

Intro to RV Power Your 12V System

Newbie Rally May 20, 2023

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Goals – what I hope you take away

- Understanding how your 12V system works.
- Ability to properly care for your batteries.
- Confidence to go camping without hook-ups.
- Enjoy worry-free boondocking.

Topics

- Electrical Basics
- Safety
- Battery Types and Care
- Charging
- Airstream Specifics
- Loads and Energy Usage

The focus is on the 12V system.

Basics

- *Voltage – Measured in volts*
water analogy: like pressure
- *Current – Measured in amps*
water analogy: like flow rate
- *Power – Measured in Watts*
equal to Volts x Amps
- *Positive and Negative Terminals.*
Current flows from positive to negative. Must have a full circuit for electricity to flow.

Safety

- A charging battery produces hydrogen and oxygen in an explosive ratio.
- AVOID SPARKS, especially on a recently charged battery.
- Batteries can produce thousands of amps in a short circuit (like a wrench touching positive and negative terminals). Use insulated wrenches (wrapped in electrical tape).

Important Points

1. The difference between power and energy. This is commonly confused.
 - Power is instantaneous, or the rate of energy usage. Like Horsepower, or watts.
 - Energy is power over time. Watt-Hours (Wh). Battery capacity is measured in Wh. (Volts x Amp Hours)
2. What we care about mostly is energy. Any battery you choose will deliver enough power for an RV.
3. A battery does not store electricity. Batteries store energy in chemical form and convert it to electricity when needed. As a chemical device, the reaction depends on temperature. A battery at freezing will produce far less energy than a battery at 80 degrees.

State of Charge for a lead-acid battery.

- Voltage is an indicator of a battery's state of charge (SOC), but an imperfect one.
- Charging and discharging effect the voltage so a battery must be tested under no load and preferably at room temperature. Voltage increases when charging and decreases when discharging. A volt meter accurate enough for testing batteries can be purchased at Harbor Freight for \$5.



No Load voltage reading	% Charge
12.73	100%
12.62	90%
12.50	80%
12.37	70%
12.24	60%
12.10	50%
11.96	40%
11.81	30%
11.66	20%
11.51	10%
10.50	0%

Your Airstream's 12V system

Consists of:

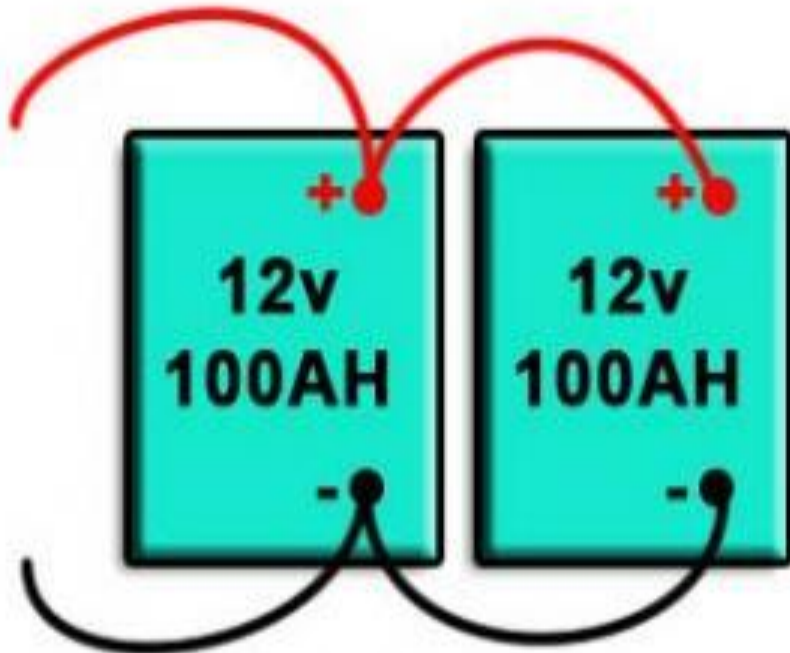
- Batteries. Usually two group 24 deep discharge batteries in parallel. “Group 24” is just a size.
- A charger, or converter. After 2018 Airstreams have smart chargers.
- Usually a SOC meter of some type.
- 12 V loads – lights, pump, furnace fan, misc small loads
- Disconnect switch (modern trailers). There are always small loads from your stereo, gas detector, etc. which is why Airstream provides this switch. Select the STORE position when storing. Select the USE position when using (including when towing).

