Inverters – What are they, and do I need one?

Another question I get asked a lot, so let's cover what inverters are and why you may want one. From there, we will cover the types, and how to choose an appropriate ***Inverter*** for your RV.

Electrical Power

Before we talk about inverters too much – let's cover the two types of electrical power generally available in your RV. They are:

- Direct Current (DC) or battery power (supplied by your RV or ***Coach Battery***)
- Alternating Current (AC) – often referred to as ***Shore Power*** (same as household power)

DC power, or battery power is the type of power you find in everything from a flashlight battery to your automobile battery. In your RV this is typically ***12 volts Direct Current*** supplied by one or more batteries very similar to a car starter battery. This battery powers items such as your bathroom or kitchen fan, water pump, inside lights, slide-outs and jack/equalizer systems, furnace, and perhaps the fridge.

AC power is the electrical power found in your house. It powers everything from game consoles and television sets to the microwave oven and dishwasher. (Hair dryers, curling irons, tool chargers, washer and dryer all use AC too). This power – for most appliances ***120 volts Alternating Current*** is produced via a power plant or hydroelectric dam and is not stored anywhere in your house.

Where Does the Inverter Come In?

When your RV is plugged into ***Shore Power***, you have access to both types of electrical power, allowing you to run everything in the RV (given any limitations of your power source).

It is when you are ***unplugged*** from ***Shore Power*** that a difference can be seen. Fans, lights, and water pump should continue to work, as they run from your (12V) ***Coach Battery***. However, those power outlets for the TV or microwave will no longer work. The difference is you no longer have access to 'The Grid' supplying AC power to your RV. (Unless, of course, you're connected to a generator).

The previous paragraph hints at something. That is: If you specifically park only in RV Resorts, Provincial/State Parks with electrical service (or 'mooch-dock), then you are always plugged into Shore Power. ***If you are always plugged into Shore Power, there is no need for an inverter.***

This is because ***an Inverter is simply an electrical appliance that allows you to convert your Coach Battery (DC power) to household (AC power),*** allowing you to run those typical household appliances that are normally only available when you have Shore Power (or running a generator).

So, an ***Inverter*** may be an option if your RV lifestyle is a combination of ***boon-docking*** (dry-camping) and a desire for those special appliances that only come with AC power. (Think: Margarita blender, ice maker, or TV and Netflix on a cold windy day).

Volts, Amps, Watts and Inverter Sizing

Inverter specifications will include several electrical terms which may become confusing, amps; volts and watts. When installing an inverter, these are important relationship(s) to understand, particularly because two different power systems are involved; the ***12V* DC** side and ***120V* AC** side. For the end-user, it's much simpler to consider an inverter based upon its capacity rating in watts.

Common inverter sizes are 750, 1000, 1500, 2000 and 3000 watts. (Inverters smaller than 750 watts will be touched on later). The size you require is determined by what you wish to run.

Putting this into context. Your typical household electrical outlet is capable of 1800 watts. This means that same outlet will run a 120-watt TV, 360-watt phone charger, and a pair of 200-watt lamps simultaneously. (120+360+400 = 880 watts). That same outlet will also run a 1,500-watt hair dryer – although not at the same time (and plugging ***two*** 1500-watt hair dryers in that same outlet should trip your circuit breaker). Keep this in mind when sizing an inverter. A 1,000-watt inverter will run that TV, phone charger and lamps mentioned previously, but a minimum 1,500-watt inverter would be required to run the hair dryer.

Inverter Power vs Shore Power

So, let's get back to your RV. A 50 Amp RV service is capable of 12,000 watts. That makes it capable of running at least six (6) standard outlets at full capacity. It's also over four times (4x) more than the largest inverter (3,000 watt) mentioned above!

> Note: If your RV only has a 30 Amp service, it is only capable of 3,600 watts (due to the way they are wired). That's only a little more than a 3,000-watt inverter.

The bottom line is that in either case is that most inverters will not run every electrical appliance you might otherwise run when plugged into Shore Power, at least not simultaneously.

Capacity Planning - What do you plan on running?

If the first answer to this question is your air conditioner, be aware that this requires some deep pockets for power consumption (and wallet). Not impossible – but a challenge. Much the same for residential style refrigerators and any type of electric heater or water heater.

However, if you want to power a TV, CPAP, tool charger, or coffee maker, sizing an inverter requires evaluating the power requirements of all the items you wish to power (simultaneously) and the budget for the inverter, plus the battery system to support it.

