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RV Electrical Systems

I have never been shy about telling you what I don't know. And I don't know much about electrical issues. But I try to learn from others and then put that information in terms everyone can understand.

So the discussions below are my attempt to simplify what can be a very complicated system to comprehend.

Basic RV Electrical

I was thinking about what I should cover in a "Basic RV Electrical" section. Then it dawned on me that I would want it to be really, really basic.

I asked myself this question: What is the absolute minimum I need to know about my electrical system so I can run my appliances?

So let's start with the assumption that you will ALWAYS park where you can plug your rig into an electrical outlet. Then we will expand from there.

Is Your RV A 30-Amp Rig Or A 50-Amp Rig?

Every RV these days comes with a power cord meant to plug into a campground electrical pedestal like the one below.

Your RV will be either a 30-Amp rig or a 50-Amp rig. How do you know? The simplest method is to check the plug on your power cord. If it is a large plug with three prongs, it is 30 amps. If it is a large plug with four prongs, it is 50 amps.

Again, take a look at the power receptacles on the campground pedestal image above. The four-prong receptacle will be 50 amps and the large, round three-prong receptacle will be 30 amps. The other two, the household looking receptacles, will be 20 amps (or possibly 15 amps).

In this very basic section, we don't need to get into an explanation of amps. Here's what you need to know.

If your main RV power plug is four prongs (50 amps), you can plug in and run almost every appliance in your rig at the same time including two air conditioners.

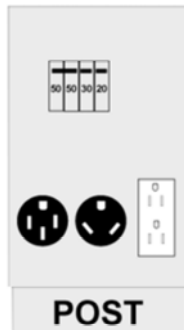
If your main RV power plug is the three-prong (30 amps) type, you can run one air conditioner and a few other appliances at the same time. If you have two high efficiency air conditioners, you MAY be able to run both of them at the same time, but not much else.

How do you know which appliances you can run? Without getting too technical, the appliances that generate heat or coolness (air conditioner, microwave, coffee maker, toaster, blow dryer, water heater, furnace, etc.) will use more electricity. The more of those items you run at the same time, the more likely you are to trip a breaker. Even I know what breakers are, so I will assume the majority of our readers do as well. :)

Many people determine what items can be used simultaneously by trial and error. They keep turning on appliances until the breaker trips. Later on, in the "Further Understanding Your RV Electrical System", we will discuss how you can figure out exactly which items you can run by using a little math.

Plugging In Your RV To The Campground Pedestal

You'll notice on the campground pedestal image below that there are four* breaker switches.



They **should** be labeled with 50, 30, & 20 (or possibly 15 instead of 20), and they **should** be labeled to tell you which position is "off" and which position is "on".

* - Note that two of the four breaker switches are labeled "50". We'll discuss why that is later in "50 Amp service vs. 30 Amp service".

The down position should be "off" and the up position should be "on", but that's not always the case. Sometimes they are mounted side to side rather than up and down - just to confuse things.

For safety, it's best to make sure all breakers are in the "off" position before plugging in AND unplugging. Also, you want to make sure that your appliances, especially the ones that draw the most electricity, are "off" when plugging in AND unplugging.

Of course, the campground pedestal may not look like the ones above. It may have any combination of receptacles.

Just match your power cord plug to the proper receptacle and plug in. Flip on the breaker that matches the receptacle. Now you can run your appliances.

Electrical Adapters

Okay, so what if your RV is a 50 amp RV with a four-prong plug, but the campground doesn't have a 50 amp outlet? That happens often, so you should always carry a 50 to 30 adapter. Most RVers prefer the "dogbone" type adapter shown on the left. We like the "dogbone" style as well, but we prefer the more expensive type with handles, called a Power Grip on the right. The handles make it easier to disconnect and make this adapter worth the extra money in my opinion.

Your 50-amp cord plugs into the four-prong receptacle on the adapter and then the three-prong end of the adapter plugs into the 30 amp receptacle on the campground pedestal. You can then run appliances in your RV, but you will be limited to the 30 amps from the power source. So you will have to manage which appliances you run at the same time.

Some older campgrounds only have 20 amp service or 15 amp service. So we carry a 50 to 30 adapter AND a 30 to 15 adapter shown below.

We use both adapters together when we only have 20 or 15 amp service at a campground or when plugged in at someone's home. We plug our power cord into the 50 to 30 adapter and then the three-prong end of that adapter into the 30 to 15 adapter and THEN into the pedestal. We can't run many items at once on 15 amps, but at least we can use our appliances.

Now, what if you have a 30-amp RV and the campground has only 50 amp service (we have seen this a few times)? Well, you can get a 30 to 50 amp adapter. Many, many people do this and have never had a problem. Basically, you will have 50-amp potential, but your 30-amp main breaker in the RV should shut down if you try to use more than 30 amps.

I personally don't like this option. It's done all the time, but there are enough risks that OUR rule of thumb is to never plug into a power source rated higher than our rig.

Now, our fifth wheel is a 50 amp rig. But we are on 30 amps at least 50 percent of the time and use our 50 to 30 amp adapter a lot. We get by just fine on 30 amps.

Now, with that said, if you are getting a rig for full-timing, it is our recommendation to get a 50 amp rig. You will enjoy the peace of mind and ability to run all your appliances when you have 50 amps, and you can easily go down to 30 amps when necessary.

