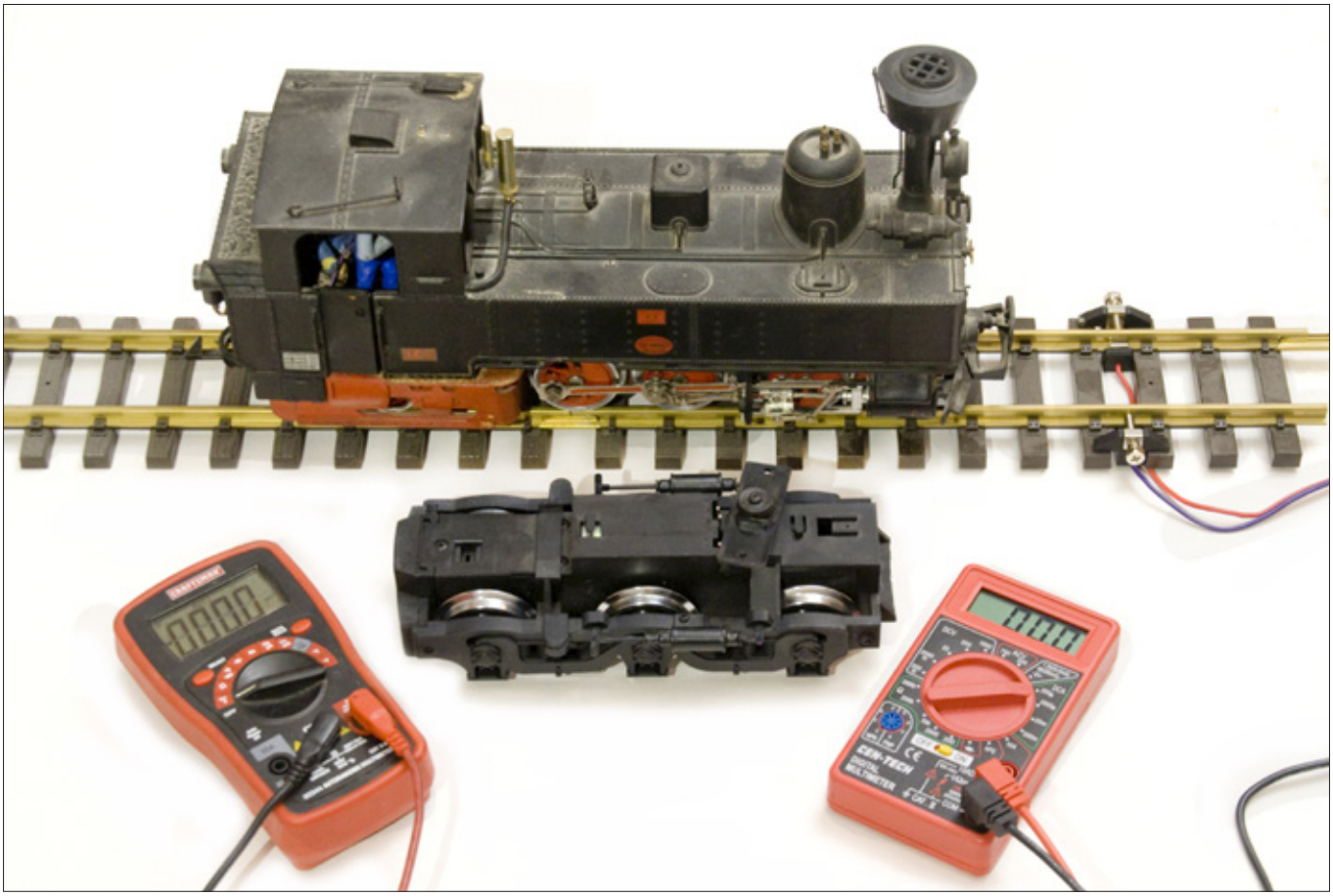
KEVIN STRONG

Understanding the multimeter



When you have electric trains, you need a way to measure electricity to make sure the electrons flow as they should. A multimeter (a.k.a. "volt meter") is an inexpensive, yet indispensable, tool for this task. PHOTOS AND ILLUSTRATIONS BY THE AUTHOR

A fellow modeler and I were talking about an electrical problem he was having. I asked if he had a volt meter. He responded that he did but didn't know how to use it. I was a little taken aback by that but, being the son of an electrical engineer, I learned how to use a volt meter about the same time I learned how to write my name. It never dawned on me that some folks wouldn't know how to use one.

