# How to Make Your Classic Car's Charging System Reliable - Part 1
## by Rob Siegel (25 April 2017)

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In our continuing series of The Big Six things likely to cause a vintage car to die and leave you in the lurch (which are, by the way, ignition, fuel delivery, cooling, charging, belts, and ball joint issues), it's time to discuss the charging system. I'll explain how the system works, reveal two crucially important numbers, tell you how to test the charging system's basic health, then offer tips on preparing your car's charging system for a road trip.

**The charging system** consists of the battery and cables, the alternator or generator, and either an external or internal voltage regulator. The function of the battery is to spin the starter motor to start the engine. Once that's done, the alternator takes over, satisfying the car's electrical demands and keeping the battery charged. The battery then acts primarily as a filter, keeping voltage spikes from damaging the car's electronics. The voltage regulator rapidly switches the alternator in and out of the charging circuit to provide the car the correct voltage.

The back of a 1970s era Bosch alternator with its battery (B+) and regulator (D+, D-, and DF) connections.

The thing most likely to strand you is the alternator not charging the battery, which causes the battery to run down.

**A quick primer on important numbers**

Let's introduce you to the charging system's two most important numbers. They are 12.6 volts and 13.5 volts. Here's why:

**12.6 Volts**: You think your car has a 12-volt battery. You're wrong. It doesn't. A so-called 12V battery actually has six individual 2.1-volt cells (one under each fill cap, back when batteries had fill caps). Thus, when fully charged, the battery should have a "resting voltage" of not 12-volts, but 12.6-volts. With each 0.1-volt drop, the battery loses about 20% of its ability to output high current on demand, so if it's reading only 12.0 volts, its ability to spin the starter quickly is basically gone.

**13.5 Volts**: With the engine running, the alternator should output a "charging voltage" that's about a volt higher than the resting voltage, or about 13.5-volts. The exact charging voltage depends on the car; it may be as low as 13.2-volts or as high as 14.2-volts.

Therefore, if you take a multimeter, set it to measure DC voltage, and measure the voltage across the positive and negative battery terminals with the engine off, if the battery is fully charged, it should read a resting voltage of 12.6 volts. Then, if you start the car, you should see a charging voltage about a volt higher than resting voltage. This is so central that we'll enshrine it in a little table.

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|---|---|
| Resting Voltage (engine off) | 12.6 volts |
| Charging Voltage (engine running) | About 13.5 volts (13.2 to 14.2 volts) |

With this in mind, you now can perform…

**The basic charging system health test**: Use a multimeter to measure the resting and charging voltages as described above. Then, with the engine running, gradually increase the electrical load by turning on the headlights and the blower fan. Then increase the engine RPM to about 3500 as you watch the reading on the multimeter. If the voltage stays about a volt higher than resting voltage (e.g., about 13.5V), then the car's charging system is functioning. But if the voltage drops (or increases) dramatically at any point, there's a problem in the alternator or the voltage regulator.

The cool thing is that you don't actually need a multimeter, or even to open up the hood. Google "cigarette lighter voltmeter." You can buy them on Amazon for six bucks. Keep one in the glove box. Stick it in your lighter socket when you need to do the test. It doesn't matter if it's absolutely accurate. What matters is that, when the engine is running, the reading jumps up by about a volt. If it does, the alternator is charging. If it doesn't, your car will die once the voltage drops too low.

Verifying charging voltage – confirmation that the alternator is working properly – from the comfort of the driver's seat with a cigarette lighter voltmeter.

**What the numbers mean and what to do**

**Resting voltage lower than 12.6 means Low or Dead Battery**: If, with the engine off, the resting voltage is less than 12.6-volts, the battery is low and needs to be recharged. Of course, it begs the question of *why* the battery is low. It could be that the alternator isn't working (see below), or that the battery has reached the end of its useful life (we'll leave that one for next week's part two).

**Charging voltage the same as resting voltage means the alternator isn't charging**: If, with the engine running, the reading *doesn't* increase by about a volt—if, instead, it stays at the resting voltage—it means that the alternator isn't recharging the battery. This could be because the alternator is bad, the regulator is bad, or the wiring between them has failed. In any case, if you drive the car, the battery *will* run down. If the car is a primitive carbureted model, the electrical load on the battery is minimal, and you may be able to drive hundreds of miles before the battery runs down enough that the ignition stops firing. Next week I'll touch on charging issues on newer cars. But even on a primitive car, it's really important that you don't simply jump-start a car with a dead battery without checking that the alternator is charging, because if it's not, the car will simply die a mile down the road, possibly in a much more dangerous location.

People often say "but I just installed a new regulator and a rebuilt alternator; they can't be bad." That's it. Diagnosis is good. Denial isn't.

**Charging voltage is too high means that the regulator is bad**: It's less common, but you may see that the charging voltage is too high, like over 15 volts. This means that

the voltage regulator is stuck in the closed position. Overcharging can generate hydrogen sulfide gas and cause the battery to explode. If you see high charging voltage, smell sulfur, or if the battery case is bulging, STOP! Replace the voltage regulator and battery immediately.

**What to do before a road trip**:

- Perform the Basic Charging System Health Test above.
- Inspect the fan belt which runs the alternator. If you see signs of cracking, replace it.
- Visually inspect the battery. If the case is bulging, replace it. If it's more than seven years old and you'll be traveling alone without easy access to a jump, replace it. It's money well spent.
- Inspect the battery cables. If there is massive corrosion or badly frayed wires, replace them.

This negative battery cable, miraculously, was still starting my '72 2002tii, though how the starter current flowed through those few remaining strands of wire I'll never know.

- Buy a battery post cleaner and clean the posts and the insides of the cable clamps.
- Inspect the ring terminal on the big "B+" post on the back of the alternator. If the wires leading to it are frayed, crimp on a new terminal.

- If the car has an external regulator, inspect the three wires (D+, D-, and DF) running between it and the alternator, and the terminals at both ends. Be sure the terminals are actually pushing onto the posts and aren't pushing out the back of the connector (very common as the plastic connectors age and crack).

The three wires connecting the external regulator to the alternator are a common source of failure on a vintage car.

Fresh battery. Good cables. Passed the Basic Charging System Health Test. No alternator connectors about to snap off. You're good. Go and drive!

(Next week: More about the charging system.)

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