Checking Campground Wiring

Perhaps this section should come before "Plugging In Your RV".

If you search the internet and read RV forums much, you will run into stories where folks have ruined appliances because the campground's wiring was improper or because the campground's voltage dropped below safe levels or surged above safe levels. Occasionally you will run into stories of people being shocked (or worse) due to incorrect wiring of the campground pedestal.

How do you combat this? One option is to buy and learn how to use a polarity tester.

You test the campground's circuit for proper wiring BEFORE plugging in your RV. If your polarity tester shows a problem, you notify the campground management and MOVE to another site!

Now, the polarity tester does not test for improper voltage which can harm your appliances.

You can get a combination polarity/voltage tester such as the Good Governor shown below.

With it, you can test the wiring AND the voltage BEFORE you plug in. However, the Good Governor cannot continuously monitor voltage and it won't prevent electrical voltage drops or surges. Such drops or surges can damage your expensive appliances and electronics.

So, we recommend that **EVERY** RV be equipped with a power management protection device also known as a "surge protector with voltage protection".

These devices will continually protect your RV and appliances/electronics from:

- Surges
- Mis-wired Electrical Pedestals
- High & Low Voltage
- Other Miscellaneous Electrical Problems

You can get them for 30-Amp rigs and 50-Amp rigs (50-Amp models work on 30-Amp circuits as well). They are also available in models that can be plugged in directly to the campground pedestal and models that can be hard-wired into your coach.

If you use the portable model that gets plugged into the pedestal, you simply plug it in and then plug your power cord into the device.

If you have the hard-wired model installed, you plug your power cord into the campground pedestal.

With either model, there is a two-minute delay to protect your air conditioner.* If all is okay with the circuits, it lights up and allows electricity into your rig. If there is a problem, no electricity is allowed in and warning lights are displayed.

Again, if there is a problem, notify the campground management and MOVE to another site. You may have to move to another campground!

Once electricity is allowed into the rig, the device protects the coach from surges. Also, it completely shuts down power to the RV if campground voltage drops below or surges above certain levels. This protects your appliances.

* - Note: The time delay keeps the air conditioner from short-cycling. If the compressor turns off and on too quickly it creates extreme stress and the compressor can be damaged. The time delay is just in case the air conditioner is "on" when plugging in initially or if the air conditioner was running during a power shut down.

An RVIA Certified Master Technician advised us that every rig should have one of these devices and recommended either a SurgeGuard product (shown here).

or a Progessive Industries product (shown here).

The "House" Or "Coach" Batteries

For the most part, the minimum you need to know is what we have discussed above. However, your RV uses battery power to run certain lights and other items.

That just happens, but you need to know just a little bit about the battery system. Most RVs will come with one or two "house" or "coach" batteries. These are batteries that provide electrical current to some appliances and some motors in the RV as opposed to the battery in a motorhome or tow vehicle that starts the engine.

House batteries need to be re-charged and most of them need a little maintenance.

If you are plugged in to an electrical outlet most of the time, you don't have to be too concerned about battery charging. The equipment that comes with your RV includes a battery charger that uses campground power to charge the batteries - it happens automatically.

Also, whether you have a motorhome or a towable (fifth wheel or travel trailer), your house batteries get charged another way. In a motorhome, the vehicle's alternator charges your batteries while the engine is running.

If you are towing, the tow vehicle has to be plugged into the trailer so that brakes and lights on the trailer work. In addition, the tow vehicle's alternator is charging the house battery in the trailer while you are driving down the road.

As for maintenance, you should keep the battery terminals clean and make sure the water levels are kept up (only use distilled water in batteries). If you don't know how to do either, just ask someone with experience or have an RV service department do it or show you how. It's not that difficult, but sometimes the batteries can be a bear to get to.

What Happens When You Do Not Have Electric Hook-Ups

Not having electrical hook-ups makes our basic discussion more complicated. But we will keep it short and simple.

If you have a generator, you can run your appliances just like you are plugged in. Well, it's not quite that simple, but a generator produces the same TYPE of power as a campground pedestal. The issue is whether or not it produces as much power.

If you don't have a generator, the only way to run the majority of your appliances is to use the power from your batteries. That requires something called an "inverter". Some motorhomes and higher end fifth wheels have an inverter, but most towable RVs do not.

If you are interested in more details on being without electrical hook-ups and more details on the electrical systems, keep reading. Otherwise, you have the basic information you need. :)

Further Understanding Your RV Electrical System

We started our RV lifestyle with the basic understanding of RV electrical systems as set forth above. Actually, we knew less than what we discussed above. Still, we were able to go on the road and fully enjoy the capabilities of our RV.

However, in time we learned a little more and the new knowledge has been beneficial in broadening our lifestyle. So we will try to pass on a little of that knowledge below.

120-Volt Vs. 12-Volt

Every RV made these days uses both 120-volt power and 12-volt power. What does that mean?

Well, 120-volt power is provided by the electrical pedestal at your campsite or by running your generator if you have one.

And 12-volt power is produced by batteries.

Volts are a measure of the "force" pushing the electrical current through wires. Think of it like water pressure. The higher your water pressure, the more water that is pushed through. "Voltage" is the potential pressure and the measurement of the actual pressure is in "volts". Obviously, 120-volt power pushes electricity through with much more force than 12-volt power.

