How to Use a Multimeter - Part 5: Measuring Voltage Drop

by Rob Siegel (11 July 2017)

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During the past month, we've covered how to use a multimeter to measure the trinity of voltage, resistance, and current. I've explained how this covers most electrical diagnosis in a car—how most of the time, you're either trying to verify the presence or absence of voltage to a device or the presence or absence of continuity between a device and the voltage source (or ground). Also, when you're trying to find the source of a parasitic drain on the battery, you're trying to determine how the current measurement is less commonly used.

The last arrow you need in your electrical diagnosis quiver is the voltage drop measurement. It's used to help diagnose high-resistance failures. People sometimes talk about the voltage drop measurement in hushed reverent tones, as if it is the key to all electrical diagnosis, and by knowing it you're inducted into the Illuminati. It's not that

big of a deal. It certainly isn't a panacea to all electrical problems. But every once in a while, it is handy.

Theory of voltage drop measurement

Here's the deal. As we discussed last month in the piece about how electricity works, Ohm's Law tells you that voltage equals current multiplied by resistance (V = I * R). This can also be written as current equals voltage divided by resistance (I = V / R). Usually, the voltage is a constant 12 volts, the resistance of the wires is negligible, the electrical device in the circuit (the bulb or motor or whatever it is) has an integral resistance, and together, the voltage and resistance determine the amount of current that actually flows.

But anywhere there is a connection—for example, a wire with a ring terminal that is screwed to the body of the car to ground it, a spade terminal that is pushed onto a lug, or even the connections between the battery terminals and the battery posts—there is the possibility for corrosion to form. Corrosion has high electrical resistance that can cause the voltage to drop, which in turn causes the amount of current flowing to fall. What's worse is that these visible terminal connections aren't the only places where corrosion can cause a voltage drop. It can happen inside a switch or a relay. The mating surfaces are simply small pieces of metal that make and break electrical contact. Over time, they can pit and corrode, and the resulting resistance causes the voltage to drop, which in turn impedes the flow of current.

Voltage drop most affects devices that draw a lot of current. At the top of that list is electric motors. By far, the biggest electric motor in your car is the starter motor. So when you turn the key and hear *Rrrrrrr… Rrrrrrr*, and when you've verified that your battery is good, the culprit could be corrosion causing voltage drop between the batter and the starter, or between the starter and ground.

So, you're probably thinking, what's the big deal? If you suspect corrosion between the battery and the starter, why not just measure the resistance? We've covered how to do a resistance measurement. You own a multimeter. Why not just check it?

The answer is twofold. First, very small amounts of resistance can have a very large effect on the amount of current that flows. Most multimeters do not measure small resistance values very accurately. And besides, you really don't know what the "good" and "bad" resistance readings are anyway.

Second, even if you *could* measure the resistance accurately with the circuit unpowered, what the actual resistance value would be when hundreds of amps of current are flowing through the circuit might be dramatically different.

Now, you're probably thinking, "OK, you say I can't directly measure resistance, but I *can* directly measure current. Why not just measure it and see if it's low?" Well, maybe. The first problem is the same one we mentioned with measuring resistance—you don't really know what the "good" and "bad" current values actually are. But another problem is that a starter motor will draw hundreds of amps, and this is way too much current to measure with your multimeter. Remember, to do a current measurement, you need to put the meter in series with the circuit. All of the current in the circuit has to flow through the meter to capture the measurement. If you try measuring the starter motor's hundreds of amps of current that way, you'll blow up your meter, or at least its internal fuse, in two seconds.

However, because of the wonderful relationship between voltage, current, and resistance dictated by Ohm's Law, you can measure the drop in voltage across a connection fairly accurately, and use it to infer the presence of resistance at that connection. Pretty neat, actually. *Science!*

The voltage drop measurement

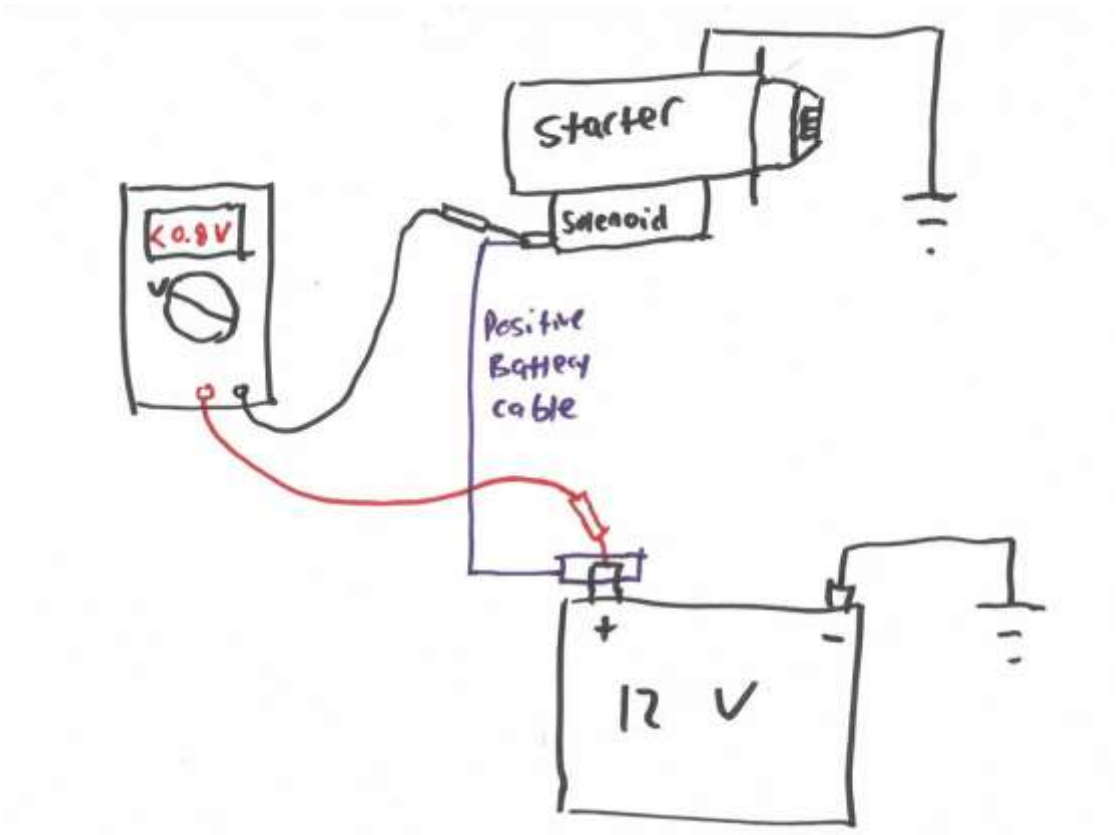
To configure a multimeter to measure voltage drop, you set it up the same way as you would any other voltage measurement:

