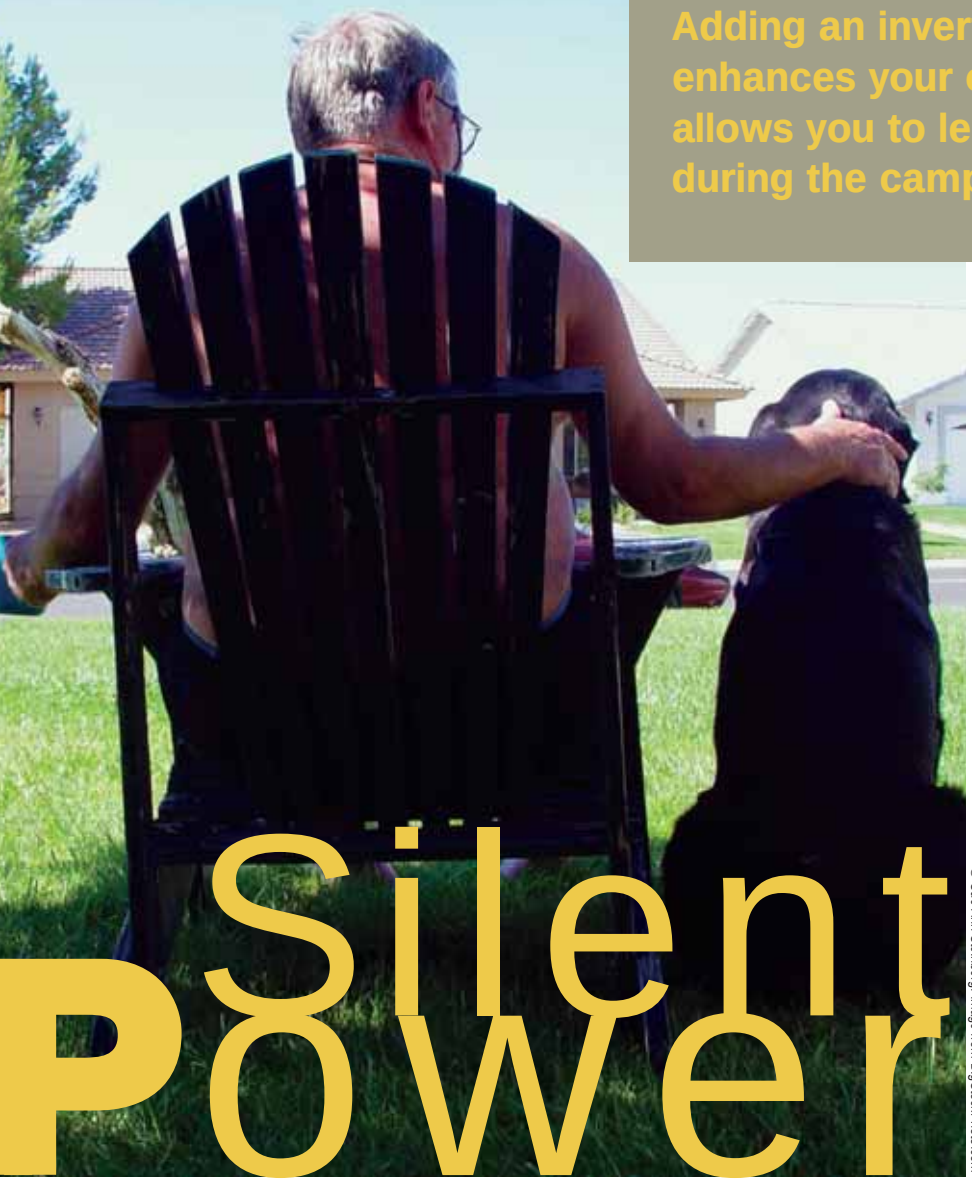
Silent Power

Adding an inverter to your motorhome enhances your onboard comfort and allows you to leave your generator off during the campground's "quiet time."