Now, I always got confused because I'd hear the terms "110-volt" systems AND "120-volt" systems. But with a little research I found that these are basically one and the same. For practical purposes there is no need for most of us to distinguish between the two. I will always call it 120-volts because it makes the math we need to understand all this easier. You'll see what I mean later.

AC Vs. DC

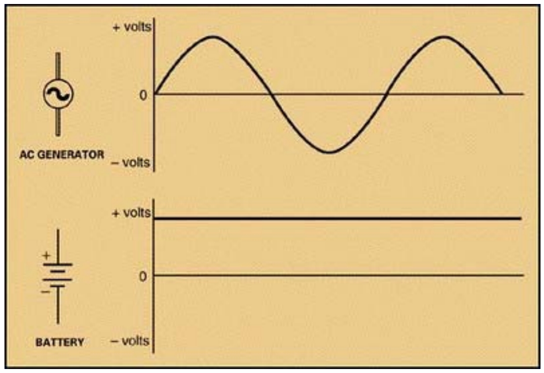
Now, there is more terminology that always comes up when talking about RV electrical systems. So let's see if we can help understand "AC" and "DC". We all learned this in our basic science classes in school, but most of us forgot it. However, in RVing it actually becomes practical and helpful to know the difference.

AC is "alternating current". That means that the electricity flows in both directions. In other words, picture electricity moving through a wire from right to left. Then it stops and moves back left to right. It "alternates" - stopping and starting and reversing direction and moving in a wave. Of course it happens so fast, we never know it.

DC stands for "direct current". This means that the electricity flows in one direction. Because DC current always flows in one direction, it stays constant. Many appliances and motors are better suited to that constant current.

DC (direct current) is produced by batteries. So your RV batteries (your 12-volt system) supply power to DC appliances like certain lights and motors. For example, motors that run electric jacks and slides, motors that run hydraulic jacks and slides, and motors that run water pumps get their power from the batteries. Also, most built-in generators use DC from the batteries to start or crank the generator.

Here is a graphical representation of the different currents. The AC current is at the top and the DC current is at the bottom.



There is no need to get into the science of how it all works. DC was once the standard in the United States. But AC took over because it could be pushed over long distances more efficiently.

Those of us that have owned houses never worried about "AC" vs "DC". In stick homes, it is all AC and we never cared much about the difference. We just plugged in stuff and it worked. The only DC we used was whatever ran on portable batteries - flashlights, etc.

Bottom line. The campground electrical pedestal and generators supply 120-volt, AC power to most of your RV appliances (TVs, microwaves, air conditioners, computers, blow dryers, satellite receivers, etc.) The batteries (called "house batteries" or "coach batteries) in your RV supply 12-volt, DC power to non-AC appliances in your rig.

Volts, Amps, & Watts

Okay, I'm way out of my league here. So I won't attempt to define these terms in great detail. But it is helpful to know the relationship between volts, amps, and watts to know how much power you need to run your appliances.

Watts are a measure of electrical power. **Amps** (or amperes) are a measure of electrical current or flow rate/volume. **Volts** are a measure of force or pressure through an electrical circuit.

Let's go back to our water pipe analogy. As I said before, **Volts** are like water pressure. **Amps** are like the water flow rate. **Watts** are then like the total water output produced by the combination of water pressure and flow.

Now for the math I promised earlier.

Watts = Volts X Amps

So, electrical power is determined by the amount of electrical current (amps) and the amount of force (volts) used to push that current. The higher the force (volts) or the higher the current (amps), the more power (watts) there is in an electrical circuit.

Doing a little algebra, we get this equation:

Amps = Watts / Volts

Why do we care?

We care because we have to determine how much electricity we need to run the goodies in our RV. These math problems help in figuring out what our batteries can do, what appliances we can run at the same time in various situations, and what future upgrades to the electrical system we might want to undertake.

We usually need to know amps since most of our RV electrical knowledge is based on amps. We plug into 20-amp, 30-amp, and 50-amp electricity sources.

We always know volts. It's either 120 or 12 for RVs depending on whether we are talking AC (120-volt) or DC (12-volt).

And wattage is usually available. It's located on the appliance nameplates or in the owners manuals. Or, wattage can be estimated by using the many online wattage tables for common

RV appliances. Of course, if you use online tables, remember they are just estimates as your actual appliances may vary.

50 Amp Service vs. 30 Amp Service

So why can we run so many appliances at the same time with 50 amp service when we were more limited at 30 amp service?

Well, using our equation above - Watts = Volts X Amps - at 120 volts, 50 amps produces 6,000 watts as opposed to 30 amps which produces 3,600 watts. Quite a difference. Ah, but there is more to the story.

Remember at the beginning when we talked about a 30-amp power cord having 3 prongs? Well, those three prongs correspond to a hot 120-volt wire, a ground wire, and a neutral wire.

But the 50-amp power cord has 4 prongs. Those four prongs correspond to a ground wire, a neutral wire, and **2** 120-volt hot wires!

So, going back to our equation - Watts = Volts X Amps - we have 2 50-amp lines at 120 volts each. We have two lines capable of 6,000 watts each, not just one. Our total is now 12,000 watts of potential power for 50-amp service as opposed to only 3,600 watts for 30-amp service. Now you can see why 50-amp service gives us so much more capability than 30-amp service.

