 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG	4 0 AWG

## AWG WIRE SIZE CHART



# Resources:

## Warning: Extreme Geekery follows:

- **OUTBACKJOE:** Possibly the best discussion that I have found for a touring vehicle. Australian site. <http://outbackjoe.com/macho-divertissement/macho-articles/design-guide-for-12v-systems-dual-batteries-solar-panels-and-inverters/>
- **Handy Bob:** Unapologetically iconoclastic solar site. Worth reading even if you don't agree with all of his choices: <http://handybobsolar.wordpress.com>
- **Northern Arizona Wind and Sun:** Really good FAQ on deep cycle batteries: <https://www.solar-electric.com/deep-cycle-battery-faq.html#Gelled%20Electrolyte>
- **Smart Gauge:** UK company founded by Chris Gibson, a canal boat aficionado. A wealth of technical information, start reading here: <http://www.smartgauge.co.uk/technical1.html>
- **Sterling Power:** US and UK websites. Founded by Charles Sterling, Sr., another canal boat fan. Technical data is found here: <http://www.sterling-power.com/datasheets.htm> Read this on the virtues of high voltage charging: <http://www.sterling-power.com/images/downloads/advancedcharging.pdf>
- **Blue Sea Systems:** Less a technical resource and more a source for excellent, marine grade switches, fuses, etc.: <https://www.blueseas.com>
- **CTEK:** Make shore chargers and a very interesting B2B. US website: <http://smartercharger.com>
- **Warning:** None of these sites agree in all aspects, for example, Handy Bob is convinced that the Smart Gauge cannot work and Charles Sterling uses diode based systems which Chris Gibson of SmartGauge loathes. ***Only you can make the final decision on which products will best meet your needs.***