POWER INVERTERS

THE BASICS OF 12 VOLT TO MAINS VOLTAGE INVERTERS EXPLAINED

When was it you last wished you had a quiet, dependable source of mains voltage AC power while parked away from hookups?

When you're camped with full hookups for several months, you may soon forget how convenient it is to use the microwave to warm up a cup of coffee at a moment's notice without needing to start up the generator. You get used to watching television into the early hours of the morning, without a thought as to what your neighbours would think if you used the generator to do the same thing on a site without hook-ups.

Power inverters excel in operating small loads for extended periods and large loads for brief periods. Modern technology inverters are reasonably efficient, even when operating microwave ovens, toasters, vacuum cleaners and big power tools. Although each of these appliances consumes a large amount of power, the short time they are typically used makes them easily handled by most of the larger-model inverters. In this regard, an inverter makes a perfect complement to a generator; having both can greatly extend the life of your generator by saving it for the few instances when it is really needed.

In travel trailers and fifth-wheels, an inverter may be a particularly attractive alternative to installing a generator, especially if no factory-provided generator compartment is available. Also, no aftermarket petrol tanks or propane plumbing are needed, although for the more powerful inverters high capacity good quality batteries will be an absolute necessity. Batteries, such as the large capacity 'Elecsol', are absolutly ideal for powering inverters.

DO I REALLY NEED AN INVERTER?

One question many RV owners ask when considering the purchase of either a generator or an inverter is: 'Is either of them really necessary? Couldn't 12-volt DC appliances be used instead?' In some cases, 12-volt DC versions are indeed available, but the variety does not begin to match that of the mains voltage AC model. For example, you are generally limited to TV sets that are 10 inches or smaller in the 12-volt versions. You can't buy a 12-volt DC microwave oven or air-conditioner. You may be able to find 12-volt DC versions of some power tools, hair dryers, steam irons, toasters, etc., but in most cases, the mains voltage AC models cost less and perform better.

WHAT DOES A POWER INVERTER DO?

Mains voltage AC generators and power inverters have been around in various forms for decades. Over the last few years both have been much improved by the incorporation of modern technology which has improved their electrical efficiency, reliability and cost-effectiveness. These improvements, along with a considerable increase in the number of models now available, help to explain their increasing favour among RVers. However, regardless of the make and model, they all perform just one basic task: converting the 12 volts DC to mains voltage AC required by most consumer appliances.

ARE THERE 110 AND 240 VOLT AC INVERTERS?

Power inverters suitable for RV use are currently available in two versions: 12 volts DC to 110/120 Volts AC at 60 Hertz and 12 volts to 220/240 Volts AC at 50 Hertz. However for the purposes of this article we will consider only the 220/240 Volt models.

HOW A POWER INVERTER WORKS

The conversion fr om 12 volts DC to 240 volts AC is achieved by using various different appr oaches, in r ecent years, depending on the design and ultimate use of a particular inverter model.

Low-frequency solid-state inverters use a 12- to 240-volt step-up transformer to provide the required voltage conversion. Since transformers only work with AC, the 12 volts DC from the RV battery is first converted to 50 hertz AC with an electronic switch before being applied to the transformer's input. The transformer then steps up this AC current to the 240-volt 50-hertz AC current required by most appliances.

The advantages of this scheme are numerous; since the process is completely electronic, no moving parts are present. This makes these inverters very reliable and totally silent. Recent design improvements make many of these models very efficient, with little of the consumed DC power being wasted within the inverter. Finally, the step-up transformer can also be used as a step-down transformer, allowing some models to double as efficient, high-current battery chargers.

Probably the only significant disadvantage to low-frequency inverters is their substantial size and weight (up to around 20kgs in a 1-cubic-foot package for the larger models), most of which is due to the step-up transformer.

High-frequency (switching) solid state inverters work similarly to their low-frequency cousins, but overcome the size and weight hurdles by feeding the step-up transformer with 12 volts at a frequency much higher than the normal 50 hertz. At this higher frequency, the

transformer can be made much smaller and lighter, without sacrificing any power-handling ability. However, since most AC appliances specifically require 50-hertz power, the transformer output must be rectified back to DC, and then electronically switched a second time at a 50-hertz rate before it can be used by the appliance.

