

# THE 02 CHARGING SYSTEM

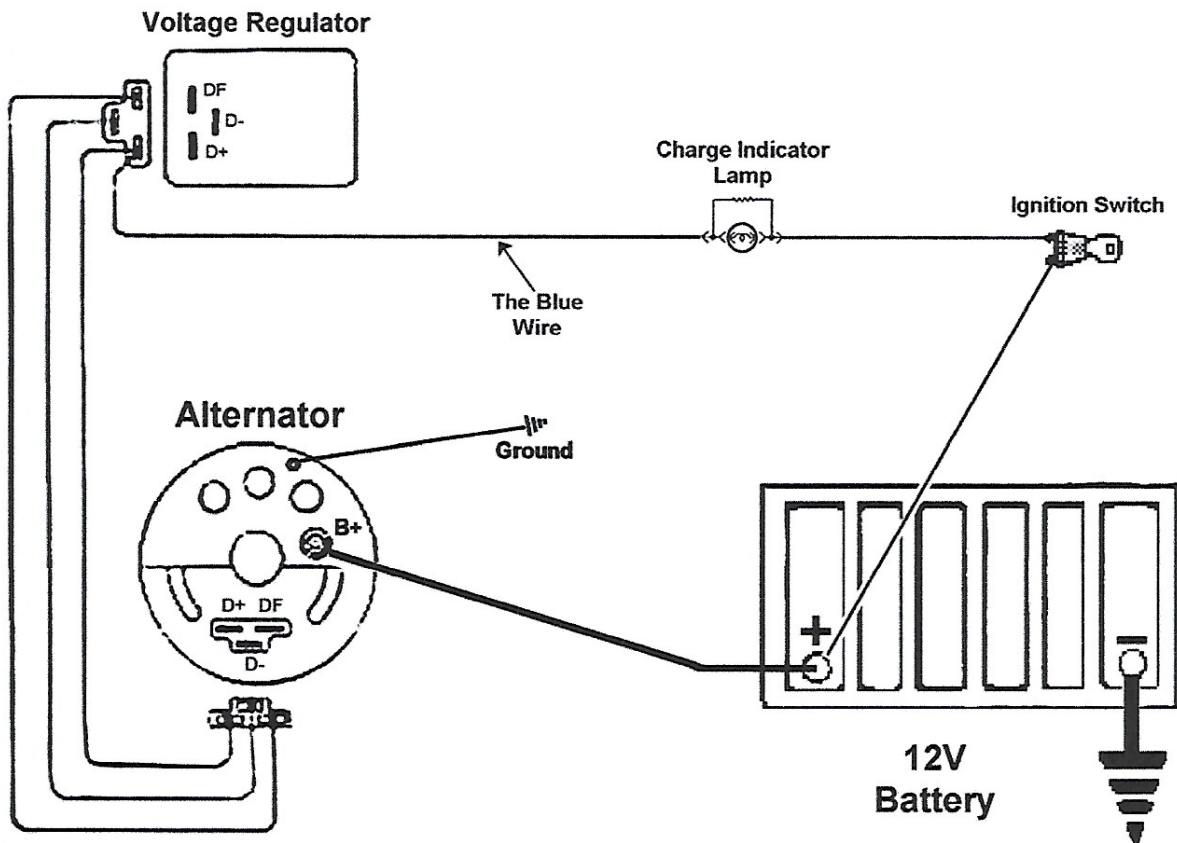
## 1. Basic Description of 02 Charging/electrical System

The 02 charging system converts mechanical energy into electrical energy when the motor is running. Your 02 requires electrical energy to (i) start the motor and run the ignition system, and (ii) operate electrical accessories (e.g., lights, wipers, heater blower, stereo). Any time output of the alternator exceeds the demand of the system, that output is available to recharge or maintain the battery's state of charge.

The charging system is comprised of the alternator, voltage regulator, battery and associated wiring. The original factory charging system includes a separate voltage regulator and alternator.

- The voltage regulator controls the voltage output, and thus the overall power output, of the alternator.
- The battery stores and produces electricity by electrochemical means, and supplies power to your electrical system at times when the demand exceeds alternator output, such as when starting the motor, when the motor is not running, or when the operating demand exceeds the output capacity of the alternator. The battery also acts a buffer to absorb excessive fluctuation in the system, which protects sensitive electrical components (like the diodes in the alternator).

Figure 1: High level diagram of 02 charging system (obviously, not to scale...)



