Ripple Pattern

Last month we discussed alternators to see what goes on inside them, and how they work. We saw that the rotor rotates an electromagnetic field inside a stationary winding called a stator. Diodes rectify the AC voltage induced in the stator, changing it into pulsating DC to charge the battery and run the vehicle's electrical systems. That's important to remember. The alternator's job has two parts: it must not only charge the battery, but also operate the electrical/electronic system all at the same time.

This article also has two purposes:

- **To show how the battery and alternator interact with each other.**
- **To show how the alternator can be tested on the car.**

The alternator tests shown in this article will show you how to evaluate the alternator's ability to do its two part job.

PART TWO

Like Birds of a Feather

Figure 1 is worth a thousand words. It shows how the alternator and battery go together. It is a basic diagram of the alternator and battery circuit with the ignition key turned OFF. Between the alternator and battery is a resistor symbolizing the electrical/electronic loads of the vehicle.

For the moment, forget about which way the electrons are flowing. Let's concentrate instead on which currents are flowing so we can understand the relationship between the alternator and battery.

Ammeter Number One measures the charging current supplied by the alternator to both the vehicle loads and the battery. When the pointer is at the left side of Ammeter Number One, the alternator is not charging (OFF). When it points to the right, it indicates that the alternator is ON, and the charging rate is high. Since the engine is not running in **Figure 1**, there is no charging voltage or current being produced by the alternator.

Ammeter Number Two keeps track of current flowing to and from the battery. Since current can flow both ways through the battery, Ammeter Number Two has a zero at the center of its scale. With the circuit set up as shown, movement of the ammeter needle to the right (C for Charge) would indicate that current is flowing into the battery to charge it.

Movement of the needle to the left toward D for Discharge would indicate a current flow out of the battery.

Since the key is off, however, there is no battery current flowing (or shouldn't be!) except for the memory in the computer. This tiny amount of current is too small to be detected by the ammeter.

Ammeter Number Three monitors the current flow to vehicle loads. Once again, since the key is off, there is no significant current through the vehicle.

Finally, the DVOM measures the battery terminal post voltage reading of 12.66 volts, indicating the open circuit voltage of a fully charged battery.

Where to Check Charging Voltage

The voltage that charges the battery is the voltage that makes it to the battery terminals. Alternator output charging voltage is of no use to the battery if it doesn't make it to the battery terminals due to a bad connection or a bad cable between the alternator and battery.

So the only logical place to check the charging voltage—is at the battery terminals, not at the alternator.

