Voltage drop testing has always been an important diagnostic tool for technicians. If anything, voltage drop tests have grown in importance as more and more vehicle functions have become electrically controlled.

Let's start by clearing up an old misconception, namely that a voltage drop is a "bad" thing. Just the opposite is the case. Without a voltage drop at the load, the circuit won't work at all. That's right, until the source voltage is dropped across the load, no work is done.

The problems start when voltage drops occur between the source of voltage and the load. "Bad" voltage drops are caused by bad connections at wiring harness connectors, damaged wiring, and poor grounds.

So whether or not we call a voltage drop good or bad depends on where we find it.

Eye in the Sky

Those of you who live in northern climates may be familiar with the old joke which suggests that there are only two seasons of the year—Winter—and Road Construction. And traffic jams caused by urban sprawl are common all over the country.

Voltage drops are a lot like traffic jams. We need to know where the jam occurs to fix it and get traffic moving in the circuit again.

Local radio stations spend huge sums of money each day sending helicopters aloft to watch for bottlenecks in real traffic. Your Eye in the Sky for finding bottlenecks in electrical circuits is your voltmeter.

Using voltage drop test procedures found in this article, we'll help you find those traffic snarls, eliminate them, and get all those electrons to work on time.

Ohm's Law For Traffic

Some of you may appreciate a more scientific approach to voltage drops. As usual, Ohm's Law explains things in a hurry. And it proves our analogy.

$$E = I \times R$$ or

Voltage = Current multiplied by Resistance

Real Examples

If we ask 1 amp to flow through 0.0 ohms we get a 0.0 voltage drop.

If we ask 100 amps to flow through 0.0 ohms, we still get 0.0 volts—no voltage drop.

(Even with an increase in traffic, we have no voltage drop without some resistance present in the circuit.)

In similar fashion, if we have no current flowing, regardless of the amount of resistance, we have no voltage drop, since 0.0 amps times any amount of resistance still equals zero volts.

(We can't have a traffic jam without traffic! We can't have a voltage drop without current!)

Ingredients for a Bad Voltage Drop

There are three ingredients in a bad voltage drop. We need:

1) Voltage to power the current along as gas engines power cars.

2) Current, which is the traffic flow on the wiring expressway,

3) And of course, we need Resistance somewhere between the voltage source and the intended Load.

Put the three together and you have—

A BAD VOLTAGE DROP!

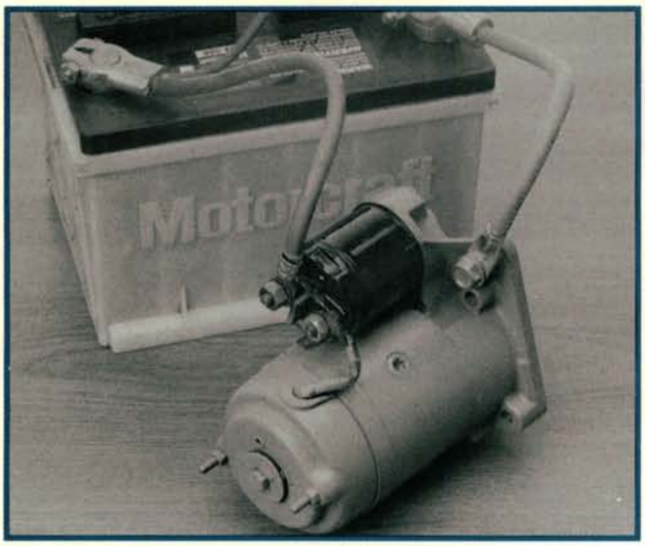
Maximum Acceptable Voltage Drops

In a moment, we'll take you through some hands on tests for common electrical circuits. But before we start, here are the SAE recommended maximum acceptable voltage drop levels for common automotive circuits:

