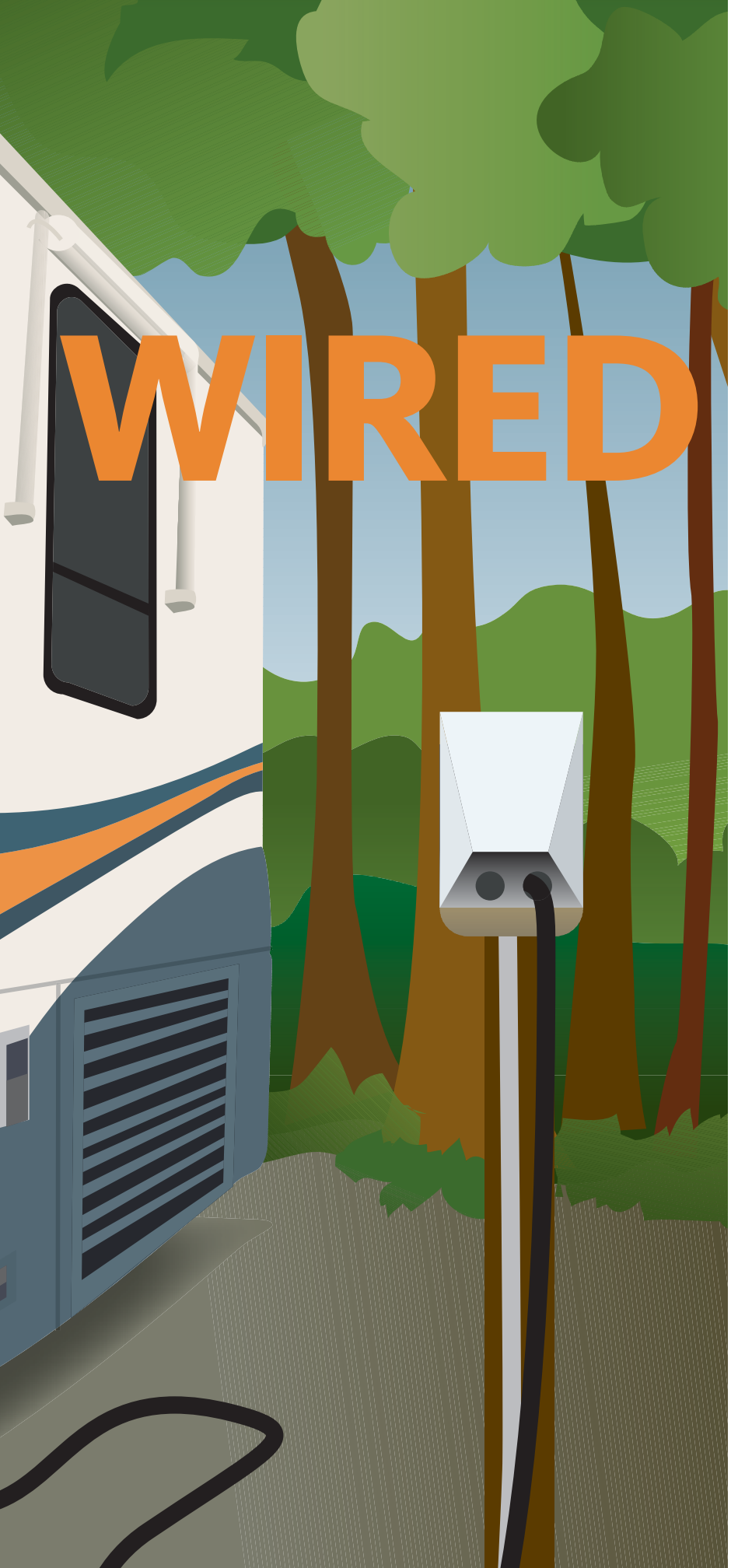


WIRED FOR

Part 1 of this series explained how the RV alternating current (AC) electrical system differs from a residential electrical system; the different testing devices every motorhomer should carry on board; and how an electrical system will respond under normal and irregular — and potentially dangerous — conditions.