While this approach may appear to be more complex than that of a low-frequency inverter, the whole process is still extremely efficient and reliable, and can result in an inverter with just one-tenth of the weight and one-quarter the package size of an equivalent low-frequency model. One disadvantage to this approach is that high-frequency transformers are not as easily adapted to serve double duty in a step-down arrangement. Consequently, battery-charger options are rare on high-frequency inverters. Another drawback is that the high switching frequency can occasionally interfere with radio and TV reception, although careful placement of the inverter in relation to the radio or television usually minimizes the problem.

INVERTER FEATURES

Probably the most obvious distinction among various inverters is their rated output power. An inverter's continuous-output-power rating is the amount of power (in watts) that the inverter will indefinitely deliver to any connected appliances. In applications where the inverter will be used to run televisions, VCRs, etc., for extended periods, this rating is probably the most useful.

Due to the limited size of an RV's battery bank, most larger appliances such as microwave ovens that are used in RVs are operated for well under 30 continuous minutes. Many inverter manufacturers realise this and provide a second intermittent-output-power rating, which is the amount of power the inverter can briefly deliver (generally for around 30 minutes). Naturally, this rating is quite a bit higher than the continuous-output rating (typically 40 percent), but is probably a more realistic yardstick in choosing an inverter for RV use, as long as the limitations are observed.

Manufacturers also occasionally provide a third output rating, which is surge power. This is the amount of power that the inverter can provide for a very brief period (usually under several minutes) and is helpful in determining if the inverter will reliably operate an appliance that requires a high starting current. For example, microwaves, power drills, compressors and fan motors draw several times their rated power consumption for the first few seconds of operation. An inverter with marginal surge-power capacity might be incapable of starting such an appliance, possibly leading to appliance or inverter damage. On some of the better inverters, surge-power ratings may be two or three times the continuous-output-power ratings.

One big selling point for some models is high efficiency. For example, in an inverter that is 60 percent efficient, only 60 percent of the consumed battery power actually does any useful work; the other 40 percent is wasted as heat within the inverter. Consequently, a high-efficiency inverter is desirable, especially where the size of the battery bank is marginal, as it frequently is in RVs. In some models, inverter efficiency can reach 97 percent, although it usually varies somewhat with load size. Most inverters are least efficient when powering a relatively small load.

In order to reduce inverter power consumption, many models are designed to partially shut down when there is no AC load present. These models periodically turn on for a brief instant, check to see if any load has been connected, and then turn back off if none is detected. This automatic standby feature allows the inverter to be left on for long periods of time, at greatly reduced battery drain (typically 0.10 to 0.25 amps).

In RVs where the inverter is wired into the AC power system, auto standby makes appliance use just as convenient as when hooked up to shore power. Simply plug something in and use it; no need to turn the inverter on beforehand or off afterward. Note that a few inverters manage to achieve very high efficiencies without an automatic standby circuit, offering no-load current consumptions under 0.10 amps while still providing continuous AC output.

Another characteristic that determines inverter quality is output waveform. Commercial AC power is a pure sine wave; this is the waveform with which all appliances are designed to operate. How closely the AC output from an inverter mimics this waveform often determines how well a given appliance will operate with the inverter. A few appliances (televisions, stereos VCRs, clocks and some motors) can be very picky about waveform; others (light bulbs, toasters and most other heat-producing appliances) will tolerate just about any waveform.

SQUARE WAVE OR SINE WAVE OUTPUT?

The lowest-price inverters generally offer a square-wave output, while the more expensive models provide a modified sine-wave output, which comes closer to looking like a pure sine wave. In general, the modified sine-wave models have few appliance compatibility problems.

If there is some question as to whether a particular inverter will operate the appliances you intend to use, ask your inverter dealer. If some doubt still remains, insist on being allowed to exchange the inverter for another model if the original model proves to be incompatible.

Inverters with pure sine-wave-output waveforms are now becoming available, but they tend to be more expense and some of the earlier models had a lower efficiency which made them good choices only in applications where no other type of inverter will work. They are particularly good at eliminating hum in audio equipment.

Like output wave-form, frequency regulation can be important when operating certain loads. Unlike commercial AC power, the output frequency of some inverters may not always be exactly 50 hertz, varying with battery voltage, appliance load or ambient temperature. Since some appliances are designed to use the 50-hertz AC waveform to perform internal timing tasks, performance may be disappointing when they are used with an inverter lacking sufficient frequency regulation. For example, most electronic clocks will not keep accurate time without precise frequency regulation. To avoid this problem, the output frequency of many inverters is indirectly controlled by a quartz crystal oscillator, which yields excellent frequency regulation.