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By JIM BRIGHTLY, F358406
Technical Editor

Daybreak is my favorite time of the day. To me, each sunrise is like a new season for an NFL coach — I never know what the future will bring, but it always looks rosy at dawn. I learned to love the early-morning stillness and freshness from a 110-pound black Labrador retriever, who woke me almost every day by touching her nose to mine as soon as it was light enough for our eyes to see each other. I'd let her out, make some coffee, and then sit outside with a fresh cup to watch her antics. Even though our ritual ended more than a decade ago, I still enjoy the quiet morning hours.

The downside of these early-morning sipping sojourns of mine, when not connected to shore power, is having to start the generator, which would wake my wife and our neighbors when we were camping. That is, until I installed a Magnum Energy ME2012 2,000-watt inverter/charger and added two more 12-volt-DC deep-cycle RV batteries to my coach's house battery pack. Now I no longer disturb my wife or our neighbors when I make coffee and toast in the wee hours just before sunup.

Those of us who have been RVing since the term "self-contained" was in common usage — back when gas/electric fridges were replacing iceboxes, and generators began appearing in new coaches — may not be familiar with inverters. But it's likely that before long, virtually every new motorhome will include an inverter as standard equipment. For those of us with older motorhomes, inverters may have to be added to their accessory package.

First, let me clear up a little confusion about the terms "inverter" and "convertor." A convertor changes alternating current (AC) into direct current (DC), such as a battery charger. An inverter changes direct current (DC) into alternating current (AC) to allow batteries to operate household appliances. In a typical coach, most of its lights, some televisions, the water pump, vent and heater fans, and a few other appliances operate on 12 volts DC. The refrigerator, most televisions, the microwave, air conditioners, and plug-in appliances run on 120 volts AC.

An inverter produces electricity in one of three wave forms: square, modified square (commonly known as "modified sine wave"), and pure sine (some folks use "true sine wave," but the terms are interchangeable). More about these waves later.

In addition to its DC-to-AC conversion capabilities, an inverter/charger is also a much more efficient battery charger. In fact, the more wattage capacity an inverter/charger has, the faster it will recharge the battery pack.

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Typical Appliance Power Consumption

Device	Load
Blender	400 watts
Coffee Maker	1,200 watts
Color TV	150 watts
Computer	300 watts
Drill	500 watts
Hair Dryer	1,000 watts
Hot Plate	1,800 watts
Iron	1,000 watts
Light (Fluorescent)	10 watts
Light (Incandescent)	100 watts
Microwave	1,000 watts
Refrigerator	500 watts
Toaster	1,200 watts
Vacuum	750 watts

SOURCE: Magnum Energy

NOTE: The listed appliance requirements are approximate, and the actual running wattage may vary between brands or models. Make sure the inverter rating you choose exceeds the total wattage requirement based on your needs, and add a 30 percent safety factor to your total requirement.

CHOOSING AN INVERTER

When considering the installation of an inverter, the first thing to determine is the size or capacity of the inverter. Establish what the primary usage will be by considering the typical electrical loads in the chart below, left.

While you generally won't be using more than one or two devices at a time, you need to figure in a "worst case scenario" to determine which inverter would best suit your needs. You also have to do a bit of math and add up the watts. For example, let's say you have the coffee on, the toaster going, the TV playing, and a couple of lights on (1,200 + 1,200 + 150 + 100 + 10 = 2,660); this would require at least a 3,000-watt inverter.

In addition, you'll need to decide what type of inverter you want. As noted earlier, inverters produce electricity in three wave forms: square wave (older technology that is rarely used now), modified sine wave, and pure sine wave. Modified sine wave inverters are less expensive but are still considered efficient devices; however, they are prone to electronic noise known as harmonic distortion, which can cause disturbances in some motorhome circuits. Modified sine wave has only one step per cycle.

