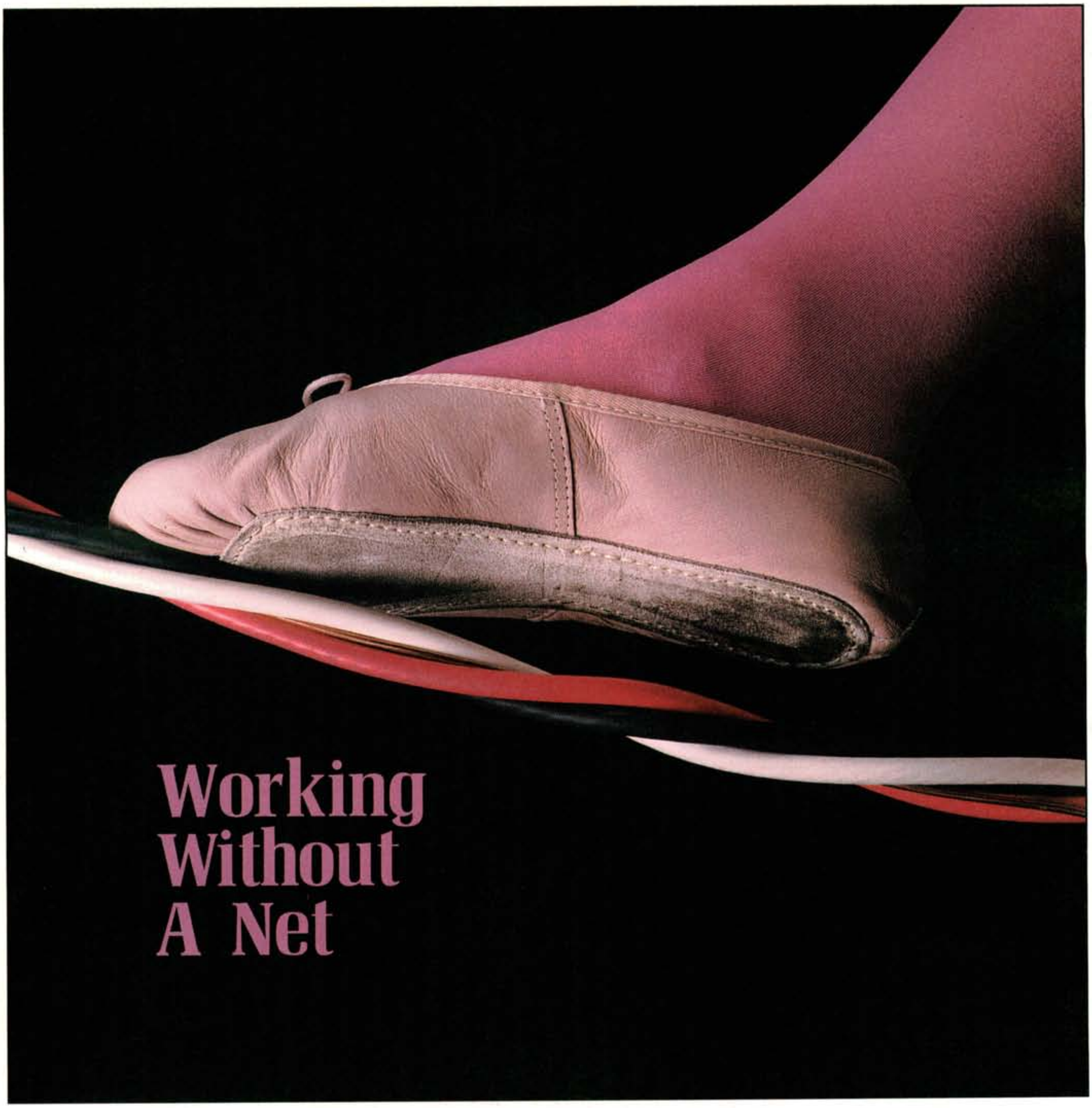


Working Without A Net

Have you ever found yourself in the middle of a complicated electrical repair, feeling like you were working without a net? Do you get frustrated because many auto manufacturers don't provide the electrical information we need to safely and accurately troubleshoot their products? If you are like most service technicians, this happens about four or five times an hour.

