Understanding the Alternator

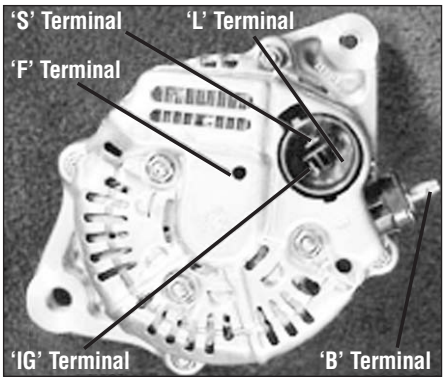
By Kevin R. Sullivan

The charging system has three major components: battery, alternator and regulator. This alternator works together with the battery to supply power when the vehicle is running. The output of an alternator is direct current (DC), however alternating current (AC) voltage is actually created and then converted to DC as voltage leaves the alternator on its way to the battery and the electrical loads.

The charging system circuit is set up as illustrated in Figure 1:

- Four wires connect the alternator to the rest of the charging system.
- B is the alternator output wire that supplies current to the battery.
- IG is the ignition input that turns on the alternator/regulator assembly.
- S is used by the regulator to monitor charging voltage at the battery.
- L is the wire the regulator uses to ground the charge warning lamp.

Alternator Terminal Identification



The "S" terminal senses battery voltage; "F" terminal—regulator bypass, full field testing; "IG" terminal—ignition switch signal turns the regulator ON; the "L" terminal grounds the warning lamp; and the "B" terminal is the alternator output terminal to the battery.

The alternator contains a rotating field winding called the rotor; a stationary induction winding called the stator; a diode assembly called the rectifier bridge; a control device called the voltage regulator; and two internal fans to promote air circulation.

Most regulators are on the inside of the alternator. Older models have externally mounted regulators. Unlike other manufacturers, this model can be easily serviced from the rear of the unit. The rear cover can be removed to expose internal parts. However, today's practice is to correctly diagnose the problem and replace the alternator as a unit, should one of its internal components fail.

Alternator drive pulleys either bolt on or are pressed on the rotor shaft. Both 'V' and multi-groove types are used. Note that this alternator does not have an external fan as part of the pulley assembly. While many manufacturers do use an external fan for cooling, this alternator has two internal fans to draw air in for cooling.

Alternator Assembly

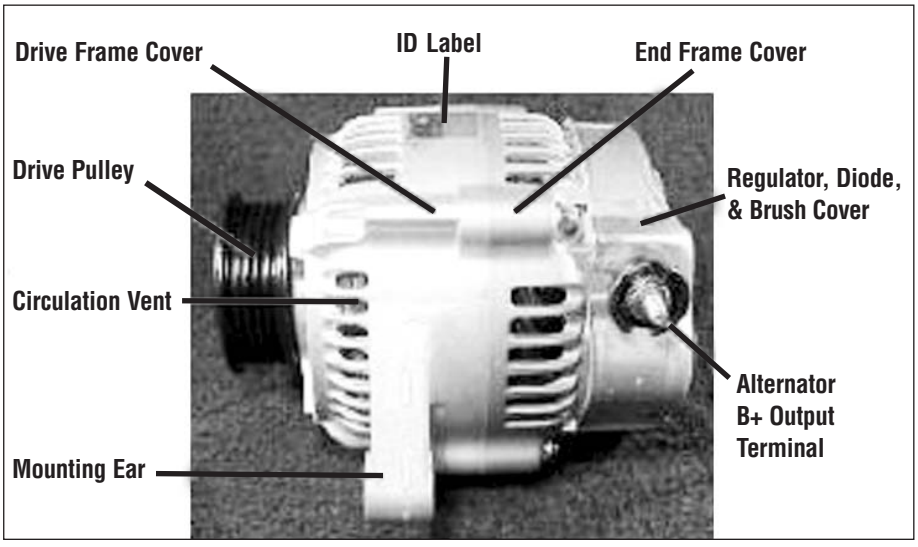
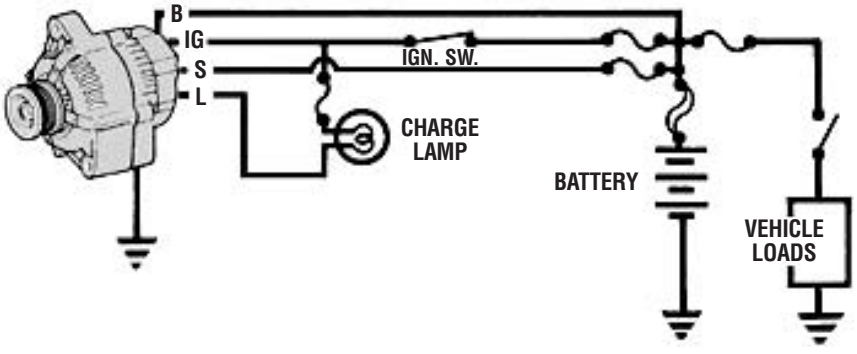
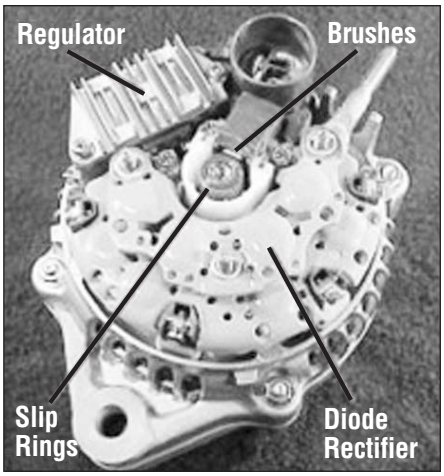