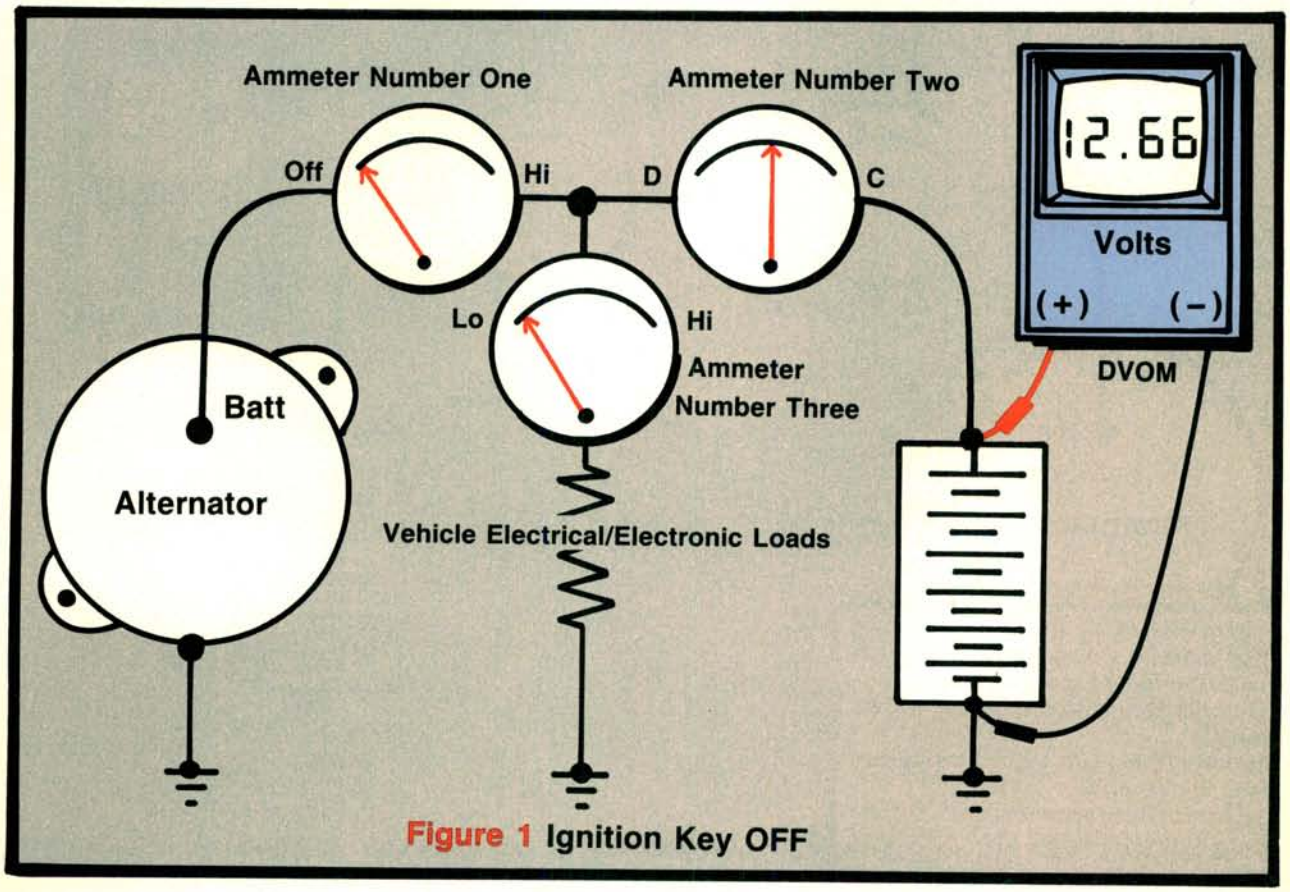


Figure 1 Ignition Key OFF

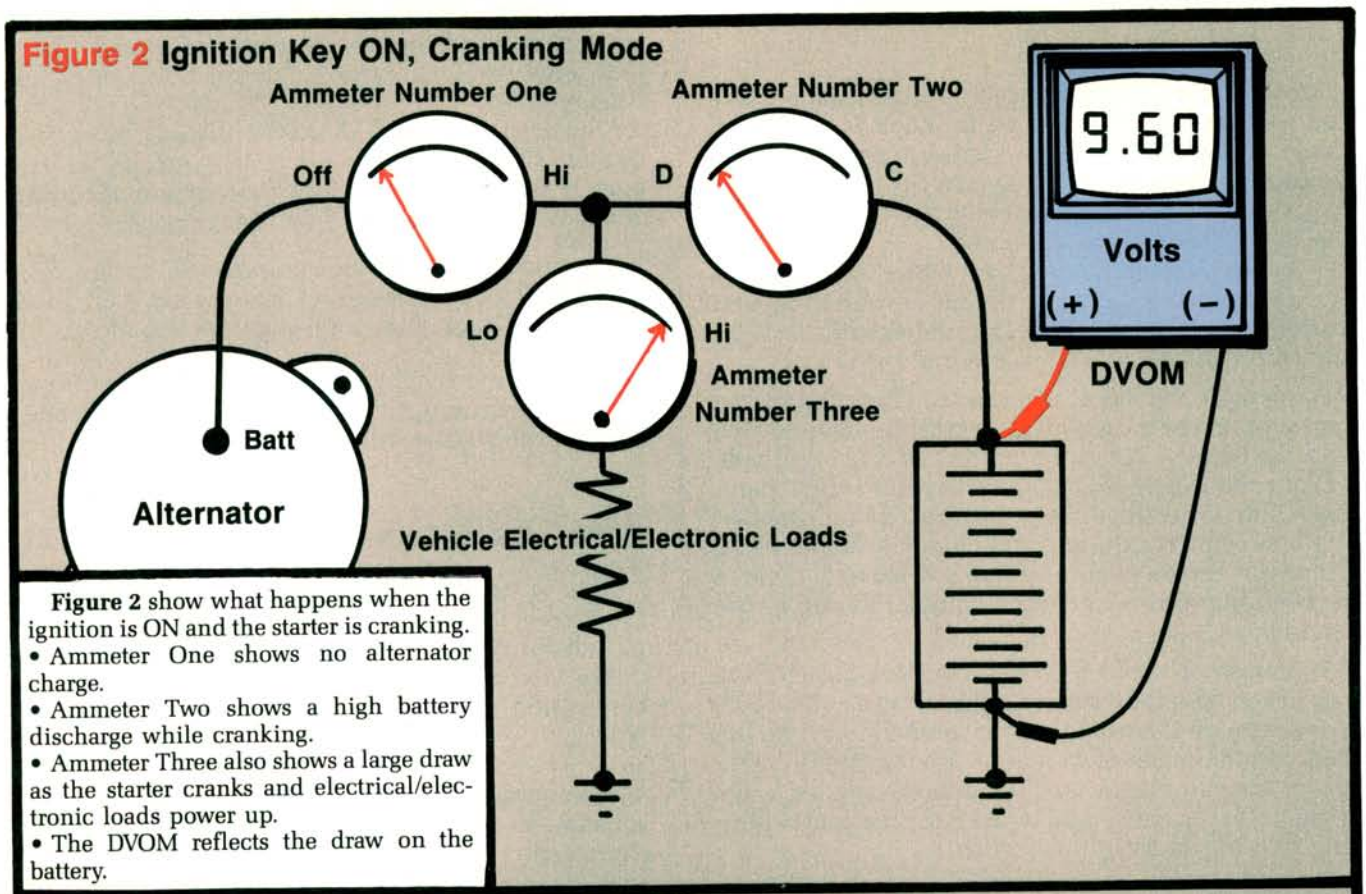


Figure 2 show what happens when the ignition is ON and the starter is cranking.
- Ammeter One shows no alternator charge.
- Ammeter Two shows a high battery discharge while cranking.
- Ammeter Three also shows a large draw as the starter cranks and electrical/electronic loads power up.
- The DVOM reflects the draw on the battery.