To put it simply, we need better electrical schematic diagrams. We need schematic diagrams that we can read. These diagrams should be laid out so they make sense and are easy to work with. Some schematic diagrams are so poorly designed, you might think the guy who drew them had a grudge against technicians.

In a perfect world, schematic diagrams would include sample wave forms, along with normal voltage, resistance, and current readings. It would also be nice if we could find the correct schematic diagram quickly, without having to hock the home and shop to finance the deal.

Well ... we don't always get what we want, do we? When you don't get what you want, you have to improvise. We've talked about voltage drop measurement in several earlier articles in *Import Service*. This article takes these techniques a step further, and shows several new ways that voltage drop measurements can be used to make electrical troubleshooting faster and more effective. In our high wire demonstration, we tackle electrical problems and do some major troubleshooting, all without the aid of a service manual or a schematic diagram.

Reviewing Voltage Drop Testing

Figure 1 illustrates a simple circuit, consisting of a battery, a switch and a resistor. The resistor is the load of the circuit. What's a load? A load is the component in the circuit that does the work — like a solenoid, a blower motor, a fuel pump, a windshield wiper motor, etc. We are using a simple resistor symbol to indicate the load because all loads have some amount of resistance. It also simplifies our discussion of the circuit.

The job of the circuit is to operate the load. Always remember, it is current through the load that makes the load come alive and do its job. For the current to flow through the load, as much of the available source voltage as possible should get to the load terminals.

The switch in our illustration is shown closed, allowing current to flow through the resistor. This is important to remember when measuring voltage drops. The circuit must be turned ON and current must be flowing through the circuit when measuring voltage drops.

As current passes through the resistor, a voltage is dropped across the resistor. The DVOM in our illustration is measuring the voltage dropped by the resistor. Consider the voltage dropped by the resistor as "voltage consumed" by the resistor. The voltage dropped is 12.66 volts, or full battery voltage.

This is a "good" voltage drop. The resistor is the only load in the circuit and is supposed to drop all of the available source voltage. With full source voltage available at the load terminals, maximum current flows through the load. Any time the load of the circuit gets all the available voltage, you have an excellent circuit. In fact, that's the whole idea of the circuit — to get all of the source voltage to the terminals of the load so that maximum current can pass through the load.

Problems On The Voltage Side Of The Circuit

In **Figure 2** on the following page, our simple circuit now has a problem. There is less voltage dropped across the load, as shown by the reading of DVOM number 1. Less current is flowing through the load, so the load can't work at peak efficiency.

Also in **Figure 2**, notice that DVOM number 2 shows 5.59 volts being dropped across the voltage side of the load circuit. For most automotive circuits, the normal voltage drop on the voltage side of the circuit is approximately 0.5 volts. The cause of the higher voltage drop in **Figure 2** could be due to a bad switch or connection in the wiring.