Back to Batteries

I'm going to talk about lithium batteries (LiFePO4) here simply because they deliver a very accurate idea of their capacity, in watts. A typical 100 Amp / 12V (12.8V) lithium battery has 1280 watt-hours of capacity. (100A x 12.8V = 1280 watts). Let's look at a couple of examples of how this relates.

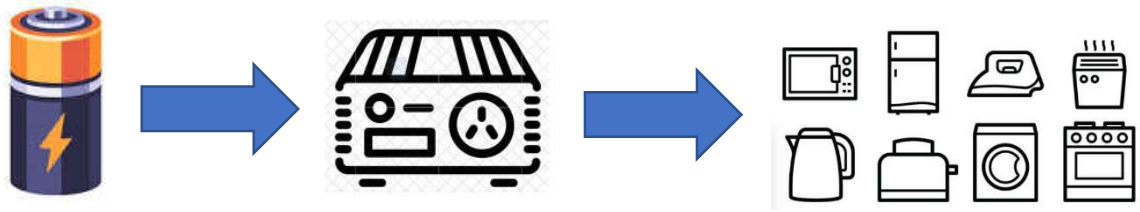
Suppose the weather is cold and windy – forcing you to run a 6-hour Netflix marathon on your TV. How does that relate to your battery capacity?

Assume that TV uses 80 watts/hr., and yes you run it for six (6) hours. That power draw would be 6 hours * 80 watts or 480 watt/hours. Not even half of your lithium battery capacity. Now add a popcorn maker running 10 minutes, once an hour for 6 hours. If that popcorn maker is 500 watts, that's 500 x 1/6 hours * 6 hours or 500 watts. 500 watts + 480 watts is 980 watts – about 75% of your battery capacity.

Here's a second example using that 1500-watt hair dryer. If you use it for 3 minutes (1/20 of an hour), it will only use 75 watts of battery capacity. (1/20 x 1500 = 75). This is only about 6% of that battery's capacity.

A last example is the typical NorCold RV fridge, using 650 watts on AC mode. If the fridge runs 30 minutes of every hour, in six (6) hours, that fridge will have used 1950 watts. More than a single lithium battery can sustain[1].

What becomes clear, then, is not only inverter size, but battery capacity required to sustain that power draw for your devices.



12V/DC Battery Inverter 120V/AC Appliances

[1] And why I suggest running your fridge on propane, not AC, even if you have an inverter system.

Inverter, Inverter-Chargers, Transfer Switches

The simplest inverters are just that – an appliance that converts your RV battery power to household power – and for simple installations (see the first four (4) wiring methods below) nothing else is required. However, as inverter capacities increase, and the ability to energize more outlets becomes feasible, other options may be included.

Automatic Transfer Switches (often referred to as just Transfer Switches) perform the function switching from one AC source to another. Generally, this is either from Shore Power to a Generator, or from Shore Power to an inverter. Automating this process prevents you from having to manually change switches or re-route your RV power cord. Many inverters now include a Transfer Switch – particularly those with built-in (battery) chargers.

Most larger inverters ***do*** include a Battery Charger (or Converter – which is simply a hard-wired battery charger) for re-charging your batteries when hooked up to shore power. By integrating the three devices (Inverter, Charger, Transfer Switch) the power is always going in the right direction to or from the batteries, which usually simplifies the wiring involved.

Wiring in the Inverter (see diagrams below)

Once you have determined which devices you wish to power, the method of wiring in an inverter becomes a consideration. Here are five common methods.

- Small Inverter with Single Appliance
- Small to Mid-Size Inverter with Power Bar Extension (or sub-panel)
- Mid-Size Inverter with Dedicated Single Circuit
- Shore Power "Wrap-Around"
- Single Leg Inverter System
- Dual Leg Inverter System

Small Inverter with Single Appliance

In this scenario, a small inverter is used to power a single, typically low-power device. Referring to those inverter sizes from earlier – a low power, dedicated inverter may be used to power a small television or perhaps a CPAP. These inverters are usually less than 750 watts. Often called a "point of service inverter".

Small to Mid-Size Inverter with Power Bar Extension

Like the first scenario – but instead of a single device, often a power bar is plugged in, or perhaps a single dedicated outlet – able to distribute power to multiple devices – although not necessarily at the same time. For example: An electric bike charger by night, and a vacuum or tool charger by day. Often these inverters are in the 750-to-1500-watt range, as they are only large enough to power a single device – or several small ones. Sometimes a small sub-panel is used to distribute to several dedicated outlets.

