Technical Training Tip of the Month

"Put the Voltmeter at the Top of the List"

By Grant Wolter

If you peer down at your instrument cluster for a moment while waiting at your next red traffic signal to change, you can't help but notice that automotive technology has advanced a little bit in the last twenty-five years. Twenty-five years ago, cars primarily had *electrical* systems, and automotive *electronic* systems generated "oohs" and "aahs" from us innocent bystanders. Twenty-five years ago, there was a testlight in every toolbox and a Sun VAT-40 in every shop (you might have to look up what that is).

Twenty-five years ago, the electronics industry was rising to the top of its game, and the computer industry was just getting started. There was a voltmeter (or its cousin, the o-scope) on every bench top in the lab, and a new fangled scan-tool thingy getting unwrapped in the boss's office. Twenty-five years ago, techs in the electronics industry couldn't remember what a testlight was, and the VAT-40 was made into a flowerpot for the company founder's office décor.

Today the automotive industry *is both* an electronics industry and a computer industry. If you haven't done so already, it's time to step up to using the tools of the electronics and computer industries to perform automotive system diagnostics. Putting aside a discussion of oscilloscopes and scan tools for a later date, let's focus on the tool that should be the most commonly used for modern electrical/electronic diagnostic tasks, the voltmeter.

Technicians with the skills to use a testlight effectively liked it because it was quick and easy to use. Two key points were that you didn't have to disturb the circuit much to get the testlight in there for testing, and the circuit could be tested under "live" conditions. Unfortunately, a testlight draws current from the circuit under test and was primarily designed for use on 12 Volt systems. A testlight is therefore unacceptable to use on most electronic or electronically controlled systems because it often interferes with the way the circuit works while you're trying to test it, or overloads it with too much current draw. So, what quick and easy tool should take the place of the testlight? The answer of course is the tool that the electronic techs have used for twenty-five years or more, a voltmeter.

A voltmeter can usually be used as a direct replacement for using a testlight. The advantage in using a voltmeter is that a reading can be taken without the worry of possibly electrically damaging the circuit you're testing, and it works with any of the system voltages present in automotive applications. A tech can also get more information from the readings on what is happening in the circuit with a voltmeter and that information can often shorten diagnostic time. The disadvantage with using the voltmeter is that it doesn't "load" a circuit by itself as a testlight does, so that you have to make sure the circuit you're testing is working under a load, or provide an artificial load in order to test the circuit effectively. Just like learning to use a testlight, there is a learning curve for using a voltmeter. Don't assume that because a tech has good testlight skills, they can instantly jump into using a voltmeter effectively.

Let's take a look at a couple of common situations for voltmeter usage:

Available voltage checks –

This is were a tech would use a voltmeter as a direct replacement for a testlight, getting more diagnostic information with each reading, but without the caveats of using testlights on electronics. An available voltage check is done by connecting the meter in the same manner as you would a testlight. Attach the negative lead of the meter to a known good chassis ground, the same as you would connect the clamp end of a testlight to ground. Use the positive lead of the meter as a roving probe, same as you would use the probe end of a testlight. The circuit should be left intact, all connections left connected, power to the system must be "ON", and whatever loads are in the circuit must be "ON" in order to get meaningful readings.

> **Example:** This would be the type of check you'd use to see if a module or lift motor was getting proper system voltage (power).
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> Backprobe the power supply wire at the connection to the module or motor and turn on the circuit or attempt to operate the lift. Take a reading of the voltage and compare that to what you know the system voltage should be, or even take another reading at battery positive to compare it to. Any difference in the readings between battery positive and your measurement at the power wire at the component represents a loss in the power circuit.
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> A loss of voltage would translate to mean that whatever switches, connections, wiring, etc., are in line with the power circuit to your module or lift motor, are "using up" some of the power before it gets there. We generally accept a loss of about 0.5 Volts past the switches, connections, and wiring on the power side of a circuit. If you had the engine running with the battery positive at 14.7 Volts, and a reading of 11.8 Volts at your lift, that would indicate a loss of nearly 2 Volts in the power circuit. A loss of 2 Volts is usually considered unacceptable. That loss of 2 Volts represents high resistance in the circuit, i.e., poor connections, burnt switch contacts, or wire gauges too small for the application. Ohm's law gives us the relationship that a current passing through a resistance will cause a voltage drop across the resistance.