Figure 1—Charging System Circuit



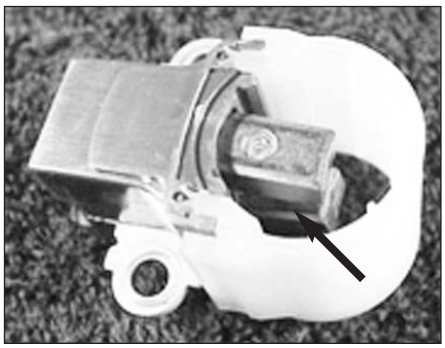
Inside the alternator, removal of the rear cover reveals:

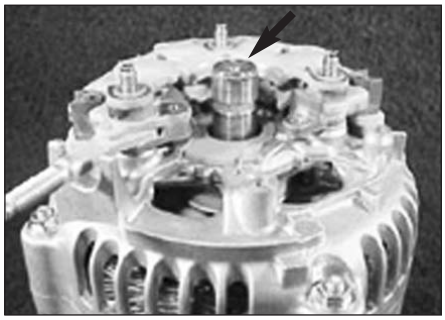
- The regulator controls the alternator output.
- The brushes conduct current to the rotor field winding.
- The rectifier bridge converts AC voltage to DC voltage.
- The Slip Rings (part of the rotor assembly) connected to each end of the field winding.



Two stationary carbon brushes ride on two rotating slip rings. Brushes are either soldered or bolted.

Two slip rings which are located on one end of the rotor assembly. Each end of the rotor field winding is attached to a slip ring, thereby allowing current to flow through the field winding.



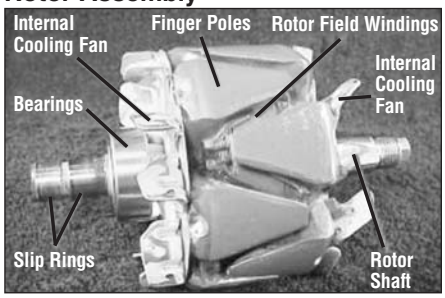


The electronic IC regulator is the brain of the charging system. It monitors both battery and stator voltages and, depending on the measured voltages, the regulator will adjust the amount of rotor field current to control alternator output. Regulators can be mounted either internally or externally. Current technology uses an internal regulator.

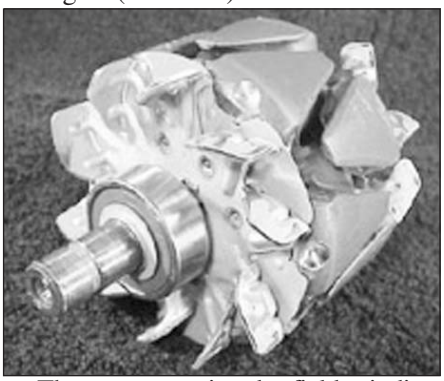
The diode rectifier bridge is responsible for the conversion or rectification of AC voltage to DC voltage. Six or eight diodes are used to rectify the AC stator voltage to DC voltage. Half of these diodes are used on the positive side and the other half are on the negative side. Further details about the rectifier bridge will be covered later in the article.

