wires to expose clean metal, reseating the connectors, and securely tightening all screws or nuts. Any wiring or switches that show a high voltage drop should be replaced.

6. Testing Switch Operation:
Use the resistance of connectivity function to find a bad switch. With power removed from the circuit, set your meter to measure resistance or continuity and probe sides of the switch. Operate the switch and watch for a change on the meter display. If the display doesn’t change, the switch is defective. (see figure 2)

If not, it may be time to replace the component completely. If you suspect a more serious problem, call a qualified certified automotive technician for help.

7. Where to Go From Here:
With the help of the tips and techniques in this booklet, you should be able to troubleshoot most of the common electrical problems. When troubleshooting automotive electrical systems, it’s important to use a logical process of deductive reasoning to solve the problem. Jumping to conclusions can be expensive and time consuming. Just use this simple approach: check for power, check fuses and switches, check connections, and check for good grounds.

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Typical Problems:
Most automotive electrical problems can be traced to a bad connection or a failed component. High resistance ground connections can be one of the most frustrating of electrical problems. They can produce bizarre symptoms that don’t seem to have anything to do with the cause, once you finally find it. The symptoms include lights that glow dimly, lights that come on when others should, gauges that change when the headlights are turned on, or lights that don’t come on at all. A failed alternator, a bad battery, or a blown fuse can all result in things just not working at all.

Task Summary:
This booklet will help you diagnose and fix common electrical problems in your car. When troubleshooting electrical systems, it’s important to use a logical process of deductive reasoning to solve the problem. This process is most important since, unlike mechanical devices, you can’t see inside or dismantle the majority of electrical components to tell whether they’re functioning. We’ll start with the battery and charging circuit, then look at bad grounds and other electrical connections, then finish by checking for failed components.

Recommended Tools:
You will need a DMM that measures dc volts, ac volts, resistance, and continuity. You will also need a current clamp accessory that measures dc current. As an alternative, use a clamp-on multimeter that combines all the above measurement capabilities. It is assumed you have basic knowledge of how to make electrical measurements and how to operate a DMM or clamp meter. If not, you should start by reading “Basic DMM Measurements” and your DMM or clamp meter owner’s manual.
Step by step troubleshooting:

1. Measuring Battery Voltage:
   If your battery becomes discharged it will be unable to provide sufficient voltage or current to the starter, hence the engine won’t crank. The first step is to test the battery and charge it if necessary.

   Verify that the connections to the battery look clean and are tight. With the engine off, blend the surface charge from the battery by running on the headlights for a minute. Now with the lights off, set your DMM to the dc voltage function, 20 volt range, and measure the voltage across the battery terminals by touching the red probe tip to the “+” terminal and the black probe tip to the “-” terminal. Use the chart below to determine the approximate percent charge on the battery. If the battery voltage reads low, the battery may be damaged or worn out, or the charging system is not working correctly. See below for how to verify the alternator is working. A more complete load test should be done to indicate battery performance under load and determine if the battery is damaged.

2. Verifying a Good Alternator:
   To perform this test, the battery must be fully charged (see step 1). Run the engine at idle and verify that no-load be fully charged (see step 1). Run the engine at a fast idle, about 2000 RPM. Check the output current of the alternator with a dc current clamp (see figure 4) (a reading higher than 0.5 volts ac may indicate damaged alternator diodes.

   To rule out the wiring as the source of the trouble, check all the wire connections between the alternator and the battery terminals. Refer to Step 5, “Testing for Bad Connections” for details on performing a voltage drop test. A resulting voltage drop of 200 mV or greater requires that the wiring connectors need cleaning and tightening, or replacement.

3. Checking Ripple Voltage:
   The alternator generates ac voltage which is converted to dc voltage. The output of a properly functioning alternator will show a small amount of ac voltage called “ripple”. A good alternator should measure less than 0.5 volts ac ripple with the engine running and loads applied.

   Run the engine at fast idle and turn on accessories to load the alternator. Measure the ripple voltage by switching your DMM to the ac volts function, 2 volt range, and connecting the black lead to a ground (such as the engine block), and the red lead to the “+” terminal on the back of the alternator (not at the battery). A reading higher than 0.5 volts ac may indicate damaged alternator diodes.

4. Testing for Circuit Integrity:
   Electrical devices need good, solid connections in order to operate properly. This is particularly true in automobiles. Parts of the engine may reach up to 138.0 volts dc, while the battery terminals may read between 12.45V and 12.72V.

   To check for a bad connection, you need to measure the voltage drop across the connection. The higher the voltage drop, the worse the connection. Current must be flowing for the meter to register the voltage drop found. Turn ON the device (and the ignition, if necessary). Set your multimeter to the dc voltage function, 2 volt range. Connect the red lead to the side of the connection nearer the battery positive (+) terminal and the black lead to the side nearer the battery negative (-) terminal or ground.

   To check for a bad connection, you need to measure the voltage drop across the connection. The higher the voltage drop, the worse the connection. Current must be flowing for the meter to register the voltage drop found. Turn ON the device (and the ignition, if necessary). Set your multimeter to the dc voltage function, 3 volt range. Connect the red lead to the side of the connection nearer the battery positive (+) terminal and the black lead to the side nearer the battery negative (-) terminal or ground.

   The measured voltage drop should not exceed the following:

   - 300 mV (0.3 V) Switch
   - 200 mV (0.2 V) Wire or cable
   - 100 mV (0.1 V) Ground
   - 0 mV to <50 mV Sensor
   - 0.0 V Connections

   If you find a higher voltage reading you have a bad connection. Try cleaning the contacts by removing any rust or corrosion, scraping the metal or (continued on back)