Pure sine wave inverters, on the other hand, are extremely sophisticated and can produce AC power at or above the quality levels of shoreline power grids. It is said that a pure sine wave inverter can eliminate static lines in televisions and improve the quality of a sound system. And a good pure sine wave inverter can have as many as 1,333 steps per cycle and have a total harmonic distortion (THD) of less than 5 percent, typically around 2 percent.

Comparisons can be made by looking at the THD (purity of waveform) produced by each type of inverter. The harmonic difference between the modified sine wave form and true sinusoidal wave shape is a percentage figure that affects the operation of induction-type loads, such as motors, compressors, or other capacitor-started devices. The higher the percentage, the higher the heat factor; and the higher the heat factor, the more damaging to the device. THD produced by modified sine wave inverters can exceed 40 percent, with some units purported to approach 47 percent. (Generators and the shore power grid can have a decent-looking waveform but a THD of 10 to 15 percent.) Pure sine wave factors into how good the THD is, and inverters, grid, and generators can all qualify as pure sine wave. In other words, an analog clock may not keep good time on a modified sine wave inverter, or you may see "snow" on your TV screen.

Finally, you'll more than likely have to add batteries to your "house" battery pack. Normally, coaches without a manufacturer-installed inverter have only two batteries for their household electrical chores. But for an inverter to operate efficiently and for any length of time, at least four batteries are needed. It is highly recommended that 6-volt deep-cycle batteries be used. Plus, all batteries should be of the same type and size. In the case of this installation, the coach already had two 12-volt deep-cycle house batteries that were less than a year old, so rather than buy four 6-volt batteries, two more 12-volt batteries were added to the pack.

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DC Fuse Ratings

Conductor Size	#2 AWG	#2/0 AWG	#4/0 AWG
Rating (conduit)	115 amps max	175 amps max	250 amps max
Rating (free air)	170 amps max	265 amps max	360 amps max
Breaker	N/A	DC175	DC250
Fuse	200 amps	300 amps	400 amps

SOURCE: Magnum Energy

Battery Safety

When working with batteries, keep these tips in mind:

- Always wear eye protection, such as safety glasses.
- Never work alone. Always have someone near you.
- Use proper lifting techniques.
- Never use old or untested batteries. Check each battery's label for age, type, and date code to ensure all batteries are identical.
- Batteries are sensitive to changes in temperature. Always install batteries in a stable environment.
- Install batteries in a well-ventilated area. Batteries can produce explosive gases. For compartment or enclosure installations, always vent batteries to the outside.
- Provide at least one inch of air space between batteries to provide optimum cooling.
- Never smoke when in the vicinity of batteries.
- To prevent a spark at the battery and reduce the chance of explosion, always connect the cables to the batteries first. Then connect the cables to the inverter.
- Use insulated tools at all times.
- Always disconnect the negative battery cable first, then the positive cable. When reconnecting the cables, connect the positive cable first and then the negative cable.
- Always verify proper polarity and voltage before connecting the batteries to the inverter.
- To reduce the chance of fire or explosion, do not short-circuit the batteries.
- In the event of accidental exposure to battery acid, wash thoroughly with soap and water. In the event of exposure to the eyes, flood them for at least 15 minutes with running water and seek immediate medical attention.
- Recycle old batteries.

INVERTER INSTALLATION

The following instructions pertain specifically to the Magnum Energy ME2012 modified sine wave inverter and are illustrated in the accompanying photos. However, Xantrex and Cummins Onan both offer aftermarket inverters for motorhomes as well, and Magnum Energy offers additional models. Contact information for all three companies appears elsewhere in this article.

Please bear in mind that this article deals mainly with information concerning inverters being installed in motorhomes after they've been on the road awhile. We're not talking about factory-installed inverter installations here. Your coach's AC circuits more than likely will all be connected through the circuit breaker panel to the inverter, so you'll need to select the appliances to use with the inverter. For instance, you'll need to remember to run the refrigerator on LP gas when not hooked up to shore power, or the battery pack will be depleted very rapidly. If you're replacing or upgrading an existing inverter, the coach's manufacturer probably has already designed the circuits to match the ability of the inverter.