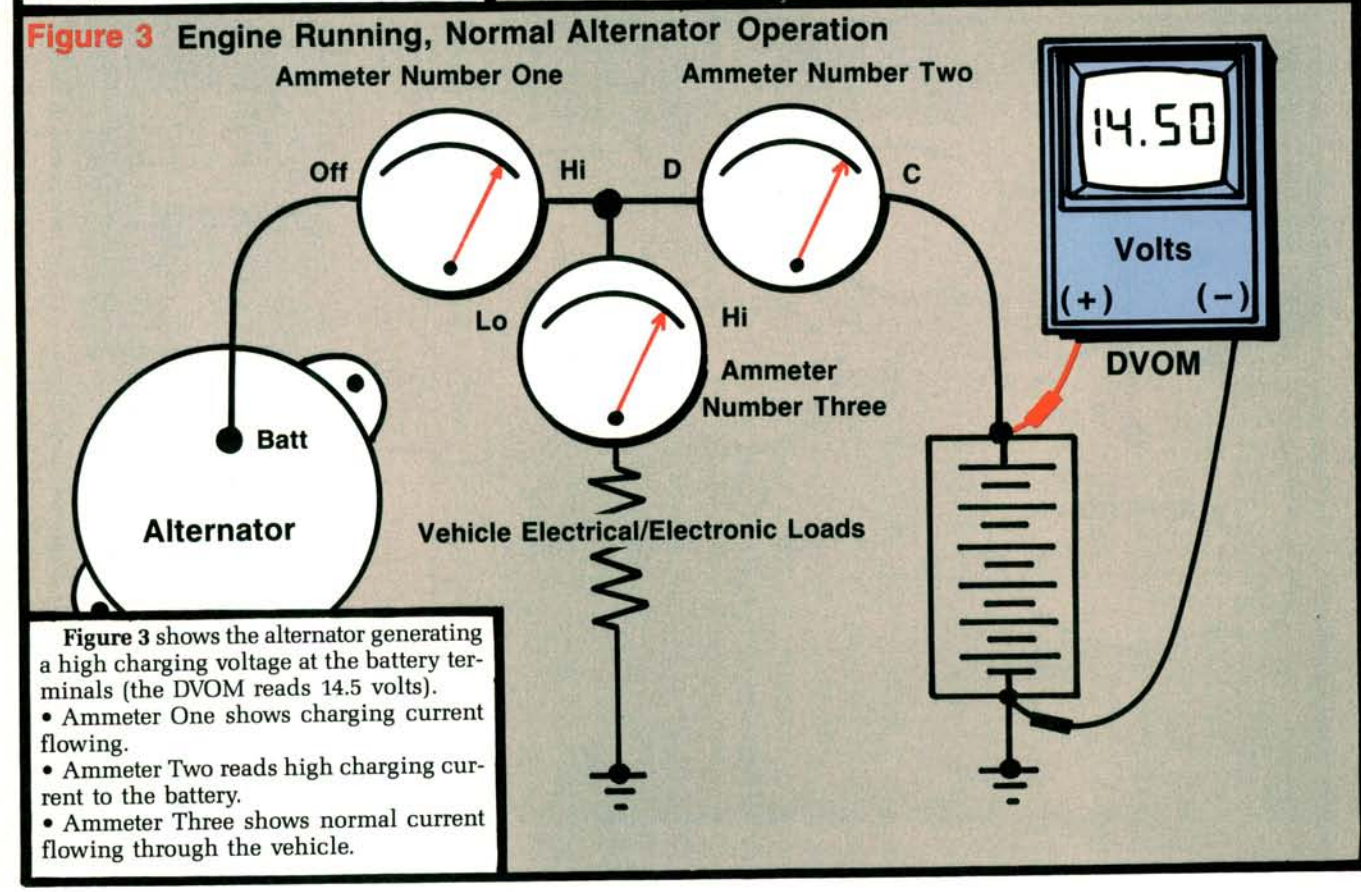


Figure 3 shows the alternator generating a high charging voltage at the battery terminals (the DVOM reads 14.5 volts).
- Ammeter One shows charging current flowing.
- Ammeter Two reads high charging current to the battery.
- Ammeter Three shows normal current flowing through the vehicle.

Engine Running With A Bad Alternator

Figure 4 shows an alternator failure with the engine running.

- Ammeter One shows no charging current from the alternator.
- Ammeter Two is registering a discharge as the battery has to take over for the failed alternator to operate the vehicle.
- Ammeter Three is reading lower, indicating less current through the vehicle loads. Why? The battery is discharging, and as it drains, battery voltage drops lower and lower.
- The DVOM is down to 12.40 volts, and will continue to drop as the battery discharges.

Lower battery voltage means less current through the vehicle circuits. This explains why a vehicle runs poorly when the alternator is not charging. Fuel injectors can't inject very well at low voltage, and fuel pumps can't pump enough fuel to keep the fuel rail pressurized when voltage drops.