Batteries

- Most Airstreams come with 2 Deep Cycle Group 24 batteries (80Ah each).
- Two 12V batteries are wired in parallel for 160aAh. Theoretical capacity = 12×160 or 1920 Watt hours. This would mean a load of 192 watts should run for 10 hours.
- However, it doesn't actually work that way for a variety of reasons. Only about $\frac{1}{2}$ the rated capacity to actually be usable. Count on 960Wh.
- Golf cart batteries are 6V 225 Ah. Two 6 volt batteries need to be wired in series to achieve 12 Volts.

Batteries In Parallel

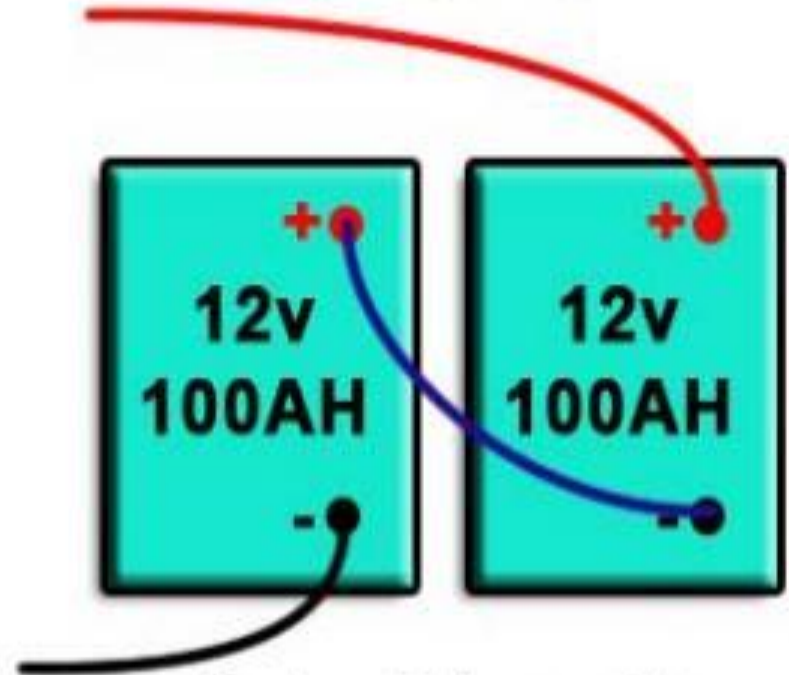
Voltage remains the same
AmpHour capacity doubles



System Voltage = 12v
AmpHour Capacity = 200AH

Batteries In Series

Voltage doubles
AmpHour capacity stays the same



System Voltage = 24v
AmpHour Capacity = 100AH

Battery Types

AGMs

- AGM (Absorbed Glass Matt) is a superior type of lead-acid battery that requires no maintenance, doesn't release gas in normal operation, and is safer and longer lasting than flooded batteries. They cost more and often have somewhat lower capacity than an equivalent size flooded cell battery so you may need 3 instead of 2, but they can be mounted inside the trailer. This provides the added advantage of keeping them out of the cold which will further enhance performance.

Lithium

- Lithium batteries are dramatically superior in every way except price. Due to their many advantages (no maintenance, light, long lasting), I expect all RV batteries will eventually be lithium. If you have a lead-based battery and it's time to replace, lithium is a good upgrade option. But there's no rush; a lead-acid battery should provide several years of reliable service and lithium will only get better and cheaper.

