The Indispensable Digital Multimeter

This tool is a must-have when it comes to electrical troubleshooting

BY BRIAN WALO

If I had to carry only one device for electrical work, it would be a digital multimeter. Most of the other electronics I carry are adjuncts that do some of the same things a basic, quality multimeter can do. Available in various shapes and sizes, these fairly small, stout boxes consist usually of a display, wire leads that attach to the item being tested, and switches or knobs to choose between multiple metering functions—hence the tool's name.

The original multimeters were analog, and they used a needle and gauge (like a speedometer in your car) to give readings. Digital multimeters (DMMs) are now more common; they use an LCD screen to display readings with numerical values. Quality and functions differ from one model to another, and prices vary accordingly.

Brian Walo is an electrician in Raleigh, N.C. Photos by Rodney Diaz, except where noted.

STYLE Some meters include a split fork, a hook, or a clamp that allows you to measure the amps running through a wire or cable without having to expose the conductors. All three styles do essentially the same thing, but each has a niche. Fork meters can fit into tighter spaces, which is helpful when cables are run close together. Meters with hooks or clamps make hands-free operation easier.

FORK

HOOK

CLAMP

LEADS Most, if not all, DMMs come with probe-tipped leads. Some more expensive models include alligator clips, which can be attached to conductors rather than having to be held in place.

Bottom photos this page, from left: first, third, and fourth, courtesy of Milwaukee; second, courtesy of Klein Tools. Photos facing page: top right, courtesy of Milwaukee; bottom left, courtesy of Klein Tools.

A SPARKY'S SIDEKICK

The quality of a digital multimeter (DMM) and the features it offers are going to play a driving role in cost, so you don't want to buy more meter than you're going to need. (The Amprobe AM-60, shown here, costs $60.) I'm a tool junkie, so I understand the desire to buy the best. But even though all the available bells and whistles sound really cool, you probably won't need a DMM capable of measuring 1000 amps for your next remodel. Functions I consider useful but not strictly necessary are temperature and noncontact voltage detection. I wouldn't spend extra on a DMM with these functions because I have tools that do the same things and cost less. That said, there are some basic functions that are must-haves for residential work.

DISPLAY A simple lamplit display will get the job done, but if I had to buy a new meter tomorrow, I'd get one with a bright backlit or other high-contrast display, the bigger the better. Milwaukee's meters have a particularly nice white-on-black display.

ACCURACY Digital multimeters commonly have an accuracy of ±0.5%. Unless a multimeter is listed as "true RMS," it can be assumed to be an "average-responding" tool. Electricity travels through wiring in waves, so an average-responding meter essentially takes an educated guess at how much current is flowing based on the assumption of a perfect waveform of electricity. True-RMS meters take actual measurements but are more geared for working with computers filled with semiconductors (or building a robot in your basement) than for doing residential electrical work.

MAX AMPS Since 400 amps is typically the absolute max for service to a residence in my area, I like a meter that can read slightly above that range, just to be on the safe side.

RANGING Changing the range of the multimeter allows you to dial in the precision of the readout. If you're measuring a 120v circuit, it's more helpful to have the range of the multimeter set between 0v and 200v than it is to have it set between 0v and 1000v. It's also a matter of safety, as setting the range too low could mean blowing a fuse in the multimeter. I prefer an auto-ranging meter so I don't have to think about setting the dial, but there are meters with both auto-ranging and manual-ranging functions.

DURABILITY Like any electronic device, a multimeter typically doesn't like to be dropped, rained on, or left in the sun. But Klein's MM500 meter is sealed completely against dust and water and is designed to withstand up to a 10-ft. drop.

