Make Sure the Power Is Off

Two testers and some basic know-how are all you need to be certain you are working safely

BY CLIFFORD A. POPEJOY

CAUTION: BEFORE YOU GET STARTED

It's important to lock or tag out a breaker panel when you're working so that nobody mistakenly turns the power back on. You can purchase locks and warning tags, but at the very least, close the door of the panel and put a piece of tape across it that reads "Danger: Do not touch. Electrician working."

Household voltage can cause serious shock and even death, so the only way to work safely on wiring is with the power off. The good news is that when used as shown here, a voltage/continuity tester and a noncontact voltage tester will tell you if the power to the wires or fixtures you are working on really is off. They also can provide other valuable information about wiring and fixtures. As far as I'm concerned, these testers are must-have tools whether you're a professional electrician working on a panel, a homeowner replacing a light fixture, or a remodeler about to knock down a wall.

Two testers work together

Every trade has special tools, and the more specialized the work, the more specialized the tools. Most residential electrical projects and basic troubleshooting work can be handled by two tools: a voltage/continuity tester and a noncontact voltage tester. Used together, these two tools can all but eliminate the chance of shock or electrocution. But there's a catch. The most-expensive electrical tester you can find—complete with beeps, flashing lights, and digital readouts—won't do you any good if you don't know how to use it. Take the time to read and follow the manufacturer's instructions. Also, no matter what kind of tester you are using, remember that batteries can die and leads can loosen or break, so always check the tester on a circuit you know to be live before getting started. It's also a good idea to send in the owner's registration card so that you can be contacted if there are any product recalls. Finally, please retire the tester if and when it is worn out or damaged.

If you're new to electrical work, or just want to brush up on the basics, The National Institute for Occupational Safety and Health Web site (www.cdc.gov/niosh) offers a free publication (No. 2002-123) with some great guidelines.

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Photos this page: left, Justin Fink; right, Krysta S. Doerfler.
Photos facing page: left, Krysta S. Doerfler; right, Clifford A. Popejoy.

VOLTAGE/CONTINUITY TESTERS ARE YOUR MAIN LINE OF DEFENSE

This tester indicates whether there is voltage on a wire or a piece of equipment. Most models indicate the level of voltage as well. You can buy voltage testers and continuity testers separately, but it's smarter to buy a tester with both functions so that when voltage is not detected, the tester will automatically switch to continuity mode (see "What is continuity?" at right). Voltage can be considered the pressure behind electrical power, and it is always measured across two points: typically from hot (live) to ground, or from hot to neutral. Ground (also known as earth) potential is defined as 0 volts and is used as a point of reference.

The voltage/continuity tester has a pair of wire leads with insulated probes that terminate in metal tips. The probe tips are placed in contact with the points being tested, and if voltage is present, it will be indicated on the tester with a light, a beep, vibration, or a combination of these. A good tester allows you to slip one of the probes into a slot on the body of the tester; this way, you can read the results and keep your eyes on the receptacle at the same time.

The electrical aisle at the hardware store is likely to have at least a half-dozen voltage testers with a wide range of prices. I recommend that you avoid the $5 models because their leads are often short and poorly soldered. A midrange model costing between $30 and $40 will likely indicate voltage level and have better leads. A high-end model like the Vol-Con Elite shown at left ($70; **www.idealindustries.com**) will have replaceable leads and more testing functions.

When shopping for a tester, always look for an Underwriters Laboratory (UL) listing and a Category III rating, which ensures that the tester won't melt or blow up if it's accidentally exposed to a surge of high voltage.

WHAT IS CONTINUITY?

Continuity is indicated when an electrical circuit is complete. For example, if you touch the probes of a continuity tester to the terminals of a light switch, it should show continuity when the switch is in the "on" position, and no continuity when in the "off" position. I rely on continuity to verify that a ground and neutral are properly connected at the breaker panel, and therefore safe to use as reference points in voltage tests.

NONCONTACT TESTERS ARE A GREAT SIDEKICK, BUT ONLY IF YOU KNOW THEIR LIMITATIONS

I often use a pen-shaped noncontact voltage tester in addition to a voltage/continuity tester. Why? It's small and fast, and it's able to detect an energized wire where a voltage tester can't. I typically use this tester to double-check the results of a voltage/continuity tester, or to check for voltage in a cable or wire where there's no exposed metal to touch the probes of the voltage tester. But this type of tester has some noteworthy limitations.