Lithium Battery Notes

- The best readily available type of lithium battery is Lithium-Iron-Phosphate or LFP battery. They operate at a slightly higher voltage than a lead based battery and will hold that voltage quite steady across the discharge cycle.
- Lithium batteries cost more but will last 3000 cycles, so lifecycle cost is lower.
- Most Lead acid chargers will still work but there can be compatibility issues depending on the type of charger your Airstream has.
- Charging from your tow vehicle may only be at a “trickle” rate because of the higher voltage of lithium.
- A battery gage that uses voltage becomes worthless with LFP and only a true energy meter will give an accurate indication of state of charge.
- Lithium batteries are sealed and can be placed inside or outside.
- Because lithium batteries can be fully discharged without damage, you can assume the full capacity is available.
- Solar charge controllers often have an option to select Lithium batteries. If you have this, use it.

Making a battery last

Lead-acid Batteries will last anywhere from 1-8 years depending on how they are used and (more importantly) how they are stored. A new battery that is allowed to remain fully discharged could be ruined in a year. Tips:

- Avoid full discharge cycles. Charge before dead.
- Store fully charged at moderate temps and do not overcharge.
- For flooded cells, check electrolyte every 6 months. Only add distilled water and only to a charged battery. The plates absorb electrolyte during discharge so adding water to a dead battery and then charging can cause it to overflow acid. You do not want this.

Charging

- **Shore Power** – This is 120V AC power converted to 12V DC with the converter. Standard chargers can overcharge if left connected for long periods. Smart chargers (also called 3, 4, or 5 stage) will properly charge, maintain, and store a battery and can be left plugged in indefinitely. Standard (old) chargers work well with lithium because the battery controls its own charging, while smart chargers may not be compatible. There are special chargers optimized for lithium batteries available.
- **Generators** – will charge faster through AC system than via 12V generator outputs. A 50A converter will deliver 100Amp-Hours in 2 hours. They are required if you want to run A/C.
- **From the Tow Vehicle** – As long as your trailer connector is wired to send vehicle power to the trailer, it should charge your batteries perfectly while towing. Test this by connecting a voltmeter to the trailer battery and seeing if voltage increases when the tow vehicle is started while connected.

Storage Recommendations:

Smart Charger - leave plugged in and battery disconnect switch on (use position).

Standard Charger - leave the battery disconnect switch off (store position). Use a battery tender connected directly to batteries if storing more than a few weeks.

Lithium – Do not charge after use. Better to store at 30-40% SOC. Charge before the next trip.

Solar

Solar is a great option when boondocking. It is silent and trouble free, but there are some things to know:

- Panel size. A 200W solar package is adequate for most campers, provided you are exposed to the sun.
- A charge controller is required between the panel and the battery. Think of it as a smart charger that is powered by a solar panel instead of shore power.
- Prices have come way down. A portable 100W solar panel plus controller costs under \$200.
- A little bit of shadow can have a big impact. Shadowing 10% of a panel might cut output 50%.
- Cloudy days will produce 30-40% as much energy as sunny ones.
- Panels should be perpendicular to the sun's rays. Mounting on a flat roof will work but is not optimal.
- All these factors can be compensated for by oversizing your system.

Efficiency and Self-Discharge

- No matter how you charge, you will have to put more energy into a battery than you will get out. This is because the battery is not 100% efficient. For a Lead acid battery, plan to put 125 watt-hours back in for every 100 watt-hours you take out.
- Charging voltage is always higher than discharge voltage.
- Lead Acid batteries will lose a few percent per month of their charge, depending on temperature. Cold temps are better for storage.
- Lithium batteries are nearly 100% efficient. They also have a lower self-discharge rate.

Discharging – using energy

- Just like in your home, the biggest users of energy are things that make heat or cold. That's why heaters and A/C run off propane or shore power. Remember, in our 2 “group 24” example, your budget is 960Wh. If you are camping for 3 days you have 320Wh per day.

