Vehicular Charging Systems

Part I

By Frank Oropeza

Editor's Note: Although manufacturing abilities and components have evolved since this series was first published in 1984, electrical parameters of alternators have remained virtually unchanged. Even the 10SI remains popular because of its economical retrofit possibilities.

The advent of alternators as the electrical generating method of maintaining a charged system in a vehicle coupled with an electronic voltage regulator has resulted in improved performance and reliability. The alternator is the power source for operating electrical accessories and charging the storage battery. It is also important that the alternator output be maintained at the proper voltage level with varying load changes throughout the entire speed range of the vehicle to prevent battery problems.

The basic alternator remains unchanged with the exception of new alternator models featuring higher amperage to accommodate higher demand. Recent improvements in charging systems are reflected primarily in voltage regulator technology, and this is evidenced by growing demand for these new concepts. The pull-in problem that relates to excessive air gap in a rotor/stator pair has been resolved by the new stator excited regulators. Also, the effects of leaky rectifiers are of no consequence, in some of the new concepts, because a capacitor is used to couple the stator signal to the regulator, hence, the effects of leaky rectifiers is precluded.

Alternators

An alternator is an alternating current source excited by a battery that also functions to store the generated electrical energy. Essentially, an alternator converts mechanical energy to electrical energy to maintain a charged condition in the battery in order to supply the various load requirements. This electrical energy is a result of rotating an electro-magnet (rotor) inside a three-phase stator assembly. The alternating current and voltage is next converted to direct current and voltage by a three-phase rectifier assembly and the output functions to charge the battery. Additionally, by using a voltage regulator we establish how much charge to divert to the battery.

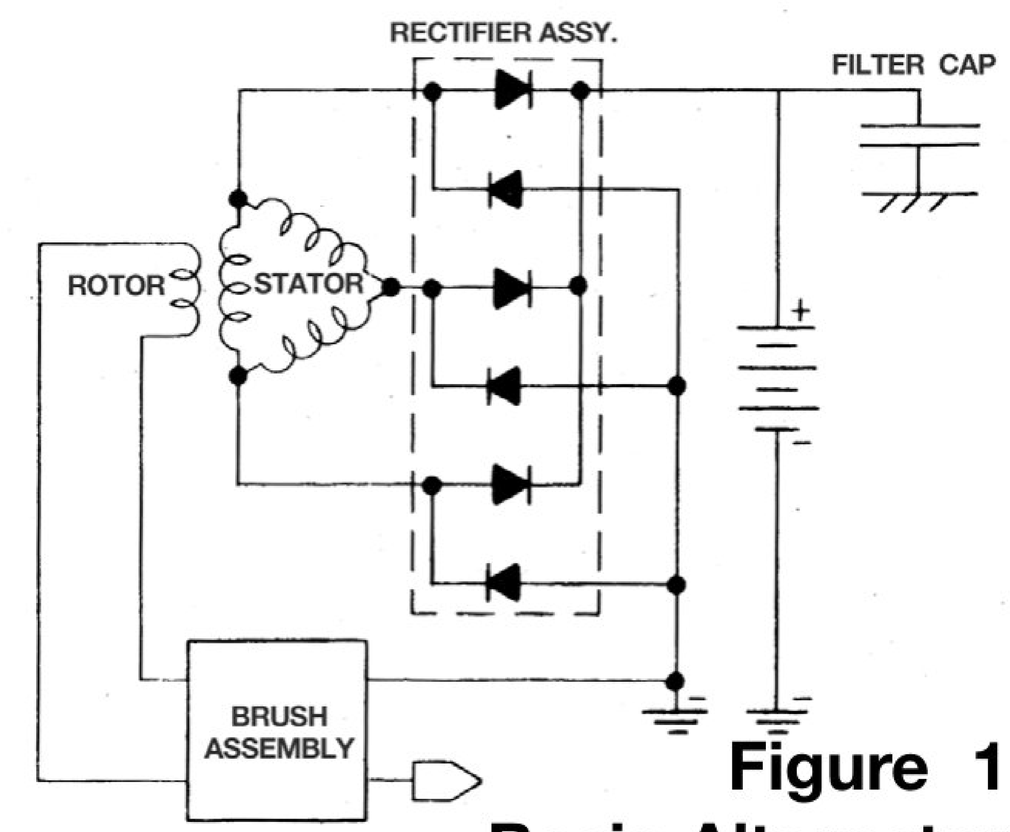

Figure 1
Basic Alternator

Alternators are still theoretically the same, however, the additional imports, Japanese and European varieties, further complicate the rebuilding industry. When one considers the voltage regulators necessary to complement the vast assortment it is difficult to keep up with all the variations and parts necessary to service them.

