PURDUE EXTENSION
INDIANA 4-H

Electric Level 5

Taking the Mystery Out of Three-Phase Power

What's it all About?

Three-phase electricity can be easily explained by knowing the concept of single-phase electricity. Single-phase electricity is what you have in your home. You will see, by routing one electric conductor through a magnetic field, energy is produced. The conductor may also be stationary and the magnetic field rotated. Three-phase uses three coils and one magnetic field. This project sheet will help you understand the types of three-phase electricity and how the power is produced.

Keys to Remember

- All utility power is generated three-phase power, at 60 cycles per second (60hz) in the US.
- Coal, natural gas, nuclear, hydro, bio-gas, wind, and solar are all three-phase configurations.
- Transformer banks are used to step down the voltage to whatever is required for the home, school, or business.
- Large three-phase motors, welders, heaters, or other three-phase equipment are relatively inexpensive compared to single-phase. Larger loads pose a problem when trying to use them on a single-phase service. Knowing how three-phase electricity works will help you understand this problem.

For the Project

- Include diagrams, schematics, and pictures to show that you understand how three-phase electricity works
- Record sheet
- 4-H Exhibit Skills and Knowledge Sheet

Understanding Single-Phase Power

Single-phase power should be understood before knowing how three-phase power can work. Electricity is produced by rotating an electric conductor through a magnetic field, or the conductor may be stationary and the magnetic field rotated. See Figure 1.

Each time the magnet makes one rotation, the coil sees one cycle of alternating current. This is often represented by a sine wave. See Figure 2.

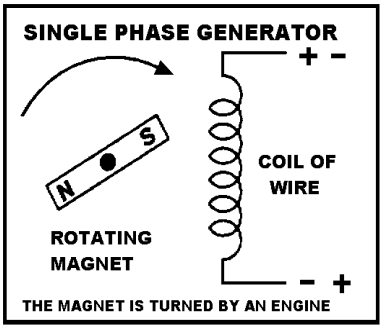


Figure 1

When the north end of the magnet moves past the coil of wire, the current moves in one direction. When the south end of the magnet moves past the coil of wire, the current moves in the other direction through the wire. When neither the south nor the north magnetic field is moving past the coil of wire, electricity is not generated.

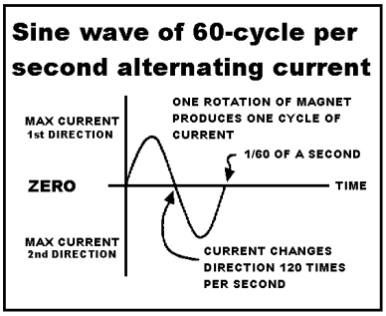


Figure 2

Understanding Three-Phase Power

Producing three-phase electricity is quite simple and it provides more power for larger electric loads. It uses three coils and one magnet. Each coil by itself is a single-phase generator located 1/3 (or 120º) of a rotation from each other. There are two ways these coils may be connected to produce three-phase electricity. One method is called the Delta system (See Figure 3) and the other is called the Wye system, also known as Star (See Figures 4 and 5).

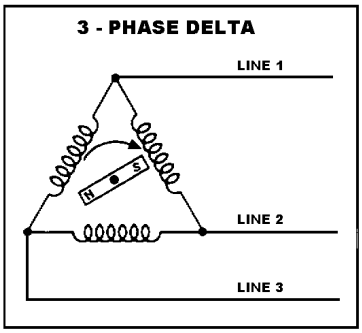


Figure 3.
For a Delta system, the ends of the coils are connected.

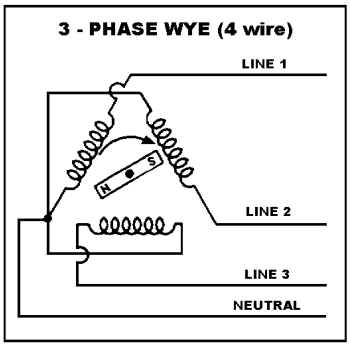


Figure 4.
For a Wye system, one end of each coil is connected for a common terminal called Neutral.

