Moving to Lithium - Why and How

Mild to Wild

Revision 1.0 2022

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Copies of this presentation can be downloaded from https://diplostrat.net/documents/

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 our personal 4x4 camper. They may or may not work with your vehicle or any other vehicle.

- 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 our 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!***

BLUF

Bottom Line Up Front

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This presentation will help you decide:

- **Whether it is worth your time and money to replace your *existing* lead acid camper battery system with a lithium Iron battery set up. Basically, how happy are you with your current set up?**
- **Some of the different ways to structure a lithium/lead acid dual battery system and how to choose between them for your needs, with a focus on reusing as much of your existing set up as is practical.**

Why Are We Doing This?

Or, do you REALLY need lithium batteries?

There are reasons why nearly every manufacturer has gone to lithium iron batteries for their campers:

- **They are lighter –** Simply put, you get more power in the same or less weight. This can be huge for vans and smaller vehicles.

- **They can give more power in the same physical space** - This can mean more power for huge loads like air conditioning, or a significant space saving for a van or smaller vehicle.

- **They can charge much faster** - The charge profile is also simpler, there is no need for a multi-stage, bulk, absorb, float cycle.

- **They *should* last much longer** - Trick is that they haven't really been around long enough to have much real world information. Still, lead acid is rated at 500 to 1000 cycles and most lithium iron claim in the many thousands of cycles.

The challenge is determining it it is worth it for YOU to change and how best to retrofit a lithium iron battery set up into your ***current*** vehicle.

Our (new) Friend, the Lithium Iron Battery

The Many Forms of Lithium:

Lithium Iron batteries have two major elements:

- **Cells.** These are typically rated at 3.2v and are combined in series and parallel to produce the desired size and voltage of battery.

- **Battery Management System (BMS).** The BMS protects the individual cells, and the entire battery from various problems and errors. For example, high voltage of an individual cell or the entire battery, high or low temperature, charge or discharge rate, etc. Varies with BMS manufacturer. The BMS may be the single most important component of a lithium iron battery. This is a new concept.

There are several types of lithium Iron batteries:

- **Drop in.** These are made to fit common battery mounting boxes or trays. Their electrical parameters are as close as possible to those of a “normal” lead acid battery. Each battery has an internal BMS. These are probably the easiest to use.

- **Lithium Iron cells with external BMS.** Here the manufacturer sells batteries with no BMS. You install the appropriate BMS as part of your overall wiring plan. The advantage here is that the BMS usually has a higher capacity and is set up to “talk” to your various chargers, assuming that you buy all your components, e.g., solar controller, B2B, inverter/charger, etc., from the same company. Also, in the event of getting a bad battery, it may cost less to replace a single battery.

- **DIY or Home Brew.** WiIn this case, you buy the cells, BMS, wire, connectors, etc. and build your own box. Easier than you might think, but not for the faint hearted. You can save a lot of money, but you can get burned at many points. You may be dealing with a supplier in the Far East, your shipment can get lost, you can drop a wrench. Whatever happens it has an Oklahoma 50/50 guarantee - if it breaks into two pieces, you own both of them.

Lithium Iron Battery Charging:
Everything you know is wrong

Lithium Iron batteries:

- **Don't need to be fully recharged. T**hey are not damaged by a partial recharge. Indeed, most manufacturers recommend that they be at 50% charge for long term storage.

- **Lithium Iron batteries do not need to float.** A float may be useful in real world use, especially during the day when solar may be available, but the voltage should be relatively low; probably under 13.5v. May be turned off when not actually camping.

- **Recharge very fast.** With lead acid, the challenge is to get the battery to accept a charge, with lithium, the challenge may be to keep the battery from drawing so much current that it overheats the alternator or other charger.