Another note on 50-amp service. Almost all RVs are wired such that the two 50-amp, 120-volt lines are used separately. In other words, some of the appliances are wired to one hot leg of the 50-amp service and the remaining appliances are wired to the other hot leg of the 50-amp service.

And now we also know why there are two 50-amp breaker switches shown on our pedestals - one for each hot line. But even though there are two switches marked "50", they do not operate independently. The whole circuit will trip if one line is overloaded.

Finally, this is another good reason to have a 50-amp surge protector with voltage protection on your 50-amp rig. Those devices test both lines of the 50-amp service and protect all your appliances no matter which leg they may be on. If you do not have one of these devices, one bad leg could be the reason some appliances work and others don't. However, one bad leg will probably lead to much worse problems than that.

The neutral in a 50-amp circuit is there to help balance the total 240 volts between the two hot lines so they each carry only 120 volts and no more.

Figuring AC Electrical Requirements

Let's look at some examples of AC appliances.

Our microwave takes 1000 watts according to the nameplate. So, using our Amps = Watts / Volts formula, the microwave would use 8.33 amps (1000 watts/120 volts).

Our toaster takes 800 watts which translates into 6.67 amps (800/120 volts).

Our living room TV uses 140 watts - 1.17 amps (140/120 volts).

Our coffee maker uses 1000 watts - 8.33 amps (1000/120 volts)

Linda's blow dryer uses 1875 watts - 15.63 amps (1875/120 volts)

Our DVD/CD player uses 80 watts - .67 amps (80/120 volts)

Our refrigerator - 3.5 amps (they made that one easy and gave us amps instead of watts)

According to our RV owners manual, an RV water heater will use about 10 amps, a roof top air conditioner uses 13 - 15 amps, and an electric space heater uses 10 - 15 amps. Any appliance that has an element to heat or cool takes lots of amps.

So if we run our air conditioner, have the water heater on electric (instead of propane), have the refrigerator on electric (instead of propane), run the microwave, the coffee maker, and the TV we will need 46.33 amps (15 + 10 + 3.5 + 8.33 + 8.33 + 1.17). We had better be on 50 amp service or we can't do that. :)

So that's how you determine what appliances you can run at the same time when you have AC power. Find the wattages for each appliance and determine the total amps. Then compare that figure to the amps your power source can supply (20, 30, 50). Obviously, you have to make more choices when on 30-amp service than you do when on 50-amp service.

Well, the above is **one** method for figuring what appliances you can run at the same time. Another method is trial and error. That is probably the most popular method among RVers - just keep turning things on until the pedestal breaker trips. :)

Computing the amps required for each appliance is also important when determining what size generator you might want. We didn't know that at the time we bought our rig, so we just said "Yes, give us the generator option."

We ended up with a Onan 5500 watt propane generator. Since generators produce 120-volt AC power, that means ours will produce 45.83 amps (5500 watts/120 volts = 45.83 amps). So, with the generator on, we can pretty much run the same appliances that we can with a 50 -amp hook-up. At least until a neighbor tells us to shut the thing off or we run out of propane. :)

One last comment on calculating amps and tripping breakers. An initial amp "surge" is typical for starting any appliance containing a motor or compressor.

So even though your total amp calculations, appliance by appliance, might be within your 30-amp or 50-amp threshholds, you can still trip breakers when you turn on a new appliance and add it to the circuit. To compensate for the start-up, build a little cushion into your calculations. And avoid plugging in with several appliances in the "on" position.

So Amps Are Amps, Right?

Well, yes they are. BUT now we are going to look at amps from a 12-volt, DC standpoint. Why do we want to do that if most of our major appliances are 120-volt, AC appliances?

Well, we may want to park our RV in places where we can't plug into an AC power source. Or we may not have a generator. Or we may not want to run our generator to produce AC power because of the noise or cost of fuel, etc. Therefore, we can use our 12-volt, DC battery system to run AC appliance **IF** we have an "inverter".

An inverter is a device that "inverts" DC current and changes it to AC current. HOWEVER, keep in mind that in an AC environment, the electrical current is pushed through wires at 120 volts, 10 times more than the 12-volt DC system.

So a 10-amp AC appliance requires 100 DC amps. The formula we used earlier bears this out.

We'll use easy math. Let's say we have a TV that uses 120 watts. That would be 1 amp when hooked up to AC power (120 Watts / 120 Volts = 1 Amp).

But if we wanted to watch TV using our batteries and an inverter, then it would require 10 amps due to the lower voltage of the batteries (120 Watts / 12 Volts = 10 Amps).

So the rule of thumb is to multiply the AC amps required by an appliance by 10 to determine the DC amps it would take to run the same appliance using batteries and an inverter.

You can see that it takes significant battery capacities to enjoy the full capabilities of an RV when not hooked up to "shore power" or running a generator.

Battery Capacities

Batteries for RVs are rated by the "amp-hours" they provide in a 20 hour period. Why 20 hours? Well, I won't get into that, but just think of it as how many amp hours a battery can supply in a day from full charge to being fully discharged (used up).

But what does that really mean?

Let's say we want to use our inverter and batteries to run our two TVs, satellite receivers, a few lights, and two laptops (all plugged into AC outlets in the rig) for five hours during the day. Let's say we've calculated our total watts and figured the appliances would take a total of 5 AC amps. We know from our previous discussion that it would take 50 DC amps (10 X 5 amps) using the batteries.