Mid-Size Inverter with Dedicated Sub-Panel or Circuit

The wiring on this gets a little more complicated. Usually a main panel is 'split' or a sub-panel added to power up a range of outlets – perhaps in the kitchen or bedroom area. While any sized inverter can be wired in this way – it usually makes more sense in the 1500 watt and up category as the overall potential load will be higher. Note: Many Class-C RV's such as the Winnebago Fuse or Leisure Travel Vans are wired in this way.

Short-Power "Wrap Around"

With this method, the inverter is mounted within the RV, in a physical position where it can be accessed by the **Shore Power** cord. (Often with a cheater/adapter) Then the **Shore Power** cord is plugged into the inverter. This method allows you to run everything within the coach, albeit within the limits of the inverter. You, in essence, become the 'Automatic' Transfer Switch; plugging and unplugging from the inverter power as required. The downside of this is you may have to turn the **Converter** off to prevent a feedback loop that drains the battery(s).

Single Leg Inverter System

Up until now we have discussed single-purpose inverters. At this level we are looking to power up all the RV in a 30 Amp service, or all the circuits, except the air conditioners, in a 50 Amp service. This is where a Transfer Switch, either integrated or as separate device, comes into consideration. Transfer Switches act as a traffic cop – switching between available AC sources of Shore Power, or Inverter/Generator.

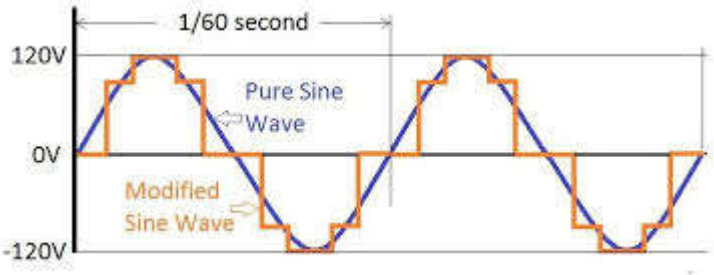
Dual Leg Inverter System

Dual Leg systems typically apply only in RV's with 50 Amp service. By powering both incoming power lines, all outlets – and Air Conditioners – can be made live. A 50 Amp service can sustain huge power loads (12,000 watts), therefore design and implementation are important. (Example: A 12 volt versus 24 or 48-volt battery system to supply the inverter).

Modified Sine Wave or Pure Sine Wave

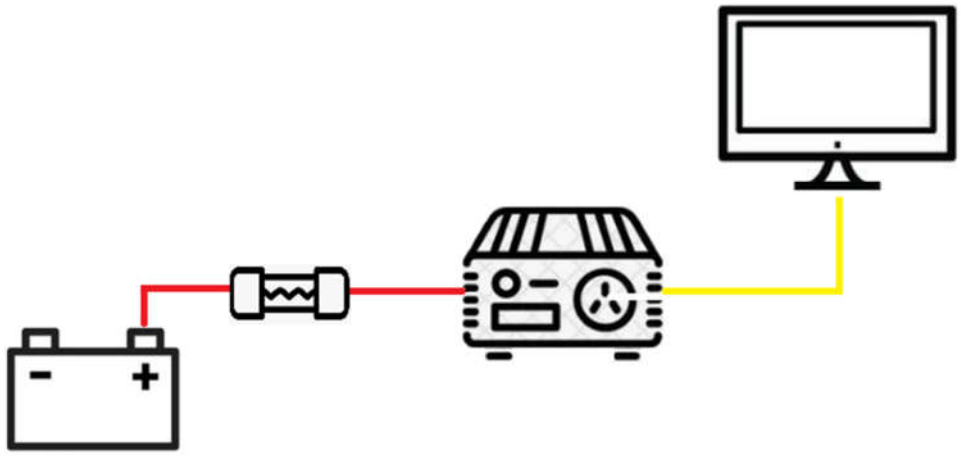
The power in your home, Alternating Current or AC, is like a smooth wave. (See below). Modified Sine Wave inverters have a choppier waveform. As such items with motors (fans) or compressors may still run – but lose some efficiency – sometimes even overheating or creating uncharacteristic noise.

Most modern electronics and medical equipment such as CPAPs and Oxygen Generators rely on the smooth waveform of a Pure Sine Wave to operate correctly. In my experience it makes no sense to use a Modified Sine Wave in any but the most specific of applications.