This installment of the series centers on getting the electricity from the source to the motorhome and its electrical components. This involves the campground electrical pedestal, any conductors that convey the electric from the pedestal to the motorhome, and the numerous connections and outlets within the motorhome. This article also will discuss electrity produced by the generator (and inverter) and how this power should be tested.

AC SHORELINE CORD

All motorhomes will have either a 30-amp or a 50-amp shoreline connection. The difference is obvious: the 30-amp plug has three contacts and conductors; the 50-amp plug has four. Since this is the umbilical cord that brings electrical life from the pedestal to your motorhome, it's important that it be in good operating condition so it can safely provide the current.

Begin by closely inspecting the entire length of the cord from the

BY GARY BUNZER

SAFETY

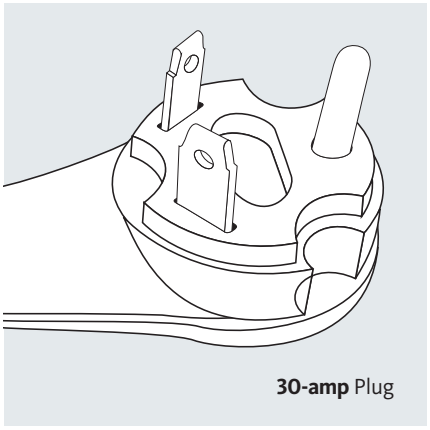
This three-part series examines the intricacies and safety issues that relate to a motorhome's 120-volt-AC electrical systems, and provides information about how to protect individuals and the motorhome when this electric source is being utilized.

PART 2

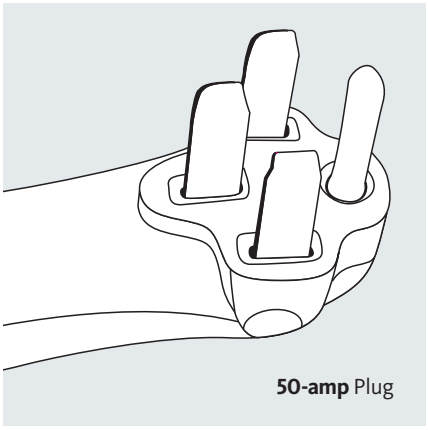
point it enters the motorhome all the way back to the plug. Look for cuts, abrasions, or any damage. At the plug cap end, be sure the molded plug is intact. Look for any sign of melted rubber where the metallic prongs emerge from the plug. Molten rubber is a sign of overheating and should be investigated further. Try to wiggle each prong with your fingers. If the prongs appear to be loose, pitted, wobbly, or otherwise burned or damaged, replace the cord.

If the plug cap has pulled away from the remainder of the cord, exposing the individual wires (such as might happen when forgetting to unplug the cord before pulling away from the campsite), it will be necessary to replace the entire cord. Yes, I know retail outlets sell individual plug caps that can be installed in the case of such an occurrence, but there are a couple of reasons to avoid doing so. First, to remain code compliant, the plug cap must be molded onto the shore cord in order to safely guard against water intrusion (important). Second, replacement plug caps usually necessitate attaching the stranded conductors with a screw-and-clamp-type mechanical device. Screw connections have a propensity to vibrate loose, which could result in an unnecessary arcing situation. Arcing can cause overheating, which can lead to other problems.

Part 2 of the series examines safety precautions and necessary tests along the route of electric from the pedestal to the distribution panelboard, as well as generator and inverter output testing.



30-amp Plug



50-amp Plug

While inspecting the shoreline plug, take the time to clean and brighten the prongs. Corrosion and oxidation on the metallic contacts can cause improper conductivity of the AC electricity. Use 0000 steel wool or 600-grit (or higher) sandpaper to remove the corrosion, leaving each prong bright and shiny. Add an electrical contact preservative such as DeoxIT to aid in maintaining the cleanliness of the plug contacts. Perform this maintenance task two or three times per year or as necessary.

For a video explanation regarding shoreline plug maintenance, check out this YouTube tip: www.youtube.com/watch?v=QoVUozvu5IU.