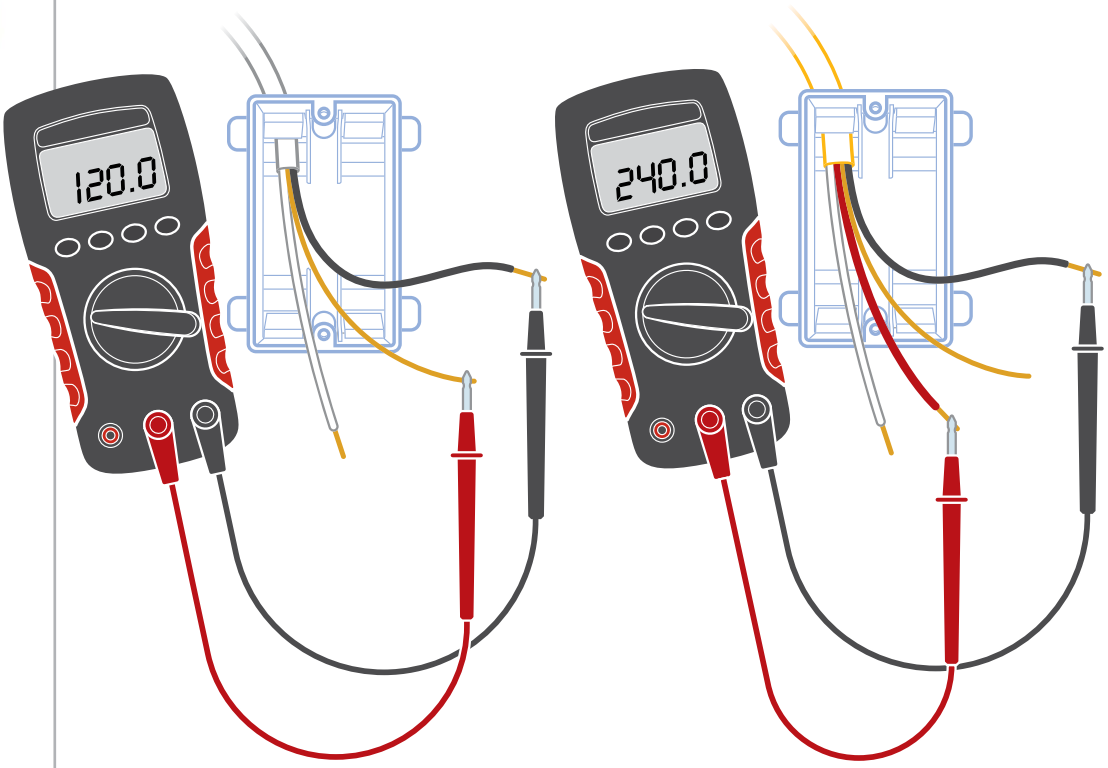
CATEGORY RATING Developed to ensure that the right diagnostic tools are used for the wide variety of applications, category ratings appear on all multimeters, ranging from category I (cable, telephone, etc.) to category IV (commercial and industrial power distribution). Category III is ideal for residential work and is approved for fixed installations such as residential panels, circuit breakers, wiring, receptacles, and fixtures.

THREE KEY FUNCTIONS

Even the most basic, dirt-cheap multimeter is designed to measure at least three fundamental components of electrical energy: volts, amps, and ohms. You can't get by without these three basic functions, and aside from the very cheapest of available options, which might not include an a.c.-voltage function, you'd be hard-pressed to find a meter that doesn't do all three.

If you think of electricity like water flowing through a pipe, volts would be like the pressure (electrical "psi"), the amps would be like the number of gallons per minute (electrical "volume"), and ohms would be akin to anything limiting water flow, such as pipe diameter or obstructions inside the plumbing.

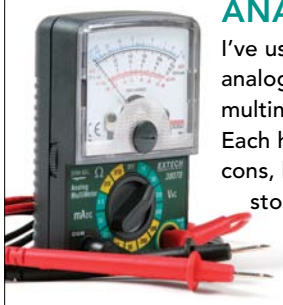
Ṽ VOLTAGE Our appliances and devices are designed to operate at specific voltages, such as the 120/240-volt services supplied to millions of U.S. homes. Anything above that designed voltage can result in catastrophic damage, which is why surge protectors are so important for computers and other electronic devices. Voltage drop, which is when the voltage reaching a device is less than designated, is also a concern. This can be caused by bad wire splices or junctions, loose connections within the circuit or on the panel, oxidation or corrosion of a connection or conductor, wiring that's too small for the load being carried, and many other variables.



IN USE: First, set your multimeter to a.c. voltage. Touch one of the leads to the neutral or ground wire*, and touch the other lead to the suspected hot wire. The meter will indicate what voltage is present within the conductors. A 120v circuit should read 120v between hot and neutral or hot and ground, and 0v between neutral and ground. A 240v circuit should read 240v between the two hot conductors, and 120v between each of the hot conductors and the ground. If the 240v circuit has a neutral wire (typical for appliances like ovens and dryers), you should get 120v between black and ground or black and neutral, and 120v between red and ground or red and neutral.