Regardless of origin, the basic alternator still functions the same and utilizes basic components (Figure 1) such as:

- Rotor
- Stator
- Rectifier assembly
- Housing assembly
- Brush assembly
- Filter capacitor

Any functional part that we add to the above is incidental because that alters the basic alternator for a particular application. Such functional changes are typically:

- Diode trio
- Isolation diode
- Excitation resistor
- Field relay
- Voltage regulator

Component Characteristics

Rotors

Most rotors look alike and if you use a 10DN rotor in a 10SI alternator with a Delco original regulator you will get questionable results. Incidentally, this is a viable concept, but you need to select your voltage regulator source and anticipate about five to 10 percent degradation on system rated output.

Measurement of rotors can be accomplished with the current draw technique or with a multimeter. The resistance range is between 2 to 5 ohms for 12 volt rotors.

Stators

The two types of stator connections commonly used in alternators are the "Y" (Wye) and the Delta connection (Figure 2). The "Y" stator is found primarily in applications with lower power requirements as compared to the Delta stator. Additionally, the "Y" stator pull-in characteristic is considerably earlier—typically 1,500 rpm and the Delta is typically 2,000 rpm.

This data is supported by Figure 3, (page 5), which shows that at lower rpm, the Wye stator has a higher power output and the Delta stator is slow in pull-in, but exhibits a higher power characteristic at higher rpm. This fact is further supported when an OEM stator is changed out for a higher amperage stator, the pull-in characteristic on a self-excited one wire system application is adversely affected. The Delta wound stator application is more common today because of the continuing demand for higher electrical loads.

The most effective stator test is to use a stator tester such as is available from JIMCO or Crumbliss wherein a current source is utilized to determine current rating. When testing stators one must recognize that the current variance between windings should not exceed three amperes. A resistance measurement is not recommended for this test due to the low resistance value of the

