Get to Know Your Multimeter

In Part I of a four-part series, learn how this useful, multipurpose tool helps you troubleshoot gremlins in your boat's electrical system.

BY STEVE D'ANTONIO

NOT SO LONG AGO, THE SIMPLE 12-VOLT test light was the tool to use when tracking down electrical problems. Increasingly, though, the digital multimeter is used by electricians and do-it-yourselfers to diagnose a wide range of problems in both DC and 110-volt AC marine electrical systems.

Even if you aren't sure how to use one, having a multimeter aboard makes good sense for two reasons: If you run into trouble, chances are that someone else aboard or nearby will probably know what to do with the tool. And if you don't have one on board, it's guaranteed that you'll never learn how to use it. Multimeters are relatively simple to operate, and the wealth of information they provide is priceless.

While meters come in a wide variety of shapes and sizes with different capabilities, features, and ranges, most function in the same way, and even an inexpensive one will do nearly everything the average do-it-yourself cruiser could ever hope for when troubleshooting common onboard electrical faults.

To get started, let's get to know the control panel, where you set the meter to perform a specific task. Once you understand the basic controls, we'll dig deeper into their various functions and explore the tasks they perform.

On my multimeter, the instrument's functions are arranged in a clockwise direction from the Off position.

A: When this function is selected, the multimeter measures AC-power voltage for doing shore-power, generator, and inverter work.

B: This function measures DC voltage for a battery, an alternator, and the other primary onboard electrical components. With an optional attachment, the meter pictured also measures rpm for gasoline engines.

C: The millivolts scale, represented by the symbol mV, measures thousandths of volts DC and is useful, among other things, for troubleshooting corrosion issues.

D: At this setting, the multimeter measures resistance in ohms, represented by the Ω symbol. Use your multimeter set to this position to identify poor connections and to evaluate the bonding system.

E: This setting, represented by the symbol of an arrow striking a wall, is the multimeter's diode-test feature. Use it to evaluate a diode or your galvanic isolator-equipped shore-power system.

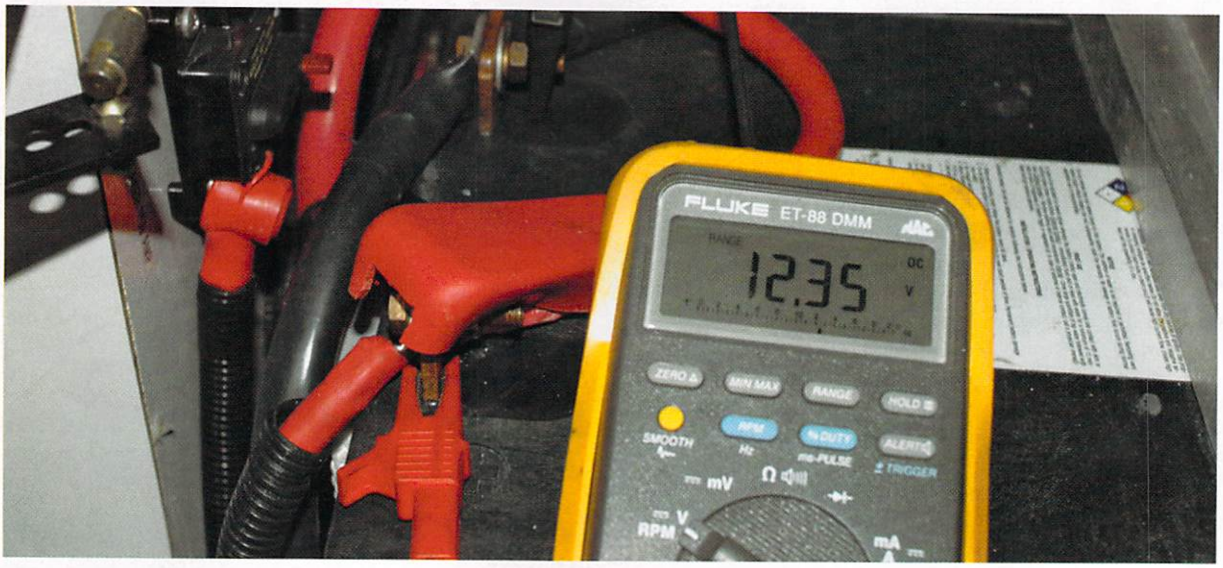
F: At this setting, the multimeter measures DC current in milliamps, useful in determining how much current is being drawn by, say, a light, fan, or motor.