If we ran all those appliances for 5 hours that would be 250 amp hours (50 DC amps X 5 hours). So we would need a battery bank that has a total capacity of at least 250 amp hours.

Ah, but it is not quite that easy. If we want our batteries to last as long as possible, we don't want to discharge them more than 50% (and less if possible). So, in our example above, we would want a battery bank with a capacity of at least 500 amp hours.

Most RVs don't come equipped with a battery bank that large as standard equipment. And most RVs have only one or two batteries with a total capacity of 100 - 200 amp hours.

RV manufacturers always try to keep costs down. Even though most mid-range and higher RVs are supposed to be "self-contained", it seems the industry presumes that all RVs will be plugged into shore power all the time.

So let's look at our options if we want to upgrade that lame battery bank that came with the rig.

Battery Types

We need to distinguish between Starting (or Cranking) Batteries and Deep Cycle Batteries.

A Starting Battery is what is used in most vehicles to start engines. They are designed to provide quick, powerful bursts of energy but are not designed to be discharged over and over.

Deep Cycle Batteries are designed to be discharged and recharged several times and to provide energy over a long period. Deep cycle means they can be discharged down to about 20% of capacity and recharged for several cycles (although they won't last as long if they are discharged that deeply over and over).

In the next section, we will look at the different types of Deep Cycle Batteries.

There are also hybrids out there that are designed to start motors and provide long-term energy. They are used mostly in marine applications. Most experts agree that the hybrids are NOT the batteries for your RV electrical batteries.

So just be sure that your house batteries are Deep Cycle Batteries and **not** Starting Batteries or hybrid (also called "dual purpose") Marine batteries.

Deep Cycle Battery Options

The basic Deep Cycle Battery choices are Wet Cell (or flooded cell), Gel Cell, and AGM (absorbed glass mat). I won't get into the technical construction differences of these types, but they are all lead acid batteries. Instead, I'll provide links to some really informative web pages.

Check out these great websites for more detailed and technical information on deep cycle batteries.

BatteryStuff.com - Battery Tutorial

Wind & Sun - Deep Cycle Battery FAQ

The 12 Volt Side Of Life

AM Solar - Batteries

And of course I can't leave out our friend Jack Mayer's discussion on batteries at

Jack Mayer - Battery Bank

Wet Cell batteries are the most common in RV use. That's because they are inexpensive compared to the Gel Cells and AGMs. Plus, RV manufacturers like to cut costs wherever they can, so house batteries will typically be Wet Cell, and the battery bank will typically be inadequate unless one **always** parks with electrical hook-ups.

Gel Cells and AGMs are two to three times the cost of Wet Cell batteries. AGMs are favored over Gel Cells for the same price, so AGMs are slowly replacing Gel Cells in RV applications.

The consensus among the websites listed above seems to be that AGMs are the best choice. However, the cost difference over Wet Cells is hard to justify for many people. If money is not an issue in putting a battery bank together, I'll join the experts in recommending AGMs. Otherwise, Wet Cells will do just fine.

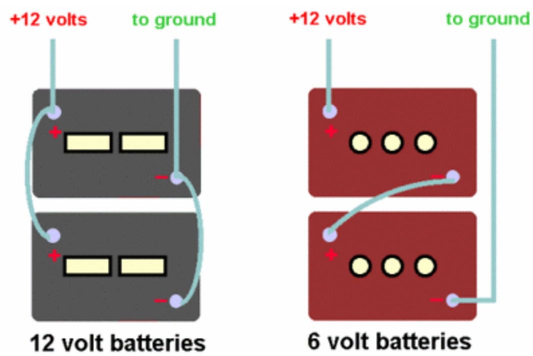
12-Volt Batteries Or 6-Volt Batteries?

Most RVs come with one or two 12-volt batteries.

However, the experts agree that 6-volt batteries are better IF you have room for them. They are larger than 12-volt batteries with similar capacity. The key to that sentence is **"with similar capacity"**.

The experts also agree that when two 6-volt batteries are wired together in "series" (basically creating a 12-volt battery), they allow for deeper discharge more times and have greater capacity than **two similar sized** 12-volt batteries. That's right, two 6-volt batteries (wired in series creating one 12-volt battery) have more capacity than two 12-volt batteries **of the same size**.

Here is a graphic of two 12-volt batteries wired in "parallel" (on the left) and two 6-volt batteries wired in "series" (on the right) to "create" a 12-volt battery.



I'll go with the experts one more time. If you are replacing batteries or upgrading and space is not an issue, I'd recommend two 6-volt batteries wired together over single 12-volt batteries. NOTE: When people tell you to put "golf cart" batteries in your RV, they are talking about 6-volt deep cycle batteries wired in "series".

Okay, by now you have either determined that the whole electrical system/battery thing is too complicated and you will just park with electric hook-ups all the time **OR** you are starting to add up the amps of your appliances and thinking about how many batteries you need and what kind/size so you can go without electric hook-ups.

If you are in the latter camp, keep reading.

Discharging & Recharging Batteries

If you have gotten this far, I'm guessing you are interested in using batteries and an inverter and parking without electric hook-ups - at least once in awhile.

At this point you have a few choices.