Connecting Your Inverter

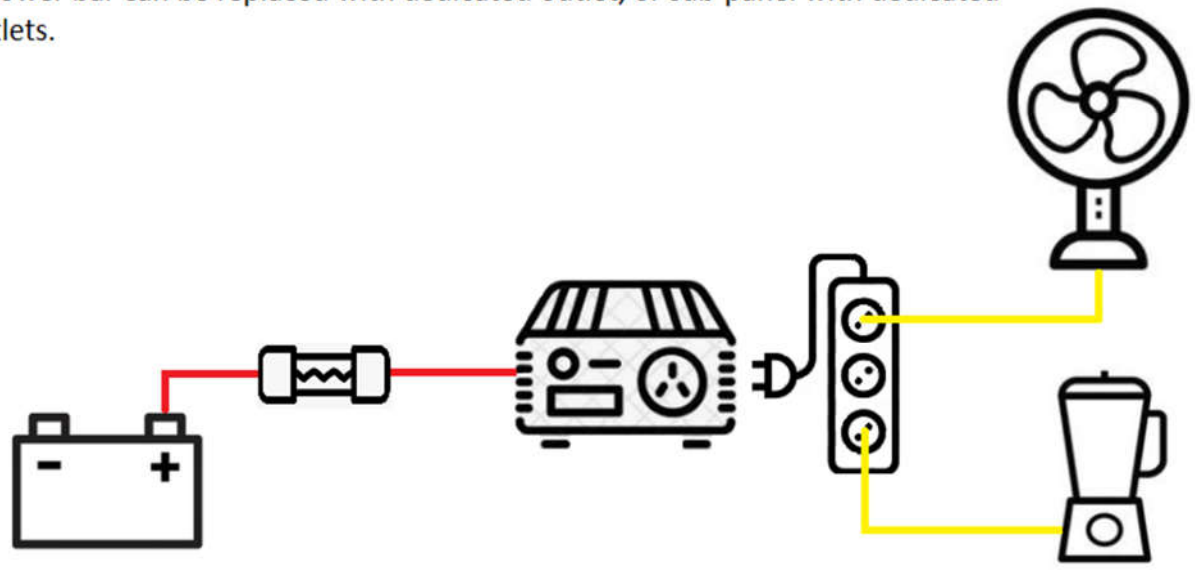
Small Inverter / Single Appliance



Typically, only used in small appliance circumstances

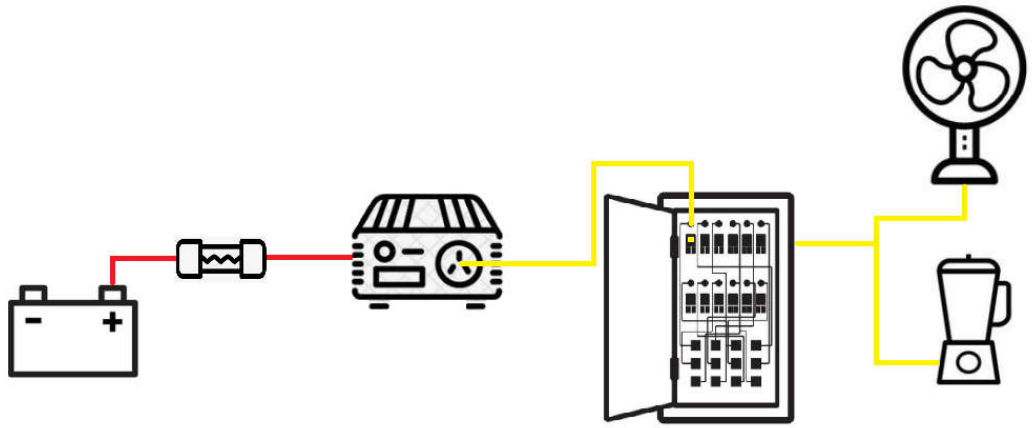
Inverter with Power Bar as an Extension

- Power bar can be replaced with dedicated outlet, or sub-panel with dedicated outlets.