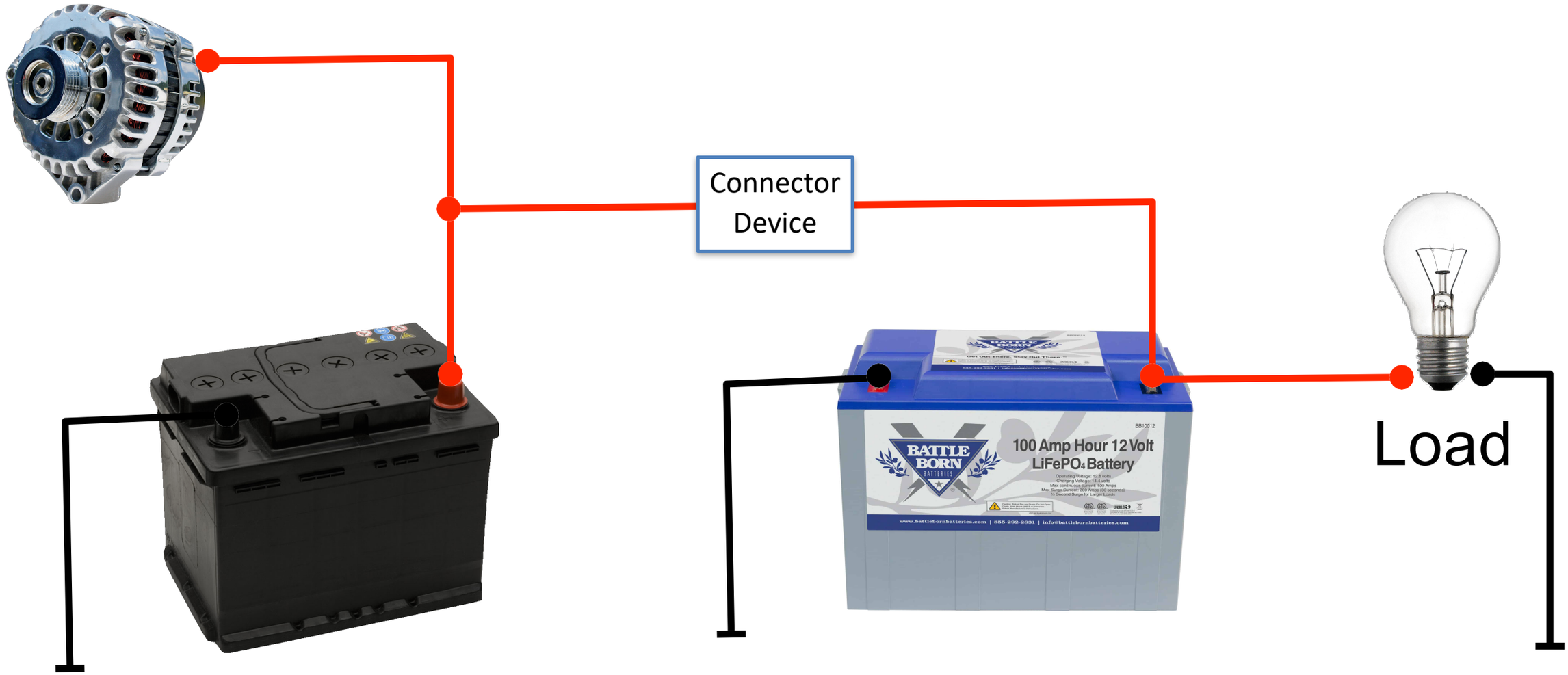
- **Cannot be charged when below freezing.** This requires interior mounting and, perhaps, a heater. (Discharging is not a problem.)

- **Require a battery management system (BMS).** While lead acid batteries can tolerate a lot of abuse and die slowly, a lithium battery can be destroyed instantly by over charging or over discharging. A proper BMS will protect against this and other damage. This can actually make a lithium iron battery more fault tolerant than a lead acid battery.

- **Can suddenly disconnect.** Unlike a lead acid battery, in the event of a problem, the BMS can suddenly and completely disconnect the battery and this can cause problems for the alternator. (Not a problem if you have a lead acid battery in the circuit, e.g., your starter battery.)