It's high time to demystify this invaluable tool for model railroaders. The term "volt meter" is generic; most, if not all, volt meters these days are what are called "multimeters." These measure volts, current, resistance, and continuity; some even measure capacitance, temperature, and other things. There will almost always be a large dial on the front of the meter with which to set the function you wish to measure.

Multimeters are easy to find. A cheap one will run $10 or so. If there's a Harbor Freight in your area, check your paper for ads; they frequently offer inexpensive meters as freebies if you buy something else. Higher-priced units tend to have more features but, for a model-railroader's tool bag, you don't need anything fancy. You'll only need to be able to measure voltage, current, continuity, and maybe resistance.

There are three basic parts of a multimeter. The display, the dial, and the probes (**photo 1**). The display is where you read the values of what you're measuring. Do yourself a favor and get a digital display. They're far more accurate than the old-style analog needle. Most of the displays I've seen have four digits, though some may have more. For our purposes, four digits is adequate.

The dial allows you to select what you're measuring: **Voltage** (DC or AC); current, measured in **Amps** (A) or **milliamps** (mA); resistance, measured in **ohms** (Greek symbol omega—Ω); and **continuity**. There are two types of multimeters: traditional and self-adjusting. With a traditional meter, you have to select the anticipated range of whatever it is you want to measure. If you're measuring a battery, for instance, you'd set it to DC

1. A multimeter has three basic parts: the display (digital shown), the dial (to select what you want to measure), and the probes (to connect to the component being measured.)

2. With a traditional meter, you must select from a range of values within which you believe your voltage, current, etc. might read. Here, the meter is set to 20V and displays the measured voltage (of a throttle) at 14.04V DC.

3. The accuracy of the value being displayed depends on the setting. In this example, the meter is set to 2,000 mV (2V). Reading a standard alkaline battery, it reads 1,304 mV, or 1.304V—accurate to a thousandth of a volt, as opposed to the hundredth shown in photo 2.

4. If the value measured is outside the meter's selected range, it will display an error message or similar, such as the "1" on this meter.

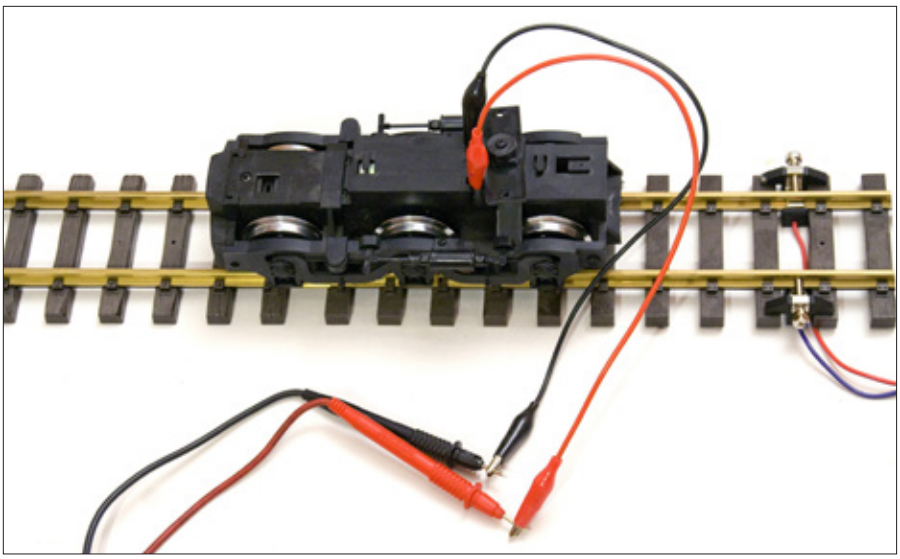
5. An "autoranging" meter will say "Auto" somewhere on the front of the meter or on the display. Also, you will not see any ranges from which to select; you'll simply see one setting each for voltage, current, etc.