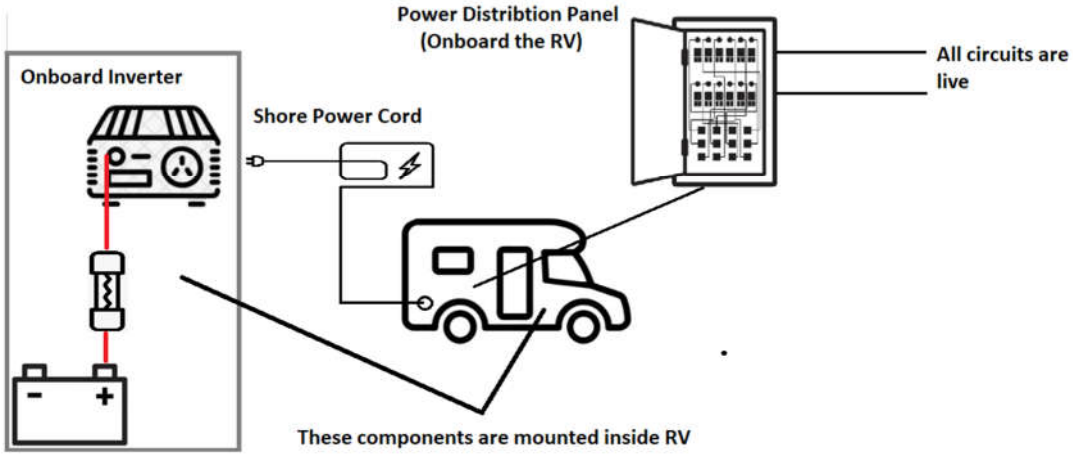
Note: The above scenario might be modified to have a dedicated sub-panel and associated outlets in place of the power bar or extension cord to the inverter.

Inverter Install - Dedicated Circuit Only



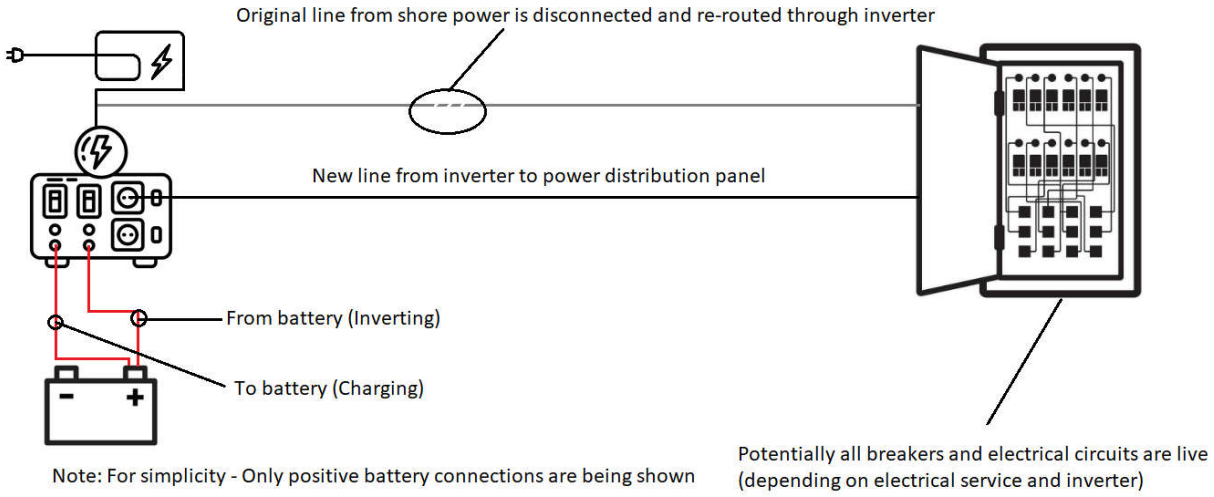
* Often used in small Class-C systems

Inverter install without Automatic Transfer Switch**



** Turning off the **Converter** is probably necessary when using this method.

Inverter Install - Inverter/Charger/Transfer Switch



Lastly – Ratios: How Much Battery and Solar do you Need?

Here are some general rules for sizing your inverter, battery and solar. While they are not universal – they do provide a good baseline for sizing your system. However, weather, runtimes, and your power audit[2] may affect these significantly.

- 100 Amps of Useable Battery Capacity per 1000 Watts of Inverter (100A:1,000W or 1:10)
- 200 Watts of Solar per 100 Amps of Battery Capacity (200W:100A or 2:1)
- 10:1 DC amps to AC amps. For every AC power amp, count on 10+ for the DC side

How many batteries, the way they are wired, and how quickly you wish to recharge them all play a significant factor for design consideration, but this is a good place to start.

[2] See Article: Power Audit – How to Perform