

Brushless Alternators

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Introduction

Several different technologies are used in the generator portion of wind turbines (wind generators). One of the older, more reliable technologies is the brushless DC alternator. The operation of them is often poorly understood by the owners and in some cases, poorly described by the turbine manufacturers. I was prompted to write this after reading one particularly bad circuit description on the Internet. (Name withheld to protect the guilty.) I'm not an expert on brushless alternators, but when I acquired a damaged Dunlite wind turbine, I became seriously interested in how they work.

Basic Theory

When an electric current is passed through a coil of wire, a magnetic field is produced (an electromagnet). Conversely, when a magnetic field is moved through a coil of wire, a voltage is induced in the wire. The induced voltage becomes a current when the electrons have some place to go such as into a battery or other load. [See Word~Power in issue ___] Both of these actions take place in alternators, motors and generators or dynamos.

Voltage is generated when a coil of wire is moved through a magnetic field. It doesn't matter whether the coil is moving or the magnetic field is moving. Either configuration works equally well and both are used separately or in combination depending on mechanical, electrical and other objectives. The old DC generators (dynamos) used a stationary field and rotating armature. Automotive alternators use the opposite configuration with a rotating field and stationary armature. In a brushless alternator, both configurations are used in one machine.

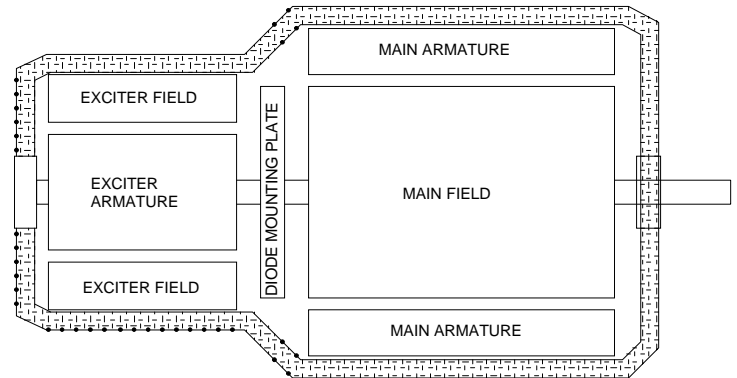
Terminology

The stationary part of a motor or alternator is called the **stator** and the rotating part is called the **rotor**. The coils of wire that are used to produce a magnetic field are called the **field** and the coils that produce the power are called the **armature**.

This can be confusing because most of us equate the armature with the rotor. Traditionally, the armature was on the rotor but this is not necessarily the case. The two terms are not synonymous. For example, in the common automotive alternator, the field is on the rotor and the armature is on the stator. The rotor and stator are the mechanical configuration. The field and the armature are

the electrical components. Either electrical component can be located on either of the two mechanical parts.

The coils of wire that are used to create the field and the armature are sometimes referred to as the "windings".



Construction

A brushless alternator is composed of two alternators built end-to-end on one shaft. Smaller brushless alternators may look like one unit but the two parts are readily identifiable on the large versions. The larger of the two sections is the main alternator and the smaller one is the exciter. The exciter has stationary field coils and a rotating armature (power coils). The main alternator uses the opposite configuration with a rotating field and stationary armature.

Exciter

The exciter field coils are on the stator and its armature is on the rotor. The AC output from the exciter armature is fed through a set of diodes that are also mounted on the rotor to produce a DC voltage. This is fed directly to the field coils of the main alternator, which are also located on the rotor. With this arrangement, brushes and slip rings are not required to feed current to the rotating field coils. This can be contrasted with a simple automotive alternator where brushes and slip rings are used to supply current to the rotating field.

Main Alternator

The main alternator has a rotating field as described above and a stationary armature (power generation windings). This is the part that can be confusing so take note that in this case, the armature is the stator, **not** the rotor.

With the armature in the stationary portion of the alternator, the high current output does not have to go through brushes and slip rings. Although the electrical design is more complex, it results in a very reliable alternator because the only parts subject to wear are the bearings.

Control System

Varying the amount of current through the stationary exciter field coils controls the strength of the magnetic field in the exciter. This in turn controls the output from the exciter. The exciter output is fed into the rotating field of the main alternator to supply the magnetic field for it. The strength of the magnetic field in the main alternator then controls its output. The result of all this is that a small current, in the field of the exciter indirectly controls the output of the main alternator and none of it has to go through brushes and slip-rings.

AVR

In many diagrams and explanations, you will encounter the term “AVR”, with no explanation of what it is. AVR is an abbreviation for Automatic Voltage Regulator. An AVR serves the same function as the “voltage regulator” in an automobile or the “regulator” or “controller” in a home power system.