Basic Dual Battery Set Up

The starting point

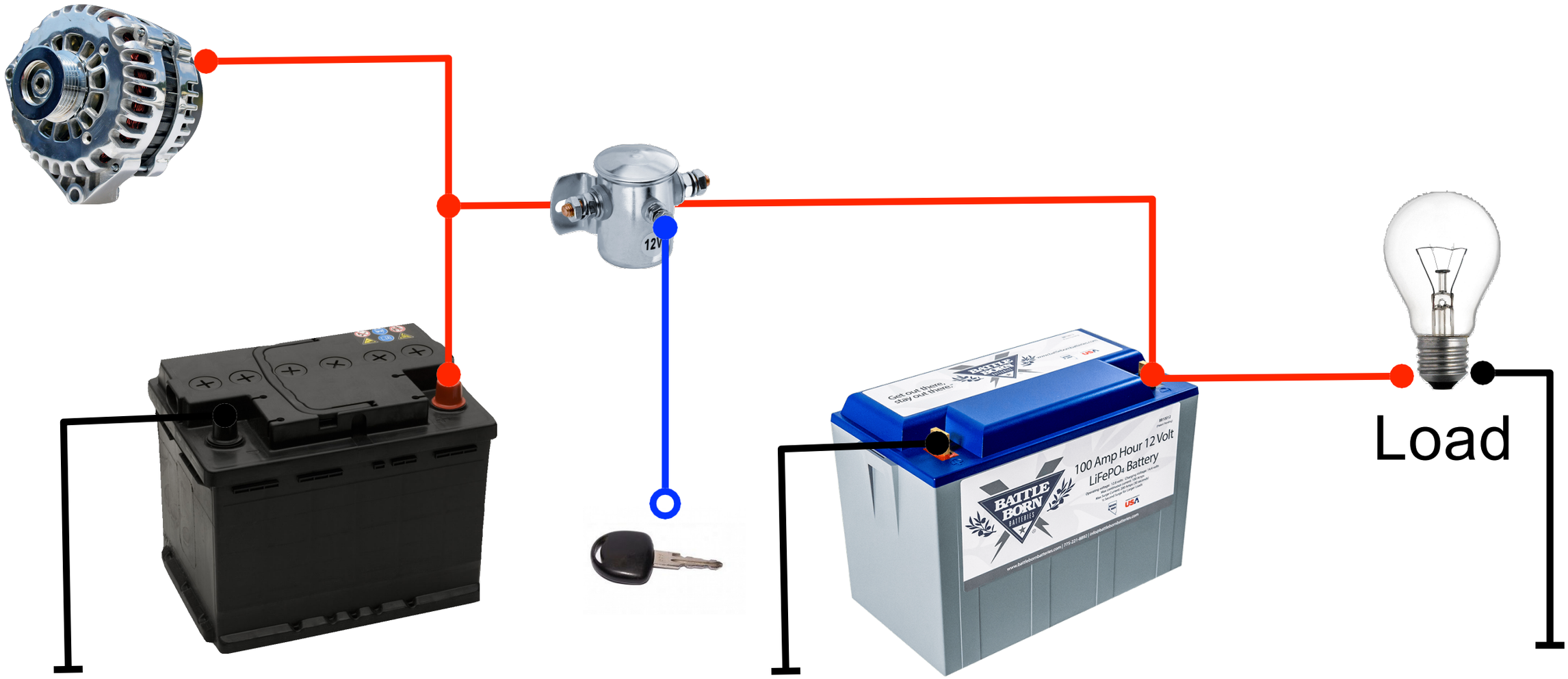


- The connector device is some form of switch - manual, ignition controlled, voltage sensing, a battery to battery charger, or some form of diode isolator. There are many options.

- The difference in voltages between lead Acid and lithium Iron batteries means that most voltage sensing relays will not work properly.

- The ability of a lithium bank to absorb a massive charge could damage a conventional alternator/regulator set up.

Dual Battery
With Key Controlled Relay

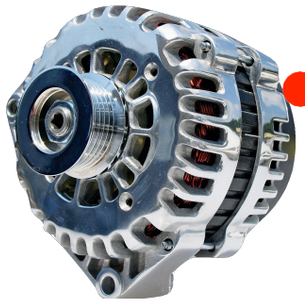


Back to the Future! This is probably the most classic dual battery set up. An ignition controlled switch means that the batteries are in parallel only when the engine is running.

The downside of this arrangement is that the charging profile for your vehicle's starter battery is less than optimal for lithium Iron. (This is probably less of a real world issue than it is made out to be.

There is also the real danger of a lithium battery drawing too much current for your alternator/regulator/wiring.

Dual Battery With B2B



Load

- The battery to battery charger (B2B) draws power from the starter battery and provides it to the camper battery according to a set, in this case lithium, profile.
- Limits the draw on the starter battery to about 10% more than the rated output of the B2B.
- B2B also isolates starter battery from camper battery.