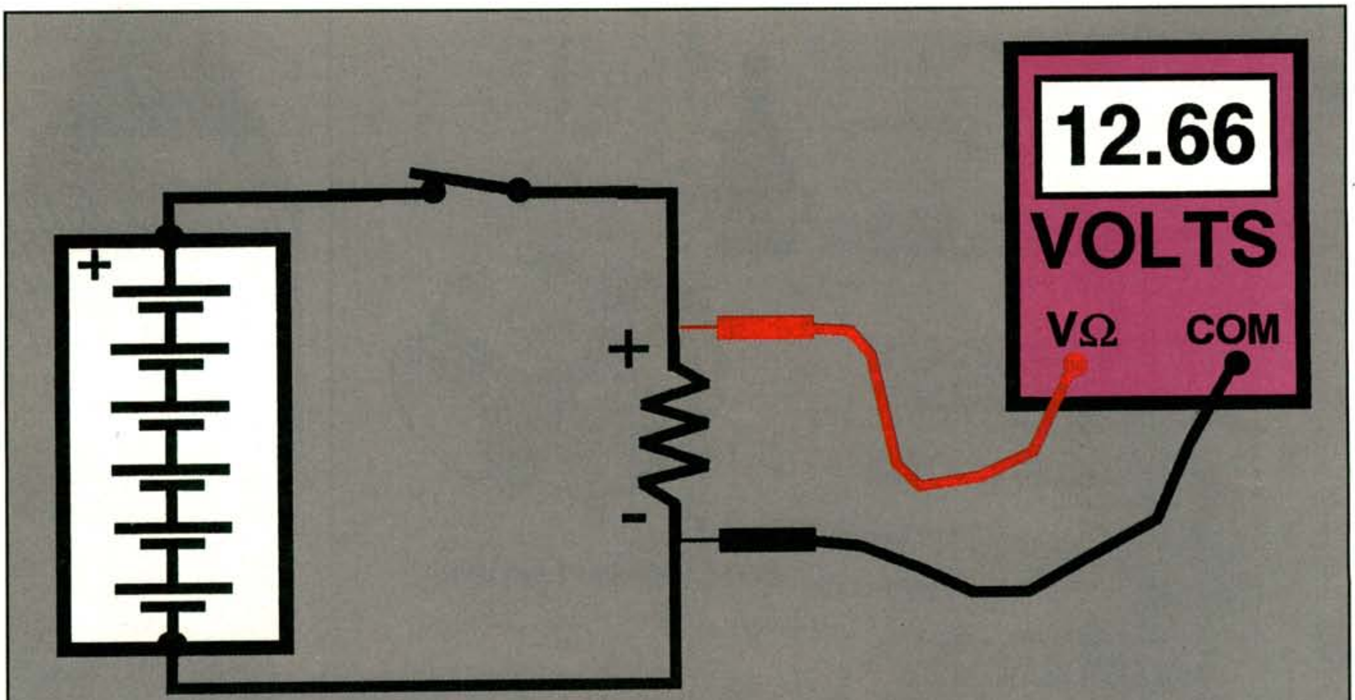
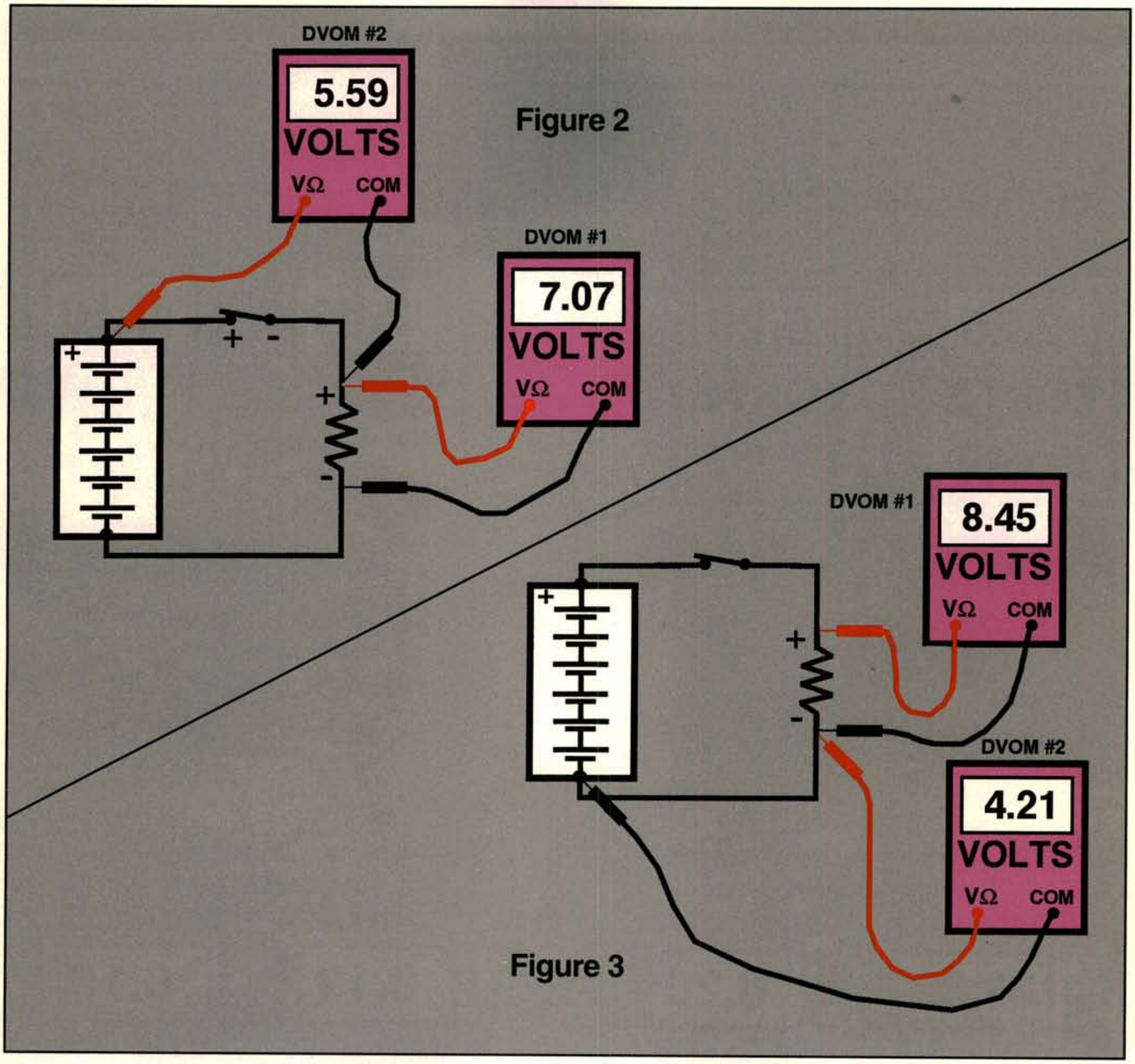