AC SHORELINE CORD TESTS

As discussed in Part 1 of the series, having an electrically sound ground connection is crucial to the safety of

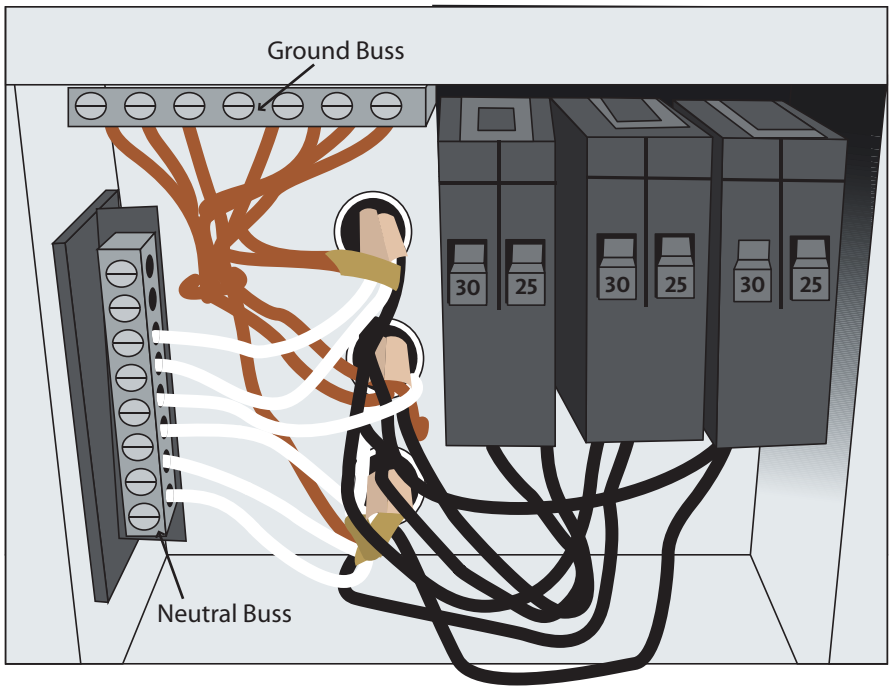
continued »

the motorhome and its occupants. The integrity of the ground wire must include a complete metallic path from the shoreline cord ground pin through the cord to the transition to Romex cable; through every connection via the internal wiring in the distribution panelboard; through the bonding wire to the chassis of the motorhome. Here's how to verify the integrity of the ground path.

At the shoreline plug, with your versatile volt-ohmeter (VOM), also called a digital multimeter (DMM), set to the ohms scale, measure the resistance between the ground pin and a clean, bare metallic portion of the motorhome chassis. Note: it may be necessary to scrape away some paint or undercoating on the frame in order to obtain a valid measurement. If the measurement is anything less than 1 ohm, the ground connection is secure and proper. Typically, the measurement will be less than 0.5-ohm, indicating continuity. As a redundant check using the DMM, reverse the test probes and measure again.

Before continuing to the next test, turn on all circuit breakers inside the motorhome. Then measure the resistance between the ground pin on the shoreline cord to each of the current-carrying flat blades on the shoreline cord. On 30-amp cords, there will be two flat blades (hot and neutral). On 50-amp cords, there will be three flat blades (hot-black, hot-red, and neutral). If the resistance measurements between the ground pin and the flat blades are higher than 1 megaohm (1 million ohms), the wiring is correct. It typically will measure "infinity" (∞). If the measurement is less than 1 ohm, there is a direct short between ground and the conductor somewhere in the system, and further troubleshooting is in order. If it measures less than 1 megaohm, there exists a high-resistance leak somewhere on that wire and, again, further troubleshooting is required.

Occasionally, you'll see a large, uninsulated solid conductor attached to the steel chassis. This, too, is a code requirement for metallic electrical boxes such as the AC-to-DC convertor, the inverter, the generator, and the breaker box itself. This is the "bonding" conductor mentioned earlier and not really a "ground" wire as it relates to the AC circuitry in the motorhome. Bonding conductors will always be uninsulated and typically made of 8-gauge or larger wire. The ground wire is a return path for the electron flow, while the bonding conductor protects and bonds the metal case of electrical devices to the chassis. Still, those connections, as with all electrical connections, must remain clean, dry, and tight.