- 1. You can use the information above to see what your current system is capable of and use it accordingly
- 2. You can use the information above to see what you might need to upgrade your current system
- 3. You can scrap your current system and start over

NOTE: When I speak of upgrading, I'm talking about a complete replacement of the batteries. It's best to have a battery bank that includes batteries of the same type, size, and age.

We stated before that your batteries will last longer if you do not discharge them fully. Ideally, you don't want to discharge them below 75% of their capacity, but certainly not below 50% of their capacity.

If I've learned nothing else about deep cycle batteries, I have learned this: Each battery has a certain number of discharge/recharge cycles and that number of cycles (and therefore the battery life expectancy) is reduced by discharging the batteries too far too often.

But how do you know how far they have been discharged? You don't know unless you have a battery monitor. Our rig didn't come with one of those. :) So a good system will have a battery monitor such as those offered by Bogart Engineering - TriMetric or PentaMetric.

My main point in this section is: Once you determine the amount of DC amp hour capacity you need, you should at least double it. That way, you are less likely to take your battery bank down below 50%. Of course, if you quadruple the size of your system, you will be even less likely to discharge the batteries too much.

But there is a fine line between buying too much capacity and having enough to keep the batteries in good shape as long as possible. It can be quite the dilemma.

Don't get enough capacity and you can't live like you want to without hook-ups. Or, if you do run all your appliances, you have to draw down the batteries too much and shorten their lives.

Or get too much capacity and you've simply spent too much money. That's another reason lots of folks stick to Wet Cell batteries. It doesn't hurt the wallet quite as bad to make sure you have enough capacity and, if you have too much, you have not thrown away quite as much as with AGMs.

Battery Charging
Well, if you are always going to have hook-ups, you don't need to worry too much about the house battery(ies). Whenever you have an electric hook-up, your battery will get charged automatically. Virtually every rig has a built-in charger of some kind. The quality of that charge depends on a couple things we will discuss later.

Most Popular Battery Charging Methods
RV batteries are charged by either a **converter**, an **inverter/charger**, or by **solar panels**. Your batteries are also charged by your motorhome or tow vehicle's alternator as you go down the road, but that is not a primary means of charging your batteries. There are other methods of charging, such as wind power, etc. but we will just discuss the three most popular.

NOTE: The different types of deep cycle batteries - wet cell, gel cell, AGM - have varying charging requirements. So it is important to make sure whatever charging method is used is suitable for the type of batteries you have.

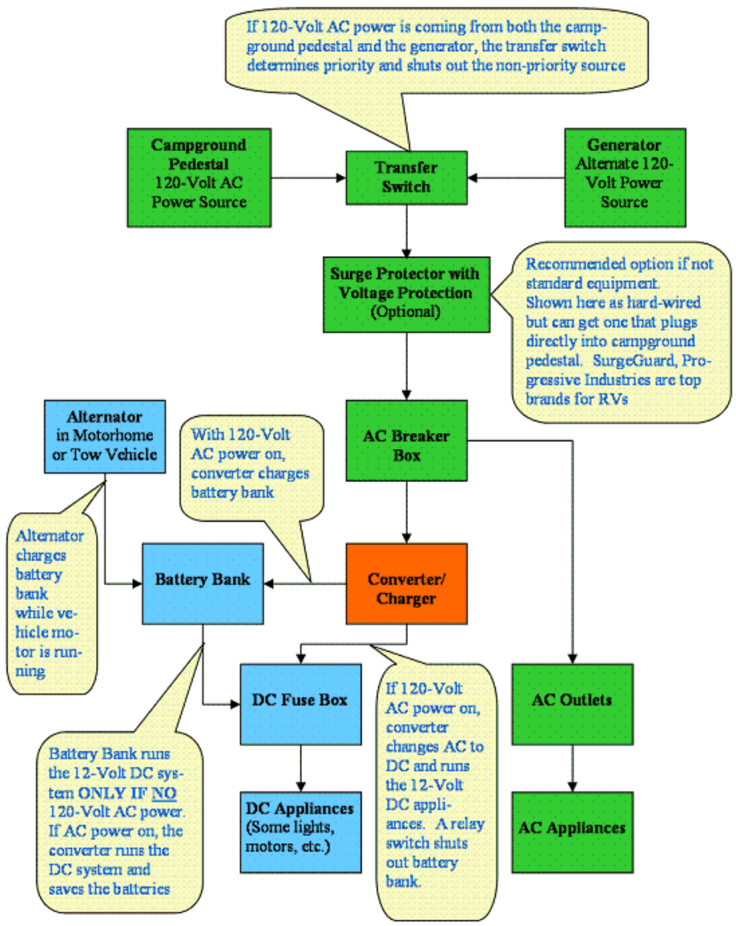
Converters
A **converter** is a device almost every towable RV comes with. It takes AC power and "converts" (changes) it to DC power. There is a relay switch inside the converter that takes your batteries out of the circuit and the converter supplies power to the DC appliances rather than using the batteries to power those appliances.

The converter's other job is to convert the AC power to DC and charge the house batteries. So if you are plugged into an electrical pedestal at a campground, the converter is automatically charging your batteries **and** running your DC appliances.

If you are not plugged in to "shore power", but you are running your generator, again the converter is automatically charging your batteries **and** running DC appliances.