Figure 1
Voltage Drop Testing



The switch could have high resistance contacts in the closed position. This causes a voltage drop across the switch as the load current, passes through the switch contacts. The added resistance of the switch contacts in the circuit means there is less current available to flow through the load.

DVOM number 2 is showing the difference in voltage dropped between both ends of the voltage side of the circuit. The way DVOM number 2's test leads are placed in the circuit, the voltage drop could be caused by any of the following:

- A bad switch.
- A bad connection in the wiring before the switch.
- A bad connection after the switch.

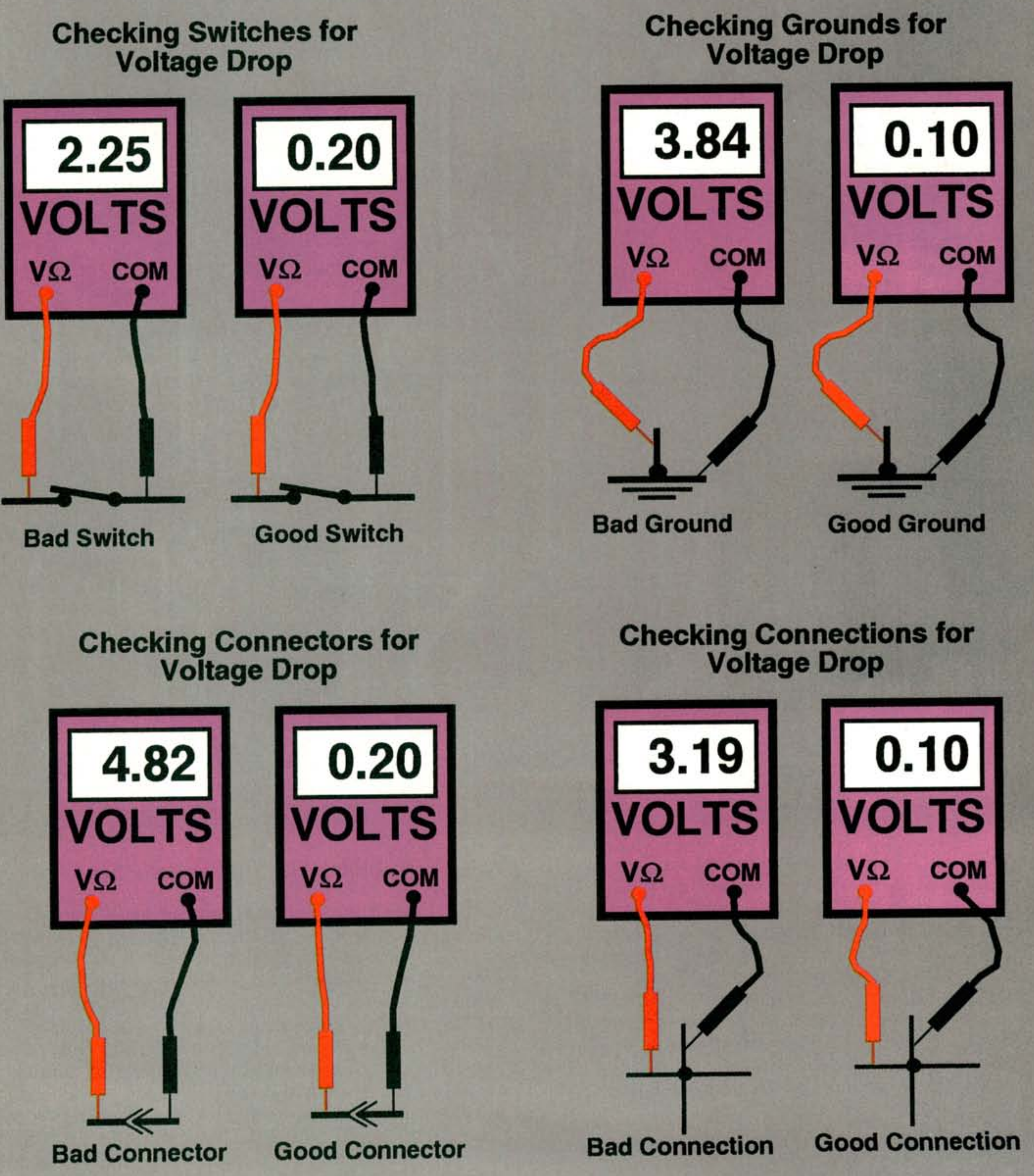
Individual voltage drop checks on the voltage side of the circuit will isolate exactly where the problem is located.