Variations

As with any other electronic or electrical device, there can be numerous variations in the design. The Dunlite 2kw wind machines that I have, use an auxiliary winding on the main stator to generate the voltage for the exciter field. These machines rely on residual magnetism to excite the auxiliary winding while some machines use permanent magnets for this purpose. On the Dunlite machines, both the exciter and main field coils use 8 poles. (3-phases multiplied by 8 poles is 24 coils of wire.) The exciter armature is wound in a 3-phase, 4-wire wye (star) configuration and the main armature is a 3-phase, 3-wire design.

Three-Phase Basics

A three phase alternator has a minimum of 3 sets of windings spaced 120° apart around the stationary

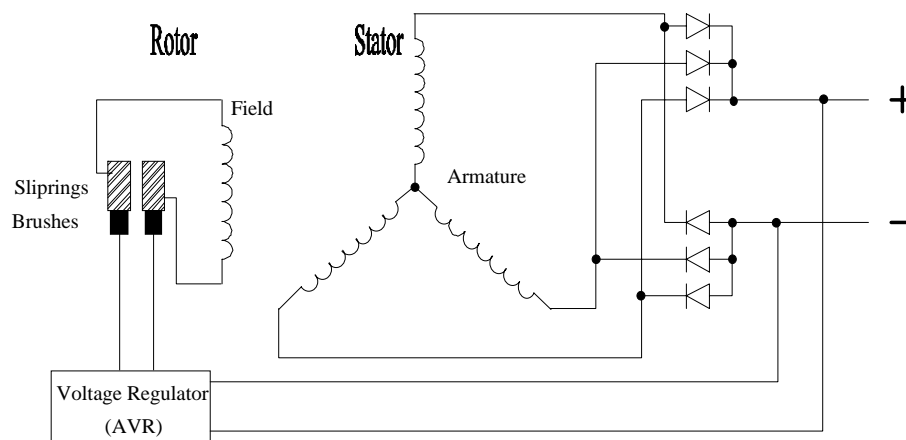
armature (stator). As a result, there are 3 outputs from the alternator and they are electrically spaced 120° out of phase with each other. A multi-pole design will have multiple sets of 3 windings. These sets of windings (poles) are spaced evenly around the circumference of the machine. The more poles there are, the slower the alternator turns for a given voltage and frequency. More poles increase the complexity of the alternator and that in part accounts for the higher price of slow speed versions.

Other than in single-phase power plants, most alternators, including the automotive type, generate 3-phase power. A three-phase AC alternator will not have any diodes in it. If the output is DC, it will probably have 6 diodes to convert the output from the main alternator to DC. This is the configuration used in automotive alternators. A 3-phase brushless alternator may have 4 or 6 diodes on the rotor for the exciter output in addition to the diodes that may be on the stator.

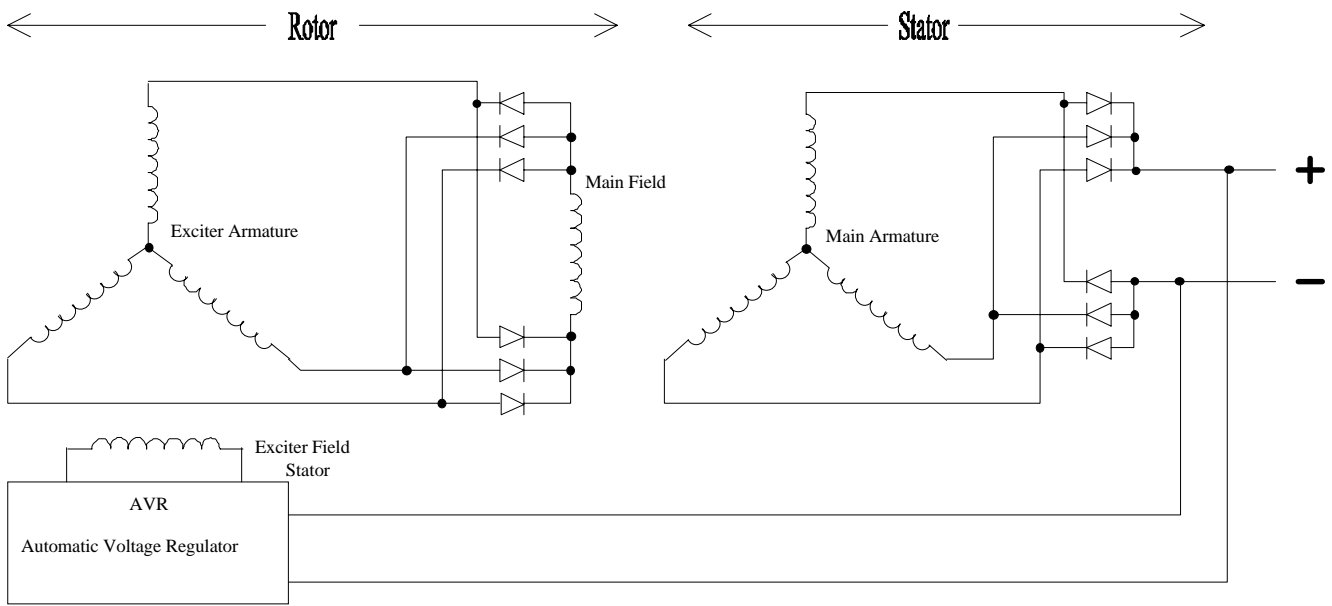
There are two ways that 3-phase machines can be wired. One is the delta (triangle) configuration with one wire coming off each “point of the triangle”. The other is the wye (Y) or star configuration. They have one wire from each branch of the “Y” and in some cases a 4th common wire is added from the center/centre point of the “Y” (the common connection point between the windings).