Separating the alternator case reveals that the rotor winding assembly rotates inside the stator winding. The rotor generates a magnetic field. The stator winding develops voltage and current begins to flow from the induced magnetic field of the rotor.

Rotor Assembly



A basic rotor consists of an iron core, coil winding, two slip rings, and two claw-shaped finger pole pieces. Some models include support bearings and one or two internal cooling fans. The rotor is driven or rotated inside the alternator by an engine (alternator) drive belt.

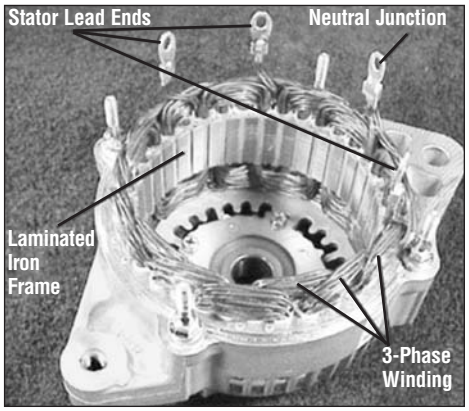


The rotor contains the field winding wound over an iron core which is part of the shaft. Surrounding the field coil are two claw-type finger poles. Each end of the rotor field winding is attached to a slip ring. Stationary brushes connect the alternator to the rotor. The rotor assembly is supported by bearings—one on the shaft and the other in the drive frame.

The rotor field winding creates the magnetic field that induces voltage into the stator. The magnetic field saturates the iron finger poles. One finger pole becomes a north pole and the other a south pole. The rotor spins creating an

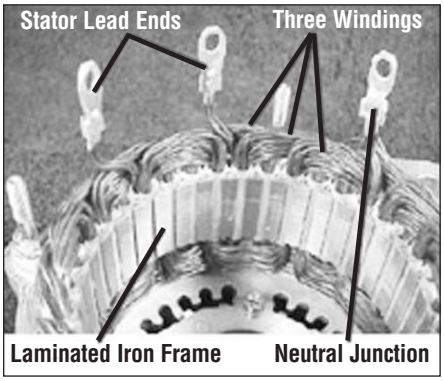
alternating magnetic field: north, south, north, south, etc.

Stator Winding



As the rotor assembly rotates within the stator winding, the alternating magnetic field from the spinning rotor induces an alternating voltage into the stator winding. The strength of the magnetic field and the speed of the rotor affect the amount of voltage induced into the stator.

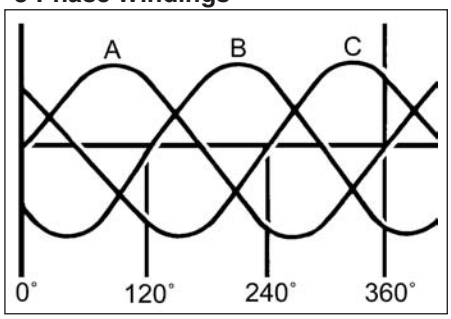
The stator is made with three sets of windings. Each winding is placed in a different position compared with the others. A laminated iron frame concentrates the magnetic field. Stator lead ends output to the diode rectifier bridge.



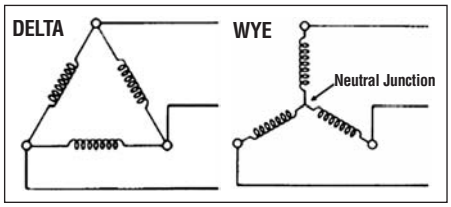
The neutral junction in the Wye design can be identified by the 6 strands of wire.

The stator winding has three sets of windings. Each is formed into a number of evenly spaced coils around the stator core. The result is three overlapping single phase AC sine wave current signatures, A, B, C. Adding these waves together make up the total AC output of the stator. This is called three phase current. Three phase current provides a more even current output.

