3 phase power supply connection

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Electrical engineering has a reputation for being mysterious, which is why the term "magic smoke" became a running inside joke among electrical engineers and technicians. However, a working knowledge of electrical engineering principles can be incredibly useful even if you"re not an electrical engineer--especially if you have to work with one!

With that in mind, this article covers a core concept in electrical engineering: three-phase electric power. We"ll start with the basics and work our way up, with the goal that by the end of this article, the magic smoke won"t seem quite so magical.

This phenomenon was initially described by Michael Faraday. If a conductor is placed in a varying magnetic field (as indicated in the picture below) the induced electromagnetic force (EMF), i.e. voltage, appears at its opposite end. An electric current flows when the loop made of the conductor circuit is closed, provided the conductor placed in the varying magnetic field is traversed by magnetic field lines.

Alternating Current and Electromagnetic InductionAlternating current (AC) has a sinusoidal shape and changes its direction and amplitude alternately. AC current is generated by an electrical AC generator operating on the electromagnetic induction (EMI) principle. Hence, the electrical generator converts mechanical energy to electrical energy. Its basic parts are a stator and a rotor. The latter represents the magnetic field source while the former contains the conductor where the EMF is induced (generally the conductor is in the form of a coiled wire).

The generator consists of the source of a varying magnetic field (a magnet or electromagnet) and the conductor traversed by magnetic field lines. The electromagnet is a ferromagnet (iron) wound by coil (conductor). The iron becomes the magnet (creates the magnetic field) when an electrical current flows through the coil. Electromagnets are the most commonly used magnetic field source because of their particular advantages in this application (e.g., magnetic strength control, greater magnet power, etc.).

The induced voltage value at the ends of the stator conductors depends on the magnetic field strength (which is proportional to the number of magnetic field lines per unit area), the rate of magnetic field change (the rotating speed of the magnet or conductor) and the angle at which magnetic field lines traverse through the conductor.

In practice, the coil (conductor with more turns) is used instead of a basic conductor in order to achieve a higher EMF value. The EMF value is directly proportional to the number of coil turns N. For example, in the case of a coil with 100 turns, the induced EMF will be 100 times higher than one in a single piece of conductor.

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The rotor (magnet) rotates in a magnetic field, making a full 360? in a period of time (t). The period t is inversely proportional to the frequency, i.e., t = 1/f. The United States uses a 60-Hz AC system (t = 1/f = 16.67 ms), while Europe uses a 50-Hz system (t = 1/f = 20 ms). This means that a rotor in a 60-Hz generator covers a full 360? rotation in 16.67 ms.

The induced voltage, as well as the current drawn from the generator, has a sinusoidal shape, as shown above as a result of the generator construction and working principle. The magnetic field lines pass through the coils at a different angle when the rotor (magnet) rotates. Thus, when the rotor is shifting, a different EMF value is induced in the coil (as indicated by the sinusoidal-shaped amplitude in the image above).

The rotor magnet has two poles, north (N) and south (S). When the rotor (magnet) rotates, the opposite magnet poles pass by the coil in each half cycle (180?), inducing an EMF with reversing polarity. The reversing voltage polarity causes a reversing current direction (i.e., alternating current).

A generator can be manufactured with a different number of the coils placed in the stator. One coil in the stator forms a single-phase generator, while several coils make up a multiphase generator. An EMF with equal amplitude is induced in each coil.

The general advantages of a multiphase generator over a single-phase generator with equal power is that the former is smaller, lighter and less expensive. Basically the only physical difference between a single generator and a multiphase generator is the additional coils with accompanying parts in the stator. Each phase generates approximately equal amounts of energy. The generated energy will be multiplied with the number of phases (i.e., installed coils in the generator).