Information Sheet # 125

Total Energy Systems, LLC

Your Reliable Guide for Power Solutions

To fulfill our commitment to be the leading supplier in the power generation industry, the Total Energy Systems, LLC. team ensures they are always up-to-date with the current power industry standards as well as industry trends. As a service, our **Information Sheets** are circulated on a regular basis to existing and potential power customers to maintain their awareness of changes and developments in standards, codes and technology within the power industry.

Selecting a Three-Phase or Single-Phase Generator System.

1.0 Introduction:

One of the most important decisions when selecting a generator system is to decide if a single or three-phase generator is required. There are several criteria to consider when making the phase selection; what is the characteristics of the load, cost factors in developing the whole system, what is the voltage input from the utility, to name a few. Generator manufacturers in North America offer single and three-phase generator packages. Most applications will dictate the phase based on the load and the utility supply, but there are some applications where single-phase may be the best option even though the connected kVA is higher than the usual single-options.

This information discusses how to determine which phase to select, advantages and disadvantages, and the differences between three-phase and single-phase configurations.

Three-Phase Versus Single-Phase

Figure 1

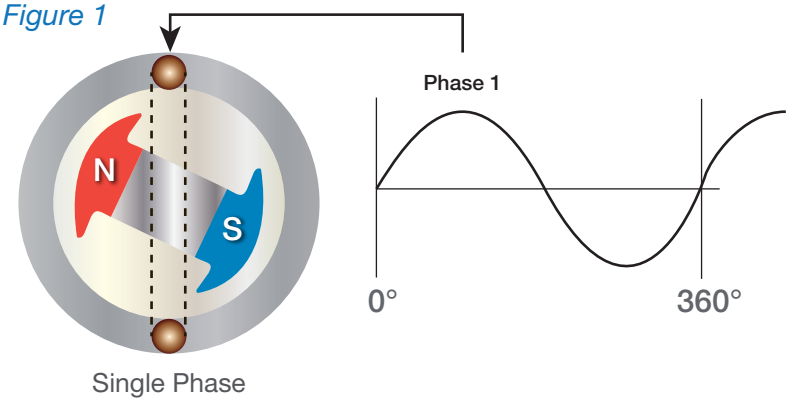
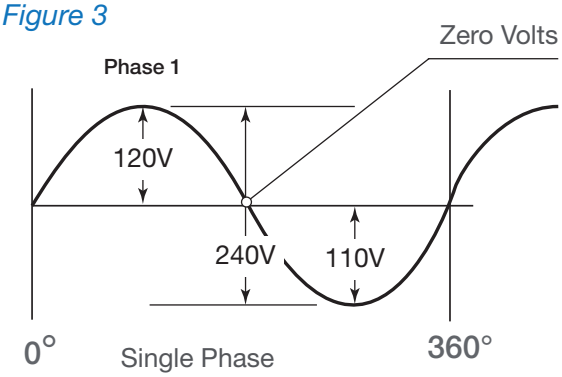


Figure 3



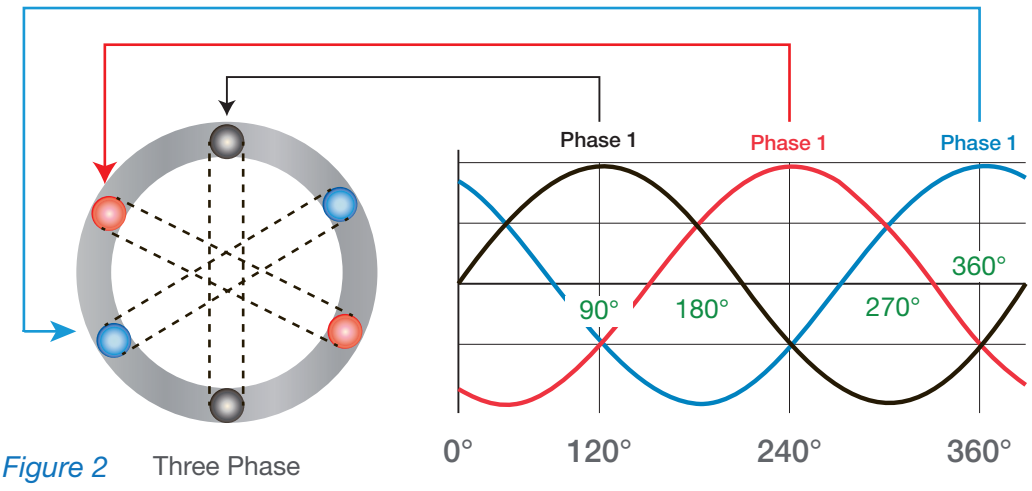


Figure 2 Three Phase

2.0 What is the Difference Between a Three-Phase and Single-Phase Generator System:

When referring to phases in voltage, it relates to Alternating Current (AC) power, not Direct Current (DC). AC power in North America, and all other countries, is the power delivered by the utility to residential, commercial, and industrial applications. The differences between three-phase and single-phase relates to how AC current is generated.