3 Phase Windings

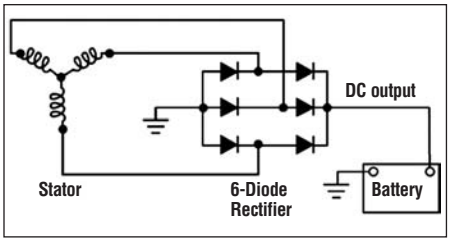


Delta wound stators can be identified by having only three stator leads, and each lead will have the same number of wires attached. Wye style has four stator leads. One of the leads is called the neutral junction. The neutral junction is common to all the other leads.



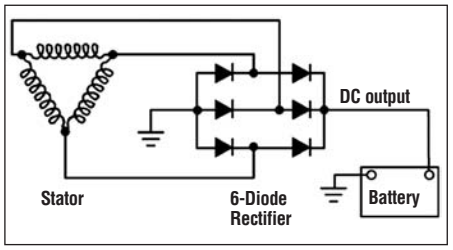
Wye wound stators have three windings with a common neutral junction. They can be identified because they have four stator lead ends. Wye wound stators are used in alternators that require high voltage output at low alternator speed. Two windings are in series at any one time during charge output.

Wye Design

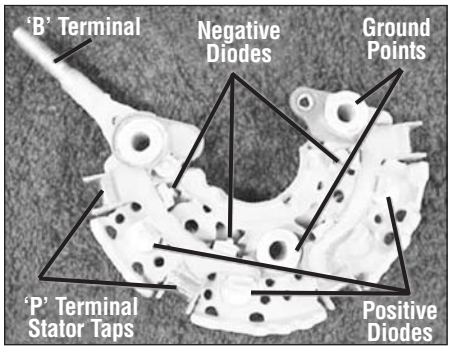


Delta wound stators can be identified because they have only three stator lead ends. Delta stators allow for higher current flow being delivered at low rpm. The windings are in parallel rather than series like the Wye design.

Delta Design



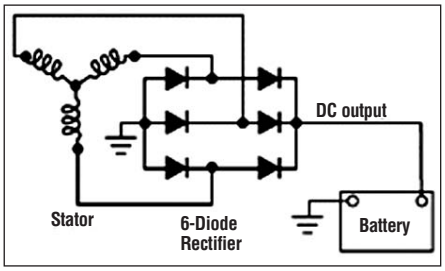
Diode Rectifier Bridge Assembly



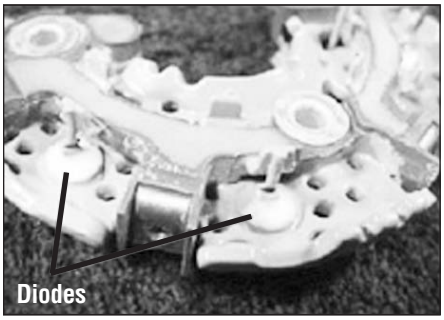
The diode rectifier bridge is responsible for the conversion or rectification of the AC voltage into DC voltage.

Two diodes are connected to each stator lead—one positive and the other negative—because a single diode will only block half the AC voltage. Six or eight diodes are used to rectify the AC stator voltage to DC voltage. Diodes used in this configuration will redirect both the positive and negative polarity signals of the AC voltage to produce DC voltage. This process is called full-wave rectification.

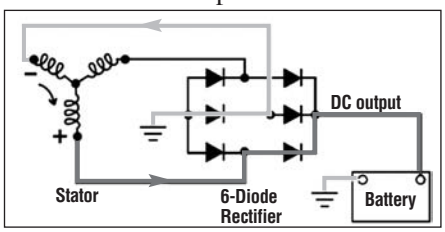
Rectifier Operation



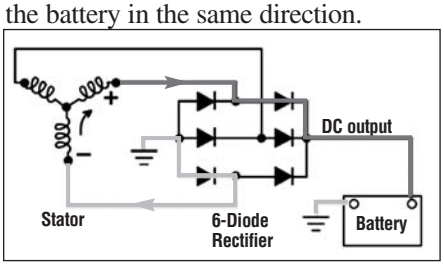
Diodes are used as one-way electrical check valves, passing current in only one direction, never in reverse. Diodes are mounted in a heat sink to dissipate the heat generated by the diodes. Diodes redirect the AC voltage into DC voltage so the battery receives the correct polarity.