Figure 4 Alternator Fails With Engine Running

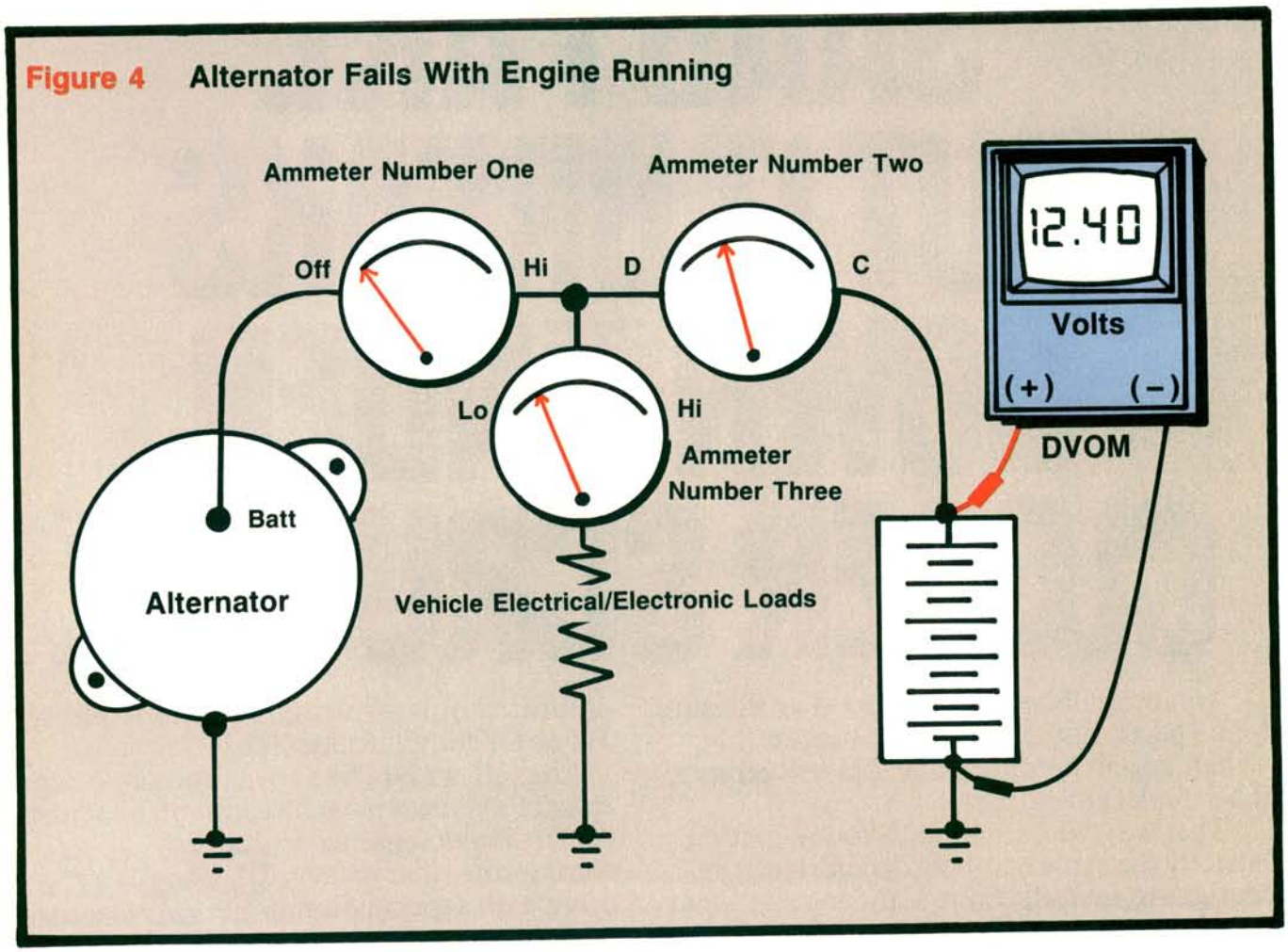
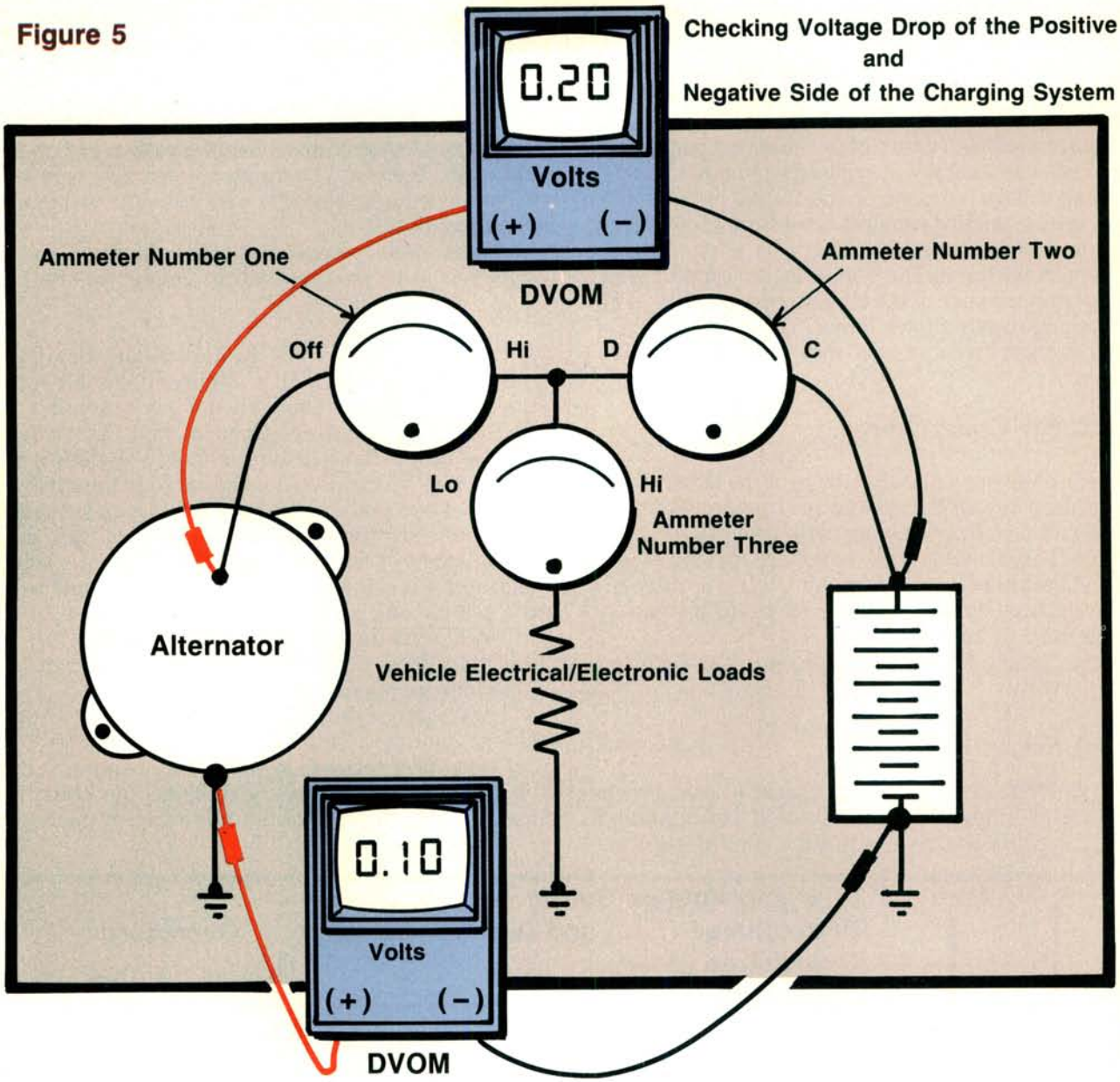