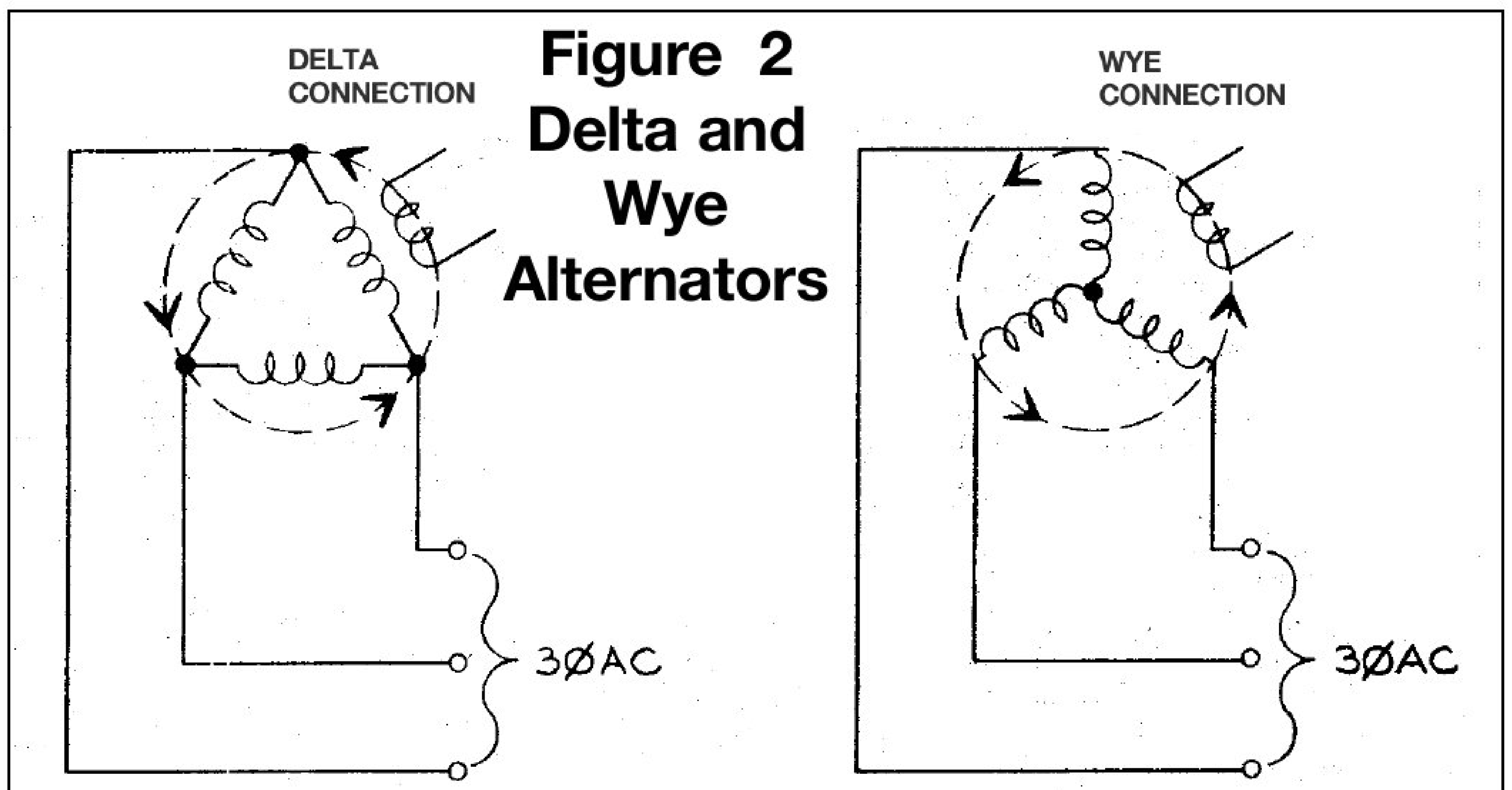

Figure 2
Delta and Wye Alternators

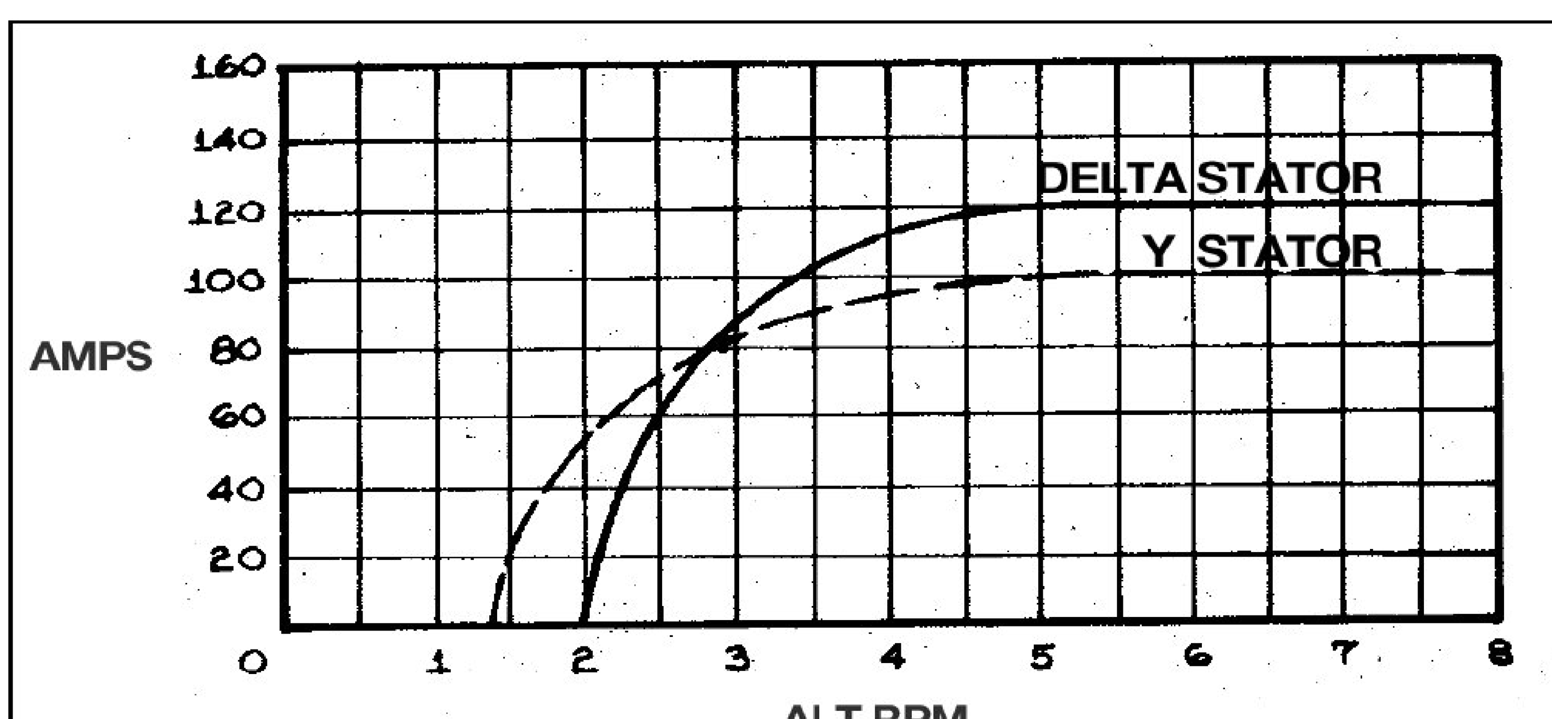

Figure 3
Wye vs. Delta Stator Output Characteristic

winding.

Rectifier Assembiles

A broad variety of three phase rectifier assemblies prevail in the industry. Some units contain the three negative and three positive rectifiers within an assembly like the Delco 10SI. Sev Marchal has a similar rectifier assembly that contains the diode trio within the assembly. Some alternator designs also feature separate negative and positive rectifier assemblies.

Regardless of the rectifier type it is critical that proper testing be performed to preclude system problems. Two basic tests are necessary, a forward characteristic test and leakage current test.

The objective of a leakage current test is to determine if a rectifier exhibits adequate blocking characteristics. This feature prevents the battery voltage from bleeding back to a stator terminal resulting in a field drain condition when the system is off. The leakage current tests can be conducted effectively by using a multimeter such as a Triplett Model 630 because it utilizes a 30 volt battery in the "R" times "100,000" ohms scale setting.

This higher voltage is vital to get a reasonable good leakage current test. With the scale set at "R" times 100,000 ohms, place the two probes in the reverse direction as shown in Figure 4 and no deflection should be observed. If a deflection of 100,000 ohms is observed the subject part should be rejected. This measurement criteria is recommended because of the following:

A. The leakage test voltage is only 30 VDC when using the Triplett meter.

B. Normally the recommended test voltage is specified at 100 VDC and 1 milliamp of leakage is the maximum acceptable amount.