1. Put the black probe in the socket labeled “COM” for “common,” meaning it’s common to all measurements. Once it’s there, it’ll never need to be moved.
2. Put the red probe in the socket with the V. It’s almost certainly the one that’s also labeled with the omega symbol (Ω) for resistance.
3. Turn the big rotary dial to the setting for DC voltage, which is a V with solid lines over it. It’s not the one with a wavy line over it; that’s for AC voltage (house electrical current). If you don’t have an autoranging meter, select the voltage range to measure a small voltage such as 2V.

Then, hold the probes across the connection where you’re trying to measure the voltage drop, and energize the circuit.

So, what’s different from a regular voltage measurement? What’s different is that, instead of putting the red probe lead on the “+” side of the circuit and the black probe lead on the negative (ground) side, you put the red and black probe leads at two different points on the same side of the circuit, between two positives or two negatives. That’s the secret sauce. It’s nothing exotic. Just ketchup and mayo, really.

For example, if your starter is engaging slowly when you crank it, to measure voltage drop in the positive battery cable hold the red probe lead on the positive battery post, hold the black probe lead on the post on the starter solenoid that the positive battery cable connects to, then have someone try to start the car while you watch the meter.



The basics of a voltage drop measurement, where both probes of the meter are placed on the same side of the circuit (here, shown between the positive battery terminal and the positive post on the starter solenoid).

If there is no voltage drop in the cable, the voltage at the terminal on the starter solenoid will be same as it is at the positive battery terminal, and the meter will read zero. But if there *is* a measurable voltage drop, the meter will tell you what it is. You then can use the meter to hone in on where the drop is (e.g., position the probes between the positive battery post and positive battery terminal, then between the positive battery terminal and the ring connector on the other end of the cable, then between the ring connector and the starter post). If you don't find a drop on the positive side, you can conduct the same test on the negative side, checking between the negative battery post and the case of the starter, then honing in on the individual connections.

If you need to do this by yourself, you can use clip leads to hold the probes in place while you crank the starter and watch the meter. Better still, if your meter has a min/max function, you can capture a few seconds of data and then have the meter tell you what the maximum voltage was.

So, how much of a voltage drop is acceptable? It helps to develop a feel by measuring voltage drop across healthy well-performing connections. On my cars, I typically see less than a 300mV (0.3 volt) end-to-end drop between the positive battery post and the starter post (or the negative battery post and the case of the starter).

You can find published tables that claim that, for a starter motor, an end-to-end drop of as much as 800mV (0.8 volts) is acceptable, but that for any individual connection (for example, between the positive battery post and the positive battery terminal) it shouldn't exceed 100mV (0.1 volts). This last point is crucial. I can't tell you how many times I've turned the key on a vintage car and had it go *Rrrrrrr* or just *click*, cleaned the positive battery post, and had the car start right up. This happens so often that I usually forego the voltage drop measurement and head straight for the post cleaner, but if I were to measure, I'd see a big voltage drop between the positive battery post and the positive battery terminal.

For devices that draw less current than a starter motor, you can find published tables that claim there should be no measurable voltage drop at all between a wire and its crimped-on connector, no more than 100mV (0.1 volts) between a connector and the terminal it's pushed onto, and no more than 300mV (0.3 volts) across a switch.

There. You now know how to perform a voltage drop measurement. You may now swagger forth among car people. Heck, send the Illuminati home. Tell them you've gotten the lights working without them.

Rob Siegel has been writing the column *The Hack Mechanic*™ for BMW CCA *Roundel* Magazine for 30 years. His new book, *Ran When Parked: How I Road-Tripped a Decade-Dead BMW 2002tii a Thousand Miles Back Home, and How You Can, Too*, is available here on Amazon. In addition, he is the author of *Memoirs of a Hack Mechanic* and *The Hack Mechanic™ Guide to European Automotive Electrical Systems*. Both are available from Bentley Publishers and Amazon. Or you can order personally inscribed copies through Rob's website: www.robsiegel.com.