CONVERTERS - INVERTERS....WHAT ARE THEY, WHAT DO THEY DO?

Basically they are transformers that do different functions. First, let's discuss ***CONVERTERS***. The converter is an electronic device that is plugged into the RV's 110VAC electrical system and converts the incoming 110VAC down to 12VDC to charge the battery(s) and supply your 12VDC needs within the RV. The converter steps down the voltage and removes the AC current to provide a DC current output.

Linear Converter

There are basically 2 types of converters used in the RV industry, LINEAR (or also known as ferro-resonant) and SOLID STATE. Most linear converters were used in older RV's; were large and bulky, produced an audible hum and provided "dirty" DC output (in other words there was AC ripple present in the DC output, up to 6VAC could be measured in the DC output). This usually resulted in sensitive electronics humming or causing problems with refrigerator control boards. This type of converter REQUIRED a good battery be connected to it. The battery acts like a capacitor to "absorb" the AC ripple and regulate the voltage output. Without a battery attached, this converter would put out excessive voltage and cause circuit damage. Some converter manufactures (like Magnetek/Parallax) provided "filtered" outputs on their DC distribution boards which were basically directly connected to the battery and powered the refrigerator, DC television and antenna amplifier power outlet which would receive the "cleanest" power from the system. When the battery was disconnected these circuits would be dead. Linear converter types are still found today in lower quality RV's and tent trailers due to the lower supply costs.

In recent years the needs of RV's have changed We are seeing more sophisticated electronics on board, many appliances are using more sophisticated electronic control boards to control the functions of these appliances and require very clean regulated DC power to operate properly .

Solid State Converter

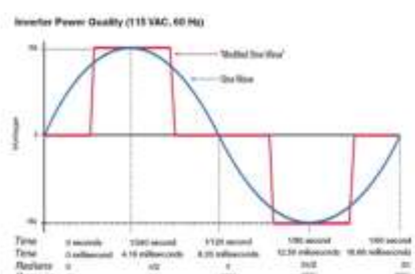
Hence the advent of the SOLID STATE converter. Solid State Technology means simply that the conversion of AC power to DC power is accomplished using electronic components such as transistors instead of transformers and rectifiers. These units obviously are more complex and like any electronics, cost more to produce hence, they are considerably more expensive than their predecessors, but offer a very clean, self-regulated voltage output with or without a battery attached to the system. This type of converter has built in voltage regulation that varies the output depending on the system demand and the battery charge condition. Properly operating solid state converters will not overcharge your batteries if they are in good condition. Failed or shorted batteries can cause the converter to read the system improperly and it may try to compensate for a shorted battery and therefore cause voltage issues. The same holds true for linear converters so it is always important to maintain your battery bank and replace any defective batteries immediately to prevent circuit damage.

Converter output is rated in AMPS (Direct current amps as opposed to alternating current amps - has nothing to do with how big your incoming shoreline is - will discuss wattage later). Most current production motorhomes, travel trailers and 5th wheels have converters rated between 45 and 80 amps output, depending on the amount of electronics onboard and the battery bank size. Obviously the larger the converter, the more 12VDC power it can provide. It is possible to "over-run" a converters output, but that's where the battery bank comes in. For instance, you could have a 45 amp converter in a trailer, turn on all the 12VDC lighting and appliances and easily be pulling over the 45 amp rating of the converter. In this case the excess draw is being provided by your battery bank, and the converters function is fully dedicated its output to replenishing the power being taken out of the battery bank. Once the electrical loads are removed, the converter will continue a high output while the battery bank is recharging and taper its output down until the battery is fully charged. Under normal load circumstances, this doesn't happen so once the battery bank is fully charged the converter just stands by at low output waiting to provide any 12VDC electrical needs inside the RV and the batteries stay fully charged and are not required to discharge while plugged in to shoreline utility power.

At this point we should discuss how much 110VAC electrical power is required to run a converter. Let's take the bigger converter for the example. An 80 amp power converter under full load, either supplying electrical needs or charging a low battery bank will consume 1300 WATTS of 110VAC power, or roughly 12 amps of your 30 or 50 amp shoreline supplied power. Of course, when the converter is idle (batteries charged/no loads), it pulls a very minimal amount of the AC power.