AVAILABLE INVERTER OPTIONS

Many inverter models offer several options that may be well worth considering. A battery-charger feature can be very handy in applications where the RV is already equipped with an AC generator. Contrary to popular belief, most generators are incapable of recharging batteries at a rate that is greater than a few amps per hour. The same is true of most RV power converters with built-in battery chargers. However, by using the inverter's high-current charger option, the batteries can be recharged very quickly, allowing the generator to be turned off after only a short period of operation.

An AC transfer switch can also be worthwhile with larger inverters, allowing permanent connection into the RV's 240-volt AC electrical system. Whenever AC power from an RV hookup is available or the generator is running, the transfer switch passes on this power to the RV. When an outside hookup isn't available, the switch makes the inverter's output available at any power outlet within the RV.

Another nice option on larger inverters is a remote-control panel. Due to the heavy 12-volt currents drawn by big inverters, it is necessary to mount the inverter as close to the batteries as is practicable. This would make the task of controlling the inverter difficult unless provision is made for a remotely mounted power switch. A remote-control panel can conveniently provide this function, as well as indicate the inverter current consumption and the battery's present state of charge.

CHOOSING THE RIGHT SIZE

An inverter must be large enough to handle the maximum load you intend to place on it. This can be estimated by adding up the wattage ratings of all 240-volt AC appliances you plan to use simultaneously. The wattage ratings are usually listed on a tag on the back or bottom of most electrical devices.

Typical small consLumers of electricity are laptop computers and printers, fax machines, clock radios, small televisions and stereos. Most of these units can be operated individually with the smallest

sizes of inverters that are rated at 100 to 150 watts continuous. These models often plug into the cigar-lighter outlet and can usually be purchased for £60 to £200.

Moving up to the lower midrange of, say, 200- to 600-watt inverters allows you to operate several of these devices together and/or add a lar ger television, a VCR, a power drill, an ice-cube maker or an electric blanket.

Upper-midsize inverters with continuous ratings of around 1500 watts and higher open up all sorts of possibilities, such as microwave ovens, vacuum cleaners, hair dryers, coffeemakers, fry pans, etc.

The larger inverters in the 2000- to 3000-watt range (and above) allow users to run several large appliances at once. These are most commonly found in luxury coaches and bus conversions.

Be sure to check the actual ratings on the appliances and add them together as applicable. By limiting the number of devices used simultaneously, a smaller inverter and, subsequently, a smaller battery pack are required. This strategy can hold down costs and weight.

Pricing varies considerably between models and brands of inverters. Obviously, the more features an inverter has and the smoother the output is, the costlier it will be. But don't use price as the only criteria. Take into consideration the difference in features, designs and warranties offered by various manufacturers.

BATTERY REQUIREMENTS

Once you have determined what appliances you want to operate from an inverter, how long they will be used, and their wattage ratings, it's time to calculate what size batteries will be needed to provide power. Deep-cycle batteries are rated in amp-hours. The amp-hour consumption of an inverter can be estimated by dividing the wattage of each 240-volt AC appliance by 12, multiplying the result by 1.1, and then by the hours (or fractions thereof):

Watts/12 x 1.1 x hours = amp-hours

For example, a 600-watt appliance run for one hour would work out like this:

600/12=50 x 1.1=55 x 1.0=55 amp-hours

Now, using the amp-hours calculated by this formula, add up all of the intended appliance usage that will occur before the batteries need recharging.

It often stated that the useful capacity of a battery when using an inverter is 50% of its rated capacity. Using more than 80 percent of the batteries' capacity can damage them, and batteries lose capacity over time anyway. It's best to have about twice the amp-hour capacity that the calculations indicate is needed. Additionally, keep in mind the other 12-volt DC requirements of the RV. It's always better to have too much battery capacity than too little. Some RVs have a bank of batteries reserved specifically for the inverter. These can be charged by using one of the electronic chargers, such as a Turecharge, which can charge more than one bank of batteries simultaneously. Two banks of batteries with a changeover switch is another way of tackling the high demand of an inverter.