Pick a basement compartment that is dry, well-ventilated, and located as close as possible to the 12-volt-DC power source — your house battery pack. The 120-volt-AC wire length is much less critical. The 12-volt-DC cable length, however, is very critical. The cable for the remote-control panel is precut at the factory, and its length cannot be altered — you must use it as is and simply loop the extra out of the way.

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Recommended Cable Sizes

Inverter	ME1512	ME2012	ME2512	ME3012
DC Rating	150 amps	200 amps	250 amps	300 amps
at 1 to 3 ft.	#2/0 AWG	#2/0 AWG	#4/0 AWG	#4/0 AWG
at 3 to 5 ft.	#4/0 AWG	#4/0 AWG	#4/0 AWG	#4/0 AWG
at 5 to 10 ft.	#4/0 AWG	#4/0 AWG	#4/0 AWG	Consult code

SOURCE: Magnum Energy

Photos by author

The new battery tray that had to be added to hold more batteries sits slightly above the original tray containing the two house batteries installed by the manufacturer.

Do not mount the inverter directly on the compartment floor. Use a piece of plywood for additional support. The inverter must not be exposed to rain, snow, moisture, or liquids of any type.

When the technician pulls the cables into the inverter's compartment, make sure the cables are not cut too short. Leave plenty of cable to allow more choices in mounting the inverter.

After stripping the insulation off the cables, be sure the locking clamps are secured on the insulation and not raw cable.

The inverter's remote-control panel should be mounted where it's easily seen and can be used to control the inverter. The panel's attachment cable length is predetermined at the factory and should not be altered.

With the exception of caulking the holes in the compartment wall to keep out moisture during rainstorms, the installation is complete.

If you'd like to save some money, you could do all the "grunt" work yourself. That is to say, you could mount and cable the batteries, drill all the holes, mount the inverter and its plywood base, and run the cables. Beyond that, I'm not going into detail on how to wire the inverter to your coach's AC circuits, because I strongly recommend that you have a qualified technician do all the wiring other than possibly the battery cables. Also have the tech check over your portion of the installation just to be safe. The kit includes a manual in which all of the installation instructions are given. Magnum Energy also includes complete instructions on testing, maintenance, and troubleshooting in its manual. For an inverter installation, you need to be expert in both electrical systems — 12-volt DC and 120-volt AC. Hire a technician! (This particular installation, including the new battery tray, took a full eight-hour day.)

An inverter does give off heat, so don't place any flammables in the same compartment. You also might want to put up a short barricade between the inverter and the rest of the compartment so road jostling won't throw something against the inverter. Be sure to leave plenty of air space around the inverter for ventilation.

Have the technician carefully determine the location of all wire routes throughout the vehicle, both to and from the inverter. Any wiring or cables that may be physically damaged must be protected by conduit, tape, or placed in a raceway, especially when passing through walls, bulkheads, or other

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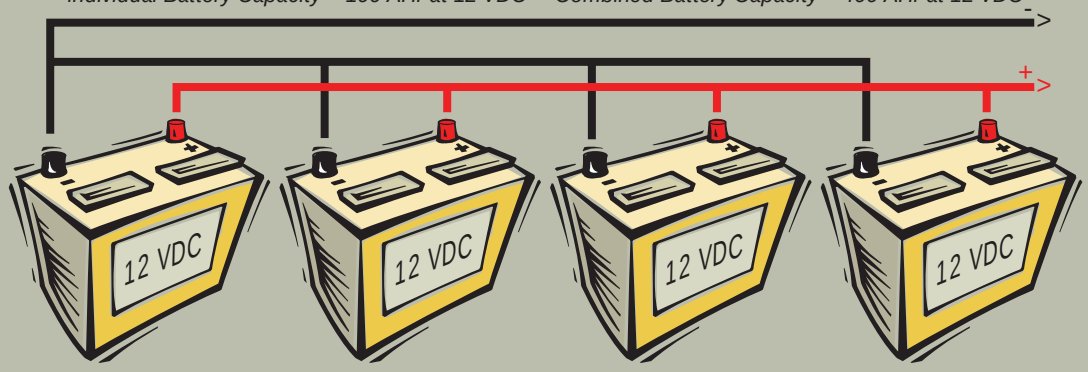
Parallel Battery Wiring