## 2. Basic Electrical Troubleshooting; Use of DMM

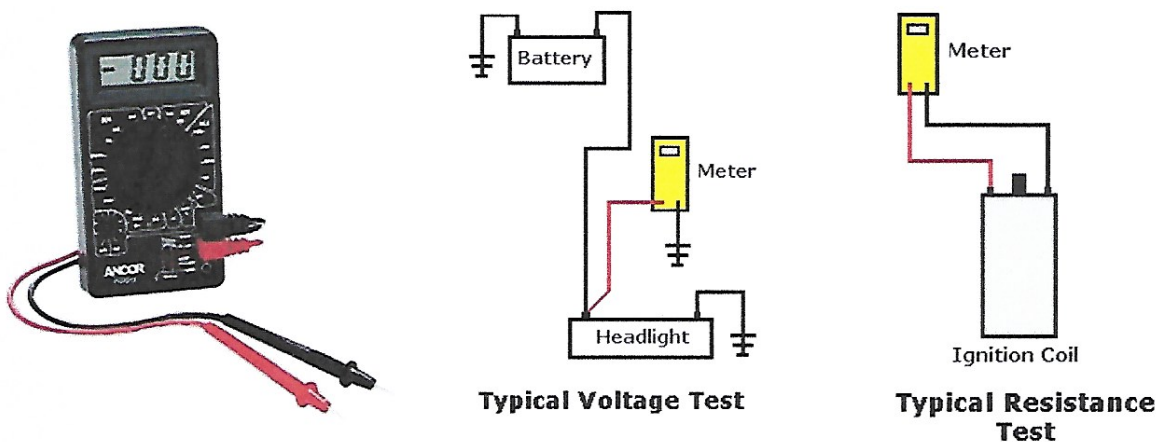
### A. SAFETY FIRST!

- Always remember to think safety first. Before you attempt any electrical system troubleshooting procedure, you should become familiar with basic car repair and use of tools and workshop equipment. If you have any doubt about the meaning of, or your ability to perform, any part of these procedures, seek assistance from and/or have this work done by a qualified mechanic familiar with '02s.
- **CAUTION: CAR BATTERIES CONTAIN SULFURIC ACID. ALWAYS WEAR EYE PROTECTION WHEN WORKING ON OR NEAR A BATTERY. BATTERIES PRODUCE HYDROGEN GAS (EVEN "SEALED" BATTERIES); DO NOT SMOKE OR CAUSE SPARKS THAT MAY IGNITE THE GAS AND CAUSE AN EXPLOSION.** Your work area should be well ventilated to disperse any hydrogen gas that might be vented by a battery..
- Further, some car batteries are capable of delivering in excess of 1000 Amps. That's enough current to melt a wrench shorted across the battery terminals, or between a good source of + to ground. With this in mind, you should never wear metal jewelry, watch bands, rings, necklaces, etc. when working on your electrical system; **DO NOT USE WRENCHES, SCREWDRIVERS OR OTHER METAL TOOLS** (e.g., removing or installing cables on the back of an alternator) **ON A LIVE SYSTEM**- remove the ground cable from the battery first and secure it away from the battery post.

### B. Using a Multimeter.

- You will need a digital multimeter (DMM) in order to perform automotive electrical troubleshooting procedures. The good ol' 12V test light is still available, but is really of limited utility and these days, costs a significant portion of the price of a DMM. You should be able to find a DMM for  $\leq \$15$ . Most auto parts suppliers have an inexpensive model in this price range that will be adequate for basic troubleshooting. Make sure to get a high impedance model, at least 10 megaohms- look at the spec sheet- most DMMs supplied for automotive testing purposes should meet this spec. If you can afford it (should be less than \$25), get a DMM that is "autoranging." This means that the DMM will automatically adjust itself to the scale of the measurement you are taking. For purposes of this discussion, you will be most interested in the voltage and resistance (ohmmeter) testing functions of the DMM.

Figure 2: DMM and typical testing examples





### 3. Signs of Trouble – Symptom/Cause Chart

HIGH LEVEL SYMPTOMS	
Symptom	Possible Cause
Battery won't maintain charge	Battery defective or insufficient output from alternator reaching battery
Bulbs burn out/battery needs water frequently	Alternator output too high
Charge indicator light is on while ignition switch is off	Current is flowing through charge indicator light to ground from alternator
Charge indicator light is on while motor is running; voltmeter reads low	System is drawing more power from battery than from alternator
Lights dim at low RPMs	Battery discharged and/or alternator output low
Motor turns over slowly when starting	Battery discharged (other non-charging system causes include defective starter, overly advanced timing, etc.)
Repetitive alternator failures	Excessive load on system
Squealing from front of motor, particularly when accelerating and/or when motor is cold.	Loose, defective or contaminated drive belt
Unusual noises or vibration from alternator area (e.g., shrieking, whining, rattling, knocking, etc.)	Worn case (mounting) bushing and/or bearing in alternator