G: At this setting, the multimeter measures AC amperage of power from shore, a generator, or an inverter. Use this to determine how much current an AC appliance is drawing and thereby gauge if it's working correctly.

In upcoming columns, we'll delve into specific troubleshooting tasks for this all-too-useful tool as well as explore techniques for measuring amperage, voltage, and resistance. Stay tuned.

Steve D'Antonio offers services for boat owners and buyers through Steve D'Antonio Marine Consulting (www.stevedmarineconsulting.com).

Looking for Trouble



In Part II of a four-part series on digital multimeters, the focus is on troubleshooting.

BY STEVE D'ANTONIO

In "Get to Know Your Multimeter" (May 2012), we discussed the basics of digital multimeters. Now we'll delve into one of the device's most useful functions—voltage measurement—and explore how to troubleshoot a range of onboard electrical maladies.

There are two types of voltage that you can measure using a digital multimeter: AC and DC. Shore power, a generator, or an inverter supplies AC power. Extreme caution must be used when taking AC measurements; this type of voltage can be lethal. DC voltage, which is most commonly measured aboard small craft, won't electrocute you. However, short circuits can be catastrophic. Use caution when placing measurement probes onto such energized surfaces as battery terminals and bus bars.

Voltage measurements are nearly always made in *parallel*: The meter's lead connections parallel those of the source being tested. For example, when testing a battery's voltage, the meter's positive and negative leads are placed on the battery's positive and negative terminals. When testing the output from an electrical receptacle, the leads are inserted into the hot and neutral (these are essentially AC terms for positive and negative) slots. By contrast, ampere measurements are made in *series*. We'll talk about this more next month.

Engines that won't start are one of the most common and useful applications for voltage measurement and troubleshooting. Your digital multimeter can quickly diagnose or narrow down the problem. If you turn the key to the On or Crank position and nothing happens—no low-oil-pressure alarm or instrument movement—the problem is certainly electrical. Begin by testing for voltage at the start battery. A fully charged, rested battery (with no charge source present) should read between 12.6 and 12.8 volts. (It's important to note that the difference between a fully charged battery and one that's essentially dead is a scant .6 volt; if your battery reads 11.9 to 12.0, it's heavily discharged.) If the battery voltage is correct, move on to the primary post on the starter (make sure the battery switch is on). The primary post is the large stud to which an equally large, usually red cable is attached. Connect the meter's negative probe to a good ground—a clean metal surface on the engine, preferably one of the large starter-securing bolts or the bolt that secures the large primary negative cable to the engine block. Ensuring that your meter is well grounded is important; if it's not, your readings will be meaningless. And if you can't establish a good ground at the engine, that, too, may be the problem.

This battery has juice but is running low. A fully charged, rested battery should read between 12.6 and 12.8 volts.

The voltage reading should be virtually the same as that of the battery; if it's zero or very low, the issue lies between the battery and this location. If it's correct, try cranking the engine. If the voltage drops precipitously, you have either a poor connection or a battery that's ready to be recycled. If you have voltage at the primary post and nothing happens when you attempt to crank, move the digital multimeter's positive test lead to the starter solenoid secondary connection, a small-gauge wire that's often but not always yellow. This wire should be energized with battery voltage when the key is turned or the starter button pushed to the Crank position. If no voltage is present, it's likely a poor connection or defective switch. If voltage is present, the starter solenoid is defective; in a pinch, it can sometimes be repaired or simply replaced.