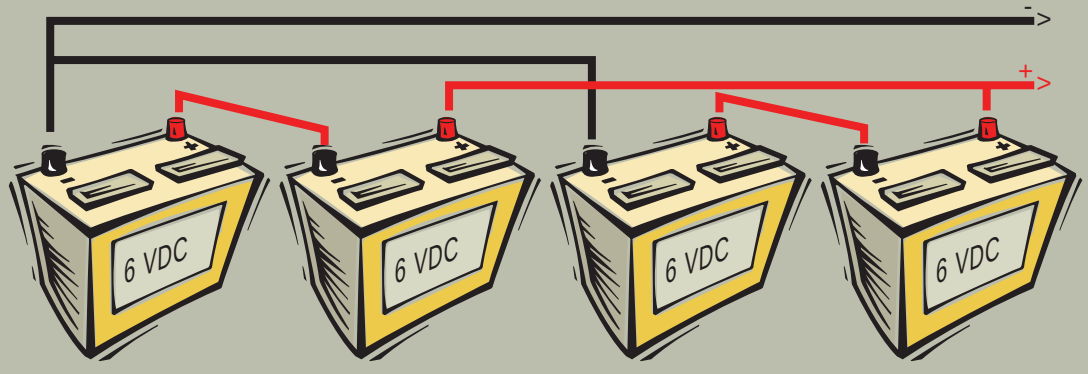
Individual Battery Capacity = 100 AHr at 12 VDC • Combined Battery Capacity = 400 AHr at 12 VDC



Parallel 12-volt battery wiring (individual battery capacity, 100 ampere-hours at 12 volts DC; combined battery capacity, 400 ampere-hours at 12 volts DC).

Series/Parallel Battery Wiring

Individual Battery Capacity = 200 AHr at 6 VDC • Combined Battery Capacity = 400 AHr at 12 VDC



Series/parallel 6-volt battery wiring (individual battery capacity, 200 ampere-hours at 6 volts DC; combined battery capacity, 400 ampere-hours at 12 volts DC)

structural members. During the installation, always avoid placing conductors near sources of chafing caused by vibration or constant rubbing.

INVERTER OPERATION

The ME Series inverter/charger has two modes of operation (both of which are fully automatic): inverter mode (providing power to your appliances from the batteries) and AC pass-through mode (running from shore power or a generator). Whenever the inverter is in AC mode, it passes power directly to your appliances and also recharges the batteries using a three-stage battery charger (bulk, absorption, and float). This approach to battery charging provides rapid and complete charging cycles without placing undue stress on the batteries.

With the search function enabled, the inverter pulses the AC output looking for an electrical appliance (typically 5 to 50 watts, depending upon the setting you've selected). When no load is detected, the inverter automatically goes into search mode (sleep) to minimize energy consumption. During this time, the inverter's green LED flashes (fast flash) to indicate SEARCH mode. When an appliance is switched on inside the coach, the inverter recognizes the need for power and automatically starts the inverter.

Whenever AC shore power is no longer sensed, the inverter automatically transfers to battery power with no interruption to your appliances. The inverter's green LED flashes once every 2 seconds (medium flash) to indicate it is running on battery power and providing AC to the coach.

Whenever AC shore power is sensed, the inverter automatically transfers to the shore power with minimal interruption to your appliances.

Following is a description of the three stages of battery charging.

1. Bulk charge: Whenever the inverter is running on nominal AC shore power, it charges the batteries. The

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inverter's green LED stays on (solid) to indicate the first stage of charging. During bulk charging, the charger supplies the maximum amount of constant current to the batteries. As the battery voltage rises to a set value (typically 14.1 volts DC for gel-cell batteries: 14.3 volts DC for absorbed glass-mat – AGM – batteries; and 14.6 volts DC for liquid lead acid batteries), the charger will then switch to the next charging mode.