LOW LEVEL SYMPTOMS	
Symptom	Possible Cause
Alternator no-op	<ul style="list-style-type: none"> <li>• Alternator defective</li> <li>• Charge lamp burned out</li> <li>• Drive belt broken (you have bigger problems...)</li> <li>• Excessive resistance in circuit (open circuit [loose connections] or corrosion in connections)</li> <li>• Regulator defective</li> </ul>
Alternator output low	<ul style="list-style-type: none"> <li>• Alternator defective</li> <li>• Drive belt slipping</li> <li>• Excessive resistance in circuit (open circuit [loose connections] or corrosion in connections)</li> <li>• Regulator defective</li> </ul>
Alternator output too high	<ul style="list-style-type: none"> <li>• Regulator defective</li> </ul>
Battery will not maintain charge	<ul style="list-style-type: none"> <li>• Alternator output low</li> <li>• Battery water low</li> <li>• Battery defective</li> <li>• Drive belt slipping</li> <li>• Excessive resistance in circuit (open circuit [loose connections] or corrosion in connections)</li> <li>• Regulator defective</li> </ul>

**4. Troubleshooting 02 Charging System Problems.** If you have any of the charging system problems described above, take the following steps to isolate the problem(s). Note that a full test of the capacity of the charging system requires load testing of the alternator and battery, which is not possible using only a DMM. Many retail auto parts suppliers and virtually all battery shops will have such testers and will generally test your charging system at no charge. Note: never operate you alternator with the battery disconnected- the battery absorbs current surges causes by sudden changes in system load, and prevents your alternator from self-destructing (keeps the diodes from frying). These tests are basically go-no go in nature, and will help you isolate major problems, some of which may require further investigation.

- A. Test battery voltage, with ignition switch ("Key") in off position, all accessories off; use DMM in volt meter setting. Put red probe on positive terminal and black probe on negative terminal. A fully charged, open lead-acid battery will read about +12.6V if fully charge; a sealed, lead-acid battery should read about +12.9V when fully charged. In any event, if your battery shows <+12.6V when it should be fully charged (e.g., after you have been driving the car for 15 or 30 mins), either your battery has a problem or your charging system is not up to snuff.
- if battery voltage reads OK, but you are having other problems like hard starting, slow cranking, etc., you have other mechanical or electrical problems not related to the charging system.
  - if battery voltage is below +12.6V, test system voltage as per item 4(B) below.
- B. Test system voltage, with motor running at least 1000RPM. Use DMM in volt meter setting. Put red probe on positive terminal and black probe on negative terminal. Turn on headlights and heater blower. Unless battery is markedly discharged, reading should be between +13.5V and +14.5V.
- If output is lower than this range, test output at alternator. Put red probe on B+ terminal on alternator (see illustration below) and black probe on alternator body. If voltage reads in +14V range, alternator is OK; test resistance of charging circuit wiring per item 4(C.) below. Otherwise, test voltage regulator per item 4(D) below. If output is markedly higher than +14.5V (say, over +14.7V), your voltage regulator is defective and should be replaced.
- C. Test charging circuit wiring. If voltage at alternator is OK, but system voltage tests low, you will need to test for continuity and excessive resistance in the charging system circuitry. For resistance testing, polarity is not important- it doesn't matter which probe is at which test point. The resistance reading in these tests should not exceed 1 or 2 Ohms.

The B+ terminal on the alternator connects to the positive terminal on the battery, and the body of the alternator must be well grounded to the car chassis. Typically, the alternator body is grounded by a short, stout wire to a bolt on the engine block Use your DMM in the ohmmeter setting, and put one probe on B+ and the other on the positive terminal of the battery and observe the reading; then put your probes between the alternator ground post and the engine block.

If the reading in any of these tests exceeds a couple of Ohms, you will need to remove the wires at the connection points and clean the connectors, or replace the wires. It is not unusual for the connectors at the battery to be corroded, or the ground wire between the alternator and block to be too small, have partially broken wires or connectors, or the like. Note that any connector in any circuit may have corrosion between the wire and the connector. Just for good measure, also check to make sure you have a good ground between the battery and the chassis and engine block. Correct problems and retest.

- D. Test voltage regulator. To test the voltage regulator, you will need to first test for the presence of +12V on the D+ circuit (see illustrations). Remove the plug from the regulator, turn your Key to the run position, and use your DMM on the voltage setting, with the red probe on the connector for D+ and the black probe on a chassis ground (you can use the negative terminal on the battery).

