Phase: Wave Alignment

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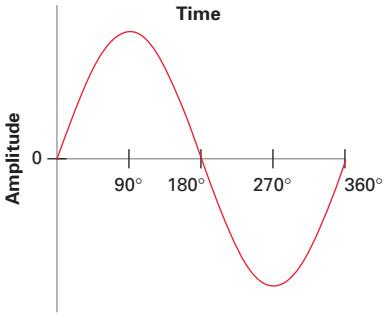
Derivation: from Greek phasis, *appearance of a star, phase of moon; from Greek* phainein, *to show, appear.*

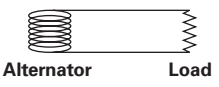
By definition, alternating current (AC) electricity alternates, or continually reverses its direction. The voltage and amperage peak, go to zero, and peak in the other direction. The pattern this takes is called a waveform, and the ideal is a sine wave—a smooth wave.

"Phase" describes the timing of waves and their relationship to each other. When two waves start, peak, and zero at the same time, we say that they are "in phase." This describes the condition necessary when a grid-synchronous inverter connects to the utility grid. The sine wave from the inverter must match up with the sine wave from the grid, so they can work together.

The common electricity in your home is called "single-phase," which means there is a single wave in the home's circuits, peaking, zeroing, and peaking in the opposite direction. A rotating generator produces this wave. A complete wiring circuit consists of one wire going from the generator to the load, and another returning from the load to the generator.

Single-Phase





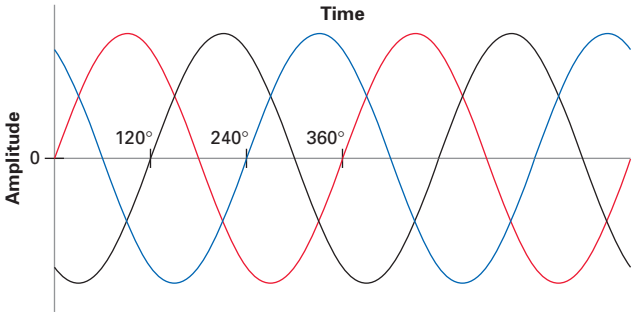
Three-phase electricity consists of three waves. Think of it as three generators sitting side by side, each putting out a single-phase wave. In fact, three-phase generators have three different electrical windings in one generator case, each putting out a separate wave. The three waves are not in phase, but are offset.

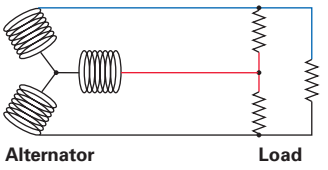
One wave starts, and the second wave starts one-third of a cycle (or 120 degrees) later, with the third wave starting another one-third cycle later (240 degrees after the first wave starts). If you look at the sine wave diagram of three-phase output, you'll see that each wave peaks positive, hits zero, and peaks negative at a different time.

Three-phase circuits can use either three or four wires, and two different, common configurations within each of these options. The diagram below shows the most common wiring arrangement.

Three-phase wiring shares wires between the phases. Because the three phases peak at different times, the output has more power than single-phase of the same magnitude, which has times when both voltage and amperage waves go to zero. Three-phase generators and motors also have more

Three-Phase





power potential for the same size of equipment (about 150% of single-phase equipment). Three-phase is widely used in industrial applications, and sometimes even in home or farm applications. Although wind and hydro generator output is often three-phase, most of the AC in RE systems is single-phase.

The term "phase" is also used in reference to the relationship between voltage and amperage in AC circuits. In a resistive circuit, voltage and amperage are in phase with each other, and peak positive, go to zero, and peak negative together (though their wave height or "amplitude" may be different). In circuits that are not solely resistive, voltage and amperage can be out of phase with each other. This relationship is called "power factor." See *Word Power* in *HP99* for a fuller explanation of this concept.

Access

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