Problems On The Ground Side

In **Figure 3** our simple circuit now has a problem on the ground side of the circuit. There is a low voltage of 8.45 volts dropped across the load. Because full battery voltage is not available to the load, the load can't work at peak efficiency. DVOM number 2 is showing a voltage drop of 4.21 volts being consumed by the ground side of the circuit. This voltage drop may be caused by a bad ground connection or defective wiring.

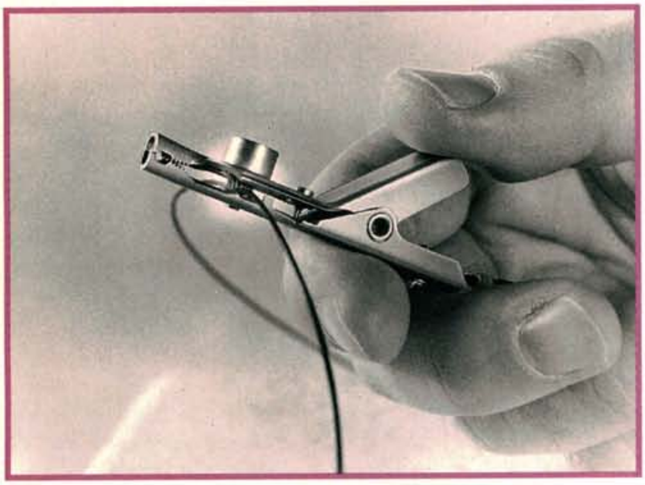
The normal voltage drop for the ground side of the circuit is 0.1 volts. When the ground side of the circuit drops more than 0.1 volts, it is usually due to corroded connections. Individual voltage drop checks on the ground side of the circuit will isolate exactly where the problem is located.

Figure 4 — Good and Bad Voltage Drop Readings



Checking Component Parts For Voltage Drop

Figure 4 on the facing page illustrates the correct way to check voltage drops across switches, connectors, grounds and connections. Make sure the circuit is turned ON and current is flowing when these tests are made. A typical bad voltage drop reading is shown on the DVOM to the left in each example and a good reading is shown on the DVOM to the right.



Notice the proper connection points for both test leads. In some cases, it may be necessary to pierce the wiring insulation to make the voltage drop measurement as shown. The EZ Hook wire piercing test lead tips or J.S. Popper's "bed of nails" test lead tips (shown above) are two alternatives when wire piercing is required. Both will pierce the insulation with as little damage as possible. If you must pierce the wiring to make a voltage drop test, repair the damage with silicone sealer or shrink tubing to prevent later corrosion damage.

Checking A Circuit Without A Schematic Diagram

The circuit in this example has a DC motor for a circuit load. The DC motor could be a blower motor, a fuel pump motor, an electrical windshield motor, etc. The problem is that the motor is only running at about 50 percent of full RPM. If it's a blower motor, it can't move enough air. If it's a fuel pump motor, the car will have low fuel pressure. If it's a windshield wiper motor, the wipers will be very sluggish. You get the picture.