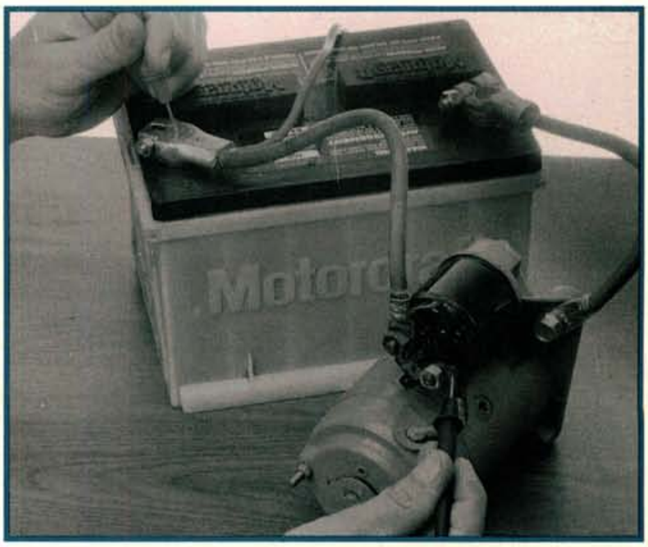
Small wire connectors	0.09 volt
High Current Grounds	0.10 volt
Battery/Starter Cables	0.20 volt
Solenoids/Switches	0.30 volt

Now that we have some guidelines, let's go out to the shop and test some real circuits.

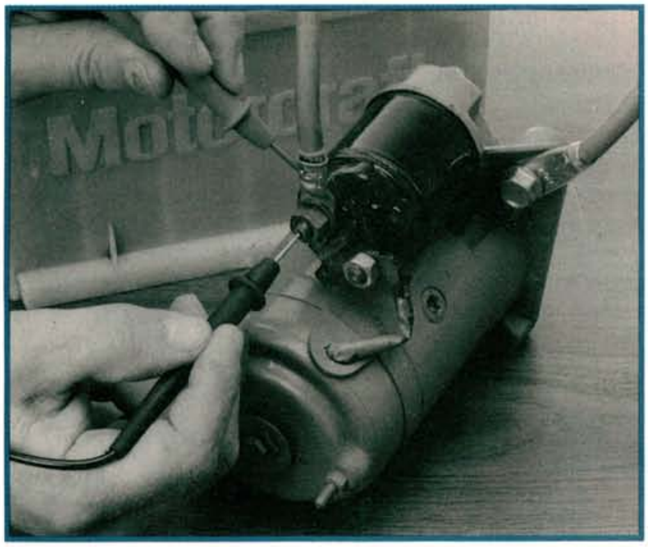
–By Vince Fischelli



1 Voltage Drops in a Cranking Circuit
Our photo shows a simple starting circuit. It includes a battery, starter solenoid, and starter. We've hooked up a real battery and starter on the bench. The solenoid is mounted to the starter and contains the switching contacts between the battery and the starter motor winding. It is one possible source of resistance along with the battery terminal ends and cable connections.

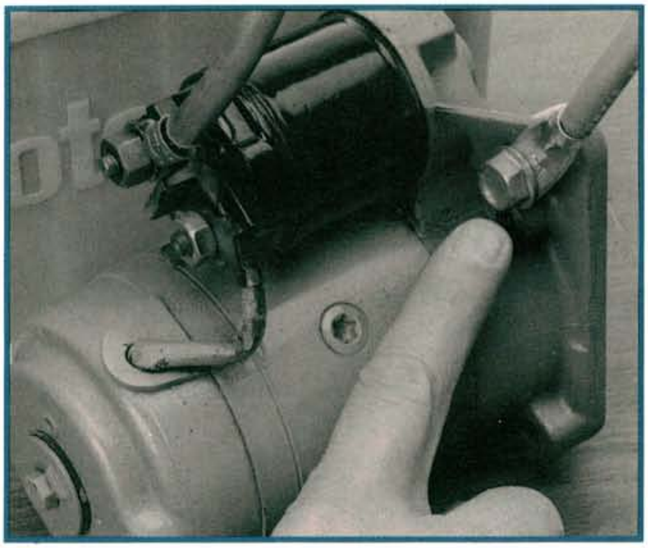


2 Checking the Voltage Side of the Starter Circuit
Place the DVOM leads between the positive battery post and the positive wire end at the starter motor winding. Disable the ignition and crank the engine. Readings of 0.3 to 0.5 volt (or less) are acceptable. For example, the battery cable in a typical car may drop 0.2 volt. The starter solenoid contacts may drop another 0.3 volt for a total of 0.5 volt.