Typical loads (an example, your mileage may vary)

Item	DC amps	Power Watts	Est. hours	Daily Energy Wh	Comments
Water pump	5.0	60	.25	15	
Furnace fan	8.0	96	2	192	34k BTU Suburban
Stereo	1.5	18	4	72	
DVD Player	2-3	24-36	2	48-72	
TV	4-6	48-60	2	96-120	
Laptop	4-5	48-60	3	144-180	Via inverter
Microwave	85	1000	.5	500	Via inverter
Halogen light	.8 (ea)	10	2	20 per bulb	Our 2005 CCD has 35 bulbs!
Fluorescent	1.3	15	2	30	
LED light	.125	1.5	2	3	
iPhone				5-8	Per charge
iPad				28-33	Per charge
Phantom loads	.5	6	24	144	Can be measured.

A word about devices

- Phones and tablets have small batteries and don't take a huge amount to charge.
- A 12V USB charger is handy and won't take a toll on your batteries. I have 225 Amp hours at 12 Volts, or 2700Wh. I should be able to charge an iPad 81 times, or an iPhone 495 times.
- If you are worried about it, get a little solar charger/battery combo.



Miscellaneous Topics

Inverters

Allow you to use 120VAC devices off battery power. Remember power (watts) = volts x amps so amps at 12V will be 10x the 120V current draw. Running a computer, TV, or a blue ray player off an inverter is okay. Running anything that makes hot or cold off an inverter is a bad idea unless you have a motorhome designed for it or a lot of solar.

Can you run A/C off an inverter?

Generally no. Your Air Conditioner will use about 15 amps running and 40+ amps to start (at 120 volts). To run off an inverter, the current from the battery needs to be 10X that to equal the wattage at 12V (actually a little higher due to inefficiency in the inverter), or $150/.9 = 167$ amps! This is why we don't have battery powered air conditioners.

Electric Refrigerators

New Airstreams use electric refrigerators. These are very efficient devices, but when boondocking, another load to consider. Solar makes a good power source as more energy is both produced and required on warm sunny days.

Resources:

Battery Info

<http://batteryuniversity.com/>

WBCCI Tech Help Group:

<https://wbcci.org/maintenance-info/tech-help-group/category/32-airstream-tech-help-group>

All things Airstream:

www.airforums.com

Quiz

1) A 1.5 Watt LED will draw how much current on 12 volts.

- a) .01 amps
- b) .125 amps
- c) 96 ohms
- d) A little over an amp
- e) I like donuts

Answer: b

2) Calculate the power used by 3 - 5 watt bulbs plus a furnace fan which draws 6 amps running for 2 hours.

- a) 21 Watts
- b) 21 Watt-hours
- c) 87 Watt-hours
- d) It's a nonsense question, but the power is 87 watts and the energy is 174 watt-hours.
- e) This was supposed to be a vacation

Answer: d

3) A solar panel will output 30-40% its normal output in cloudy conditions.

- a) True
- b) False
- c) 30-40% True

Answer: a

4) Batteries will produce more energy when warm but last longer in storage when they are kept cool.

a) True

b) False

Answer: a

5) Yesterday you started with a full battery. You ran 24 watts of lighting for 3 hours and charged your 28 Wh iPad. Today you want to replace that energy with your 100W solar panel, but it is supposed to rain this afternoon. Calculate the energy used and time required to fully recharge. Assume full sun and a battery charging efficiency of 80%. Will you have enough time to get a full charge?

Energy_____

Time_____

Answer: Energy=

$24 * 3 = 72\text{Wh} + 28\text{Wh} = 100\text{Wh out.}$

$100 / .8 = 125\text{Wh in}$

Time: $125\text{Wh} / 100\text{W} = 1.25 \text{ hrs}$

6) You should always switch the battery disconnect to off (STORE position) when towing

a) True

b) False

False

7) Power is:

a) Energy x time (expressed in watts)

b) Energy / time (expressed in watts)

c) Total heat (in BTU's)

d) Everything

Answer: b