Note that we now know, in the above example, that there is resistance in the circuit, but we did not "ohm out" the circuit to find this out, and did not have to worry about the pitfalls of ohmmeter usage to get the diagnosis. Another important note is that we don't care how many Ohms of resistance is causing the voltage loss, only that there is too much resistance. The repair is not going to be to change the resistance with another resistance, but to replace the bad switch, or clean the connections, etc. If you used a testlight to perform the check done in the example, you would have to decide if the testlight was "a little too dim" or "sort of dim, but OK". If the power you were trying to test for was 5 Volts, you could not use a testlight at all.

Using the voltmeter for available voltage checks means that you do not have to disassemble the circuit, you didn't interfere with the circuit operation while you were testing (i.e., you didn't burn it up), the circuit is being tested under "real world, live" conditions, and the readings give a clear indication of circuit condition. Using a voltmeter to perform the available voltage check in the above example gives the best balance of diagnostic information, speed, and ease of use when compared to the other tools available. Think of all the tests that you might of thought to perform with a testlight, and use a voltmeter instead.

Voltage drop checks –

These are checks that really cannot be performed with a testlight. Voltage drop checks are generally used to isolate a problem in a circuit. Voltage drop checks are often used as a follow-up to some available voltage checks that have uncovered a general problem, such as low voltage to a lift motor. A voltage drop check is simply a measure of the voltage that a component "uses up". To make a voltage drop measurement, simply connect the voltmeter positive lead to the power side of the component, and the negative lead to the ground side of the component. You might also think of this as connecting the voltmeter "across" the component.

> **Example:** Given available voltage readings of 14.7 Volts at the battery and 11.8 Volts at the lift, you understand that there is an unacceptable loss in the circuit to the power side of the lift. You want to find which components are "bad" in the circuit supplying power to the lift. The component is "bad" because it has a high resistance and therefore also has a **voltage drop** of more than it should have. We are again using an Ohm's Law relationship by looking at a voltage reading to indicate a resistance problem.
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> Pick one of the components (this includes the wiring and connections) that is in the line of the power circuit to the lift, for example, the lift power relay contacts. Backprobe the relay connection to the relay contacts on the power side with the positive lead of the voltmeter, and the negative meter lead backprobing the ground (or output) side of the relay contact connection. Activate the lift and note the voltage measurement while the lift is operating. If the voltage reading is close to the 2-volt loss that you were looking for, then you've isolated the problem down to the relay contacts, and you should replace the relay to fix the problem. If the voltage drop (voltage loss) across the contacts is only 0.1 – 0.2 Volts, the relay contacts are fine, and you should move on to checking another component in line with the power circuit. If the voltage drop across the contacts is say, 1.1 Volts, then the relay contacts are *part* of the problem, *but* you need to check some other components in line with the power circuit to find out where the rest of the voltage drop is.

There are techniques that can be performed using a testlight to isolate problems with components in a circuit; however, it is difficult to calibrate your eyeballs to differentiate the change in brightness of a testlight down to a ½ Volt. And again, if the circuit were a low voltage electronic circuit, the testlight would be worse than useless (i.e. circuit damage may result). Using an ohmmeter to isolate component problems would usually involve disconnecting or removing each component, in turn, to test them. The ohmmeter also does not check the components under "real world, loaded" conditions. Ammeter measurements are good for testing particular components in a circuit, such as motors, but they cannot be used for isolating circuit problems.

We've only covered a few brief examples of using a voltmeter on automotive electrical/electronic systems. Hopefully you'll get the idea that a voltmeter should be the primary tool used for diagnosis of today's automotive electrical/electronic circuits. If a technician is still using a testlight as their primary diagnostic tool, then they are most likely not performing complete diagnosis of electrical/electronic systems, and are either; asking for help quite often, or replacing parts in a shotgun approach to repair. Learning to use a voltmeter effectively will help avoid the time loss of calling for help whenever a technician comes to the end of the possibilities of diagnosis with a testlight, and save some of the costs associated with shotgun repair. Move learning effective voltmeter use to the top of your to-do list.

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