Let's say it's a windshield wiper motor that is only able to move the wiper blades very slowly. It turns out that the customer's brother-in-law, who was a part-time mechanic in junior high school, has already replaced the wiper motor.

Through some stroke of luck, he actually replaced it with the right motor. All mechanical linkages seem to be in good working order, but the problem remains.

At this time, you could begin a search for the schematic diagram in your service manual library. Or you could save some time by using voltage drop measuring techniques that do not require a schematic diagram. You know where the wiper motor is located and have access to the harness connector with the motor's voltage feed and ground wires. You also know where the battery positive and negative terminals are located. You already have most of the information you will need, and you haven't looked at a schematic diagram.

Grab your DVOM and set it to the 20 volt range. You are now ready to dazzle this guy's brother-in-law. There are two basic steps. We'll begin by checking the voltage drop on the voltage side of the wiper motor circuit. Then we'll check the voltage drop on the ground side of the same circuit.

Checking Voltage Drop On The Voltage Side

In **Figure 5**, the DVOM is checking the voltage drop on the voltage side of the wiper motor circuit. Notice the switch is closed so the wiper motor is in the running mode. Consider the 12.66 volts at the top of the switch to be the battery's positive terminal where the positive lead of the DVOM is placed.

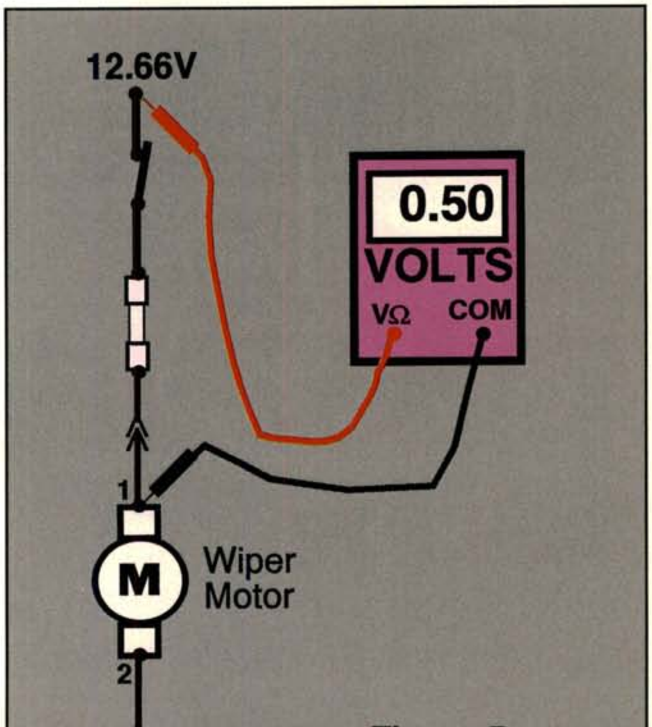


Figure 5
Checking Voltage Drop on Voltage Side of the Circuit

You don't need a schematic diagram to find the positive post of the battery. The other DVOM lead is placed at the voltage feed pin in the connector to the motor winding. Again, you don't need a service manual to find the wiper motor connector.

As we saw earlier, a good reading should be 0.5 volts. This is a normal voltage drop for a properly functioning voltage side of the circuit. It means the wiring, the switch, the fuse panel and all connectors on the voltage side of the circuit are only using 0.5 volts while they deliver source voltage to pin 1 of the motor.

If the DVOM reading is higher, then voltage is being dropped by a bad switch, fuse connection, wiring, or connector. Check the individual drops, as shown in **Figure 4**, to find the component on the voltage side of the circuit that is causing the higher than normal voltage drop. Clean and repair as necessary. Make sure all is well by taking a final voltage drop check. This should confirm that the voltage drop reading on the voltage side of the circuit is back to normal.

Checking Voltage Drop On The Ground Side

In **Figure 6**, the DVOM is checking for voltage drops on the ground side of the wiper motor circuit. The switch must be closed and the wiper motor must be in the running mode to take this test. Place the positive DVOM lead on pin 2 of the DC motor. This is the motor ground connector. Place the other DVOM lead on the battery's negative terminal. You don't need a service manual to find the battery or the wiper motor connector.

