How to Repair & Rebuild your Alternator

by Lars Grimsrud
Colorado Corvette Crazies (CCC)
The Ultimate Corvette Tuning & Beer Drinking Fraternity
Lafayette, CO

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This tech paper will discuss the disassembly, diagnostics, and repair of GM Delco alternators used after 1971, and specifically discuss the alternators used from 1971 to 1986. Alternators used after 1986 are similar (called the "CS" alternators), and the same troubleshooting techniques/principles apply. However, disassembly techniques are significantly different for the CS units due to the Stator wires being crimped & soldered to their mating components. Pre-'71 alternators are also similar, but do not have an internal voltage regulator, and use individual diodes in place of a diode trio and bridge rectifier.

Alternators fail frequently, and good rebuilt units are pricey (typically in the $150+ range). But virtually any alternator can be easily repaired for less than $50. You can do it yourself in your garage or driveway using ordinary hand tools and a little knowledge.

History & Principles

Electricity is produced by moving coils of wire through a magnetic field, thus producing a current flow in the coils of wire. Two different devices have been used on cars to produce electricity: Generators and Alternators.

Early GM cars, up through 1962, used a Generator to produce electricity. Generators, for those of you too young to have seen one, are about the size, weight and shape of a GM starter. They use permanent magnets to produce Direct Current (DC). The magnets are located stationary around the case, and the current-producing coils are spun on a shaft in the center of the generator. Generators are neat in that they do not need any external source of power (a battery) to begin producing electricity: all you have to do is to spin them, and they produce a DC output. But they are heavy, and they do not produce much output at low rpm: you'll typically see the headlights on older cars with generators go noticeably dim at idle.

In 1963, GM introduced Alternators on its cars. Alternators do not have permanent magnets, but rather send a small current through a series of coils to produce an electrically-induced magnetic field. In an alternator, the magnetic field is created by spinning the electrically-induced magnetic field in the center of the alternator, producing current in the stationary, case-mounted coil. This makes an alternator much smaller and lighter, and its output at low rpm can be maintained by increasing the strength of the magnetic field. An alternator, however, does not produce DC output: Due to its design, an alternator, as the name implies, produces Alternating Current (AC). This AC must be changed to DC before it can be utilized in an automotive electrical system.

Alternating current, if visualized, is like a wave moving up and down: it cycles from positive to negative. It the mid point between positive and negative, there is no current flow at all. Obviously, then, if we only had a single coil producing AC power at low rpm, this cycling and "dead spot" would make our lights and electrical system blink on and off very quickly. Not good for our application. An alternator, then, typically has three separate coils, each producing its own "wave." These waves are set as far opposite each other as

possible, so by the time they "overlap," they are producing a steady stream of AC power. But now we must convert it to DC.

Each of the three current producing coils is attached to two diodes. A diode is an electrical component that allows current to flow one way, but not the other. It's like a one-way door. One of the "one-way doors" is set to "open" in one direction, while the other one "opens" in the opposite direction. Thus, when the alternating current is flowing in the "positive" direction, the positive output is shuttled out of the one diode. When the current shifts to the "negative" direction, it is allowed to go only out of the other diode. Thus we have separated out the two elements of the alternating current into a positive and negative DC power output. With all three of the coils doing this at staggered times, a steady stream of DC power is realized.

Pretty simply, huh?

Component Parts & Systems

The alternator consists of 4 basic systems:

Housing
Current Producing Parts
Rectifying Parts
Regulating Parts

Each of these can fail, and each can be repaired at a very nominal cost.

Housing

The housing serves to contain all the parts in one place, provides a bearing surface for the Rotor to spin within the Stator, and acts as a heat sink to dissipate the heat generated by the internal parts and components.

Failure modes (listed in order of frequency):

1. Bearing failures. Most common failure is the housing front bearing. The front bearing takes most of the load imposed by the fan belt. In spite of this, the bearings are surprisingly durable, and will easily give 150,000 miles of service provided the belt is tensioned correctly. Front bearing failures were much more common in the days of the V-belt drive: "real" men would use a crow bar on the side of the alternator and tighten the V-belt up so tight that it could be played like a violin string. Alternator bearing failure then occurred within a few miles of operation. Now, the serpentine belts have automatic belt tensioners that provide correct belt tension at al times. Bearing failure is evidenced by a growling or howling from the alternator.