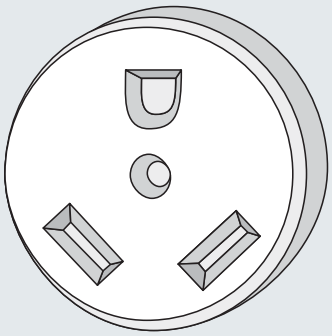


Once you are satisfied the shoreline cord is in good shape, next take a look inside that first junction box (J box). In the J box, the stranded conductors of the shoreline cord usually transition to the solid conductors in the Romex cable. Wire nuts typically are used to make this connection. During travel, wire nuts can vibrate loose, so it's the wise motorhome owner who verifies that all wire nuts in the AC system are wrapped with electrical tape as a precaution. Rooftop air conditioners on older motorhomes often will have a J box located in the ceiling next to the air conditioner. Be sure to check the wire nuts at all J boxes throughout the entire motorhome.

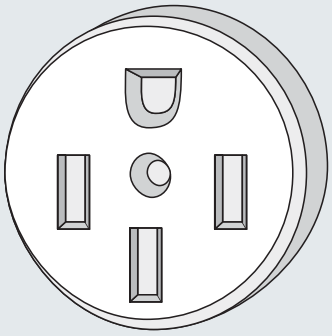
Make sure to also check the wiring connections at the generator J box. Code requirements specify that the conductors coming from the generator be stranded wires sheathed inside a flexible conduit. This is because vibrations caused by the running generator coupled with heat accumulation may cause solid conductors (such as those found in Romex) to fatigue and break over time.

DISTRIBUTION PANELBOARD INSPECTION

Perform the following procedure only with the shore power disconnected and the generator and inverter turned off. At the panelboard distribution box, remove the cover and gain access to the breakers, the buss bars, and all the wiring. Begin by inspecting the neutral buss bar. Is it indeed insulated and isolated from the metallic components inside the box? Only white wires should be attached to the neutral buss. Take the time to tighten the setscrews for all the white wires attached to the buss, making sure the screws are indeed contacting the copper conductor rather than



30-amp Receptacle



50-amp Receptacle

clamping down on just the white insulation. The same thing applies for all the bare copper ground wires. They should be securely attached to their respective buss bar. Likewise, tighten all the black wires where they are attached to the "load" side of each circuit breaker, again making sure the copper conductor is firmly attached to the circuit breaker, not just the insulation. Give a little tug on each black wire to ensure it is secure.

Look intently at everything inside the breaker box. Inspect for burned or scorched insulation or any evidence of arcing and sparking. Remember, this is a motorhome. Rolling and bouncing down the highway causes setscrews to work loose and connections to deteriorate over time. Also inspect the Romex connectors, those clamp-like devices that protect the Romex where it passes through the metallic walls of the enclosure. Today, most of these are made of plastic, but make sure each section of Romex that enters and leaves the panelboard distribution box is protected against rubbing and chafing. If cuts or abrasions are noticed, it may be necessary to replace that section of Romex. Any break in the outer casing of the Romex cable or in the insulation of any individual conductor is cause for concern within the 120-volt-AC system.

Inside the distribution panelboard is where you truly can see the quality and expertise of the installer and perhaps extrapolate the attitude of the motorhome maker. When I evaluate the quality of a coach manufacturer, the distribution panelboard is one of my key inspection areas. True electrical craftspeople will ensure all the wiring is neat and tidy inside this box. All the insulation will be precisely and evenly trimmed, and each conductor will be routed in an organized manner, guaranteeing that when a circuit breaker is removed, there is enough slack in the black wire to enable the breaker to be pulled clear of the enclosure for inspection and testing. Pride in workmanship that is evident in the hidden areas indicates a quality mind-set that typically endures throughout the motorhome.