The diagram below shows a typical RV electrical system set-up with a converter.

Typical Electrical System Set-up With A Converter But No Inverter



In this configuration, there is no inverter. Therefore, without shore power or a generator, you can't run AC appliances.

Now, most electrical experts will agree that the converter that comes from the factory in most RVs, while functional, is not the best method for charging your house batteries. In fact, that is probably an understatement.

Standard converters do a terrible job of regulating how much charge goes into the batteries and they can "cook" them. Batteries are sensitive little critters.

Also, standard converters are designed only to keep the batteries topped off. So they also do a terrible job of re-charging deeply discharged batteries.

An option is to upgrade to a converter that has multi-stage charging capabilites. They are "smart" chargers and prevent the overcharging of batteries. You can also get external devices (Charge Wizard brand, for example) that plug into some existing converters to regulate battery charging.

Inverters
An **inverter** is a device that inverts (changes) DC power (battery power) to AC power so that

you can run AC appliances in your rig without being hooked up to shore power or without running a generator. Many motorhomes and some upper line fifth wheels come with an inverter as standard equipment. Ours did not.

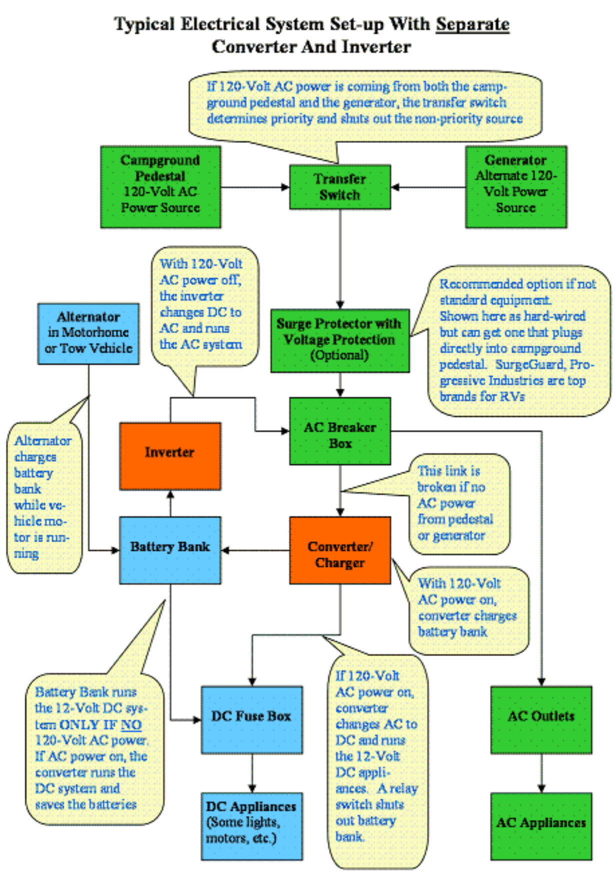
Those RVs that have an inverter will also have a converter **OR** the inverter will be an inverter/charger.

Again, the standard inverter that comes with your rig may not have the capability that you want or need. This is another reason why it is very important to determine the watts required to run the appliances you want to run when not hooked up to AC power. You can have all the battery capacity in the world, but if your inverter cannot produce the watts you need, you won't be happy.

Inverters are rated by the number of watts they can supply to your AC appliances. In other words, a 3,000 watt inverter can provide 3,000 watts of continuous power to a combination of appliances.

Inverters also have a surge rating that will be higher than the continuous watt rating. If you recall, AC appliances require a little extra power upon start-up, so the inverter should be rated to handle those surge wattages.

The following diagram shows a typical set-up where the RV has both a converter and a separate inverter.



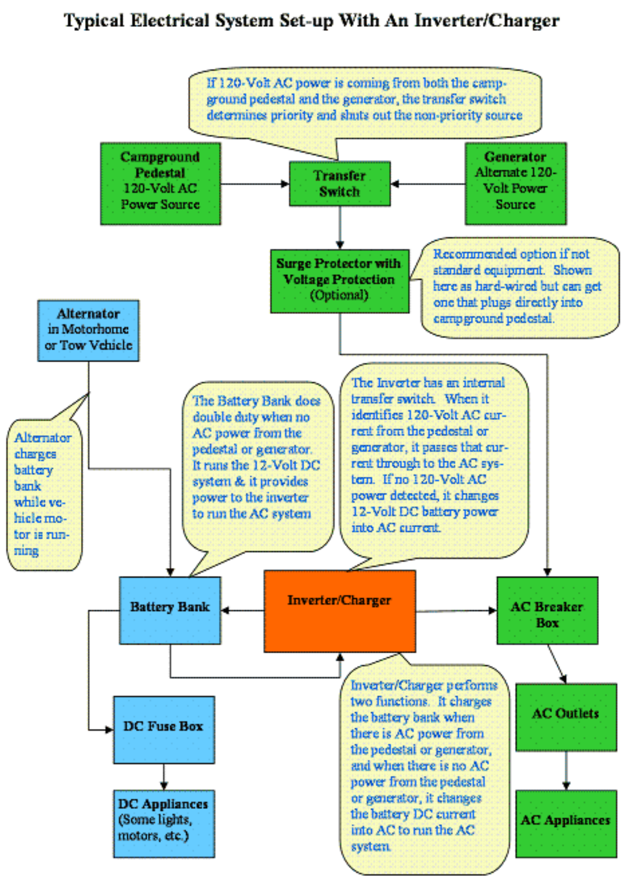
An **inverter/charger** performs both duties. It inverts DC power to AC and also converts AC to DC to charge batteries.