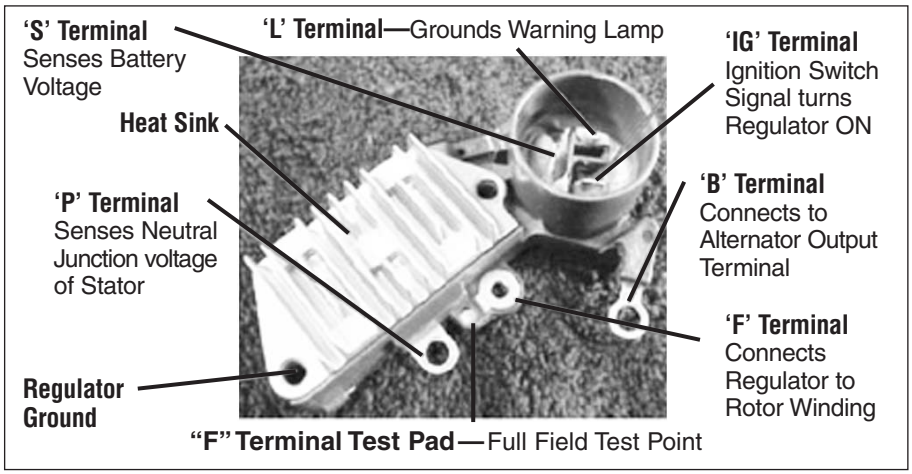
The figure below illustrates rectifier operation. In dark grey you can see B+ current pass through to the rectifier as it goes to the battery. In light grey you can see the return path.



Now, in dark grey B+ current passes through to the rectifier, however, this time current has the opposite polarity. In light grey you can see the new return path. Even though it enters the rectifier at a different location, current goes to the battery in the same direction.



Electronic Regulator

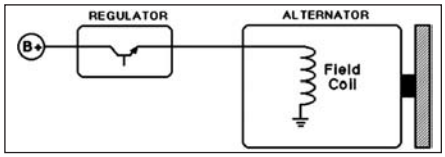


The voltage regulator will attempt to maintain a pre-determined charging system voltage level. When charging system voltage falls below this point, the regulator will increase the field current, thus strengthening the magnetic field, which results in an increase of alternator output.

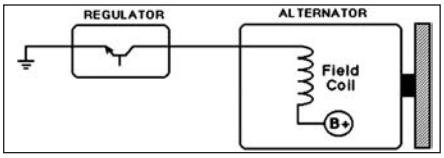
When charging system voltage rises above this point, the regulator will decrease field current, thus weakening the magnetic field, and results in a decrease of alternator output.

Regulator Types

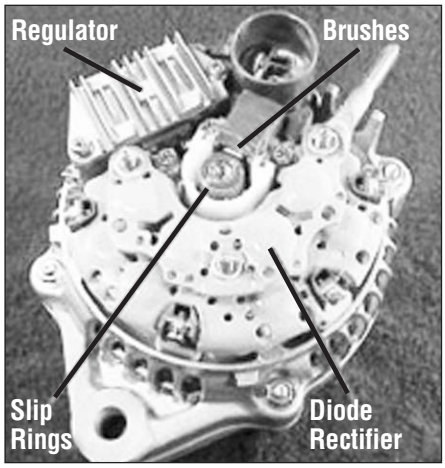
Any one of two regulator designs can be used. The first type illustrated is the grounded field type. The regulator controls the amount of battery positive (B+) going to the field winding in the rotor.



The second illustrated is the grounded regulator type. The regulator controls the amount of battery ground (negative) going to the field winding in the rotor.



In a working alternator, the regulator monitors battery voltage and controls current flow to the rotor assembly. The rotor produces a magnetic field. Voltage is induced into the stator. The rectifier bridge converts AC stator voltage to DC output for use by the vehicle. The slip rings are part of rotor assembly.



For more great information go to www.autoshop101.com.

Kevin R. Sullivan is a professor of automotive technology at Skyline College in San Bruno, Calif.