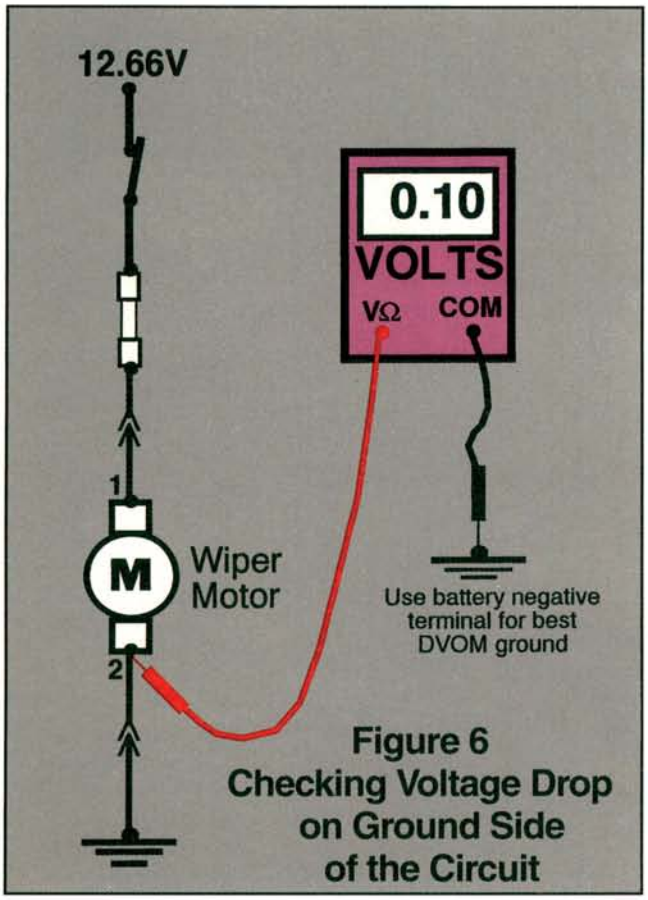


Figure 6
Checking Voltage Drop on Ground Side of the Circuit

As we stated earlier, a good ground side voltage drop reading is 0.10 volts. This is an SAE-approved voltage drop for a properly functioning ground side of the circuit. A reading of 0.10 volts tells us that the ground side wiring and connectors are only using 0.10 volts of the source voltage. The ground side of the circuit is providing a good return path for the wiper motor current.

If the DVOM reading is higher than 0.10 volts, voltage is being dropped by either a bad connection or a wiring problem. To find the problem, check the voltage drops at the wiper motor ground terminal and the battery ground. If your voltage drop tests at these locations show a reading of 0.10 volts or less, there may be a hidden connector somewhere in the harness that is responsible for the higher than normal voltage drop.

Searching for a hidden connector without a service manual or wiring diagram can be a time-consuming process. You might have to open the book in this case. Once the bad connector has been located, clean and repair it as necessary. Finish up by doing a final DVOM check between the motor ground terminal and the battery ground post to confirm that the ground side voltage drop reading is back to normal.

Computer Controlled Switches

Automotive computers are now commonly used to switch electrical loads ON and OFF. This means that the mechanical switches shown in **Figures 1 through 6** may have been replaced by a computer. What effect does this have on the voltage drop readings performed on the voltage and ground sides of the circuit?

We may see an increase of a few tenths of a volt in our voltage drop reading on the side of the circuit that the computer controls. This is shown in **Figure 7** on the following page, which illustrates a computer that is controlling the fuel pump circuit.

In **Figure 7A**, the computer switches a ground to control the fuel pump motor. With the fuel pump ON, the solid-state switch inside the computer causes a voltage drop of 0.8 volts on the ground side of the circuit. The actual voltage drop may vary, depending on what type of solid-state switching circuit is used.

Check a few circuits of this type before deciding what the normal voltage drop should be. Write the results down for future reference. Voltage drop on the voltage side in **Figure 7A** is unaffected by the solid-state switch, and shouldn't change. It should be no more than 0.50 volts.

In **Figure 7B**, the computer switches voltage to control the fuel pump motor. With the fuel pump ON, the voltage drop on the voltage side of the circuit is 0.8 volts, due to the solid-state switch in the computer. The actual voltage drop may vary, depending on the type of solid-state switching circuit that is used by the computer.

Check a few computer controlled fuel pump voltage circuits before deciding what a normal voltage drop for this type of circuit should be. Write down the results of your tests for future reference. Voltage drop on the ground side in **Figure 7B** is unaffected by the solid-state switch, and shouldn't change. It should still be no more than 0.10 volts.