Once the entire shoreline cord, the plug, its attaching points and connections, etc. have been inspected and all the measurements indicate a sound system, the next step is to plug the shoreline cord into a land-based source of AC voltage. Ah, but how do we know the value and the safety of that voltage source? Good question.

Here's the rule: never plug the motorhome into any AC voltage source without first checking the amount of voltage and the polarity of that source. By following this precept, you can be guaranteed you are doing the most you can to protect your recreational investment. Plugging into an unknown source of voltage is akin to filling your fresh water tank without even tasting the water first. It's doubtful you'd want to fill the water tank with brackish, stale water, right? Have the same mind-set with the incoming AC voltage.

First, make sure all AC devices are in the "off" position or remember to turn off the main breaker(s) at the coach distribution panelboard. As with the generator, never plug into an AC source with a load applied. Doing so may cause arcing at the contacts and subsequent damage to the blades on the plug cap.

MEASURING PEDESTAL VOLTAGE

At the park pedestal, or any power source for that matter, begin by performing a cursory inspection. Look closely for signs of overheating or burning, as well as evidence of water intrusion, abnormal oxidation, dirt, leaves, wasp nests, etc. If you have any doubt as to the condition and safety of the pedestal, before or after performing the following tests, do not plug in. Inform the park manager or maintenance department immediately. It may be necessary for you to move to a different site. This is especially true when staying at older RV parks that have not upgraded the AC service and campsite pedestals to accommodate 50-amp motorhomes.

TESTING A 30-AMP RECEPTACLE

Next, turn on the main breaker at the pedestal, but don't plug in yet! Measure the voltage first. Make sure the DMM is set to the AC voltage scale. Insert the black test probe from the DMM into the neutral slot in the pedestal receptacle. On a 30-amp receptacle with the ground pin at the top, the neutral slot will be on the lower right. Insert the red test probe from the meter into the "hot" slot on the park pedestal receptacle (the slanted slot on the left). The voltage measurement should be approximately 120 volts AC. Voltage measurements below 107 volts AC and above 130 volts AC should be avoided.

Next, insert the black test probe from the DMM into the round, ground contact in the pedestal receptacle and measure the voltage to the hot slot again. This voltage measurement

continued »

should be within 5 volts of the previous measurement. If so, all is well . . . so far.

TESTING A 50-AMP RECEPTACLE

If the motorhome will be connected to 50-amp, 120/240-volt service, measure the voltage between the neutral vertical slot (the lower center slot) and each leg of 120-volt power at the two vertical side slots on the pedestal receptacle. As stated earlier, the voltage measurement should be approximately 120 volts AC, falling between 107 volts and 130 volts.

Then measure the voltage at both hot legs again, but with the black test probe of the meter inserted into the upper rounded ground connection in the receptacle. Again, a 5-volt difference or less is acceptable.

VERIFYING PEDESTAL VOLTAGE POLARITY

Once the incoming voltage has been measured at the pedestal and it falls safely within the limits required by the motorhome, continue testing to verify the proper AC polarity of the incoming voltage. Remember, have the DMM set to the proper AC voltage scale. All told, you'll be making the following measurements:

- Measure from the hot slot(s) to the neutral slot in the same receptacle.
- Measure from the hot slot(s) to the ground connection in the same receptacle.
- Measure from the neutral slot to the ground connection in the same receptacle.
- On a 50-amp receptacle, measure from one hot slot to the other hot slot.

Compare your results to the Testing Alternating Current (AC) Polarity chart.

If the results are anything other than correct at the pedestal receptacle being measured, do not connect the motorhome to that voltage source. If this happens at a campground, immediately notify the park manager and ask to be moved to a different site. Be sure to verify the voltage and polarity at the new site, too!

