TECH TIP

BASIC A/C ELECTRICAL TESTING

Many components fail repeatedly, or are misdiagnosed as defective, because of a voltage drop in the power supply circuit to the component. Here we will explain the operation of a simple electrical circuit and the tests you should perform to confirm the integrity of the circuit when replacing a component such as the A/C compressor (clutch), cooling fan or blower motor. The components of a basic electrical circuit are a voltage source, a load, a conductor and a switch. Here is a diagram showing these components in a simple light circuit.

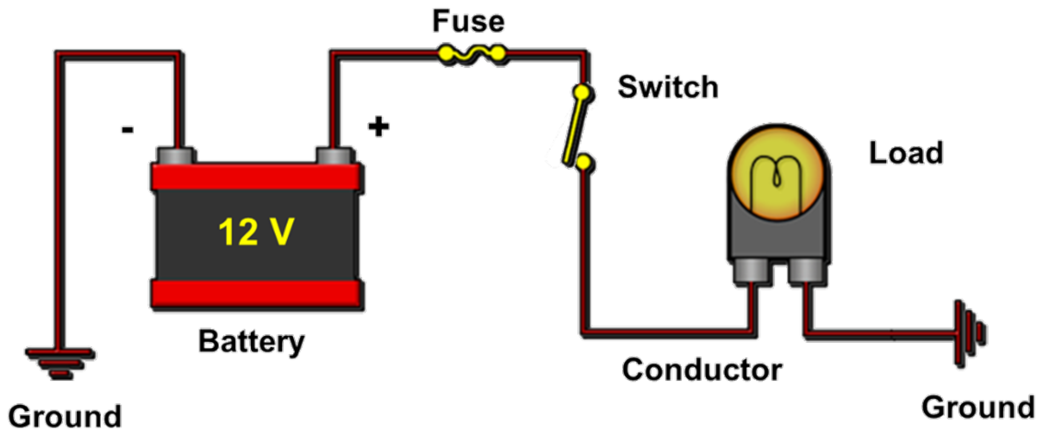

Fig. 1

There are four basic properties of electrical circuits that are helpful to understand in order to test them effectively. They are voltage, current, resistance and Watts.

Voltage: Voltage (V) is a measure of electrical pressure, similar to how pounds per square inch (psi) is a measure of water pressure. The higher the electrical pressure or voltage, the more electrical work that can be done. The battery is the basic source of voltage in an automotive circuit. Battery voltage is nominally 12 volts. A fully charged battery is actually about 12.6 volts. With the engine running the alternator maintains battery voltage at approximately 14 volts. For the purpose of this discussion we will use the nominal 12 volts' value. When we refer to "system voltage" we mean the actual voltage measured at the battery – this could be around 12 volts with the engine off and 14 volts with the engine running. A symbol similar to the one in Fig. 2 is usually used to represent the battery in automotive schematics.

Fig. 2

Current: Current is a measure of the volume of electrons (electricity) flowing in a circuit, just like gallons per minute is a measure of water flow in a pipe. Electrical current is measured in amps (A). For example, many A/C clutch coils draw between 3 and 4 amps (approximately). It's the flow of current through the load in a circuit that gets the work done – turns the fan, engages the clutch.

Resistance: Resistance is anything in a circuit that creates resistance to the flow of current. For example, corrosion at a connector will restrict current flow. Ideally there should be no resistance in an electrical circuit, except the actual load itself -

the component doing the work. However, as a practical matter, all the components in a circuit, the wires, switches etc., have a small, nominal amount of resistance. Electrical resistance is measured in ohms. Many A/C clutch coils are between 3 and 4 ohms.

Watts: Watts is a measure of the electrical work being done in a circuit. You can think of watts as electrical horsepower. It is calculated by multiplying volts by amps. A blower motor for example would have a higher wattage rating than a typical light bulb.

Other Electrical Circuit Terms:

Load: The load in a circuit is the component that performs the work, for example the A/C clutch or cooling fan motor.

Conductor: The conductors are the wires or “pipes” that connect all the components through which the current flows. For a circuit to work, current must be able to flow from the positive side of the battery, through the load and back to the negative side through all the connected components. Note that in an automotive circuit, the metal chassis or frame of the vehicle is also a conducting part of the circuit. The battery negative terminal and the ground side of the load are both connected to the frame allowing current to flow through the frame.

The gauge or diameter of the wire in a circuit will be proportional to the amount of current flowing in the circuit. A bigger load, such as the cooling fan, will require heavier gauge wires than a smaller load such as a parking light bulb.

Switch: The switch in the circuit makes or breaks the flow of current to turn the load on and off.

Ground: The ground side of a circuit is any part of the circuit that is connected to the negative side of the battery. It is that part of the circuit through which current returns to the negative side of the battery after passing through the load. In a typical automotive circuit, the negative terminal of the battery will be connected to the engine block and also to the frame of the vehicle. The ground circuit for all the different electrical circuits on a vehicle will typically be bolted to either the frame or to the engine block. The ground point is usually represented in electrical diagrams by the symbol in figure 3.

Fig. 3

Checking Circuit Integrity

The primary goal when testing an electrical circuit, is to confirm that the circuit is capable of delivering full system voltage to the load at the desired current. For this to happen, there must be no unwanted resistance in the wires and switches that carry the current to the load and just as importantly, carry the current back to the negative post of the battery on the ground side of the circuit.

The easiest way to check the electrical integrity of a circuit is to perform a voltage drop test while the circuit is stressed. In other words, when the load is turned on and working.

A rule of thumb is that there should be no more than a 0.1-volt difference across a typical switch or connection. Note that we are discussing power circuits here, circuits that carry a significant amount of current. There should be virtually no voltage drop in sensor type circuits such as an air conditioning pressure transducer circuit for example.

Here are the three Ohms law formulas for calculating each of the unknown values in an electrical circuit. In these formulas: V=Volts, A=Amps, Ω=Resistance (in ohms), and W=Watts.

$V=A\times\Omega$; $A= V\div\Omega$; $\Omega=V\div A$. Recall also that the formula for calculating watts is VxA (volts multiplied by current).

The important point is a voltage drop in the A/C clutch circuit is a common, often undiagnosed, cause of catastrophic compressor failure. This is why it is so important to perform a voltage drop check at the clutch when a compressor is replaced.

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The circuit should be back-probed right at the clutch connector or at least as close as possible. The voltage must be checked with the air-conditioning on and the clutch engaged. Voltage should be within 1 volt of charging system voltage but never less than 12 volts. Also, visually check the integrity of the harness connector terminals. It is possible to have the proper voltage right up to the clutch, but a poor connection right at the connector can still reduce current flow. If in doubt, an additional check is to use an inductive amp probe to check actual current through the clutch. A typical clutch will draw approximately three to four amps. To be more precise, find the resistance specification for the clutch coil and use the formula $A = V \div \Omega$ to calculate what the current draw should be.

A voltage drop in other critical circuits can also have serious consequences. A voltage drop in the cooling or condenser fan circuits will reduce airflow across the condenser and radiator causing A/C head pressure to increase and the engine to run hotter or even overheat. The increased A/C head pressure stresses the compressor, often leading to catastrophic failure.

A voltage drop in the blower motor circuit will reduce blower speed and therefore duct airflow. The customer will probably complain of poor air-conditioning performance.

The bottom line, is that whenever an electrical component is replaced, it is vitally importance to perform a voltage drop test to confirm that the circuit is capable of delivering full system voltage to the component while it is actually working.