A noncontact tester works by detecting the difference in electrostatic charge between its plastic tip and the body of the person holding it. For instance, a wire or other object energized by AC-voltage usually has an electrostatic charge in it. You and your hand holding the tester usually do not. When you're holding the tester and touch it to an energized cable, wire, or other surface, a light goes on (or flashes), and a beep might sound. Some testers are more sensitive than others and could indicate voltage when held near, but not in contact with, an energized object. The VoltAlert tester shown at left (**www.fluke.com**) sells for about $22. The important thing is to make sure the model you choose is rated Category III or higher.

If noncontact testers are so safe and easy to use, why not use them for everything? If you try to use the tool without being relatively well grounded, there might not be sufficient difference between you and the tip of the tester to trigger the voltage indicator. This can be a problem if you're holding the tester in a gloved hand, are standing on a fiberglass ladder, or are working in an area of low relative humidity (an attic, for instance). It's also a problem if you are working in tight quarters and your body is accidentally brushing up against the jacket of a live cable.

Also, unpowered cables or wires might show voltage when tested with a noncontact tester. That's because the tool could detect electrostatic charge that has bled over from an adjacent energized cable or wire, an effect called phantom voltage or ghost voltage.

Finally, a noncontact tester might not show that a cable is live if the cable is in contact with a well-grounded surface (lying on a concrete floor or in contact with a grounded metal surface, for instance). In this case, the electrostatic charge from the AC-voltage is bled off to the concrete floor.

In spite of these limitations, I still consider this tester to be essential. Double-checking results with a noncontact tester can save your life.

TEST A RECEPTACLE FOR POWER

Receptacles are one of the most-common elements of a residential electrical system, especially because building codes require one every 12 ft. in most areas of a house. They also are a good demonstration of how the two voltage testers can work together to ensure that power is off and the box is safe to work in.

CHECK FOR VOLTAGE AT THE RECEPTACLE FACE

After I've shut off the breaker that I think is feeding power to the receptacle, I take a few seconds to check for voltage with a voltage/continuity tester while the receptacle cover plate is still in place.

1. To test for power, put one probe in the receptacle's taller neutral slot, then put the other probe into the hot (shorter) slot. If you get a no-voltage result, make sure the probes are in contact with the metal strips in the slot by moving the probes side to side in a slight arcing motion. If I get voltage at the face of the receptacle during any of these tests, I know that I've shut off the wrong breaker. So I go back to the panel, look for the correct breaker, then start again.

2. To test for correct grounding, I use the continuity function on a voltage tester. If the receptacle is wired correctly, the tester should indicate continuity between the neutral slot and the grounding hole because the neutral and the ground should meet at the service panel. If you get continuity between hot and ground (or hot and neutral), it means there might be a load on the circuit, like an incandescent light left in the "on" position.

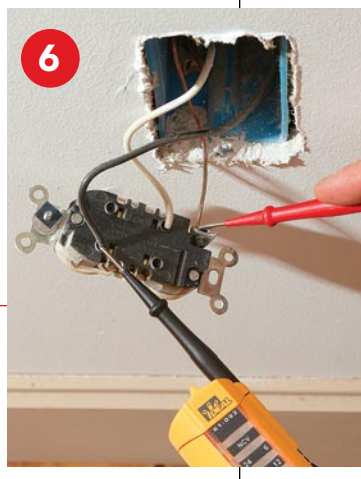
REMOVE THE COVER PLATE AND DIG IN

If the voltage/continuity tester shows no voltage at the face, I unscrew the cover plate, remove the receptacle-strap screws, and carefully pull the receptacle away from the box for a closer look. At this point, I still am treating the receptacle as if it is powered. The receptacle face might be dead, but that could be due to an intermittent, poor connection to the receptacle, or a wire in the box could be live and loose.

3. To test for power inside the box, I use a noncontact tester (testing it first on a known live circuit) to touch each of the wires near the point where they land on a terminal or enter the back of the receptacle. **4.** Run the tip of the tester along each wire back into the box. **5.** You never know if a live wire is broken farther back in the box, sometimes inside the wire's insulation. Also, the noncontact tester alerts you to other live circuits that could be just passing through the box on the way to another box.