6. Probes connect the meter to the object being measured. Most meters come with simple probes, such as these. Other varieties can be purchased for specialized circumstances.

voltage, 20V (**photo 2**). This gives you the most accurate measurement of the voltage. If you set it to DC voltage, 200V, it will still display the voltage, but not to the same degree of accuracy (**photo 3**). If you set it to 2V, it will display an error (**photo 4**).

A self-adjusting meter takes the guesswork out of the equation. Rather than a range of values to choose from, you simply set what you want to measure (DC voltage, AC current, etc.) and the meter will adjust the display to match what it's reading as accurately as possible given the number of digits it can display (**photo 5**).

The probes (**photo 6**) are used to test the component you want to measure. Some meters may have multiple ports for the probes; typically, there will be a



7. Alligator clips can be easily employed to adapt your probes for hands-free operation.

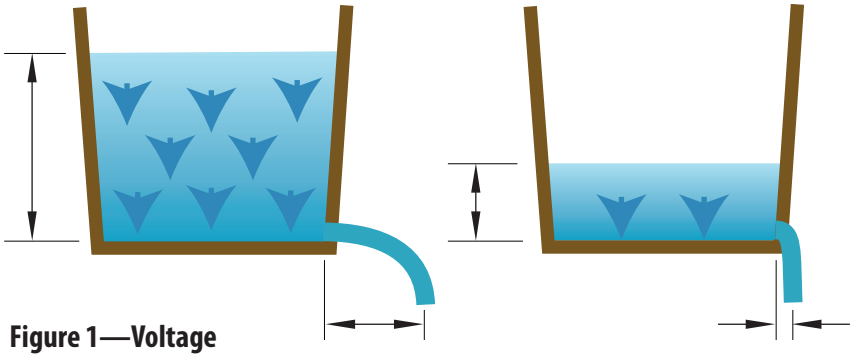


Figure 1—Voltage

Voltage is a measure of potential, like water in a bucket. The more water that's in the bucket, the greater the pressure, and the further a stream of water will travel when emptied from the bottom. Likewise, the greater the voltage, the greater potential for power when applied to a motor or lights.

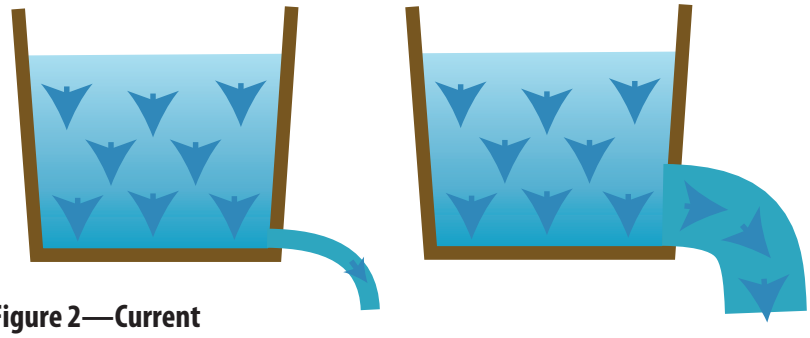


Figure 2—Current

Current (measured in Amps) is a measure of how swiftly the electrons are flowing. A small opening in a bucket allows only a slow flow of water. Increasing the size of the opening increases the rate of flow.