2. Dirt, Oil & Grease. Since the housing serves to dissipate the heat generated by the internal components, dirt and grease on the housing will impede this process and lead to early component failures. Keep the alternator reasonably clean at all times to help increase its life.

Current Producing Parts

The parts which actually produce the current are the Rotor, Stator, and Brush Assembly.

The Rotor spins in the center of the alternator. It is charged with a variable current to produce a variable magnetic field, thus producing variable output of the alternator.

The Stator is the three-field coil mounted stationary circumferentially in the case. It produces the actual power output.

The Brush Assembly provides electrical contact to the spinning rotor. The brushes "feed" the current to the Rotor to produce, and alter, its electro-magnetic field.

Failure modes (listed in order of frequency):

1. Brush failure. The brushes, since they contact the rotating Rotor, are subject to wear. Typically, brushes will last over 100,000 miles. Once worn out, they will no longer provide a good electrical connection to the Rotor, and alternator output will fail.

2. Open or Ground ("short") failures in the Rotor or Stator. These failures are extremely rare. They would occur if one or more of the wires in these parts burned, broke, and shorted to ground due to an insulation failure. In all my years of fixing cars, I've never seen a Rotor or Stator failure.

Rectifying Parts

To change the AC to DC, the early alternators used 6 separate diodes that were pressed into the alternator case and into a diode "bridge." The next generation alternators (starting in '71) used a finned Rectifier Bridge and a transistorized Diode Trio. The Rectifier Bridge is attached to, and grounded to, the alternator case. It allows the "negative" element of the AC power to go to ground through its three terminals hooked up to the three current-producing stator fields. The Diode Trio, also attached to the same three stator fields, allows the "positive" AC element to go to the "+" side of our DC system and to the regulator.

Failure modes (listed in order of frequency):

1. Any of the three "one-way doors" on either the Rectifier Bridge or the Diode Trio can fail. Failures occur when the "one-way doors" either allow current to flow both ways ("leak"), or allow no current through at all. This will either produce a lower-than-normal output of the alternator, or produce no output at all. It can also allow current to slowly "leak" through the alternator while the car is sitting, producing a slow drain on the battery (typical "dead battery in the morning" symptom). The Diode Trio is one of the most common failed parts in these alternators.

Regulating Parts

To control the output of the alternator, a regulator varies the flow of power to the Rotor, thus changing the strength of its magnetic field. From 1963 through 1970, this was done by an externally-mounted, mechanical voltage regulator, normally mounted on the firewall. Starting in '71, GM used a small transistorized, internal regulator in the alternator.

Failure modes (listed in order of frequency):

1. The most common of all alternator failures is the failure of this regulator. It is simple to diagnose and replace.

Tools Required

Ohm Meter (For this process, I prefer one of the really cheap analog meters (the kind with a needle and scale. This type of meter will provide instant, easily understandable information about circuit continuity. For this purpose, I find these quicker and easier to use than the more expensive digital meters. You can get a cheap analog ohm meter at Radio Shack or your hardware store for about $12.)

15/16" ½"-drive socket

½" drive impact gun

¼"-drive socket set with ratchet, extension, and nut driver. For pre-"CS" alternators, socket sizes 5/16", 11/32" and ¼" are required.

Philips Screwdriver

Plastic or rubber mallet

Toothpick (obtain a toothpick by mixing a good, dry Martini with two Jalepeno-stuffed Olives on a toothpick before starting this alternator procedure. By the time you need to use the toothpick, you'll have just finished the Martini)

Procedure

Now that you have an understanding of the operation of the alternator, and know the component parts and their typical failures, you're ready to start your alternator repair. I like to lay out a clean towel on my workbench. As I disassemble the alternator, I carefully lay all the parts out on my towel in the right sequence and order: there are several insulating washers inside your alternator, and it is imperative that they all end up back in all the right places. So lay your parts out in a nice, orderly way.

1. Disconnect battery negative terminal.

2. Remove the serpentine belt (simply release tension on the idler tensioner on the passenger side of the block and remove the belt).

3. Disconnect the wires from the alternator and unbolt it from its brackets.

4. With a felt marker, draw a straight line across the alternator case where the front and rear case halves bolt together. The alternator case can be reassembled and "clocked" in any way to customize the alternator to various bracket end engine configurations, so you want to be sure you "clock" the cases correctly when you reassemble your alternator. If you intend to paint your case, use a scribe to make a line instead of a marker.