Again, it is best if the charger portion of the inverter/charger is a multi-stage charger that regulates the charge to the batteries. Multi-stage chargers provide a "bulk" (or boost) charge to quickly get batteries to 75% to 90% of capacity. Then the charger changes over to an "absorption" (or normal) charge in which the charge slows down as the batteries approach a full charge. Finally, the multi-stage charger goes into "float" (or trickle or storage) mode to top off and maintain the batteries while making sure the batteries do not get overcharged.

I won't get into the technical reasons why this multi-stage charging is best for your batteries. That could go on and on. Just remember to have a multi-stage or three-stage charger in your converter or inverter if possible.

Also, if you have a good inverter/charger and solid battery bank, the need for a converter goes away.

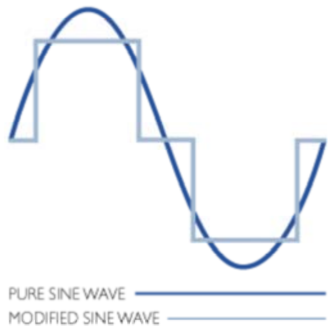
The next diagram is a typical set-up with an inverter/charger and no converter.



While we are on the subject of inverters, we have to discuss pure (or true) sine wave vs modified sine (or square) wave inverters. Huh? Yeah, that's what I said.

Let's keep it simple. The utility company supplies AC power that comes into a house or campground pedestal in a pure sine wave form (as shown in the graphic in the AC / DC section above). It's a nice up and down smooth curve. All appliances like the pure sine wave.

Higher priced inverters change battery power into AC power with a pure sine wave. However, many inverters change battery power into a modified sine wave. The two wave forms are shown below.



Modified sine wave inverters are much less expensive than pure sine wave inverters, and they will run most AC appliances. That's why RV manufacturers use them and why many people choose not to go with pure sine wave inverters.

However, many electronic devices (such as laptops), medical equipment, laser printers, and other appliances can be fried by modified sine wave inverters. So, if you want to be able to run all your AC appliances without worry, a pure sine wave inverter is the way to go.

Of course, if cost is an issue, then the modified sine wave inverter will work with most things. But you need to be very careful about which appliances will be okay and which ones won't.

My suggestion would be for full-timers to spend the extra money, if possible, and go with a pure sine wave inverter.

Solar Panels
The quietest, cleanest, cheapest (after initial purchase) way to charge batteries is via **solar panels**. It is the preferred choice of serious boondockers and all those that like to park without hook-ups and not use generators.

Sunlight is free as opposed to fuel (propane, gas, or diesel) for generators. And there are no noisy motors required (as in generators) for solar panels to charge batteries.

Of course the downside is you can't always depend on clear, sunny skies and solar panels are not real productive in shade. And solar panels are very expensive battery chargers. As said before, they provide the cheapest energy once installed, but the upfront costs make it hard to recover your investment.

Many folks think solar is complicated. I did too. But the complicated part is what we have already discussed on this page. Once you have a solid battery bank, and a good inverter/charger, the solar panel part is a piece of cake.

Solar panels are nothing more than battery chargers. Sure, you still have to figure out what type, size, and number of panels, but just remember that they are still simply battery chargers.

Okay, there are a few different types of solar panels. But we aren't going to get into that. They all work in basically the same manner. The important things to know are what output they have, how many you need, and how many you can fit on your roof.

Solar panels are rated by watts of output and the more watts they produce, the larger they are. But they also have volts and amps ratings as well. That is helpful because our Watts = Amps X Volts equation can be used to help us determine what solar panels we might need or want.

Keep in mind, we don't need to know output to power appliances - the batteries and inverter do that. We just need to know output to make sure we have enough panels to re-charge our batteries based on our battery usage when not hooked up to electric.

The calculations to determine how much charging power you need in solar panels can get extensive. A general rule of thumb is to get 100 watts of panels for every 100 amp hours of battery capacity. Of course all individual needs will vary, so if you are serious about solar panels for your RV, check out the following websites:

AM Solar

RV Solar Electric

Palmer Energy Systems

Jack Mayer's Solar Introduction

In addition to the panels themselves, you will need a solar controller or regulator. This is a device that is mounted between the panels and your battery bank. Because solar panels can produce more volts than the batteries can take, the controller manages the charge and makes sure the batteries get the charge they need.

The great thing about solar is you can add panels in stages. In fact, developing an entire system for "boondocking" can be done in stages. That's what we did. For a complete look at our electrical system upgrade click on Our Electrical System.

RV Electrical Wrap-up

Well, that wraps up our discussion of RV electrical systems. Hopefully, it was basic enough and detailed enough to satisfy a broad range of readers.

Our first goal here was to let novices like me know that they don't need to know everything to get started.

Our second goal was to try to break down the terminology and systems so that even the novice can understand the details, and so the more electrical saavy person can see how RV electrical systems are laid out.

Our third goal was to help all RVers in the selection of their systems up front or in the modification of their current systems.

Please let us know if there are any glaring errors in the above discussion. Thanks!

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