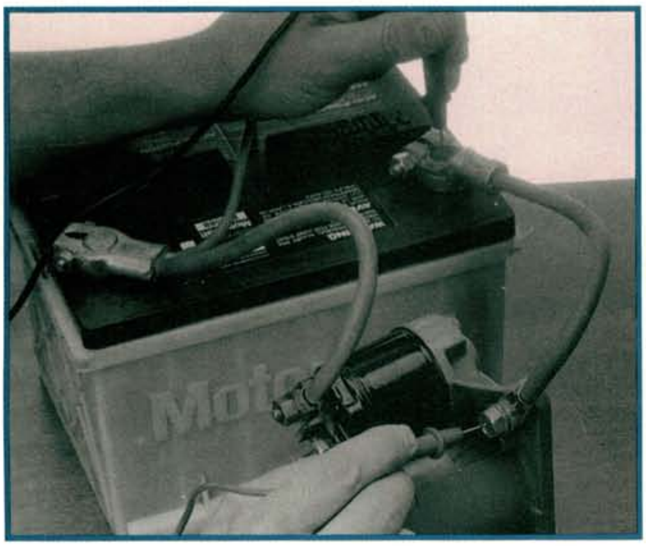
3 A Bad Voltage Drop in the Voltage Side of the Starter Circuit

If the voltage drop in the voltage side is greater than 0.5 volt we need to isolate the cause or causes of high resistance. Place the leads across each connection in the starter circuit. Crank the engine for each test. In some cases, one bad connection is causing the drop. In other cases, several smaller resistances will add up to more than 0.5 volt.



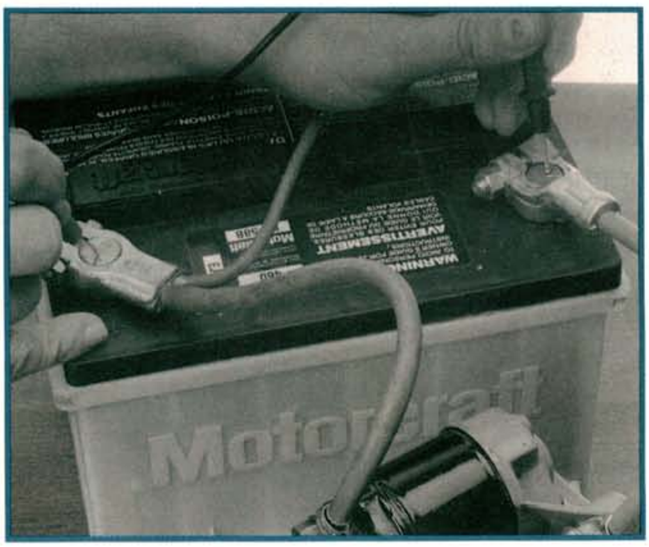
4 A Bad Voltage Drop in the Ground Side

Our electrical expressway has two lanes running in both directions. Let's not forget that after the Load is powered, electrons need a way home. A closed lane of the wiring expressway of the ground side can result in a Bad Voltage Drop. Our photo shows a ground cable bolted to the starter. In most cases, the starter will use a bolt-to-ground connection.



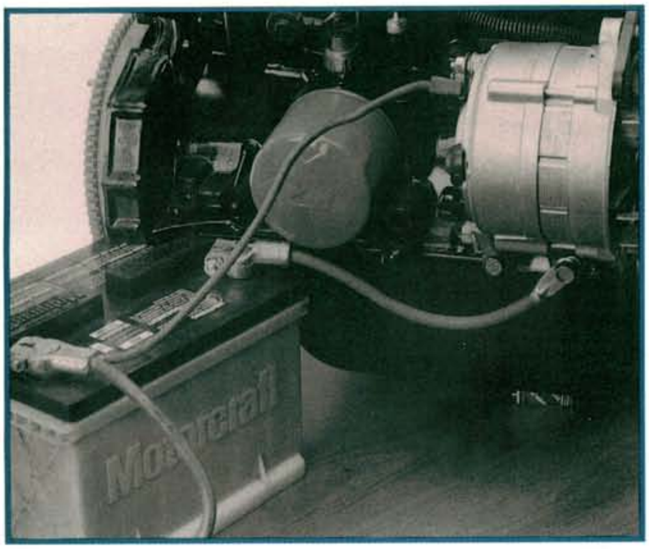
5 Testing the Starter Ground

Use the same procedure you used to check the voltage side of the starter to check the ground side. Place your DVOM leads between the starter ground (or body of the starter) and the negative post of the battery. Crank the engine. The ground circuit should have less of a voltage drop than the voltage side, about 0.1 volt if the circuit is good.