Portable Inverter

INVERTERS are an electronic component that basically operates just the reverse of a converter. There are 2 basic types of inverters, a stand-alone inverter and an inverter/converter combination. First, let’s just focus on what an inverter is designed to do. Inverters are designed to take power from a 12VDC battery bank and produce 110VAC power for use inside the RV when not on shoreline (i.e. traveling or dry-camping). Inverters use a transformer and sophisticated electronics to boost the 12 volt DC power and produce 110 volt AC power. Inverter output is rated in AC WATTAGE. Inverters are available in many sizes ranging from a 45 watt unit you can plug into your cigarette lighter socket to power a small appliance like a laptop computer all the way up to 3,000 watts and larger which require hard-wiring into your electrical system. Inverters are available in 2 types of outputs; modified (or "quasi") sine wave, and pure sine-wave. Pure sine-wave inverters use much more sophisticated circuitry, and produce as accurate a 110VAC power source as utility power. Consequently, they are much more expensive then modified sine wave versions. Modified sine-wave inverters are less expensive and are the more common type found in RV's. The only drawback to the modified sine wave inverter is that the output is not a true sinusoidal wave form as utility power is. In other words if seen on an oscilloscope, the "edges" of the sine-wave are squared off instead of a smooth uniform wave. Under normal circumstances, this is of little consequence except some appliances like microwaves make an unusual humming noise during operation and digital clocks which rely on measuring 60 Hertz power



will not keep time properly. *Some small plug in transformers, like cell phone chargers may run hotter or not at all on modified sine wave power, or could even be damaged by the modified wave form.* Inexpensive television sets that have minimal power filtering built in may display unusual lines rolling across the screen or have an audible buzzing. But for the most part, most 110VAC appliances don't seem to be affected by modified sine wave power. The obvious down-side of an inverter is that they require considerable amount of 12VDC power to produce 110VAC power. Therefore they are normally used sparingly when off shoreline to produce power and their use is limited by the amount of 12 volt power available to them.

The stand-alone factory installed inverter is utilized by some RV manufacturers to provide temporary power to certain appliances when dry camping, usually the audio video system and/or 1 or 2 power outlets inside the RV. They are usually rated at 200-1000 watts. Most incorporate some form of internal power switching which allows the normal power to flow through them under shore-power conditions, and a remote switch which will turn the inverter on when the RV is off utility power so no “plug switching” is required.

Combination Inverter/Converter Hard Wired – Modified Sine Wave

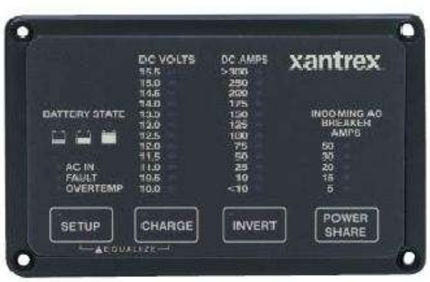
The more commonly found inverter, the **INVERTER/CONVERTER COMBINATION** –or- “Combi-Inverter” is found usually on mid to upper level RV’s. These systems are sizable and hard-wired into your electrical system by the manufacturer, or can be added aftermarket with considerable wiring modifications. The Combi-Inverter incorporates the converter functions described above plus the ability to provide inverter power all in one electrical unit. This type of unit requires a considerable battery bank to operate properly, and is usually paired with a minimum of 2 deep cycle batteries, but often 4-6 or more batteries are paired to the unit. Connections to the battery bank are made with heavy gauge wiring and are protected by an in-line “T” type or “ANL” fuse rated just above the highest charge or discharge amperage the unit will handle. Obviously, the more battery power available, the longer the inverter can provide power. This “hard-wired” version inverter is usually set up to supply power to the RV which can include the microwave, audio/video systems, and the 110VAC outlets within the RV. They are not wired to heavy load items such as the electric water heater element, the air conditioner or the refrigerator electric heating elements as operation of these components off the inverter would quickly deplete the battery bank. When incoming utility power is sensed at the combi-inverter, as when the shoreline is connected, or the genset is in operation, it will automatically go into charge mode. These units are capable of heavy bulk charging of the battery bank, usually at a much higher rate than a standard converter. Some 3000 watt inverters can charge at a rate of 140 amps of DC current! The combi-inverter has internal transfer switches which close and the incoming power is now routed to the outlets that the inverter is capable of providing power to. Some of the incoming power is also utilized for the converter function. This can, under certain circumstances cause issues, we will discuss *power share* later. Usually, circuit protection for inverter output supplied circuits are incorporated into the inverter via a resettable circuit breaker on the unit or at an electrical "inverter output sub-panel" which is separate from your main 110VAC circuit breaker panel. The combi-inverter is powered via a circuit breaker (usually 20 or 30 amps) in the main electrical panel labeled "Inverter". Hence, if an over-current condition occurs on one of the inverter supplied branch circuits, the corresponding circuit breaker will usually be found on the inverter or the sub-panel, but if the combined overcurrent was excessive (such as a high charge rate plus heavy loads), it could trip the circuit breaker in the main panel.