5. Spin the alternator by hand to check the bearings. It should spin smoothly and freely with no jerkiness or noise. A slight "swishing" sound from the brushes riding on the Rotor is normal. Any roughness indicates bad bearings.

6. You will need to use a 15/16" socket on an impact gun to get the pulley and fan retaining nut off. Before I owned my own compressor and impact gun, I used to just take the alternator down to any local shop and have someone with a gun zip the nut off at no charge. To do this, wear a glove to hold the pulley & fan, or wrap a rag around the pulley and fan, hold on tight, and zap the nut with the impact gun. It'll take about 2 seconds. If you don't wear a glove, or use a rag, the fan will rip your hand up when you hit the nut with the impact.

7. Pull the parts off and lay them out carefully in sequence on your towel: first the nut itself, then a lockwasher, pulley, fan, and finally a little shaft spacer.

8. Using a 5/16" socket on an extension with a ¼" drive ratchet, break loose the four case through-bolts. I prefer a 6-point socket for this, as a 12-point will sometimes round off the bolts. These case bolts can sometimes be in pretty tight. Once you've broken them loose, switch over to your nut driver and pull all the bolts out of the case.

9. Split the case. The front half of the case should now come off of the alternator. Make sure the centrally-mounted Stator (sandwiched between the front and rear case halves) stays with the rear case and does not want to come off with the front case. The Rotor, if the shaft is dirty, may come out with the front case. Use your plastic hammer or rubber mallet to tap things if they don't want to come apart. Use the mallet on the Rotor to tap it out of the case front bearing if it doesn't want to slide out. When the case comes apart, and the Rotor comes out, you'll hear two little "snaps,"and you'll see loose springs and parts

in the bottom of your alternator. Don't worry: it's normal. Pick the two springs out of the alternator and lay them on your towel with the other parts.

10. Remove the three nuts that attach the three Stator wires to the Rectifier Bridge. These are 11/32" and have lockwashers under them. Lay the nuts and lockwashers side-by-side on your towel. Now, lift the Stator out of the rear case.

11. The Diode Trio is the small component attached to the three studs on the Rectifier Bridge (that you just pulled the nuts off of). It has a single strap connecting it to a Philips screw on the Regulator. Note that the screw has an insulating washer on it. Remove this screw and remove the Diode Trio.

12. Remove the other two Philips screws holding the Regulator in the case. Make sure you note where the insulating washers go. Remove the regulator.

Troubleshooting

You do not need to do further disassembly in order to troubleshoot the alternator and its components. Do the following tests:

1. Test the Rotor. Using you Cheap-O ohm meter, set it to the 1000 ohm scale (or any other fairly high scale). Touch the leads together to make sure the needle pegs out on the scale, and make sure it returns to the left when you disconnect the leads. Put one lead on the one copper-colored slip ring on the Rotor, and the other lead on the other copper ring. The needle should peg to the right (continuity). Now leave one lead on the copper ring and touch the other lead to the central shaft of the Rotor. The needle should show no continuity. If you get any other reading, the Rotor is bad.

2. Test the Stator. There are three wires (terminals) coming off the Stator. Place the ohm meter lead on any one of the three wires and verify continuity to the other two. There should be continuity between all three of the wires (ohm meter should "peg out"). Now leave the lead connected to any one of the three wires and touch the other lead to the metal frame of the Stator (the part that gets sandwiched between the case halves). There should be no continuity. If you get any other reading, the Stator is bad.

3. Test the Diode Trio. Place one of the ohm meter leads on the single connector on the Trio (the strap that was connected to the Regulator). Touch the other lead to each of the other three connectors, one at a time. The meter needle should either show continuity or no continuity, but should be the same for each of the three connectors. Now reverse the ohm meter leads and do the test again. The meter reading should now be reverse of the reading achieved on the first test (if the needle "pegged" on the first test, it should do nothing with the leads reversed). All three connectors should be the same. This test verifies that current can only flow in one direction, and the same direction, through all three of the diode connectors. If any of these readings is not correct, the Diode Trio is bad.

