



Getting AC from the batteries

STORY AND PHOTOS BY DAVE McCAMPPELL

The front panel
of a Gandel
2200-watt PSW
inverter.

One of the more useful electronic devices on a cruising sailboat is an inverter. Simply put, inverters convert direct current (DC) battery energy into alternating current (AC) power. They can run much of our common household equipment like cooking appliances, power tools, TVs and electronic chargers. When there is no shore power or a generator available this is a great option. But there is much

more to choosing, installing and using inverters. Let's have a closer look.

Basics

Inverters are able to increase 12- or 24-volt DC energy into 120- or 240-volt AC silently and on demand. They can be made to produce AC at a frequency of either 50 or 60 hertz. Loads up to about 4,000 watts are within an appropriately sized inverter's capability. They must

also have proper wiring and a suitably large house battery source so that voltage can be maintained at a reasonable level. For most cruising boats with modest intermittent AC loads, a 2,000- to 3,000-watt inverter will work well. But for most daily continuous charging of small wattage devices like cell phones, computers and flashlight batteries it is more efficient to use a smaller inverter of around 400 to 600 rated watts.

Inverters come in two flavors:

- Pure sine wave (PSW) are more expensive but best for sensitive electronic equipment like computers, TVs, some variable motor loads and induction cooking devices.

- Modified sine wave (MSW) are relatively inexpensive and work for many common AC devices like lights, fans and most resistive equipment.

PSW inverters produce a voltage wave form just like shore power; MSW inverters have a somewhat different voltage in that the top and bottom of the sine wave form are chopped off. Many AC devices can use this modified wave, but some have trouble with it. So, it is always safer and better for most equipment to use a PSW inverter.

Inverters have both a continuous wattage rating and a surge rating that is twice the continuous rating. Starting devices like an electric motor or TV may require two to three times the continuous load of the equipment for a few seconds, so the surge rating of the inverter must be capable of this or the device won't start. So for most heavy loads it is always better to have a larger rated wattage than necessary.

When designing an elec-

trical system to support a large inverter and its expected loads, we suggest sizing the house bank's *useable capacity* for at least three times the boat's daily load. This provides a three-day holdover with no charging available. West Marine Advisor suggests that the total capacity of the house bank in amp hours should be 20 percent of the continuous rating of the inverter in watts. For example: a 2,000-watt inverter should have a house bank total capacity of at least 400 amp hours.

Combination inverters and shore chargers may be an attractive option for lead acid battery users, but a fault could render inoperative both charger and inverter. Long ago in Trinidad we had a local shore power surge blow apart several components in our combo's mother board. The local repair technician said he made good money replacing components of devices left continuously plugged into shore power. We learned our lesson from that incident and no longer plug our boat's AC system into shore power when we are in the developing world. Also, the combined inverter/charger is not a good option for some lithium battery users as some battery management systems need to be able to

control loads and charging separately. For example, the BMS needs to be able to shut down charging because of a high voltage disconnect but not shut down the loads also.

Desirable features.

Besides the basics, below are a few desirable inverter features to look for:

- Is the unit marine rated? Often this includes such things as conformal coated circuit boards, higher quality components and use of



corrosion proof fasteners and fittings.

- Does the unit have any safety ratings such as UL 458, CSA and FCC Class A? The FCC rating deals with electromagnetic interference (EMI) that often affects HF radio reception.

- Is there an onboard or available transfer switch for auto switching of AC power from inverter to shore power when you plug in?

A TBE 500-watt PSW inverter.

- Is there a detachable remote available with an on/off switch? The type of on/off power switch is important for lithium battery users for the BMS to have control of the inverter. Momentary push button switches are difficult.

- Are the onboard output receptacles 15 or 20 amp? How many are there, and are they the ground fault (GFCI) type? Are there any USB ports?

- Some more modern units have an onboard solar charge controller which is useful as a primary or backup for your solar system controller.