The voltage drop tests we have demonstrated can be performed on any electrical circuit. Unless you run into a hidden connector, you probably won't even need a schematic diagram — or a safety net.

— By Vince Fischelli

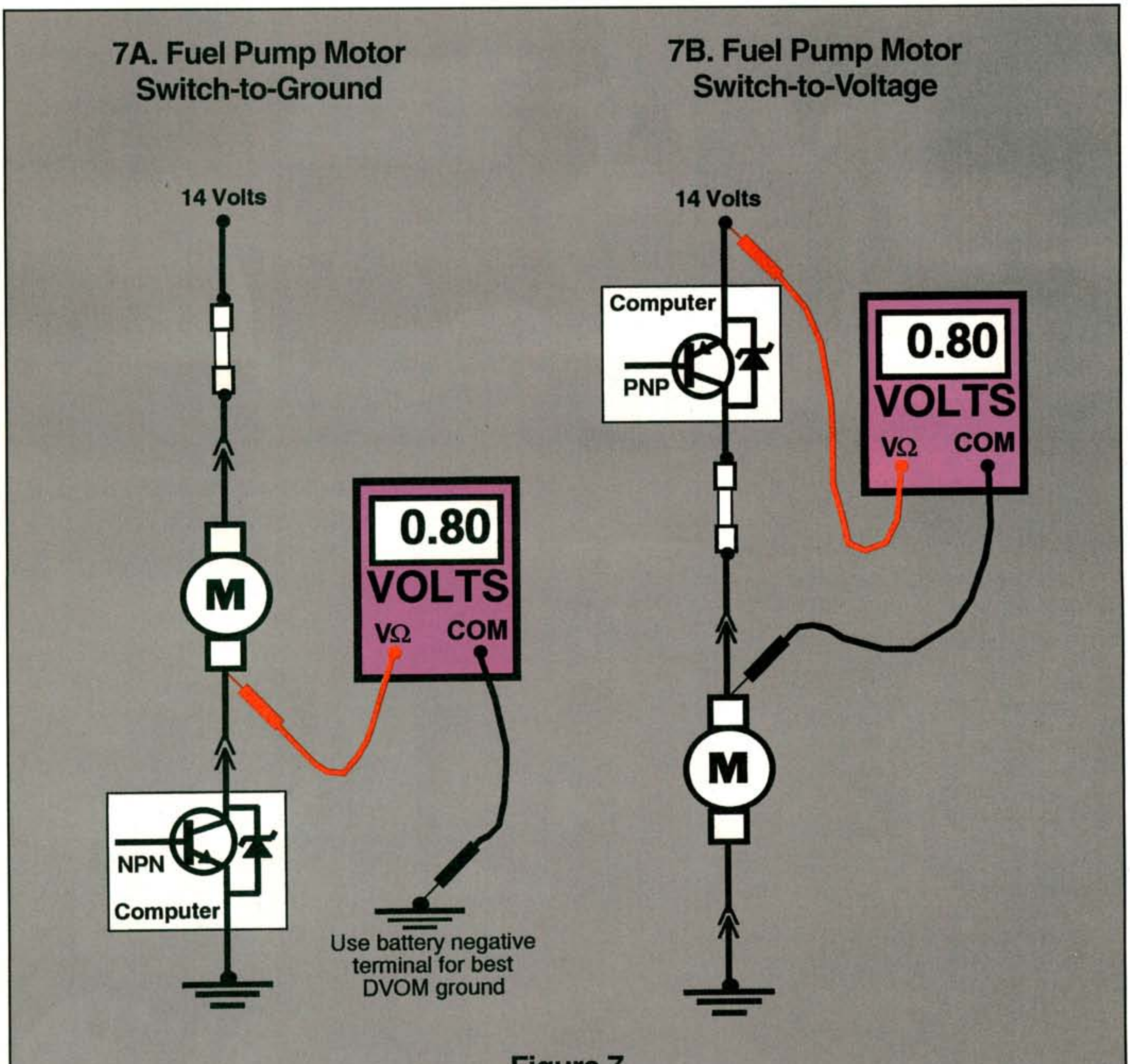


Figure 7
Checking Voltage Drop
With Computer
Switching