Multiple voltage machines will have additional wires to allow them to be configured for the desired system voltage.

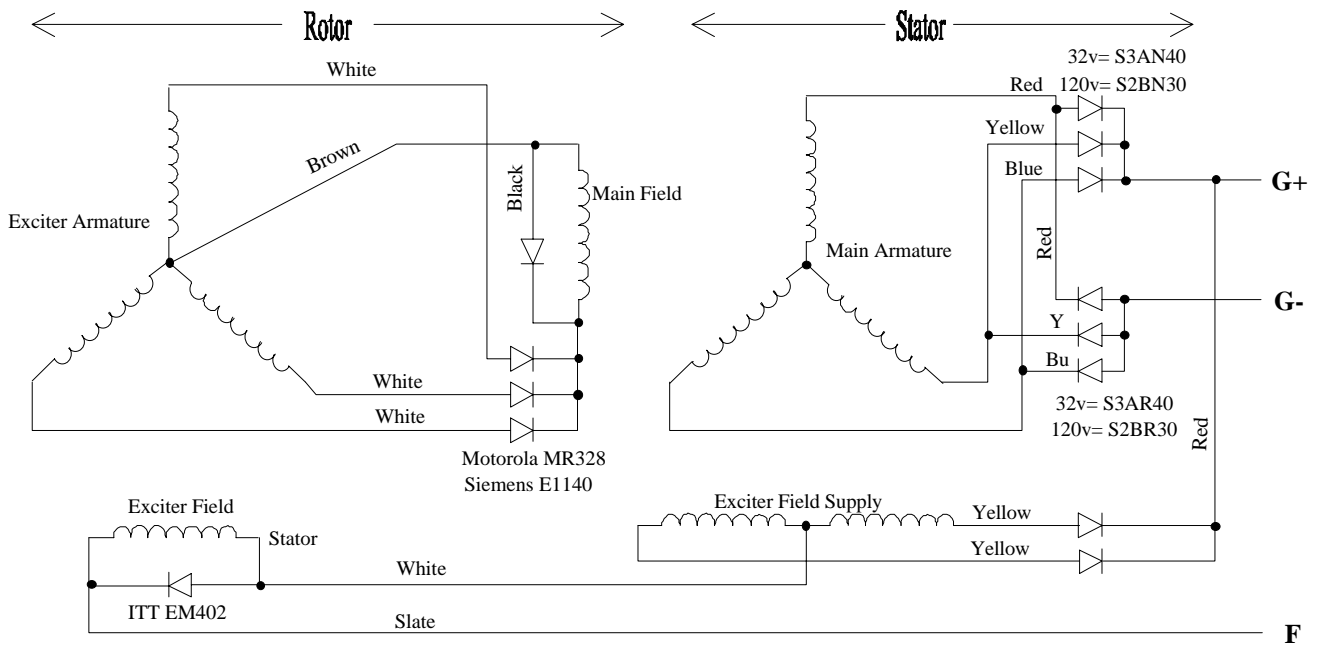
If you ever have to service your wind turbine, this brief description may help you to understand how it works or at least let you talk the same language as the repair shop staff.



Automotive Alternator



Basic 3-phase Brushless Alternator



Dunlite Type BL 2KW Wind Turbine Alternator