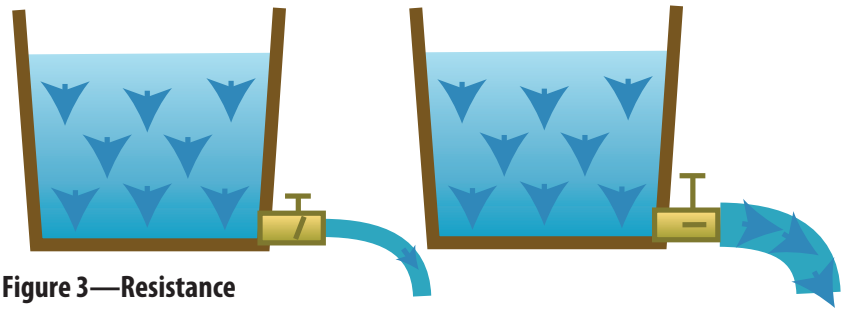


Figure 3—Resistance

By putting a tap on the bucket, the rate of flow can be controlled by increasing or decreasing the opening through which the water flows. A smaller opening offers more resistance to flow than a larger opening. In the electronics world, this is known as Ohm's Law: Voltage = Current x Resistance

Related reading

For more hobby basics, check out the author's book, ***Garden Railway Basics*** **(#12468)** at *www.Kalmbach Hobbystore.com*

special one for measuring high currents. In most cases, the probes are just short metal posts used to touch the various components. You can always connect alligator clips to them if you need hands-free measurement (**photo 7**).

Current, voltage, & resistance

Let me explain current, voltage, and resistance, so you understand what is being measured. Voltage is a measure of energy. Consider a tank filled with water. The more water that's in the tank, the more potential energy there is to be used (**figure 1**). The higher the voltage, the more energy there is to make our motors turn—they will turn faster with higher voltages. Now, let's tap a hole in the bottom of the tank. The larger the hole, the faster the water will leave the tank. That's current (**figure 2**). Now, let's put a spigot on the bottom of the tank instead of just a hole. The spigot is resistance. The more the spigot is closed, the greater the resistance and the less current passes. The more the spigot is open, the less resistance and the greater the current (**figure 3**). This is known as Ohm's Law: Voltage (V) = Current (I) x Resistance (R).

Using the meter

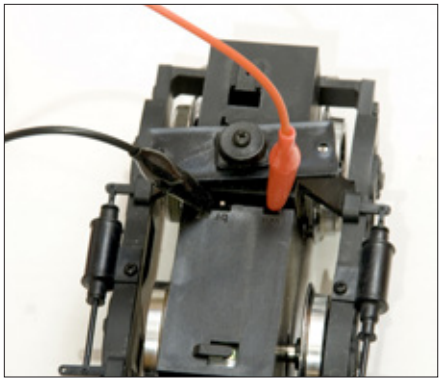
Measuring voltage is probably the most common use we'll have for the meter. We need to know how much voltage is going to the track, the motor, a light, etc. For most model trains, the voltage will be DC (direct current). Lionel trains and others (particularly three rail, 0-gauge) run on AC (alternating current) voltage. Certain accessories, like switch machines, may also work on AC. Direct current flows in one direction (negative to positive), while alternating current flows back and forth. On the meter, DC voltage may be indicated by a straight line, while AC may be indicated by a wavy line (**photo 8**). Voltage (AC or DC) is measured in "parallel," meaning the probes go from one terminal to the other, or parallel to whatever load is on the circuit, be it a motor, light, etc (**photo 9**).

To measure the voltage going to the motor of a locomotive, you would ideally put the probes directly on the contacts of the motor itself (**photo 10**). To measure the voltage on the rails, you'd put one probe on each rail (**photo 11**).

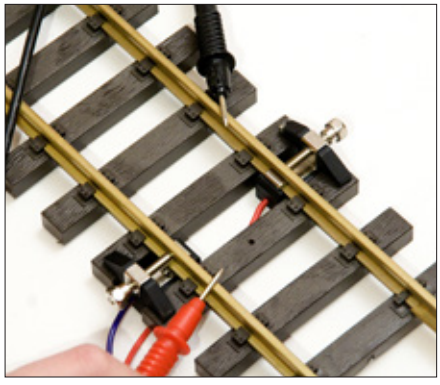
Another common measurement is determining how much voltage drop there is along the track. To check this, measure the voltage at the output of the throttle, then at various points along the track. The farther away the track is from the point where the power is fed, the greater the resistance (which causes voltage drop).