If you check a home receptacle that you plan to use and end up getting an abnormal reading at that location, call an electrician. If you plan to connect the coach to your house AC system often, it is recommended that you have a licensed electrician, familiar with RV wiring, install a dedicated 30-amp or 50-amp circuit, complete with the appropriate subpanel and protective devices. If plugging into your residential power will be done only temporarily, be sure to use the correct adapter and extension cord (more about this later). Note: Owners of motorhomes with 50-amp electric should never plug the shoreline into a 240-volt-AC clothes dryer or range circuit. Some 240-volt house circuits do not contain a neutral conductor. Therefore, it's simply not worth the risk. Temporarily reduce down to a 30-amp, 20-amp, or 15-amp house circuit and be judicious in the devices you employ within the motorhome. The best situation is to have the correct branch circuit and receptacle installed by a licensed electrician so that an adapter is not needed.

POWERING UP

If after testing the pedestal you determine that the voltage measures around 120 volts AC and the polarity of that voltage has been verified, it is

TESTING ALTERNATING CURRENT (AC) POLARITY

120-VOLT, 30-AMP RECEPTACLE

Hot to Neutral	Hot to Ground	Neutral to Ground	Status
120 volts	120 volts	0 volts	correct wiring
120 volts	0 volts	120 volts	hot & neutral reversed
0 volts	120 volts	120 volts	hot & ground reversed
0 volts	0 volts	0 volts	open hot
120 volts	0 volts	0 volts	open ground
0 volts	120 volts	0 volts	open neutral
120 volts	120 volts	120 volts[1]	neutral to ground bonding connection may be missing at the inverter or generator.

120/240-VOLT, 50-AMP RECEPTACLE

Same as above as measured from either hot blade to ground and to neutral and from neutral to ground. Hot (black) to hot (red), however, will measure 240 volts.e

[1] *Reading may be caused by capacitance. Voltage measurement may actually be less than 120 volts.*

SOURCE: BILL TRIMMER

safe to power up the motorhome. But first, turn off the main breaker on the pedestal. Remember, it's best to avoid any rapid transfer to any load that may be activated in the coach.

With the main breakers off on the site pedestal and inside the motorhome, plug the shoreline cord in a couple of times. You previously removed the corrosion and oxidation on the contacts of the plug cap, but don't assume the campground pedestal receptacles will have clean contacts. In fact, assume they will not. By plugging in, unplugging, and plugging in repeatedly with the circuit breakers off, the male plug cap will help scrape away any oxidation on the female connections inside the park pedestal receptacle. At the very least, it cannot hurt and it just may help.

Once the shoreline is firmly connected at the pedestal, turn on the pedestal breaker. Inside the motorhome, turn on the main breaker at the distribution panelboard. Then turn on each individual breaker one at a time until all are in the "on" position.

Switch on the AC loads inside the motorhome one at a time. Be sure the water heater is filled with water prior to activating its 120-volt-AC heating element. And be sure the absorption refrigerator is adequately leveled prior to activating the AC mode on it.

Note: if two roof air conditioners are installed on a 30-amp motorhome, it will be necessary to first check the operation of one air conditioner, and then switch to the second unit by the means supplied on that motorhome. Two air conditioners cannot be powered from a single 30-amp shoreline connection.

Using the plug-in circuit analyzer mentioned in Part 1 of this series, check for the proper polarity at each receptacle in the coach. You already know you have the proper polarity coming in through the shoreline cord, right? If the plug-in analyzer finds an electrical anomaly such as reversed wiring at any given receptacle, you'll know the problem is located within the motorhome. This test should be done at least once a year (full-timers and frequent users); whenever the motorhome is brought out of storage; and following any repairs, installations, or alterations made to the coach.

Be sure to locate all the standard duplex receptacles inside and outside the motorhome. Some may be hidden beside cupboards, under cabinets, or inside storage compartments. A problem could exist at just one receptacle that could affect others on that same circuit.