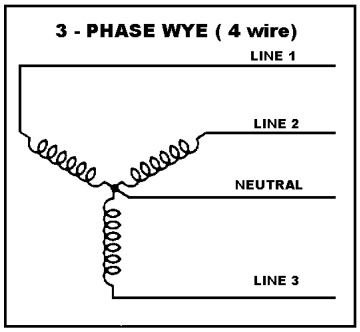
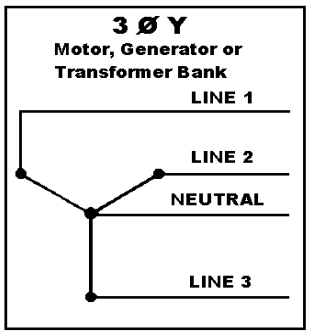
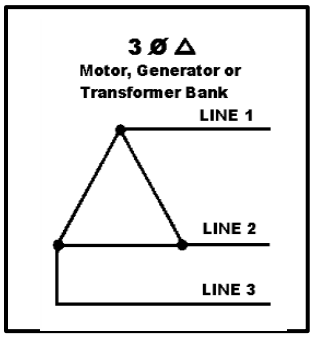


Figure 5.
Here is an uncomplicated way for drawing a Wye system.

For the word phase we use Ø (Phi) and we use Y for Wye and △ for Delta.

The drawing for a three-phase motor looks like a three-phase generator or a three-phase transformer bank. A motor, however, has a rotating armature instead of a rotating magnetic field.





Voltage Configurations

What is confusing for many people are the "strange" voltages from three-phase power. There are several different voltage configurations.

Figure 6 shows a 4-wire Wye. The voltage between the neutral and any line is 120 volts. The voltage between any two lines is 208 volts. The 3-phase 208 voltage is often used by 3-phase motors to power elevators in tall apartments and condominiums. This same circuit is available in 277/480 volts. (277 v × √ 3 = 480 v) The 3-phase 480 voltage is desirable for large motors and the single-phase 277 voltage is often used for fluorescent lighting. Large schools and other buildings often use this configuration.

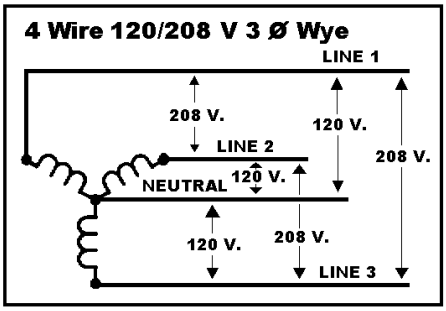


Figure 6

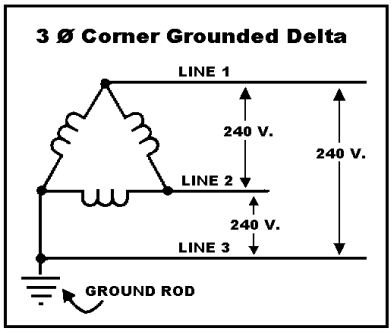


Figure 7

The corner grounded delta circuit is common for motor loads, such as large pump motors. The voltage between each line is 240 volts. It is also available in 480-volts. (See Figure 7)

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A common 3-phase Delta is the 4-wire Delta. This circuit provides 240-volts 3-phase for motors. However, one transformer winding has a center tap connected to ground and provides 120/240-volts single-phase service along with the 3- phase service. This is a good circuit where 3-phase is needed, and single-phase 120/240-volt is also needed. There is a concern with the "wild phase" or "long leg" as it is sometimes called. The voltage between L2 or L3 to the neutral is 120-volts. The voltage from L1 (wild phase) to the neutral is 208-volts. The electrician must take care, not to mistakenly use the wild phase for a 120- volt circuit. The transformer used for the 120/240-volt single-phase is often larger than the other two transformers. (See Figure 8)

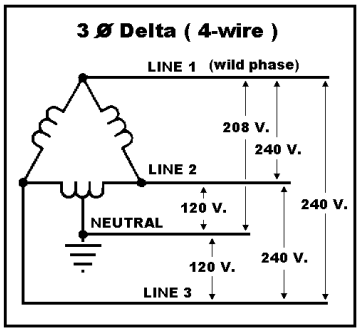

Figure 8

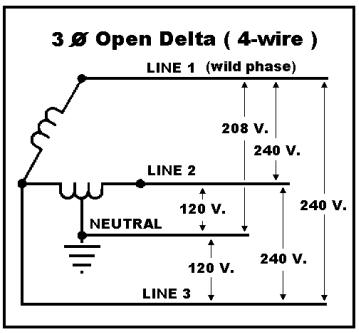

Figure 9

There is also a circuit known as an open Delta 3-phase. Only two transformers are used to produce 3-phase power. This circuit is used in areas when only two of the 3- phase distribution lines are available. (See Figure 9)