This Chicago Electric 400 watt MSW inverter is for smaller loads.

- Is there an onboard digital display with at a minimum DC battery input and AC output readouts?

- What is the no load current if left on continuously? Most larger inverters draw 0.1 to 0.5 amps.

- What fault protections are available? Common protections include over/under (10 volt to 18 volt) input voltage, tempera-

ture compensation, over temperature, overload, short circuit, and AC back feed. An audible alarm is helpful if any of these are activated.

- How much DC gets converted to AC is called inverter efficiency. Around 90 per cent efficiency is normal. However, using a big inverter to power small loads reduces efficiency. It is much better to size loads near rated inverter wattage. So, two inverters, large and small, may be useful.

- Are there multiple cooling fans, what is the noise level, and are they variable speed depending on the internal temperature?

- Warranties are commonly one to two years, but don't cover installation or operating mistakes.

Installation tips

There are several things worth considering when installing an inverter. The best location is a cool, dry, well-ventilated spot. It should not be mounted in the engine space because of heat and moisture. Most inverter installation instructions will give details. It should be firmly mounted as close as possible to the house bank to reduce wiring size. Units less than 300 watts often use a cigarette lighter plug, but larger units should be hard wired to the boat's DC system. An inverter's AC output can

be done several ways. It can be hard wired into the boat's AC system which would be the most convenient to access onboard AC power using receptacles. An extension cord or multi receptacle could be plugged into one of the inverter's onboard receptacles. Finally, you could just use the inverter's receptacles to directly plug AC equipment into.

Even if you have lead acid batteries now, many cruisers will be tempted to switch to lithium in the future because of the significant benefits. For those using lithium batteries and a BMS with control relays, inverters present special problems.

- Using combo charging inverter units, as mentioned above, are problematic.

- When an inverter is in constant use the BMS must be able to shut down if the battery state of charge (SOC) reaches a dangerous low level. In order to do this, there must be appropriate wiring to allow control of the on/off switch or possibly a battery disconnect.

- The type of on/off switch or remote capability can make BMS control wiring easier.

- The inverter's capacitor inrush current, when first connecting the inverter to DC power, can be damaging. The popular Victron series of Battery Protect relays in particular can be damaged by this cur-

rent. Inserting a large resistor or bypass resistor circuit in the DC positive cable wiring, temporarily before making the connection, will prevent this problem.

Purchase

Some well-known and reputable brands suitable for marine use are: Sterling, Xantrex, Magnum, ProMariner, KISAE, and Victron. Victron especially makes very high quality products for electrical systems. They are highly recommended on internet electrical resources and groups. The others are commonly advertised in marine outlets such as Defender and West Marine. West Marine has a good features comparison page in their catalog. There are many other options available through Amazon and other internet sources, some better than others. And there is sometimes misleading advertising regarding which wattage rating, continuous or surge, is being sold.

Inverter AC output specifications should match that of the AC equipment being used with them. If the inverter continuous or surge wattage is too small, the frequency or voltage is different, or the equipment requires PSW instead of MSW, the device might not work and could be damaged. There are numerous complaints on internet groups regarding inverters



A Micro Solar 600-watt PSW inverter.

not working that lead back to one of these mismatches. So it may be necessary to use more than one inverter in order to run all the boat's AC equipment.

Before buying, shop carefully and read the reviews and recommendations on the manufacturer's and trusted websites like Marinehowto.com and Mobile-Solarpower.com. I also like to look at the many YouTube videos on evaluating various models and their repair after an owner makes a mistake.

For most cruisers, especially at sundowner time, using an inverter instead of having to fire up a noisy, smoky generator is well worth the research and installation effort. ■

Dave McCampbell is a former US Navy officer who spent most of his time as a diving and salvage officer. He commanded the Rescue Salvage ship, Bolster, and two shore-based diving commands. He and his wife Sherry voyage aboard their St. Francis 44 Mark II cat Soggy Paws.