Figure 5



Keeping the Charging System at Peak Efficiency

Let's stop and do a quick review. Any voltage drop between the alternator and the battery will reduce battery charging. Get rid of voltage drops between the alternator and battery.

Figure 5 shows a DVOM connected between the alternator's BATT terminal and the battery positive terminal. With the engine running at 1500-2000 RPM, the voltage drop should not be greater than 0.2 volt under a normal electrical load.

Connect the test leads of a DVOM across the negative side of the charging system (ground side). With the engine running at the same 1500-2000 RPM, the voltage drop should not be greater than 0.1 volt under normal electrical load.

Testing the System

Now we're ready to test the charging system for both undercharge and overcharge. The point to remember here is that the charging voltage is the key indicator of charging system performance. For the rest of this article, keep an open mind about the charging system test. We'll explain all aspects of charging system performance, and show indications of an over- or undercharge condition.

Setting Up the Charging System Test

Glance back at **Figure 1** for a moment. It shows the set up for the charging system test, with a DVOM connected across the battery terminals.

Figure 6 shows a graph of the charging system test so you can see what the readings mean on the DVOM. Charging voltage is plotted on the Y-axis (vertical). Different voltage readings are indicated from a low of 12.0 volts, to a high above 15.0 volts.

Time drags out on the X-axis as the test proceeds.

The performance of the charging system during an undercharge test is shown in red. The performance of the charging system during an overcharge test is shown in blue.

Check For Undercharge

Record the open circuit voltage of the battery with the ignition key OFF. Expect a reading around 12.66 volts for a fully charged battery with no surface charge. Surface charge is what makes a battery reading higher than 12.66 immediately after the engine is shut off. Surface charge will dissipate slowly until the battery voltage rests at 12.66 volts.

Refer back to **Figure 6.** The red line starts our test at 12.66 volts.

Check For Undercharge

STEP ONE. Make sure all electrical accessories are turned OFF (lights, wipers, blowers, radio, and so forth). Start the engine and run the engine speed up to 1500-2000 RPM. Hold it steady at this speed for the remainder of the undercharge test. The DVOM should rise to the normal charging voltage for the car being tested.

Notice that in **Figure 6**, the voltage rises to 14.5 volts, the selected normal charging voltage for this test, although "normal" charging voltage may vary with different vehicle designs, and changes in ambient temperature.

Pause 5-10 seconds as the charging voltage stabilizes at its reading (still at 1500-2000 RPM).

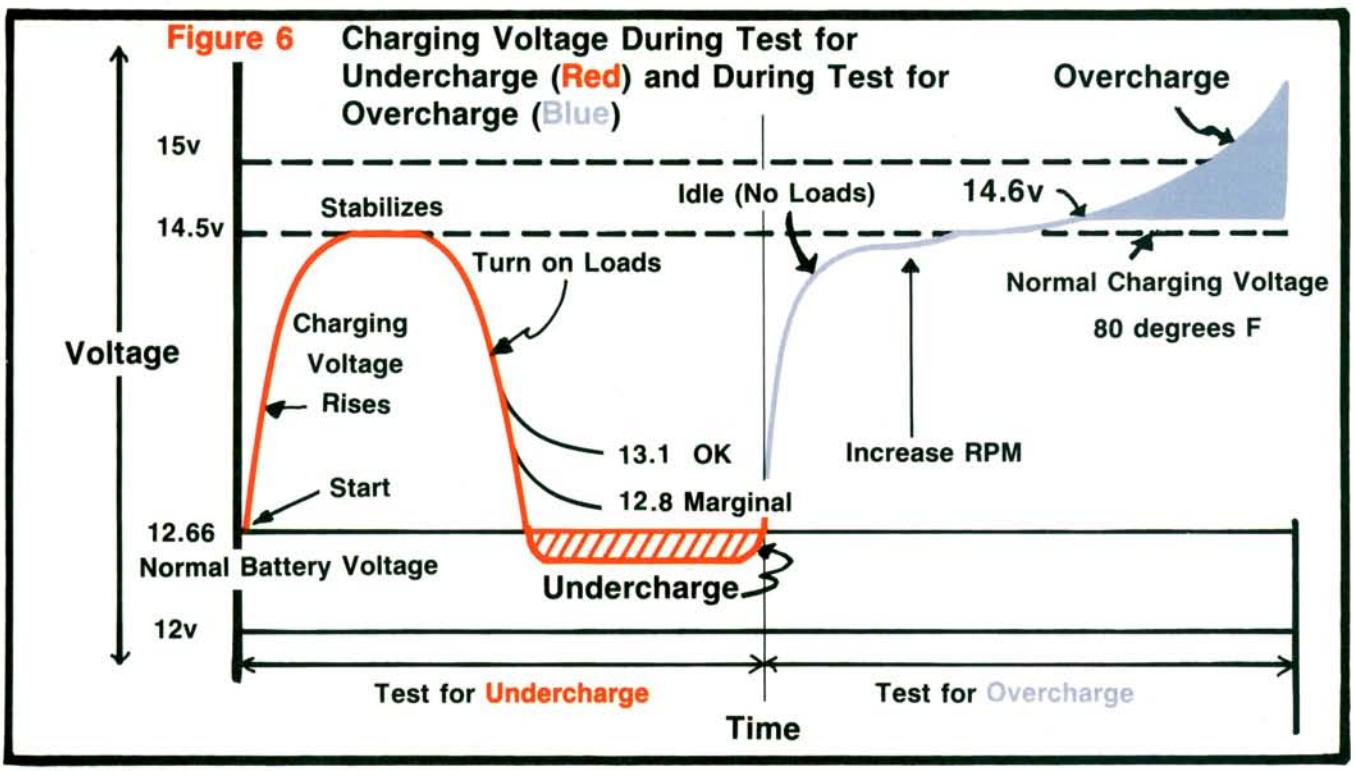
STEP TWO. Turn ON all normal electrical loads used while driving (high beam headlights, air conditioning high blower, windshield wipers, car radio, and so forth). As the load increases and the charging voltage drops, the question is, how low does it go?