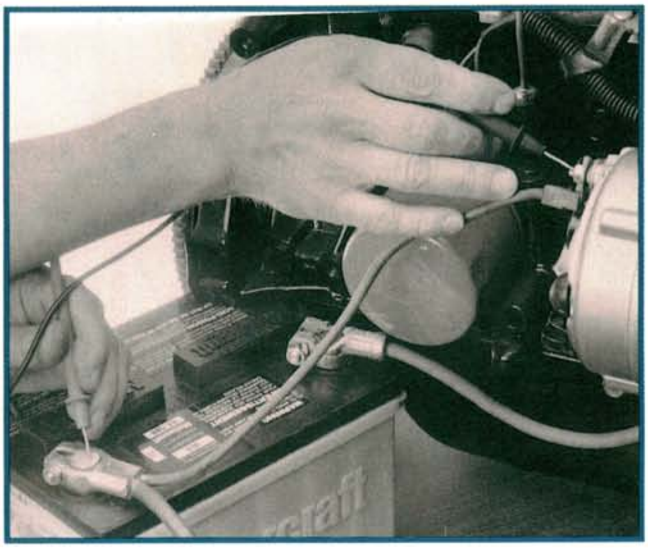
6 Figuring Total Voltage Drop in the Starter Circuit

When both the voltage and ground sides of the starter circuit are within acceptable limits (0.5 volt on the voltage side and 0.1 volt on the ground side) the total voltage drop in the starter circuit should be 0.6 volt. If the battery (source voltage) maintains 9.6 volts during cranking, that leaves 9.0 volts to power the starter. Enough to crank the engine.



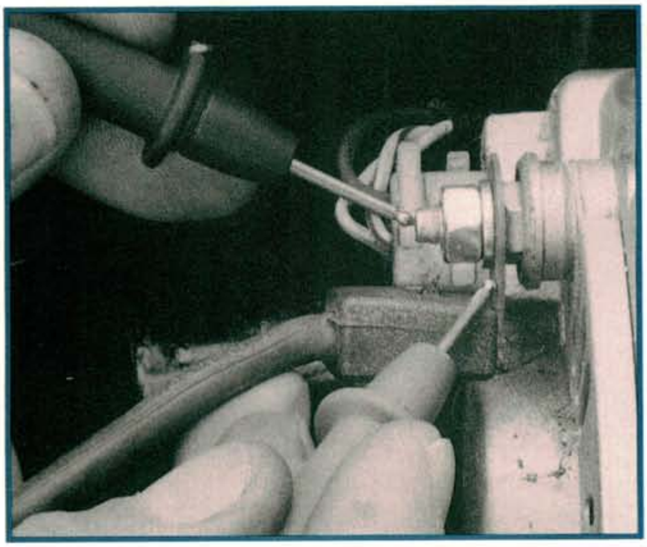
7 Voltage Drops in Charging Circuits

Another high current circuit is the charging circuit. The alternator provides source voltage which we commonly call "charging voltage." In this circuit, the battery is the Load. For proper charging to occur, most of the charging voltage generated by the alternator must reach the battery. Voltage drop testing of both the voltage and ground sides of the charging circuit is the fastest way to find a problem.



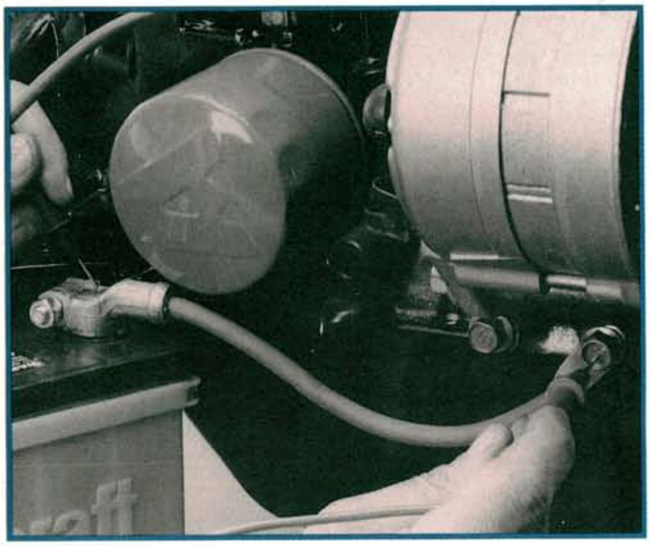
8 Testing the "Hot" Side of the Charging System

Reconnect the ignition. Place your DVOM leads as shown and crank the engine. Keep watching the DVOM as the engine starts. The charging system should generate a high charging current immediately after starting. Why? Because we have a high idle and the charging system should be trying to replace the battery power used during cranking. Peak charge is a good time to check for a voltage drop in this circuit.



