

A Primer on RV Electricity

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/Negative Terminals. Current flows from positive to negative. Must have a full circuit for electricity to flow.

1. Difference between power and energy. This is commonly confused.
 - a. Power is instantaneous, or the rate of energy usage.
 - b. Energy is power over time. Watt-Hours (Wh). Battery capacity is measured in Wh.
2. What we care about mostly is energy. This is different from a car battery where you need a lot of power to start the engine, but not for long term loads which are supplied by the car's alternator.
3. A battery does not store electricity. Capacitors do that. 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 half the power and energy of a battery at 80 degrees.
4. Voltage is an indicator of the state-of-charge of a battery, but it is also a function of load and temperature and age of the battery. When using voltage to determine state of charge, it is critical that the battery not be under load. See tables below.
5. Self-discharge – Lead-Acid batteries have a self-discharge rate around 5% per month. So in 6 months, SOC would be $.95^6 = 74\%$. If you remove your battery for storage, place on something insulated to slow the self-discharge.

Safety

- Battery explosions really do happen. I have personal experience. Biggest issue is acid, which can spray and eat through clothes or skin. 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). I use insulated wrenches (wrapped in electrical tape) and have a non-conductive battery tray.

Your Airstream's 12V system

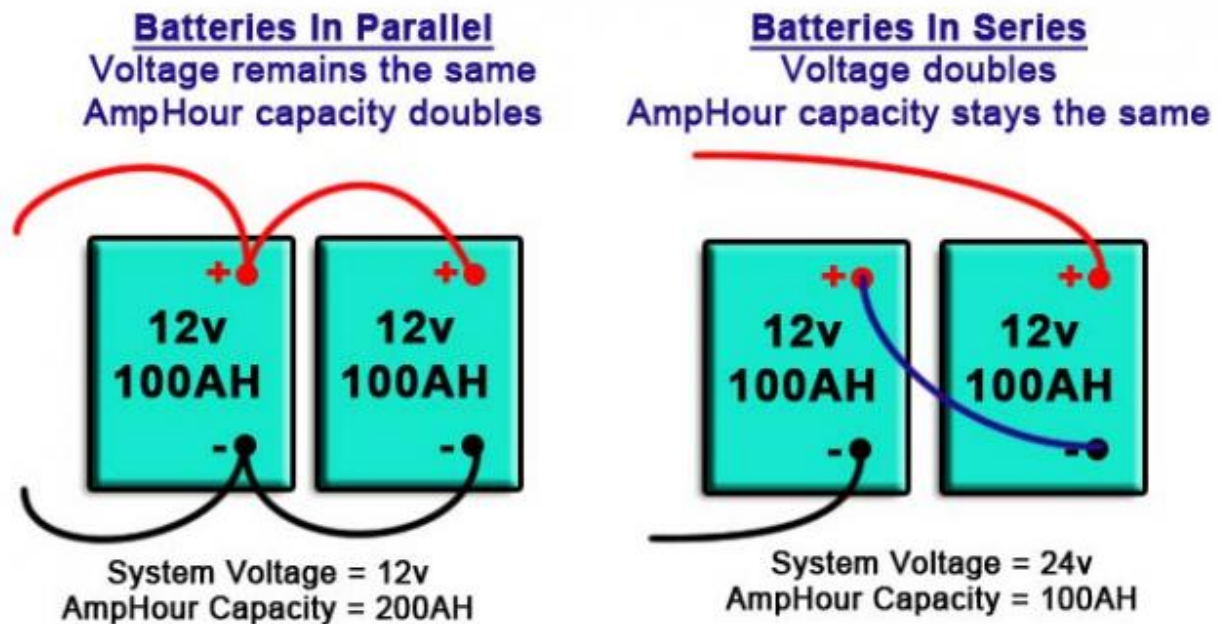
Consists of

1. Batteries. Usually two group 24 deep discharge batteries in parallel. "Group 24" is just a size.
2. A charger, or converter. Airstream used to call them "Univolts".
3. 12 V loads – lights, pump, furnace fan, misc small loads
4. Disconnect switch. 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 ½ the rated capacity to actually be usable. Count on 960Wh.

Golf cart batteries are 225 Ah. Two 6 volt batteries need to be wired in series to achieve 12 Volts.



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%

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



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

Due to their many advantages (no maintenance, light, long lasting), I expect all RV batteries will eventually be lithium, but right now they are so expensive that even Airstream owners don't use them.

Making a battery last.

Batteries will last anywhere from 1-5 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.

- Avoid full discharge cycles. Charge before dead.
- Store fully charged at moderate temps and do not overcharge.
- 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.
- An old battery may have life extended with anti-sulfation additives.

Charging

There are at least 3 ways to charge the batteries in an Airstream – Shore power, Tow Vehicle charging system, and solar chargers.

Shore Power – This is 120V AC power converted to 12V DC with the converter. There are two basic types- smart and dumb (or standard). 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 chargers can overcharge if left connected for long periods. For a smart charger replacement, I like Progressive Dynamics Intellipower with charge wizard. \$150 - \$250. Another option is using a battery tender. This is a smart charger designed for maintaining a charged battery.

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 months.

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.

Solar - I always use solar when boondocking, never a generator. It is silent and trouble free, but there are some things to know:

- Panel size. A 100W solar panel should charge a battery at approximately 7 amps in full 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.
- A panel that tracks the sun will produce 1/3 more than a fixed one.
- All these factors can be compensated for by oversizing your system a bit.
- Still, you probably don't need as much panel as you think you do. I use one 75 watt panel, keep it out of shade, and I never run out of power.

Recommendation:

One or two 100 watt panels will keep you going.

Mount on your roof for maximum convenience, keep portable for maximum flexibility.

Generators – will charge faster through AC system than via 12V generator outputs. A 50A converter will deliver 100Amp-Hours in 2 hours. That is quite a bit. They are required if you want to run A/C. See Ray Putnam's article in the Blue Beret to learn how to run A/C off a single 2000W inverter generator.

Efficiency

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. Plan to put 150 watt-hours back in for every 100 watt-hours you take out. This is 67% efficiency.

Discharging – using energy

Just like in your home, the biggest users of energy are things that make heat or cold. In an RV, those things need to run off propane or shore power. Remember, 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	
iPad				5-6	Per charge
iPhone				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 too large 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. Even after you de-rate the capacity to 50%, that's a lot of charges. If you are worried about it, get a little solar charger/battery combo.

Miscellaneous Topics

Little known fact – new batteries require break in

New deep discharge batteries take 20-50 cycles to develop full capacity (called "forming"). Manufacturers recommend no high loads during this period. Limit to 100-200 watts.

Inverters

These are cool and 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 of an inverter is a bad idea unless you have a big motorhome 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 maybe 30 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.

Measuring Power/ Calculating Energy

If you have a specific device you want to run and don't know the power requirement, there are ways to measure and calculate how long your batteries will last. This will be covered in the advanced course.

Resources:

Battery Info

<http://batteryuniversity.com/>

WBCCI Tech Help Group:

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

Gone with the Wynns – Real life solar powered adventures

<https://www.gonewiththewynns.com/solar>

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
- 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
- 3) A solar panel will output 30-40% its normal output in cloudy conditions.
 - a) True
 - b) False
 - c) 30-40% True
- 4) How much charge will a lead-acid battery lose in 6 months due to self-discharge?
 - a) 5%
 - b) 15%
 - c) 25%
 - d) 50%
- 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 67%. Will you have enough time to get a full charge?
Energy_____
- 6) You should always switch the battery disconnect to off (STORE position) when towing
 - a) True
 - b) 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