4. Test the Bridge Rectifier. This will be tested in the same way as the Diode Trio: place one of the ohmmeter leads against the cast, finned body of the Rectifier. Touch the other lead to each of the three terminals, one at a time. The meter should be either pegged or have no reading, but all three readings should be the same. Reverse the ohm meter leads and do it again. The reading should be opposite, and all three should be the same. If not, the Bridge is bad. The Rectifier for a "CS" alternator (the most expensive part you can buy to repair an alternator) is $47.

5. Visually examine the brushes. If the brushes are shorter than ¼", they're worn out and should be replaced. The brushes are available complete as a brush and brush holder assembly.

6. If everything so far checks out good, you have a bad regulator. You can take the regulator down to your local NAPA store, or other properly equipped parts store, and they can test it for you on a dedicated

machine. If it tests bad, buy a new one. The regulators for the pre-‘CS” alternators cost about $30. “CS” regulators cost about $45.

You have now identified your problem and procured a replacement part. There is no part in an alternator that normally fails that costs more than $50.

Other Work

Bearings

Besides replacing bad electronic components, you may need to replace your bearings. If your bearings felt rough, or made noise, when you spun the alternator by hand earlier, they need to be replaced. If not, leave them alone: they really do last for a long time.

The front bearing is held into the front case by a retainer plate. Remove the three screws holding the retainer plate into the case. Find a socket that’s bigger than the diameter of the bearing and use this socket to back up the case on the inside. Use a socket that’s slightly smaller than the bearing on the outside (front side) of the case. Now, use a hammer to lightly tap the bearing out of the case. I’ve seen guys do this without using the backup socket on the back side, and I’ve also seen some of these guys crack their alternator case when they've beat the bearing out. The new bearing simply taps in from the back side. Then install the retaining plate.

The rear bearing very seldom fails. It is pressed into the case. I remove these by placing the alternator rear case in a vice, with a large socket providing backing on the inside of the case, and a smaller socket pushing the bearing in from the outside. Tighten the vice, and the bearing is pushed out. Press the new one in the same way.

Paint

To do a nice job, I always paint my alternators. If you glass bead blast the cases, you have to remove the bearings to prevent contamination. If you clean up the case and paint it, you can leave the bearings in place. The Eastwood Company makes a really good “Cast Aluminum” paint in a spray can. If you don’t want to mail order, VHT, carried by most independent parts stores, also makes a great “Cast Aluminum” paint. If you clean up your alternator case and give it a light coating of this specialty paint, it will look better than new. VHT and Eastwood also offer a “Cast Iron” color. This color is almost identical to the dark, phosphate coating used on the pulleys.

Assembly

Now that you’ve procured your new parts and cleaned everything up, the assembly process is very straight forward.

If you have procured a new brush and holder assembly, it comes pre-assembled with a retainer stick in the holder. If you’re re-using your old brushes, and did not pull the brush holder out of the case, you need to install the springs and brushes into the holder as follows:

Drop one of the springs into the brush holder in the rear slot (closest to the rear case). Slip the brush into the holder on top of the spring and depress it with your finger. Now, eat the last olive from your Martini to liberate the toothpick, and slip the toothpick in through the little hole in the back of the alternator case, across the top of the brush, and into the center “toothpick hole” in the brush holder. The toothpick will hold the brush in the holder against the spring pressure. Drop the second spring into the forward brush holder slot, and push the brush into the holder. Depress it with your finger, and push the toothpick over the top of the second brush. This will hold the brushes in place until you get the alternator assembled.

Assemble the rest of the components in the same sequence as you disassembled them. Once you have the regulator and rectifier/diode parts installed, with all of the correct insulating washers in all the right places, drop the Stator into the case and install the nuts securing the Stator terminals to the Rectifier. Carefully

drop the Rotor straight down into the case until it drops into the rear bearing. Place the front case onto the assembly, assuring that your marks align for the case "clocking." Slip the 4 case bolts in, and tighten it up. Pull your toothpick out of the back side of the case to release the brushes, and re-install the fan spacer, fan, pulley, lockwasher, and fan nut. Give it a one-second zap of the impact gun, and it's ready to install.

Rebuild Service

If you're still not up for doing a rebuild yourself, but want to keep your numbers-matching stock alternator on your 'Vette, you can send me your non-CS alternator for rebuild. I will tear it down, replace any bad components, clean it up, make it look nice, test it, and send it back to you. I charge $30 for my time, plus my cost on the parts and shipping. If you're interested, drop me an e-mail at:

V8FastCars@msn.com