2. Absorption charge: As the inverter continues to run on nominal AC shore power, and the batteries have been successfully bulk charged, the charger enters its second stage of charging. The inverter's green LED flashes once every second (fast flash) to indicate absorption charging for one to three hours, depending upon battery bank selection. The charger then switches to its final charging mode.

3. Float charge: As AC shore power continues, the inverter's green LED flashes once every 8 seconds (slow flash) to indicate the third and final stage of charging. The batteries are held at the float voltage (typically 13.6 volts DC for gel-cell, 13.1 volts DC for AGM, and 13.4 volts DC for liquid lead acid) as long as AC is present at the inverter's input. Float charging reduces battery out-gassing, minimizes watering requirements (for flooded batteries), and ensures the batteries are maintained at optimum capacity.

Following are other functions performed by the ME Series inverter; this may be a good starting point when evaluating the various inverter models on the market today.

Battery saver: This feature is designed to keep batteries fully charged over long periods (storage) without drying them out. Whenever the charger is in float for four hours with no DC loads running, the charger will turn off. If the battery voltage drops below 12.5 volts DC, the charger will automatically initiate float mode to return them to a full charge.

Fault or alarm conditions: The inverter monitors the AC shore power, the batteries, and itself. Whenever a condition occurs that is outside the normal operating parameters, the inverter will take the necessary steps to protect appliances, batteries, or itself from damage.

Low battery: Whenever the battery voltage reaches a low level, the inverter will initiate Low Battery Cutoff (LBCO), which automatically shuts the inverter down, along with all connected loads, to protect the batteries from over-discharge damage. The inverter's LED turns off to indicate the fault condition.

High battery: Whenever the battery voltage reaches a high level (15.5 volts DC), the inverter/charger will shut down, along with all connected loads, to protect the inverter/charger from damage. The inverter's LED turns off to indicate the fault condition. High battery voltage may be caused by excessive voltage from the alternator, solar panels, or other external charging sources.

Overload: During inverter and AC shore power operation, the inverter monitors the AC and DC circuits. In the event of a short circuit or overload condition, the inverter will shut down. The inverter's LED turns off to indicate the fault condition.

Over-temperature: During inverter/charger operation, if the inverter becomes overheated, it will shut down to protect itself from damage. The inverter's LED turns off to indicate the fault condition.

MAINTENANCE

Although the ME Series inverter/charger has no user-serviceable parts, it is recommended that every six months you perform some maintenance to ensure optimum performance and extend battery life. For a list of all the maintenance steps, refer to the inverter's owners manual. Check off each step in the manual as you perform it.

When placing your coach into seasonal storage, it is recommended that you perform the following to ensure the system is properly shut down (or properly configured for seasonal storage). This is especially important for maintaining the batteries.

For storage, perform the recommended maintenance steps found in the owners manual and fully charge the batteries. Verify that the inverter is switched off, and switch off all AC and DC loads. Disconnect shore power and disable the generator auto-start feature (if applicable).

THE RIGHT FIT

To wrap it up, when the output AC is not being called for, most inverters will go into a simmer mode until the demand for power is evident again. During this downtime, certain monitoring functions must continue. This results in a continuous draining of current from the battery bank. Obviously, the inverter that draws the lowest amount is preferred. Once you know your total daily requirement for power, you'll know what size inverter to purchase. Once you know the size of the inverter, then you can effectively approximate the size of the battery bank needed to power that inverter. You may need more than just that one extra battery. You'll need a battery bank large enough to produce the daily wattage requirement for as many days as you want to remain free from a charging source. So, as you can see, it takes some math, some homework, and some forethought in choosing the most effective inverter for your motorhome. The payoff? Silent, smooth appliance operation at daybreak or any time of day.

Inverter Sources

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