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STEVE D'ANTONIO

All Amped Up

When an inductive clamp is placed on a shore-power cable, it should read zero. The reading of 10-plus amps (above) indicates a serious problem.

In Part III of a four-part series on multimeters, it's all about amperes.

BY STEVE D'ANTONIO

IN THE THIRD OF THIS ONGOING SERIES on digital multimeters, we'll address ampere measurement. Electrically speaking, amps do the heavy lifting. Sufficient amperage enables starter motors to overcome the compression and resistance of an engine's pistons for cranking purposes. Amps allow a high-output alternator to recharge a large battery bank relatively quickly. The ability to measure amps with a multimeter is invaluable for identifying or isolating a variety of problems, from a malfunctioning voltage regulator to a defective or shorted battery.

Amps aren't measured the way that voltage is, a critical difference. Last month, we discussed how voltage is measured in *parallel*; for instance, when a multimeter's positive and negative test leads are placed on the positive and negative terminals of a battery. Conversely, amperage is measured in *series*. When any electrical component is placed in series—be it a multimeter, a light, or a battery—it's essentially inserted into a circuit rather than alongside it or in parallel. For measurement purposes, this means that up to about 10 amps, the multimeter becomes part of the circuit as a current-carrying conductor. For example, if you wanted to determine how much current an anchor light used, you'd separate one of the light's conductors at the base of the mast or the electrical panel. Setting your meter to AMPS DC, you'd then attach one lead (it doesn't matter which) to the wire leading to the light and the other to the energized conductor that ultimately travels to the source of power, the battery. (These two conductors are referred to respectively as the "load" and the "line.") When power is applied, the light is illuminated, and the meter will simultaneously indicate how many amps are being drawn. A 12-volt, 20-watt light should draw about 1.5 amps. If, however, it's drawing 8 amps, you might conclude that the insulation on the positive wire leading up the mast conduit (all mast wiring should be in a conduit) has chafed and is creating a "pseudo" short circuit. This will unnecessarily consume battery power, and it may also accelerate mast corrosion.

Most multimeters will safely carry up to 10 amps for measurements of this sort. Beyond that, however, their internal fuse *should* blow to prevent damage to its circuitry. For obvious reasons, try to avoid testing that function. If you want to measure the amount of current (another name for amperage) produced by the alternator or consumed by the starter, buy an amp meter that includes an inductive "amp clamp." These scissors-like jaws can be spread and placed around a conductor, enabling you to measure hundreds of amps safely and easily without ever touching or disconnecting a wire. I rely upon this useful tool regularly for troubleshooting.

There's one caveat to using an inductive amp clamp: If you wish to measure current, the clamp must be placed around a single wire only. If you place it around several wires within a cable, such as an AC extension cord, the hot and neutral conductors within the cable will neutralize the inductive field, and the meter will read zero. If you place your inductive amp clamp around your shore-power cable, for instance, it should read zero. If it doesn't, that may indicate a serious and potentially dangerous fault that's allowing the water in which your boat floats to act as a return path for electricity. Should that be the case, unplug your boat from the dock and call an American Boat & Yacht Council-certified marine electrician to check the system for faults.