*It's good practice to check for voltage against both the ground and the neutral conductors in the event that one is damaged or malfunctioning and would give a false negative.

ANALOG vs. DIGITAL



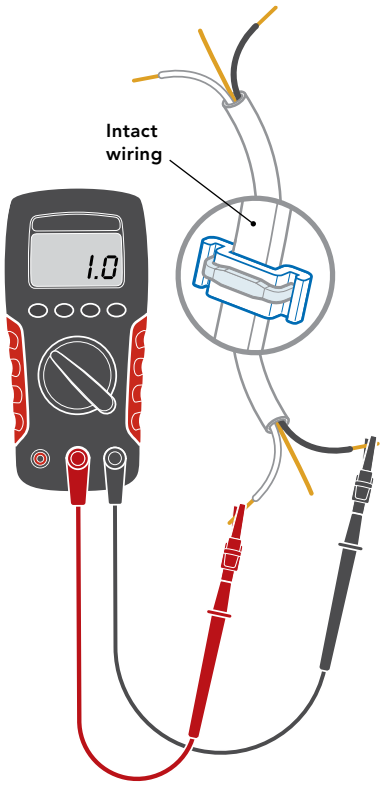
I've used numerous analog and digital multimeters (DMMs). Each has its pros and cons, but I'll take a stout DMM over an analog model any day of the week. Because analog meters have moving parts that must be calibrated, they're more delicate and susceptible to damage from the rigors of job-site use. Also, unlike DMMs, analogs generally have to be set manually to a specific range for measurements, which can lead to incorrect readings or even damage to the meter if you're not paying careful attention to the settings or where the leads are plugged in. Still, it's worth noting that although DMMs offer more consistent results, they aren't always as true to reality as a comparable analog meter with similar specs. DMMs also can pick up "phantom" voltage—nonexistent voltage induced into a circuit by other nearby sources—that analog meters won't register. I'd still rather have a DMM, since they're easier for me to read and are less sensitive to the beatings I dole out every day. I've also found that you can get a good-quality digital meter with numerous features for less than a good-quality analog these days.

Drawings: Trevor Johnston

Ω OHMS Measured in ohms, resistance is what slows down the flow of electricity and creates heat. Therefore, it's helpful to know what, if any, resistance is present in your wiring that should not exist.

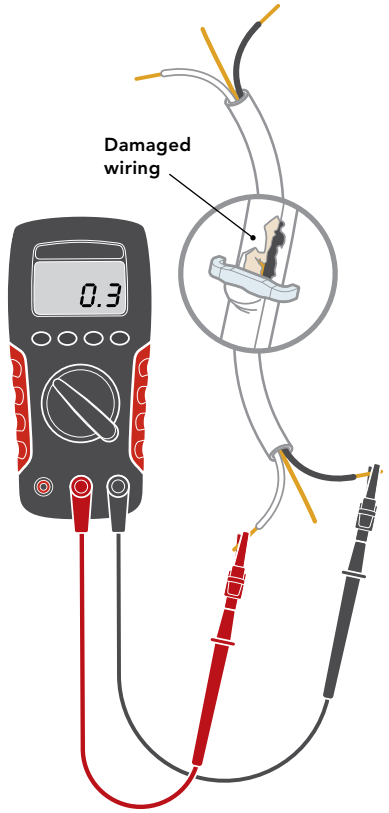
Resistance can be created by anything that changes the characteristics of the device or wiring connected to it. For example, a staple that's overdriven to the point of damaging the wire, wiring that's too small for the breaker it's attached to, corrosion on conductors and devices, or poor connections can all lead to resistance.

Continuity is the ability of electricity to flow through a component. It's measured by way of the resistance of the wiring and/or device. A multimeter's continuity function can tell you whether there's a fault in a run of wiring, can be used to trace runs of wiring between workboxes, and can allow you to test the function of devices such as toggle switches, which have to be completely disconnected from all wiring.