During charging, the combi-inverter/converter's charge rate is varied as described above under solid state converters. They are self-regulating, and charge rates are varied depending on battery charge condition, temperature and 12VDC loads in use. One condition that can occur is a power source circuit breaker tipping due to high charge rates – let me give you an example of how this can happen. In this scenario, let's assume you have been out "dry-camping" for a weekend and have been relying heavily on your RV's batteries to run your loads, the inverter has been in use and your house batteries are pretty well depleted and very low on charge. You get to the point where you can plug in the shoreline to utility power to recharge your batteries, but instead of a 50 amp supply, you only have 30 amps service or less available. You plug your RV in and within a minute or so, the circuit breaker at the utility service trips off. Why? With the capability of very high charge rates, the combi-inverter/converter can draw a high rate of current from the 110VAC power source in an attempt to quickly charge the batteries with a bulk charge rate. A 3000 watt combi-inverter/converter will pull up to 28 amps of the 110VAC source during full load charging. It's trying to put it's 140amps of 12VDC charge into the discharged battery bank to bulk charge the bank. Obviously, anything more than 2 amps being used inside the RV will exceed the incoming 30 amp breaker rating and cause it to trip. For this reason, most inverter remote panels will have an option to either set the incoming breaker size down, or some units call it "power share". In any case, changing this feature to a lower setting will cause the charge rate to slow down. So in our scenario, if you are on a 30 amp incoming power source, and you set the combi-inverter/converters power share or incoming breaker setting down to say 15 amps or lower instead of the default setting of 30 or 50 amps, the charger will limit the amount 110VAC amperage it will pull from the incoming power supply and slow the charger rate down and thereby allow it to "share" some of the available 110VAC with your other power needs inside the RV. It will just take longer to charge the batteries at the lower rate. You can modify this scenario in different ways to say include a situation such as being plugged into a 50 amp power source, and needing to run 2 air conditioners (12 amps each, so 24 amps plus the charger pulling 28 amps= 52 amps, not to mention other loads like the refrigerator) and causing an overcurrent condition thereby tripping the source circuit breaker, the resolve is the same, set the incoming breaker rating down to slow down the charger. These scenarios can also trip circuit breakers on gensets for the same reasons.

Now let's talk a little bit about what the inverter can do for you. Many times when out "dry camping", use of the genset is undesirable for various reasons. When you need electricity inside the RV, the inverter is a very convenient way to supply it. But convenience has its limits….your battery bank size and condition. One nice feature for motorhomes is that during travel the inverter can be left on whenever the engine is running as the alternator charging will offset the power being consumed by the inverter.