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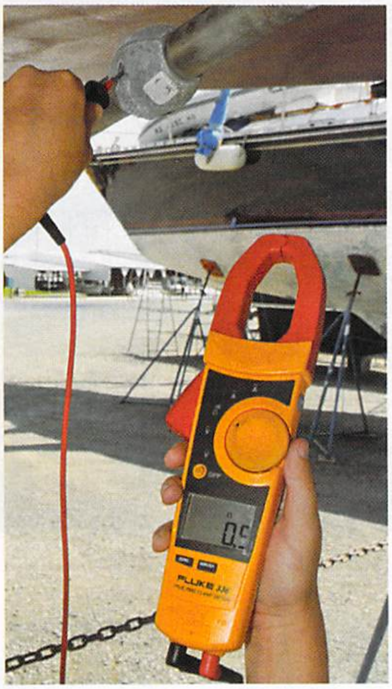
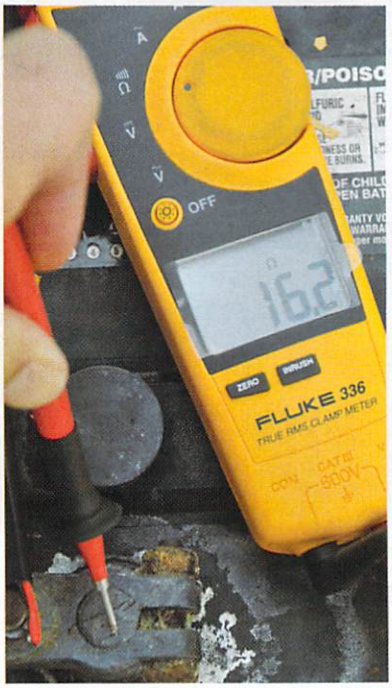
Ohm, Sweet Ohms





This shaft anode (far left) is making good contact with the shaft and prop, with low resistance of less than 1 ohm. The resistance between this battery lug and its adapter (middle) is higher than it should be. Resistance across a good fuse, like this one (above), should be very low, no more than a few ohms.

STEVE D'ANTONIO

In the conclusion of our multimeter series, the push is on resistance.

BY STEVE D'ANTONIO

In the fourth and final installment of this series on understanding and using multimeters, we'll examine the resistance function and how it can be used for various troubleshooting and repair procedures.

The ability to measure resistance is among a multimeter's most basic, and valuable, functions. With electricity, resistance is the ultimate arbiter of the efficiency with which any electrical system, appliance, or component operates. In most cases, a certain amount of resistance is to be expected; all wiring, incandescent lights, and batteries impart resistance to an electrical circuit. With regard to wiring and connections, less is best.

How does this affect the way gear operates? With wiring runs, the wire's length and gauge (or diameter) present some of the most commonly encountered resistance issues faced by cruisers. With longer runs, the electricity flowing through those wires will encounter greater resistance. With navigation lights and wiring to the masthead, for instance, resistance invariably diminishes the voltage that reaches the light. (Voltage is also lost in the form of heat radiating from the wire, though this is usually an amount almost too tiny to measure.) In extreme cases, however, high resistance can and often does lead to overheated wiring, and even to fires.

In addition to length, wire size has a dramatic effect on resistance, with larger-diameter cables presenting less resistance to the flow of electrical current. For instance, if the cable between the alternator and the battery or the one between the battery and starter is undersized, it will impart significant resistance, thus generating heat and causing these components to lose efficiency.

On a regular basis, use your multimeter's resistance function—marked by Ω, the Greek letter omega, which is the symbol for ohms, the unit of measure for resistance—for a variety of troubleshooting tasks. You can, for instance, determine the resistance in circuits that aren't performing properly. You can also check an ignition switch to determine if its contacts are connecting when the switch is turned on and completely breaking contact when it's turned off; a switch that's wet, for example, can often retain some degree of connection, which can lead to a dead battery or an engine that starts itself. If the engine refuses to start and there's sufficient voltage at the starter's positive or secondary post but no voltage at the primary connections for the solenoid, the switch is often the culprit, and using a multimeter set to the resistance function can confirm this. The resistance function can also be used to verify the condition of a fuse, determine if it's blown, and identify oxidation on the contacts, which could lead to overheating.

Troubleshooting or confirming the operation of a bonding and zinc-anode system is yet another area where resistance measurements are extremely valuable. The resistance between an anode and a propeller or shaft should be no more than 1 ohm, and the same holds true for resistance measurements throughout a vessel's bonding system. Use the multimeter to test those crusty, green bonding connections at your seacocks or keel bolts: Chances are good that you'll encounter significantly more resistance, the consequences of which will be zinc anodes that aren't able to do their job properly and, potentially, increased galvanic-corrosion activity.

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