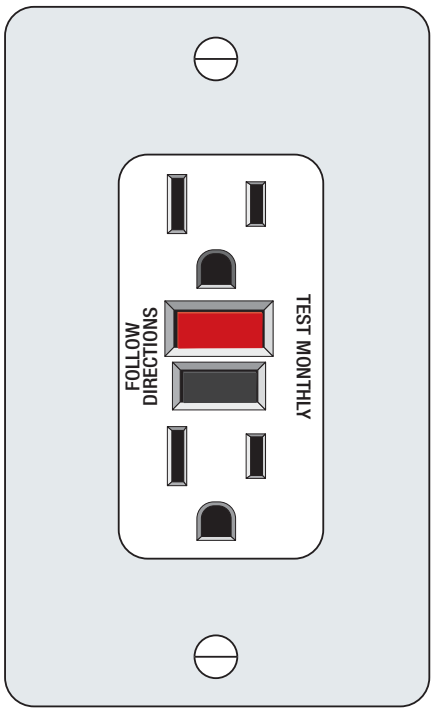
Though it's possible to make these same checks using the DMM, it's much easier to use the plug-in analyzer. Since there is no need to actually measure the voltage (barring an unknown issue with any of the onboard AC devices), the three LEDs on the tester will suffice for quickly checking for the proper polarity at the receptacles.

GROUND FAULT CIRCUIT INTERRUPTERS

Most coaches will be equipped with a special ground fault circuit interrupter (GFCI) receptacle located in the lavatory area (some motorhomes may be equipped with a GFCI breaker inside the distribution panelboard). This receptacle can be used just like any other receptacle, but it also contains special circuitry that monitors the current balance between the hot and neutral wires on that specific circuit. The GFCI is another code requirement for circuits at or near water receptacles (sinks) and for exterior receptacles on the motorhome.

It is a common misconception that the GFCI is a circuit breaker or an overcurrent device. It is not. While circuit breakers obviously do protect against overcurrent, they cannot sense or protect against potentially lethal low-level ground faults. Most GFCIs will not sense a direct short to ground. The exception, of course, would be the breaker-type GFCI, which does both.

The benefit of the GFCI is evident in the fact that it will indeed sense the low-level current leakage that might occur in a 120-volt-AC system and could permit lethal current that the circuit breaker may overlook. Low-level current leakage can occur as the result of oxidation, burned wiring or insulation, water intrusion, or a simple loose connection. (See the importance of my three key words: clean, dry, and tight?) The GFCI employed in the motorhome will sense and monitor current leakage up to 5 milliamps (0.005-amp), and then it will "interrupt" that circuit by tripping. Following is an explanation as to how it works.



GFCI Outlet

AC current from the power source flows through the hot wire to a load and back to the power source through the neutral wire. In most cases, this current flow to and from the load is always equal. Remember, the current alternates between the hot and neutral wires in any given AC circuit. If the current to and from the device is equal, it is said to be balanced. If the GFCI senses an imbalance between the two measurements that approaches 4 to 6 milliamps, the GFCI will trip, interrupting the current at that point. All receptacles

continued »

PHOTO BY AUTHOR

Make sure the electric pedestal breaker for your service outlet — and the main breaker at the motorhome's distribution panel — are turned off before connecting the shoreline cord.

downstream of the GFCI on that same circuit (including the GFCI) will now be dead.

All GFCI receptacles contain a test function that is user-invoked. This allows the internal electronic components of the GFCI to be tested. It also verifies the integrity of all receptacles on that same branch of the circuit. The GFCI should be tested at least monthly. Simply push the test button (usually black) on the GFCI and watch the reset button (usually red), which should pop out with an audible click. While in this tripped condition, use the plug-in analyzer to determine what other receptacles are on the same circuit. If you ever find that any plug-in load will not operate when plugged into a galley receptacle or exterior receptacle, chances are the GFCI is tripped. Simply reset the GFCI (push in the red button) to restore voltage to that circuit. Note: the test function will work only when the motorhome is connected to an AC power source.

There are three ways to test the integrity of any GFCI circuit. The first is by using the integral test function on the device itself. Second, purchase a plug-in circuit analyzer equipped with a GFCI test function. Finally, some professional RV service technicians have a specific stand-alone polarity/GFCI test device that creates an incremental series of amperage imbalances until the GFCI trips at the desired level.

AC PIGTAIL ADAPTERS AND EXTENSION CORDS

Not all campgrounds will be equipped with 50-amp-AC service at every site. When plugging in a motorhome rated higher than the service provided, it's necessary to use a common pigtail reducing adapter, sometimes referred to as a "dog bone" adapter.