IN USE: To check a wire for a fault, it must first be completely de-energized and disconnected from all other wiring. Clip one lead to the hot conductor and one to the neutral conductor. As long as the opposite ends of the wiring aren't touching anything, most meters will read 1* (for infinite resistance) in a perfectly intact section of wiring. If you get a reading other than 1, there is something in that run of wiring that's bridging the hot and neutral. This could be an errant drywall screw or an overdriven staple that has damaged the insulation and allowed a fault in the line.

*Verify the reading in your DMM's manual.

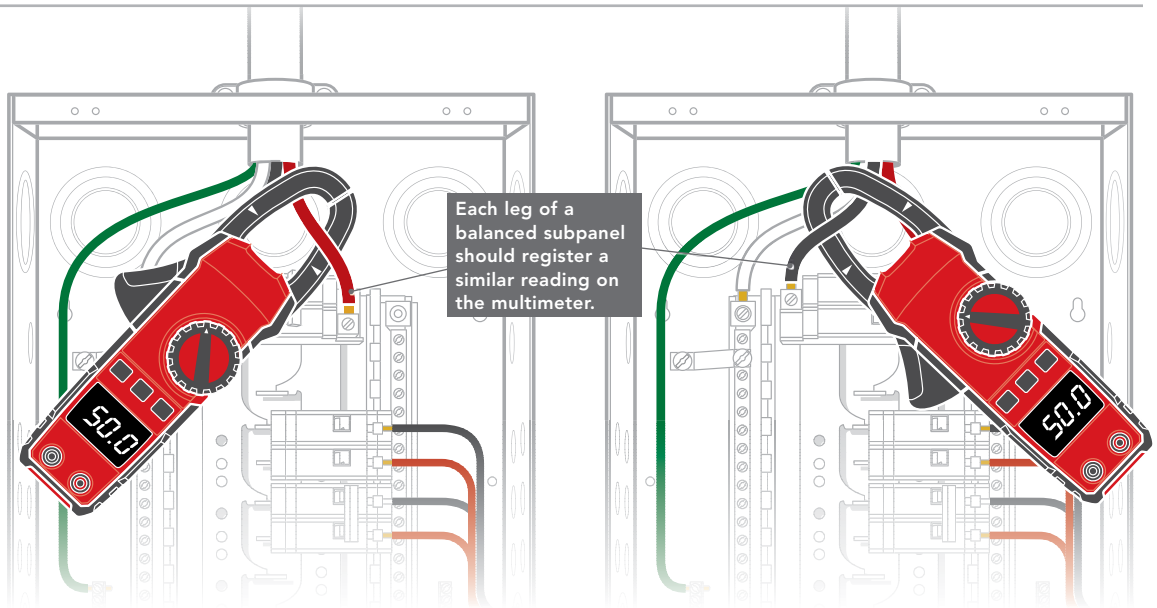


Ã AMPS While voltage remains more or less constant, amperage varies based on use. For instance, if you have a toaster plugged into the wall, your multimeter will show voltage running through the wire, but if the appliance is off, no amps will be flowing through the wire.

Amps are important because they measure how much electricity you're using when you turn on the oven or when the air conditioner cranks up. Having too many amps running through a circuit creates friction (resistance), which creates heat. If the breaker doesn't trip soon enough, a fire could start.

I use the amp function most often to balance the load in a breaker panel. If you have a lot of equipment on one leg of the service and the other leg isn't carrying anything, your neutral has to carry a more substantial load, which wastes energy and may create an overload. This is more of a problem with heavy 120v loads (such as those from a tablesaw or a window air conditioner) than for 240v circuits on a double-pole breaker.

If you expect to do this type of work, I recommend using a clamp-on meter because it allows you to check amperage safely without having to touch any exposed conductors.



IN USE: Without touching any bare conductors, and while everything is off, remove the cover to your subpanel. Insert one leg of the wire feeding the panel into the jaw of the meter. Turn everything on, and write down how much current is being used. Power everything off, and do the same to the other leg of the feeder. Compare the two results to see how close to balanced you really are, and adjust circuits from one leg to the other as necessary if the loads are drastically different. Try to put things that run at about the same time on opposite legs. For instance, a one-man shop won't need enough amps to run the tablesaw at the same time as the thickness planer, but it may be likely that the tablesaw and dust collector are running simultaneously.