This is probably the simplest solution for most retrofits.

How does a B2B work?

The back end is a battery charger, adjusted to a profile that matches your camper battery. When it detects that the camper battery needs charging, it demands power from the front end.

The front end is attached to your starter battery. When the back end charger demands power, it draws from the starter battery. It may have circuitry that allows it to draw down the starter battery down to a lower voltage.

This, in turn, causes the alternator to start producing current to recharge the starter battery; current that is then passed on to the camper battery.

Traditionally, the B2B traded amps for volts so that it could raise the charging voltage, but these devices gained a new life ***reducing*** the voltage for lithium Iron batteries.

Various safeguards assure that the B2B cannot deplete the starter battery. Typically, a B2B will shut down if the input voltage drops to below 13.2v. (A Lead Acid battery will never have a voltage higher than about 12.7v unless it is actively under charge.)

Most B2B will not back feed a charge from the camper battery to the starter battery. There are various ways to accomplish this, if required.

Lithium Iron Battery Charging:
How you gonna do it?

Lithium Iron batteries don't need a four stage charger:

The ideal charger for lithium is a constant current/constant voltage charger (CC/CV)

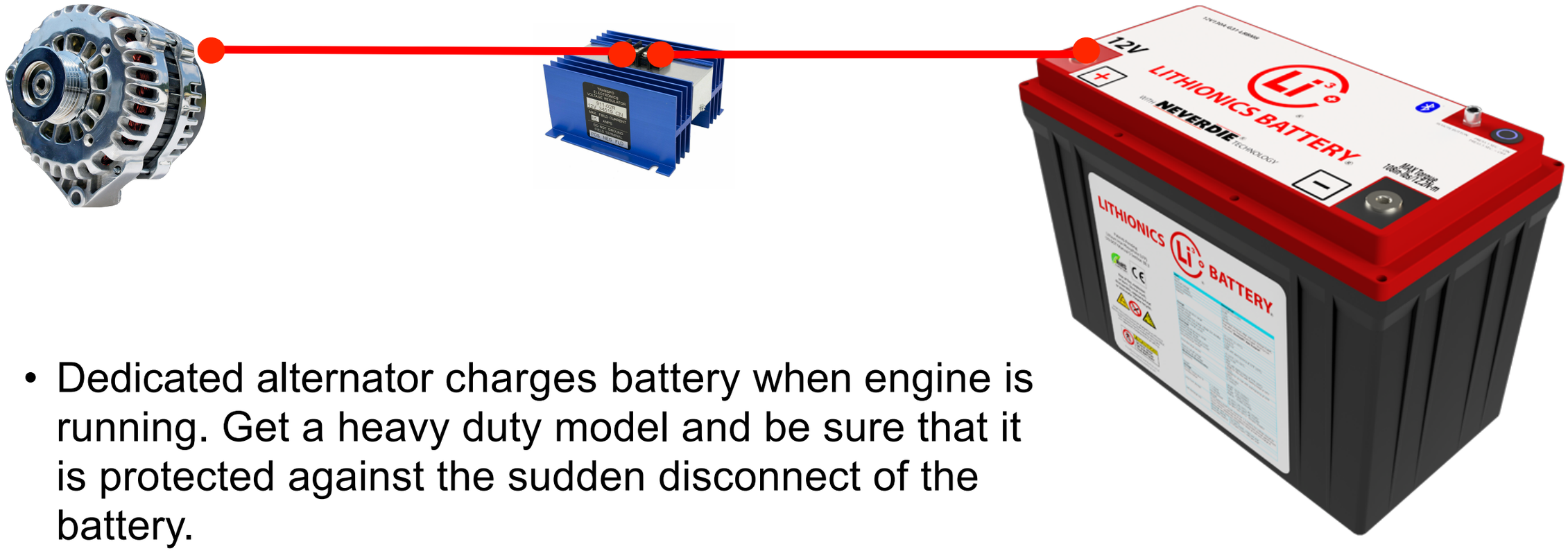
- Charge to target voltage (typically 13.9v – 14.5v) - full charge. The lower voltage is always safer.
- Follow with a short constant voltage until the trailing volts drop to target trailing amps, typically 0.5A per 100Ah of battery. This allows time for the cells to equalize, but is generally limited to about one hour.
- Turn off the charger until the voltage drops to a target recharge level, typically about 13.2v. lithium batteries want to cycle, not to float.