8. A side-by-side comparison of an autoranging (left) and traditional meter. Note that the autoranging meter will also automatically determine AC or DC voltage, as indicated by the icon with the straight line underneath the wavy line.

9. To measure the voltage of a battery or power supply, the probes are touched to the positive and negative ends of the power source.



10. To measure the voltage going to a motor, simply touch the probes to both contacts of the motor.



11. Measuring track voltage is simple; just touch one probe to each rail.

This is mostly due to rail joiners and poor connections between them, which is why it's recommended for longer railroads to use multiple feeds for power.

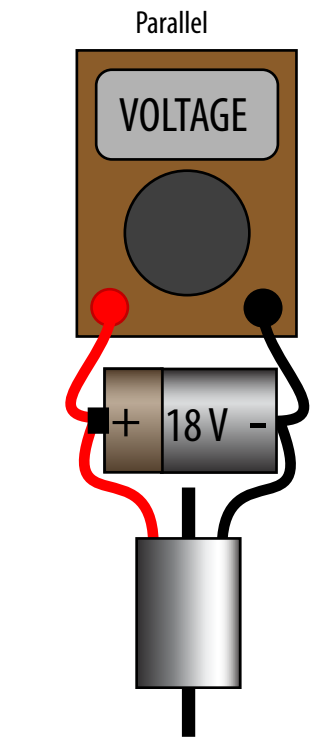
Continuity is another common measurement. This makes sure there's a good connection between point A and point B. Poor continuity might be caused by corroded rail joints, broken wires, loose plugs, or blown fuses. Some multimeters will emit an audible sound with a continuity check, while others just have a graphic display. Less expensive ones rely on the resistance meter to check the continuity. When the resistance reads 0, there's good continuity.

The resistance setting measures the resistance of a resistor or circuit, but that's typically not something done in routine maintenance on a railroad. The only time I measure resistance is when I need to confirm the value of a resistor if I can't remember the color codes.

Finally (at least for this column), the multimeter can be used to measure current. Current is measured in "series." Since you're measuring how fast the electrons are flowing, they need to flow through the meter (**figure 4**). This is harder to measure because the meter must be physically inserted into the electrical loop—it's not just a matter of touching the probes across the components.

You must be careful about how much current you're expecting to measure; if you're measuring high amounts of current, use the high-current-probe port. Using the wrong port, high current could cause damage. Typically, our motors will draw anywhere from half an amp to three or four amps under heavy load. A good rule of thumb is to always err on the high side.

As long as electrons make our locomotives run (or, for live steamers, provide lights and/or controls for our fire-breathing dragons), having the tools to check on them is pretty much mandatory. A multimeter is not an expensive tool and is pretty indispensable. Next time, I'll finish my "electronics toolkit" with a look at other tools we should have on hand to fix things when the electrons stop flowing.



Voltage (above) is measured by touching the probes to the terminals of the battery in parallel. To measure current, the meter becomes part of the whole circuit and is wired in in series.

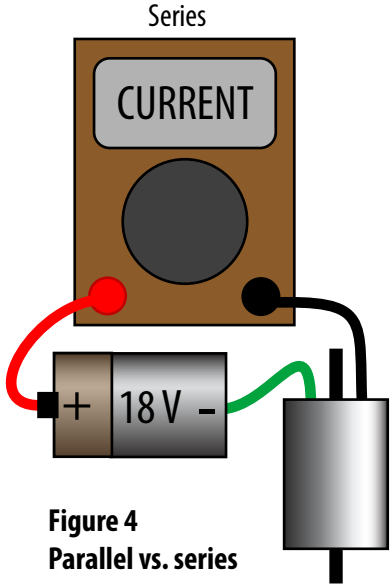


Figure 4
Parallel vs. series