9 Good Versus Bad Voltage Drops in the Voltage Side of the Charging Circuit

If the voltage drop in the voltage side of the charging circuit is greater than 0.3 volt with the engine running, it's a bad voltage drop. Place your DVOM leads across the connections in the voltage circuit. Also check between the BAT stud on the back of the alternator and the cable eyelet. Fix the bad connections until the total voltage drop of the voltage side is less than 0.3 volt.



10 Testing the Ground Side of the Charging Circuit

The maximum allowable voltage drop in the ground side of the charging circuit is 0.1 volt. If the alternator bolts directly to the engine, and the ground side drop is more than 0.1 volt, check the voltage drop between the negative battery post and the engine. This ensures a good engine ground. Some alternators need an extra wire between the alternator and the engine to ground properly.

Let's look more closely at our analogy between road construction and voltage drops. It may clear up what a voltage drop really is, and why the location of the voltage drop in the circuit is so important.

First, a few definitions for our analogy:

• The Freeway used in our analogy represents the Wiring Harness and all its connectors. Our wiring harness normally has two lanes going to the load (voltage), and two coming home to the battery in the other direction (ground).

• Think of the flow of cars on the freeway as the flow of current. Cars and current need to get to work.

• The Workplace is the Load. For any work to be done, a high percentage of the cars need to get to work at the same time. Skeleton crews can't get all the work done.

• Inherent resistance is the normal resistance to traffic. On the expressway, Inherent Resistance is caused by the speed limit and the normal resistance to flow caused by traffic. In a wiring circuit, inherent resistance is caused by the fact that no circuit is a perfect conductor.

• A Voltage Drop is caused every time a car gets stopped. If all the cars get to work on time, then the voltage drop at the workplace is good. All of the voltage is dropped across the load. Work gets done.

• Road construction is Resistance. Resistance causes voltage drops. Every time the boys with the orange barrels close one lane of the expressway, some of the cars have to stop. The same thing happens when a bad connection, or damaged wire slows the flow of current in a wiring circuit. As a result, there isn't enough current arriving at the workplace in time to do any work.

What Causes a Voltage Drop?

Let's stick with our traffic analogy for a while, and see what circumstances cause a voltage drop on our electrical expressway.

• Let's say that the expressway has a capacity to carry 1000 cars between point A and point B in one hour. This assumes that both lanes are open, and that traffic moves at the posted speed limit. That's the capacity of the expressway.

In similar fashion, our wiring circuit may be rated too, based on its ability to carry current. A small circuit may be rated at 5, 10, 20, or even 30 amps. Larger circuits, like the starter circuit may be rated at 200-300 amps.

• If there is no resistance on our expressway, (both lanes are open in both directions) we can run any number of cars from 1 to 1000 without a voltage drop. As long as we stay below the maximum rated capacity of the expressway (or wiring circuit).

Similarly, we can run 10 amps in a small circuit, or 200-300 amps in a large circuit until resistance enters the circuit. We won't have a voltage drop until we add resistance.

• Add resistance. Go on, close one lane for repairs. Make a loose or dirty connection in the wiring circuit. What happens next depends on the number of cars or electrons we try to send to work.