THE LAST 10% CAN SAVE YOUR LIFE

If I've gotten no signs of voltage so far, I can be 90% sure that the circuit is dead. But a noncontact tester has limitations that can lead to false-negative results, and I want to be 100% sure that the power to this receptacle is off before I handle the wiring. **6.** So I do one last check of each bare wire for voltage to ground, this time with a voltage/continuity tester. The ground reference in a receptacle box is typically either the grounding terminal or the neutral terminal on the side of the receptacle.



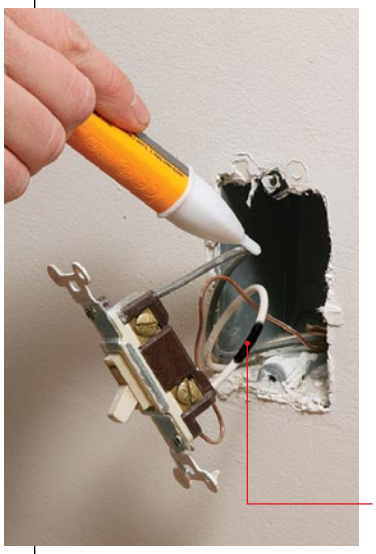
Don't buy a digital multimeter

I see lots of newbies buy a cheap digital multimeter (DMM) when getting ready to do electrical work in their homes. A DMM will get the job done, but I don't recommend starting out with one. It's easy to goof and set it to the wrong range, or to measure DC voltage, which will give deceptive readings. Also, the high internal impedance of a DMM, which is designed to protect electronic components from damage during testing, can give false voltage readings on dead circuits under common conditions. In fact, I've measured up to 90v on a dead circuit using a DMM.

Photo this page: bottom left, Krysta S. Doerfler. Photos facing page: top, center right, Clifford A. Popejoy; bottom right, Krysta S. Doerfler.

TESTING SWITCHES IS DIFFERENT

There's a big difference between checking voltage at a receptacle and checking voltage at a switch: A switch has no neutral. There might not even be a neutral in the switch box, and if the wiring is old, the box might not be grounded. In the case of a switch, I use a noncontact tester to identify the hot wire and team up a voltage/continuity tester with a portable ground to determine whether there is voltage to the switch.



SNIFF OUT VOLTAGE WITH A NONCONTACT TESTER

Unlike a receptacle, a light switch can't be checked for voltage with the cover plate still on. So after shutting off power at the appropriate breaker, remove the cover plate, and use a noncontact tester to check for voltage at each switch terminal.

If there's no voltage, unscrew and remove the switch from the box, treating it as if it is live. Then use the noncontact tester to check each terminal. Next, trace each wire back into the box to check for breaks in the wire, and rule out the danger of another unknown live circuit running through the box. **Note:** As shown at left, you might find a neutral (white) wire marked black to indicate that it is being used as a hot.

What if there are no terminals? If the switch is old, the wires might be connected via back-wire holes. A noncontact tester will still indicate voltage through the wire insulation, but a voltage/continuity tester will need a bit of exposed bare wire to place the probes on. To do this, rotate the wire while pulling it out of the back-wire hole.

VERIFY THAT POWER IS OFF WITH A GROUND

You might have noticed that the switch has two, or sometimes three, hot terminals. But you won't find a neutral terminal, and maybe not a ground. A noncontact tester doesn't need a neutral or a ground as a reference point, but the goal is to **double-check results with a voltage/continuity tester**. If the switch is in a metal box, that's a good candidate for a ground reference, but don't assume a metal box is grounded without checking first (photo right). If the box is plastic, you can probably still find two or more neutral (white) wires spliced together with a wire nut and tucked in the back of the box (photo left). If there are no neutral wires either, you will need to use a portable ground reference (see below).

Metal boxes may not be grounded. Check for continuity between the metal box and a neutral (or a portable ground) before using it as a ground reference.

WHAT IF THERE IS NO GROUND?

Most of the time, I'm working in an electrical box that has a neutral wire or a bare copper grounding wire, or the box itself is grounded. If installed correctly, any of these things acts as a ground reference when I use a voltage/continuity tester. But there are times when I don't have a nearby ground, as when there's an ungrounded switch box with no neutral in it, which is pretty common in a house 50 years old or older. To get around this, I use a three-prong extension cord plugged into an outlet in some other area that I know is properly wired and grounded. This way, I can insert the probe into the grounding hole in the end of the extension cord and use that as a reference point when testing for voltage.

FineHomebuilding.com Look for the Magazine Extras section on our home page to see more demonstrations using noncontact and voltage/continuity testers.