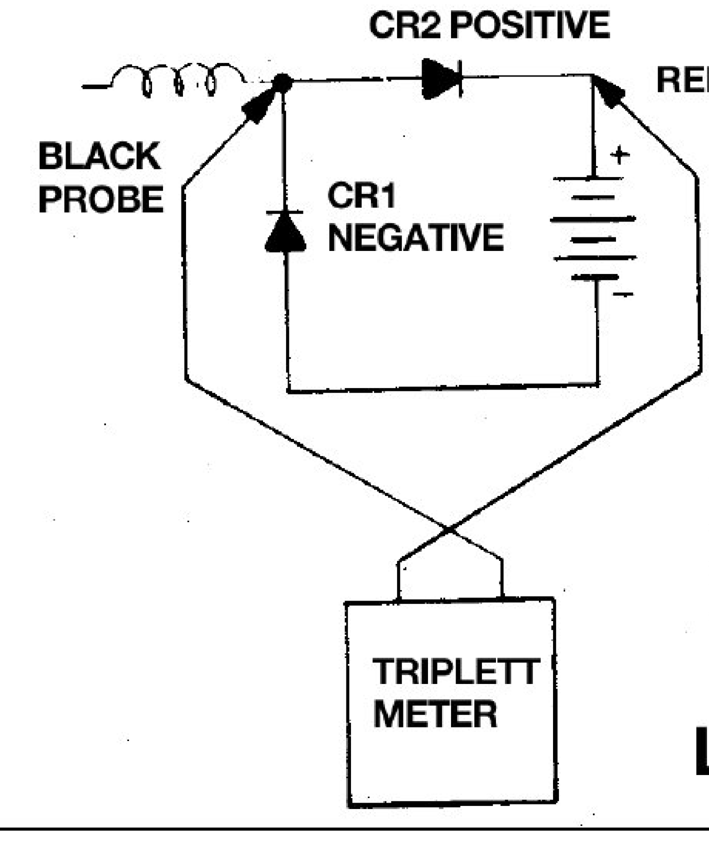

Figure 4 Reverse Test-Leakage

The forward characteristics of a rectifier determines if the rectifier is open, shorted, or functionally acceptable. This test does not require a high voltage to obtain the resistance reading and the Triplett meter is highly recommended. Set the scale on the Triplett for "R times 10" for this test and a reading between 30 and 50 ohms should be observed for all of the rectifiers (Figure 5).

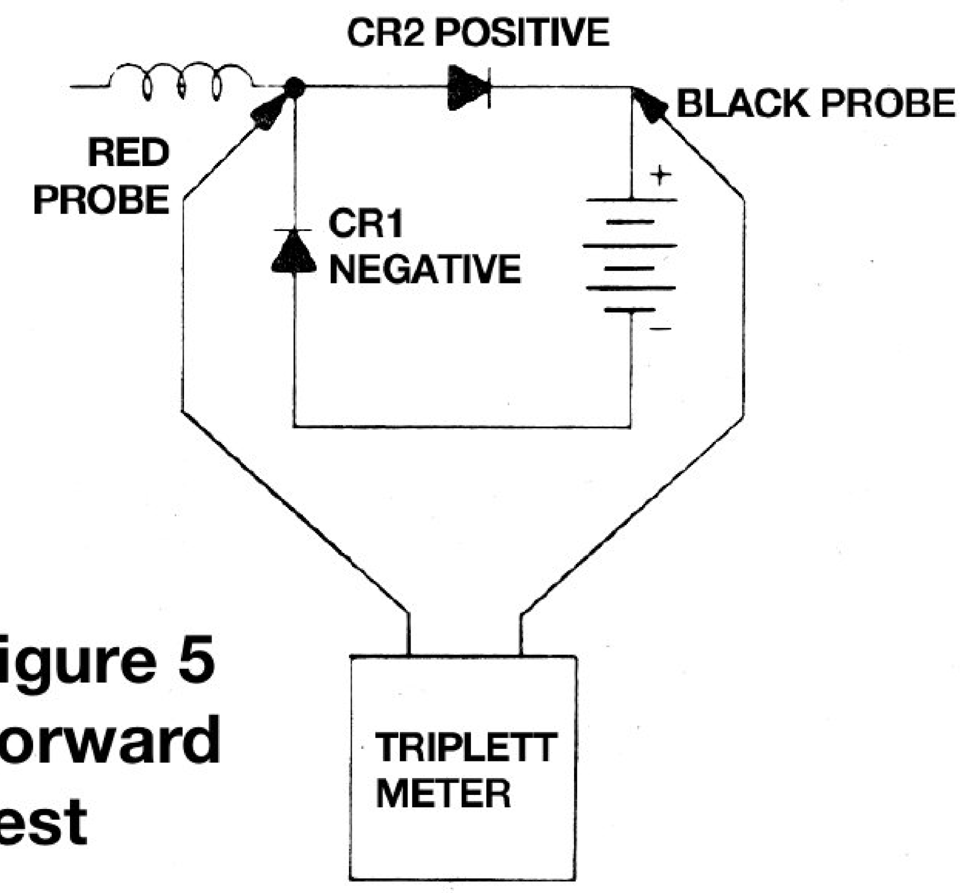

Figure 5 Forward Test

Note: Before taking a resistance reading always check the calibration of the Triplett meter by shorting both probes on the "R" times 1, 10, 1K, 100K scale to be used. If necessary adjust the "zero" knob to get a "zero" balance on the meter. If a different meter than a Triplett is used the test polarity may be reversed, hence, your measurement has to take this into consideration.