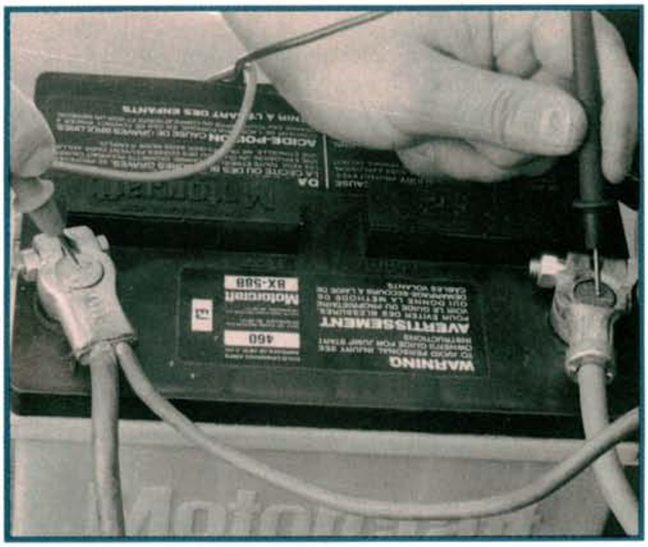
1)If we close one lane at midnight and there are no cars on the road, the closed lane means nothing. No cars—no slowdowns. The same thing happens in an electrical circuit. We don't know what effect the resistance has until current flows through the circuit. No current—no voltage drop.

2)Early next morning, the cars begin to trickle onto the expressway. As long as there are only a few cars, the one closed lane won't cause us any serious problems.

3)At the peak of the rush hour, we begin to see the effects of the closed lane. The same thing happens when we put a peak load on a damaged wiring circuit. Cars and current get stuck in traffic.

11 Correcting a Bad Engine Ground

The engine ground is very important, since many components either bolt directly to the engine block or use a short jumper between a component and the engine block to get their ground. Most starters and alternators bolt directly to the engine to get their ground. They also handle the heaviest current loads in the vehicle. It's easy to see how a small amount of resistance at this negative battery terminal end can bring traffic to a halt.



12 Total Voltage Drop in the Charging Circuit

When both the charging circuit and ground side voltage drops are within limits, the total voltage drop in the charging circuit should be about 0.4 volt (or less). That gives us a maximum drop of 0.3 volt on the voltage side, and 0.1 volt on the ground side for a total of 0.4 volt. If the alternator is charging as it should and maintains a 14.5 volt charging rate with the engine running, we still have 14.10 volts left. Enough to charge the battery.

Checking a Radiator Cooling Fan

Let's use a diagram to diagnose a radiator cooling fan problem. Temperature controlled radiator cooling fans are also big current consumers. When the coolant in the radiator gets hot, a thermo switch closes to complete the circuit to the fan motor. In this car, the fan doesn't come on and the engine overheats.

One technician unplugs the connector between the thermo switch and the blower motor. Using his old test light, he checks the plug. The test light lights and he replaces the blower motor.

The new blower motor doesn't work and the engine overheats again. What gives?

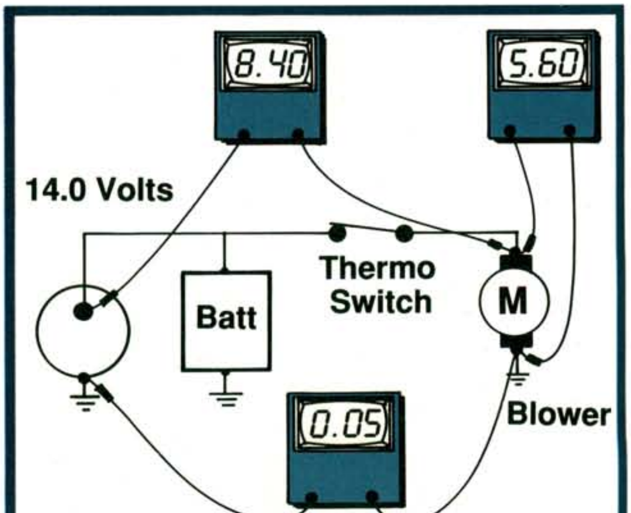
The current draw through the test light (light traffic) isn't enough to produce a big voltage drop through the thermo switch. The load the test light places on the circuit is far less than the heavy traffic current demands of the blower motor.

If the tech had substituted his DVOM at the unplugged connector, he'd have still read source voltage. (The DVOM loads the circuit even less than the test light.)

What the technician should have done was test the entire circuit with everything still plugged together. If he had, he'd have discovered that there was 8.4 volts dropped across the thermo switch with the blower motor loading the circuit.

That's because the heavy load placed on the circuit by the blower creates a big voltage drop. The circuit needed to be tested with it's normal load applied.

A voltage drop test across the blower motor terminals would verify the rest of the story. Of the 14 volts available as source voltage, only 5.6 volts is available to power the blower. Not enough.



Cooling Fan Blower Motor Circuit