Understand that not all pigtail adapters are created equal. Purchase only high-quality adapters. I've inspected lesser-quality adapters and have found undersized internal connections that can lead to overheating. I've also seen 50-amp-to-30-amp pigtail adapters with undersized conductors. Overheating at the adapter connection can lead to melted insulation, loosened contacts, and open circuits, amid a plethora of other electrical ailments.

Never use a modified or homemade adapter. Always check the polarity of any adapter to be sure the hot is hot and the neutral is indeed neutral. It's not uncommon to find reversed polarity in the cheaply made or homemade pigtail adapters. Also check the continuity through the adapter for all three or four conductors.

The two most common adapters reduce a 50-amp shoreline to a 30-amp receptacle and a 30-amp shoreline to a 15-amp or 20-amp receptacle. Reverse adapters that make it possible to plug a 30-amp motorhome into a 50-amp receptacle also are available; however, if a campground has a 50-amp receptacle at the pedestal, it most likely will be equipped with a 30-amp receptacle as well. Newer campgrounds or those that have upgraded their service usually provide three separate circuits (50-amp, 30-amp, and 20-amp), accommodating any motorhome without the need for an adapter.

If it's necessary to employ an extension cord, be sure to use one rated for the same ampacity as the shoreline cord itself in order to avoid an overheating situation. Be sure it contains the same number of conductors as the shoreline cord (three for 30-amp, four for 50-amp). Never use an extension cord without a ground conductor! Also, try to use the shortest extension cord available. Extra length in any conductor increases the resistance in that circuit. Remember, use approved extension cords and pigtail adapters only when necessary and purchase only quality components.

GENERATOR AC OUTPUT

Though it's impossible to correctly adjust the RV generator's AC output without employing specialty equipment, it is prudent to at least measure the voltage periodically to be sure it remains within safe operating parameters. This can be accomplished by measuring the voltage at any receptacle inside the motorhome from time to time while the generator is powering the coach. Perform the same voltage measurement for AC output from the inverter.

Another RV "Fact of Life" is that RV generators require periodic tune-ups and set-ups. RV generators cannot be tuned by ear! Every mechanical adjustment on the generator has an electrical consequence. It's doubtful that many coach owners carry a generator load bank with them, so leave generator adjustments to the certified technicians.

However, aside from monitoring the generator output voltage from time to time, there's one more periodic measurement I would recommend: the output frequency. Every electrical device in North America is manufactured to operate at 60 hertz (cycles) per second, meaning that the current alternates above and below a time line 60 times

per second. In contrast, European countries operate electrically at a frequency of 50 hertz. (That's why every airport sells those international AC adapters.) While shoreline electricity from the power grid remains stable at 60 hertz, oftentimes the generator output frequency needs tweaking. Although the Extech EX830 meter mentioned in Part 1 of this series can safely measure AC frequency, most meters cannot. But an aftermarket device called the Kill A Watt, produced by P3 International Corporation (www.p3international.com), can measure hertz as well as true RMS voltage, current, and watts, among a few other handy measurements. It's a simple way to monitor the voltage and frequency when operating the motorhome on shore power or via the generator or inverter.

Remember, the safe AC voltage range is 107 volts to 130 volts AC. The safe operating range for the generator output frequency is 59 hertz to 62 hertz. If you measure voltage or frequency from the RV generator that is too high or too low, contact your local RV service center and make an appointment with them at your earliest convenience. Do not utilize the generator until the problem has been rectified.

Keep in mind, the generator output voltage will fluctuate as individual AC loads are applied. It's best to measure the voltage and frequency of the generator when it is carrying about a 50 percent load. You'll have to do some basic math to determine how much current that will be for your particular generator. Professional RV service techs will actually measure the no-load voltage and frequency, then the full-load voltage and frequency by using a load bank, but a happy medium can be obtained if you apply a 50 percent load or slightly higher.

Indeed, AC electrical safety is paramount. Diligent and thorough inspections, periodic maintenance, and quick resolutions when problems are located will keep your 120-volt-AC systems in top condition. **FMC**