2.1 AC Power Generation – As discussed in Information Sheet, "Generator 101 Part 1", AC power is the average of the peak values in voltage generated in one 360 degree turn off the generator as the voltage induced in the windings in the form of a sine wave going from a positive to a negative peak. The term alternating current refers to the peak and valley of the sine wave through one cycle (one 3600 turn) see ***figure 1***.

2.2 Single-Phase – Refers to how the power is generated and delivered to the load. Single-phase generators only have one coil of wires crossing through lines of magnetic force to induce a current into the wires, see ***figure 1***.

2.3 Three-Phase – As the generator turns AC power it is induced into the coil, but with 3-phase there are three coils, not one coil as for 1-phase, see ***figure 2***.

Whether the power is supplied from the generator or the utility it is configured as single or three-phase output.

3.0 Different Utility Supply Voltages:

When determining the generator phases for a standby application, a good indicator of whether to select a single or three-phase generator is the utility supply into the facility. Utility supply voltages in North American to residential, industrial, and commercial applications usually falls into one of the following groups:

3.1 220/110 Volt Single-Phase – As indicated in ***figure 1***, this is called single-phase where the relationship between the lower and upper voltage is where the lower voltage is half the higher voltage. Single-phase is a two-wire AC power circuit. Typically, the utility feed in one power wire, the phase wire, and one neutral wire, with electrical current flowing between the power wire, via the load and the neutral wire. In a utility supply 220/110, the single-phase 220V power is when the load is connected line to line (see ***figure 3***). The 110V power supply, of which there are two, is when the load is connected line to neutral.

Most residential and small commercial applications that consume less than 15kW have a 220/110 utility input. Larger power consuming appliances (i.e. dryers & Air con) are connected line to line 220V, whereas the other loads are line to neutral 110V.

3.2 380/220 Volt Three-Phase – As indicated in ***figure 2***, this is called three-phase, where the relationship between the lower and upper voltage is root three, or 1.732. Typically, this is the utility input into a facility having an average power demand higher than 15kW. Example connected loads are larger 3-phase electric motors. It is not typical for a residential load to have a 3-phase utility input.

When a generator selection is being made for an application that has a 3-phase utility supply, a generator system provider would specify a 3-phase generator to manage all the application's connected loads. However, in some standby applications, standby power is only required to provide standby power to one segment of the applied load if the utility power goes off line. If the critical load, in this case is single-phase, then a single-phase generator could be selected. The distribution of the power will be via a change-over-contactor through the bus bar of the incoming utility power. 3-phase utility power into an application can also provide a single-phase supply by connecting from one phase to the neutral.

4.0 Why Selecting 3-Phase over 1-Phase is the Preferred Option:

The selection process of a standby unit is somewhat dictated by the existing utility supply and the connected load of the application. However, even is these factors were not a consideration, there are several reasons to choose a 3-phase generator system over a 1-phase system including:

4.1 Voltage Stability and Efficiency – As indicated in ***figure 2***, a 3-phase system has three coils generating power in three separate waves of power delivered in 120° intervals through one complete turn of 360° ensuring a continuous uninterrupted flow of power that never drops to zero. Unlike a 1-phase system, see **figure 3**, at no time does the power output return to zero.

Having three outputs results enables a 3-phase generator and connected 3-phase electric motor to be more efficient with a smoother overall power output and a more stable voltage pattern.

4.2 More Compact – In a 1-phase generator all the power generated is carried in one set of wires and these wires have to conduct the total capacity of the kW/amperes generated. The higher the amps, the greater the wire gauge for the wires conducting the current. This means for any given rating the wires and generator size of a 1-phase is larger than the equivalent 3-phase generator. For this reason most generators and electric motors over 15kW are 3-phase.

4.3 More Cost – A 1-phase generator has heavier gauge wiring than a 3-phase system and an increased frame size. A 1-phase generators as a rule are more expensive than the equivalent kW of a 3-phase generator. If the load in a facility is all 1-phase all electrical distribution components will have to be sized for carrying a larger current, resulting in higher costs for the connected load.

5.0 Typical 1-Phase Applications:

As a general rule, 1-phase generators are supplied for applications below 15kW. Above 15kW the wiring and frame sizes are not the most efficient and best price option. Typical 1-phase applications include:

5.1 Residential – Most residences have an electrical system designed for a 220/110V utility input.

5.2 Industrial/Commercial Less Than 15kW – These applications have electrical systems designed for lighter loads.

5.3 Single Phase Motor Loads – Some applications above 15kW have large 1-phase individual motor loads, and the best option is to apply a 1-phase generator. In this type of application, a greater than normal generator frame size is used to manage the higher starting amps drawn. Several agricultural applications use 1-phase generators for 1-phase motor loads.

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