An alternate rectifier test method is to impress an AC power signal such as is found on your standard test equipment available from JIMCO or Crumbliss. Unfortunately several discrepancies have occurred in the industry wherein this type of power test did not isolate a leaky rectifier and the resulting field draw upset several rebuilders. In retrospect possibly when an unusual failure occurs the rebuilder should have some test reference samples to verify operational status. This is an area that demands attention at all rebuilding levels and requires further investigation by the rebuilding industry.

In all instances the Triplett meter concept was subsequently utilized as a more effective method of leaky rectifier isolation. When in doubt it is always best to use an alternate method to check your test concepts.

Filter Capacitor

The filter capacitor functions to suppress transients and to smooth the AC ripple from the three phase rectifier assembly. A capacitor can fail in the open or shorted mode but both are quite rare. The Triplett meter is an ideal instrument for this measurement as well. With the scale set at "R times 100,000" connect both probes across the capacitor and observe the deflection on the multimeter. This deflection is the effect of the 30 volt battery, in the meter, charging the capacitor.

Next with the meter set on the "R times 10" scale, observe that the capacitor is not shorted—no deflection. Most alternators utilize a 0.47uf (micro-farad) capacitor for filtering of the AC ripple which is residue from rectification of the three phase stator signals. Only the 12 and 15 SI alternators are different in that they utilize a 1.5uf capacitor.

Diode Trio

The primary purpose of a diode trio or field diode is to supply power to the rotor when the system is operating. This concept results in a method of controlling the no charge warning lamp. Diode trio concepts are found in:

- Delco 10, 12, 15, 27 and 30 SI
- Motorola
- Sev Marchal
- Leece-Neville

Diode trios are readily tested with a Triplett multimeter as described earlier and should be tested to determine the forward and reverse characteristics of the diodes. In an emergency a diode trio can be readily made up of three discrete diodes such as the 1N5060 or 1N5395. These are 1.5 ampere diodes that are appropriate for this application.

In the Leece-Neville alternator the diode trio No. 79027 functions differently in that it turns on the regulator and the current requirement are extremely low as compared to Delco application. The Sev Marchal system and recently others have commenced placing the diode trio within the rectifier assembly and the trio functions like the Delco system. Unless you are aware of the concept and where the trio is located it can be overlooked.

Isolation Diode

Alternators with isolation diodes provide a means of electronically operating the alternator warning lamp. The isolation diode is placed in series with the alternator output, and the warning lamp is electronically connected in parallel or across the isolation diode. Isolation diode alternators are capacity limited because the isolation diode is in series with the alternator output. Also, this type of alternator requires that the voltage regulator be set 0.8 VDC higher than conventional regulators or the battery voltage condition will be marginal forever.

Excitation Resistors

The purpose of the excitation resistor

is to provide a priming current to force the alternator to pull-in faster. Alternators requiring excitation resistors are primarily Motorola and Prestolite. Some of the older Motorola alternators still require an external excitation resistor, but the more recent models have the excitation resistor within the voltage regulator.

Field Relay

The field relay functions to prevent field current drain when the system is off. It can be controlled by the ignition switch or by a diode trio, the important issue is to disconnect battery power to the regulator when the system is off to prevent field current drain. This concept is antiquated and has been superceded by the diode trio concept.

Caution: An alternator should be used to maintain a battery and not as a battery charger. When servicing an alternator an important procedure is to check the battery when a remanufactured alternator is installed in the vehicle. This procedure makes you money in that every warranty you service costs money to you and your supplier.

Frank Oropeza is founder of Transpo Electronics, Orlando, Fla.

See Part II in the April Issue.