If you do not have +12V on this circuit, then verify that your charge lamp is working (turn Key on; the red charge indicator in the instrument panel should light; if not, then the bulb likely needs to be replaced. The instrument panel must be removed for this purpose. See other FAQ writeups for instructions. If the



reading is  $\sim +12V$ , then you can proceed with the voltage regulator bypass test. This temporarily eliminates the voltage regulator from the charging circuit. You will need to use a small jumper wire between the D+ and DF connectors in the regulator plug, per the following illustration. If charge indicator light goes out with this jumper in place and system voltage tests OK as per item 4(B) above, then your regulator is defective. Note: do not operate charging system with regulator bypass in place more than momentarily for testing purposes.

Figure 3: alternator bypass test

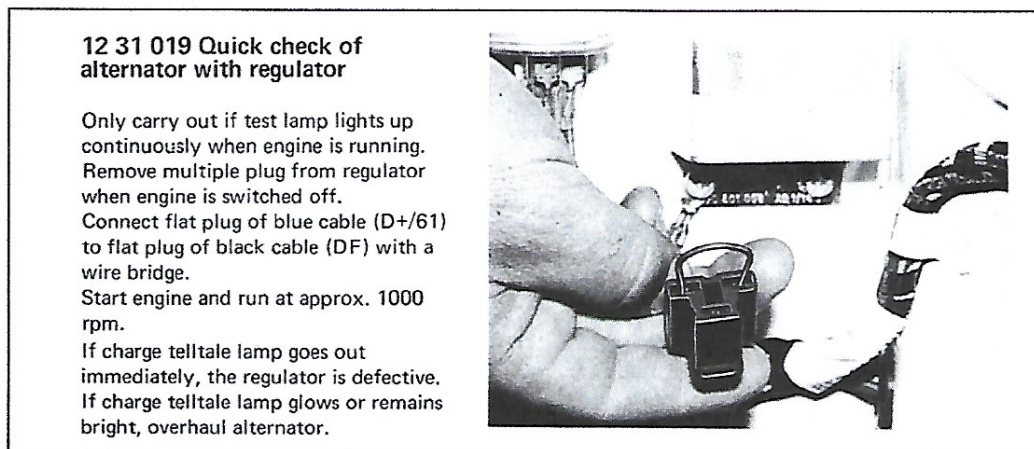
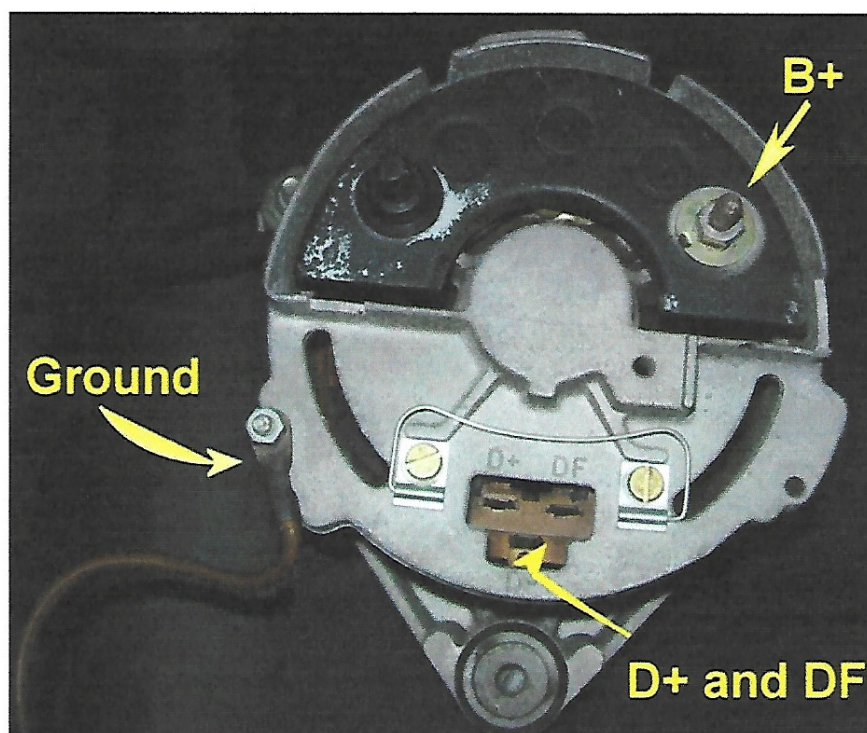


Figure 4: The back of an actual 02 alternator.



Questions on any of this material? Send me an email: [blumenthal@aechelon.com](mailto:blumenthal@aechelon.com).