If you use a multi-stage charger, e.g. a solar or shore charger, then you modify the settings to get as close to the conditions above as possible. For example:

- Absorb voltage – Set to target full charge voltage. This is the voltage that will be used during the bulk stage.
- Absorb time – Set to one hour or less.
- Tail current – Set to 0.5A per 100Ah of battery.
- Float voltage – Set to 13.5v or less.
- Equalization – Turn off or set as low as possible.
- Temperature compensation – Turn off. (This is the feature that changes voltage with the temperature. You will still need to protect against charging when freezing.)

Dedicated Alternator/Regulator Set up

(The gold standard)



- Dedicated alternator charges battery when engine is running. Get a heavy duty model and be sure that it is protected against the sudden disconnect of the battery.

- Charge is managed by a new, dedicated regulator. (e.g. Balmar, Wakespeed).

- Many new vehicles (e.g. Sprinter, Transit) come with brackets for an extra alternator. Some US alternator sellers (e.g. Nations) sell brackets for common US pickup trucks.

- Design is entirely your responsibility.

Standard and Metric Wire Comparison Table

Available Wire Size AWG	Available Wire Size Metric
16	1.5
14	2.5
12	4
10	6
8	10
6	16
4	25
2	35
1	50
0	
2|0	70
3|0	95
4|0	120

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
CIRCUIT LENGTH	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		14 AWG	12 AWG	12 AWG	10 AWG	8 AWG	6 AWG	4 AWG	4 AWG	4 AWG	2 AWG	2 AWG	2 AWG	1 AWG	0 AWG	3|0 AWG
	50 ft	15 ft		12 AWG	10 AWG	10 AWG	8 AWG	8 AWG	6 AWG	4 AWG	2 AWG	2 AWG	2 AWG	1 AWG	1 AWG	0 AWG	2|0 AWG	4|0 AWG
	65 ft	20 ft	14 AWG	10 AWG	8 AWG	8 AWG	6 AWG	6 AWG	4 AWG	2 AWG	1 AWG	1 AWG	1 AWG	0 AWG	0 AWG	2|0 AWG	3|0 AWG	
	80 ft	25 ft	12 AWG			6 AWG		4 AWG	2 AWG	1 AWG	0 AWG	0 AWG	0 AWG	2|0 AWG	2|0 AWG	3|0 AWG	4|0 AWG	
	100 ft	30 ft		8 AWG	6 AWG		4 AWG	2 AWG	1 AWG	0 AWG	2|0 AWG	2|0 AWG	3|0 AWG	3|0 AWG	3|0 AWG	4|0 AWG		
	130 ft	40 ft	10 AWG			4 AWG												
	165 ft	50 ft		6 AWG			2 AWG	1 AWG	0 AWG	2|0 AWG	3|0 AWG	4|0 AWG	4|0 AWG	4|0 AWG				
	200 ft	60 ft	8 AWG		4 AWG	2 AWG	1 AWG	0 AWG	2|0 AWG	3|0 AWG	4|0 AWG							
		70 ft		4 AWG														
		80 ft	6 AWG		2 AWG	1 AWG	0 AWG	2|0 AWG	3|0 AWG	4|0 AWG								
		90 ft		2 AWG														
		100 ft			1 AWG	0 AWG	2|0 AWG	3|0 AWG	4|0 AWG									
		110 ft																
		120 ft			0 AWG	2|0 AWG	3|0 AWG	4|0 AWG										
		130 ft		2 AWG														

AWG WIRE SIZE CHART

How not to do it Wrong:

Most dual battery systems fail because the wiring is, by an order of magnitude, too small.

If your camper batteries are not under the hood, you may need something as large as 0 AWG. This is large, heavy, and expensive.

Size everything to the rated output of your alternator or your B2B, depending on how you wire your vehicle.

A B2B makes voltage drop less of an issue, but you still have to be able to more the amps.

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

http://circuitwizard.bluesea.com http://

www.calculator.net/voltage-drop-calculator.html