Whenever the inverter is in use (even in “stand-by”) it is drawing power from your batteries and draining them. How fast it drains them depends on what you are powering with the inverter. Most inverter owner’s manuals include charts of common appliances and how much power they consume and how they relate to the battery discharge rate. But suffice to say, the more power they need, the faster they will discharge your batteries. For example, use of a LCD or LED television is a relatively low draw on the electrical system, so if you were to use your inverter to power the television and maybe a satellite system, depending on your battery size, you could easily get a full days’ worth of entertainment from the inverter before the batteries require recharge. But if you had a roast in your convection/microwave you wanted to cook that took 30 minutes, you may not make it through the cook cycle before the batteries discharge. This is because the microwave is a high-wattage appliance (the inverter pulls around 130-170 DC amps during operation). Another major consumer is the coffee pot. Because of the heating element in it, it has a high wattage rating, and is best used to brew the coffee then shut it off; continued use of the hotplate to keep the coffee warm will eat up your batteries quick. It makes more sense to brew the coffee, turn off the coffeemaker and use the microwave for a short period to reheat a cup if necessary. Parasitic loads are another issue. These are items that have memories and consume power even when turned off. A lot of electronics these days are parasitic loads, and they can add up. Digital clocks, plug in transformers (i.e. phone chargers), VCR’s, satellite receivers, televisions, microwaves (with clock display), even when turned off are continuing to consume power. Most of these loads are very small, but when your power source is limited they add up quickly and needlessly cause the inverter to pull valuable power from your batteries. Unfortunately, the only real resolve for this is to unplug these devices when not in use.

There is another issue that may arise with a hard-wired inverter on-board your RV. If you use adapters on your shoreline power cord to adapt down to a 15 or 20 amp normal household 3 prong plug that is controlled by a GFCI (Ground Fault Circuit Interrupter), which all exterior household outlets are required by code to have, you will probably trip that GFCI device. The reason is that the internal circuitry of the inverter bonds the neutral and ground together during inverter operation, and even though the inverter is not in operation, the GFCI will sense this connection as a ground fault and trip the device. Unfortunately, there is no resolve for this issue. Higher end inverters, and pure sine wave inverters are less likely to cause this malady.



Typical Inverter Remote with LED Bar-graphs

It’s important to understand what your inverter remote is telling you. Once again, you must familiarize yourself with your particular unit’s remote. It’s also worth mentioning at this point, there are manufactures out there that equip your new RV with an inverter and give you only a simple remote on/off switch to control it. Most if not all of these inverters can have a remote control/display panel added to them and the remote should be considered a necessity. You should ask your selling dealer to include one in the sale, or contact me to have one installed. Your best gauge of how hard your inverter is working is the amperage read-out (or bar-graph). Actually, a comparison can be drawn here with your automotive gauges. The amperage readout is akin to your instant MPG readout, in other words how much “fuel” (battery power) you are using at any one time, and the voltage is akin to your fuel tank level – the lower the reading, the lower your “fuel” level. One word of caution about the voltage meter, during heavy load operation it is not uncommon for the voltage reading to significantly drop – this is temporary and a more accurate reading will be obtained once the heavy load is removed.

Most inverters will turn themselves off if the battery voltage reaches 10.5VDC to prevent a deep discharge of the battery bank. This is called LBCO (Low Battery Cut Off), and on some inverters the point that LBCO occurs can be adjusted. Some inverter remotes also include features for automatic generator starting (AGS) when certain circumstances occur like low voltage, set temperatures to turn on the air conditioners or excessive load draws are detected. They may also have options to set generator “quiet time”.

Another important consideration is the *inverter set-up mode*. This tells the inverter what type and size battery bank it is attached to. *<u>If the set-up is incorrect, damage to your batteries can occur</u>*. Please refer to your specific inverters documentation to properly set up the inverter. Battery capacity is rated in AMP-HOURS (Ah). The inverter needs to know the Ah of the battery bank to judge charge and discharge rates. For instance, if you have 4 x 6VDC (golf cart) batteries, your battery bank is 440Ah. If your inverter is set for 2 batteries (220Ah) it will not fully charge the batteries. If set for a higher rating, say 660Ah it will overcharge the battery bank, so you can see that this setting is critical for proper inverter charge operation. The other critical setting is the type of battery bank. Different types of batteries require different charge parameters. For instance, if you have gel-cell batteries, which require a lower charge voltage and your inverter is set for lead-acid batteries, it will charge at a voltage rate that will quickly damage your battery bank. You must set the inverter for the type of batteries you have, lead-acid, gel-cell, or AGM because of the different charge parameters.

So in summary, an inverter is a very useful piece of equipment to have included on your RV, but it is important to understand that they do have limitations. I hope you have found this article enlightening and informative, and if you have further questions on how your particular system operates, or would like to have a system installed, please contact me.

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