Notice the red line in **Figure 6**. If the charging voltage drops to about 13.10 volts, this is an acceptable minimum reading. This leaves about 0.5 volt above 12.66 volts to keep charging the battery (at a slower rate) and still maintain enough alternator output to run the vehicle and all its accessories.

- There is no undercharge at 13.10 volts.
- If the voltage drops to 12.8 volts, it is a borderline undercharge condition.
- If the voltage drops below 12.66 volts, an undercharge condition exists.

Wait 10-15 seconds to see if the charging voltage is able to rise above an undercharge condition. If it doesn't, look for one of the following problems:

1) A loose belt.



2) A voltage drop (bad connection) between the alternator and the battery. Glance back at **Figure 5** to see how to check both the voltage and ground side of the charging circuit.

3) A weak alternator. This example is an alternator rated for 80 amps that is only capable of generating a 40 amp charge. The alternator may have a bad diode, a shorted stator winding (which would be evident in a larger than normal ripple pattern). Worn brushes are also a possibility.

4) A bad voltage regulator, or bad regulator electrical circuit, if full fielding corrects the undercharge condition.

Check For Overcharge

Immediately following the undercharge test, let the car return to an idle, and turn all those electrical accessories OFF again.

Notice in **Figure 6** how the red line rises and blends into a blue line as we begin the test for overcharge. At idle, with all accessories turned OFF, the charging voltage should be close to normal.

STEP THREE. Increase engine speed to 1500-2000 RPM again with all loads turned OFF, and watch charging voltage. It should rise about 2.0 volts above battery voltage to a level of about 14.6 volts and stabilize at that point as the engine continues to run at high RPM.

(If the ambient temperature is below 60 degrees F, it may rise about 2.5 volts to a high of 15.1 volts before stabilizing.)

- If the charging voltage stabilizes at about 14.6 volts, without a continual rise above 15.1 volts, there is NO overcharge condition.
- If the voltage rise is more than 2.5 volts and continues to rise as long as the engine is held at high RPM there IS an overcharge condition.

There are two reasons for an overcharge condition:

1) The voltage regulator is defective because it cannot control the upper limit of the charging voltage at the proper set point (about 2.0 volts above battery voltage).

2) There is a voltage drop on the negative side of the charging circuit. The ground between the battery's negative terminal and the alternator ground is defective. If you haven't already checked for a voltage drop on the ground side, go back and check it now.

It takes a minute or so to verify an over- or undercharge condition using this procedure. Do it once or twice using the steps in this article, and you'll be able to do it from memory from then on. Try it on cars you see most often in your shop to get a feel for normal charging levels on common models. The test is quick enough that you can afford to do it several times to determine good readings for different cars.

And that's all there is to it.

—By Vince Fischelli