WHERE TO PUT THE INVERTER

Installation of a smaller inverter (i.e., under 200 watts) is usually very easy – just plug the inverter's 12-volt DC power cable into any cigarette-lighter socket of adequate capacity, connect a 240-volt AC appliance to the inverter's output and turn the inverter on. Larger inverters require more permanent installation as close to the batteries as is practicable. In many cases, it will be necessary to beef up your RV's existing battery system, either by substituting larger batteries or supplementing the existing ones.

Since many RV factory battery systems are woefully inadequate in the first place, the installation of an inverter provides a good excuse to make the upgrade. This will entail some planning in order to determine where to mount any additional batteries, as well as the inverter itself. With larger inverters, these decisions are critical because mounting the inverter too far from the batteries will cause excessive voltage drop in the wiring that connects them, resulting in poor performance under heavy loads. If your inverter will incorporate an AC transfer switch, you will also need to develop a plan for routing AC power between your RV's circuit-breaker box and the transfer switch.

If additional batteries are to be installed, they should be mounted in an area that will provide plenty of ventilation. During – and for some time after – recharge, most batteries produce hydrogen gases that can become explosive if they are allowed to concentrate in an unvented area. Even with totally sealed or gel-cell batteries, the chosen compartment should include provision for venting, in the event an electrical malfunction exposes the batteries to charge voltages high enough to force the cells to rupture.

In selecting a mounting location, remember that the considerable weight of large battery banks must be well supported. Finally, since most batteries will require periodic maintenance (whether it be adding distilled water or just checking the terminals for corrosion), the mounting location should be chosen for ease of access, particularly from the top of the battery.

In some instances, sufficient additional battery capacity can be obtained by merely installing larger batteries in the space currently occupied by the old batteries (e.g., new golf-cart 6-volt batteries wired in series for 12-volt output in place of a pair of existing smaller 12-volt batteries). Or, if the RV is equipped with an unused generator compartment, batteries can be installed in it without very much modification. Due to a generator's inherent weight, the compartment should already be strong enough to easily support several added batteries and at the same time provide excellent ventilation. If you have removed one of the larger on-board generators you should be able to ultilise the existing battery cable.

WIRING CONSIDERATIONS

In situations where additional batteries must be mounted some distance from the original set, heavy-gauge wiring should be used to connect the two banks together. The wire should be large enough to keep the voltage drop between the two ends at well under 0.6 volts during maximum inverter current draw. For maximum currents of 25 amps or less (small-size inverters), 4-gauge wire will suffice for compartment-to-compartment runs of up to 35 feet. At 100 amps or less (medium-size inverters), 2-gauge wire will suffice for up to 20 feet. At 200 amps or less (large inverters), heavy-gauge wire will work with lengths of up to 30 feet. It's always better to have wiring that's too heavy than too light. Consult a wire chart for other wire lengths and wire gauges.

For the larger wire sizes, welding cable can be used which is extremely flexible and has scuff-resistant insulation. Route the cable in the shortest possible direct path, safety permitting. Use tie-wraps to position the cable away from hazards, and use rubber grommets when passing the cable though holes in metal compartments. Be sure to label the cable for battery polarity before making any connections to the batteries.

Circuit overload protection is also an important consideration, due to the tremendous energy-storage capacity of a large battery bank. Also on the combined inverter charger units the AC power from the inverter will attempt to charge the batteries and power any attached 12-volt appliance using the RV built-in battery charger and transformer-rectifier. All this process does is waste power, so provisions should be made for switching out the charger whilst the inverter is running. The combined inverter chargers do this automatically.

Other phantom loads to look for include the clocks on some VCRs and microwave ovens, and remote-control receivers or channel memory on many TV sets. Anytime an appliance continues to consume AC power when it is turned off, a phantom load is present. If your inverter has an adjustable standby mode, it is sometimes possible to increase the setting so that the inverter ignores these loads.

CONCLUSION

In conclusion, you should now have some idea of what to expect from inverters. Most users agree that inverters work very well, as long as you don't make unreasonable demands on them.

If you want to purchase an inverter ensure that you buy it from a dealer who knows something about them and sells them on a regular basis. If you buy at a Show most reputable dealers will allow you try one or two of the smaller models out before purchasing. Do not just buy a unit in a box from a show stand which is nothing much more than a market stall. If you do may well land up with problems and the inverter will probably remain in its box in a cupboard for every more.