How Does a Generator Work?

Clifford Power Systems is one of the largest full service generator providers in the United States. Our generator experts specialize in equipment, service, parts and rental of power. To assure your continuous power needs see: cliffordpower.com or contact us directly at 1-800-324-0066. This article was written by Clifford Power Systems’ president, Tom Clifford.

Generators and the process of making electricity is a relatively simple process. Before we can understand how a generator works perhaps we should first try to define what electricity is. At its simplest form electricity is a positive or negative charge within the electrons of an atom. Because of the nature of atomic elements electrons can be made to flow from one atom to another. This flow of the electrons between atoms generates electrical current. Electrons flow readily in some materials but not in others.

So, based on the above essentially what a generator is doing is creating negative and positive charges within an atom and moving electrons. How does it do this? The simple answer is that we rotate a magnet in a coil of wires.

A bar magnet is created by exposing ferromagnetic metals and exposing them to a magnetic field. Once heated to a certain temperature the ferromagnetic metals become permanently magnetized.

If you place a piece of paper over the magnet and sprinkle metal shaving on the paper you will notice that the metal shavings line up in a pattern similar to that shown here:

The pattern shown is magnetic lines of flux. Most of the metal shavings will line up close to the magnetized end of the magnet. This is the point where the magnetic flux is strongest. This is also as follows:

If we rotate the magnet through a coil of insulated wires, the magnetism coming from the magnet will affect the electrons within the coiled wire. The electrons will receive a positive or negative charge. The strength of this charge is measured by a term called voltage. So in essence, the stronger the magnet is the higher the charge and thus the higher the voltage. Note that the voltage in the wire is strongest the closer it gets to the positively or negatively charged end of the magnet.

As the magnet rotates through the coil, the induced electrical charge at any given portion of the wire coil goes up and down. This creates a sine wave of voltage in the coil in which the voltage rises to a positive maximum and then decreases to a negative maximum. One complete sine wave is one cycle. If we attach a time frame to the cycle, we can create an event that occurs over time. We call this a unit of frequency. In electricity, we refer to that cycle as a
hertz. If the magnet rotates completely around the coil 60 times in one second, we have 60 occurrences of the complete sine wave. In the United States, we have a standard for electrical utilities that they must operate at 60 Hz.

As long as nothing is connected between the ends of the two wires coming from the coil of wire the electrons in the atoms of the wire material remain charged but are not moving.

When a load, or resistance, is connected to the two end wires of the coil a circuit is completed and atoms will begin to flow back and forth. The movement of electrons in electrical wires is called current and is measured in terms of amperage.

To control generator output voltage we need to have a means of increasing or decreasing the magnetism of the rotating magnet. Another to make a magnet is to wrap a wire coil around a metal core and then apply a direct current (DC) voltage to the wire coil. By increasing or decreasing the DC voltage on the wire coils, we can make the magnetic of the magnet stronger or weaker.

AC Generators include a voltage regulator. The voltage regulator will sense the voltage output and then raise or lower the DC voltage of the rotating magnet.
In AC generators we refer to the different components as:

- Stator: AC Output Coil Windings
- Rotor: The rotating magnetic field
- Voltage Regulator: Controls the magnetism of the rotor to achieve desired output voltage.

Three Phase Stators

Most three phase stators, up to approximately 1000 KW, consist of 6 sets of windings, 10 or 12-Wire (2 per set). 10 or 12 lead generators can be rewired for different voltage output configurations.

- Each pair of windings forms a phase
- Phases are named A, B, and C.
- Phases are 120° out of phase with one another.
- Phase rotation matters
- Power is derived from each phase and contributes to total power output.

On generators above 1000 KW, most are specifically wound for the generator voltage required for the specific job requirements. These generators are sometimes referred to as 4 Bar. Primary voltage output on these units cannot be changed.

12 Lead Generator Connections (Please note, these drawings are typical configurations, manufacturer drawings must be followed prior to making any connection changes.)

Hi Wye Connection:
• For Nominal 277/480V,3f 4W, which means 277 volts phase to neutral, 480 volts phase to phase, 3 phase, four wire

• Industrial and sub-distribution voltage

Low Wye Connection:

• For Nominal 120/208V,3f,4W, which means 120 volts phase to neutral, 208 volts phase to phase, 3 phase, four wire

• User voltage, very common

Delta Connection

• For Nominal 120/240V,3f,3W, which means 120 volts phase to neutral, 240 volts phase to phase, 3 phase, three wire

• Industrial heavy 3-phase loads usage such as large motors

• Caution: On a High Delta connection (as shown below), one of the lines to neutral connections will have a higher voltage than the other two. This is sometimes referred to as “The Wild Leg.”. In the diagram below the L0 connection (neutral) will typically be 120 volts between L0 and L1 and between L0 and L2. The voltage across L0 and L3 will be approximately 190 volts. In generator systems that have an automatic transfer switch
it is very important to match the high leg with the high leg from the utility on the same pole on the automatic transfer switch. Failure to do so could cause expensive damage to customer equipment.

Zig Zag Connection

- For Nominal 120/240V, 1f, 3W, which means 120 volts phase to neutral, 240 volts phase to phase, single phase, three wire
- Light commercial, industrial, residential where 120V is heavily used.
- This configuration usually reduces generator efficiency by 30%

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