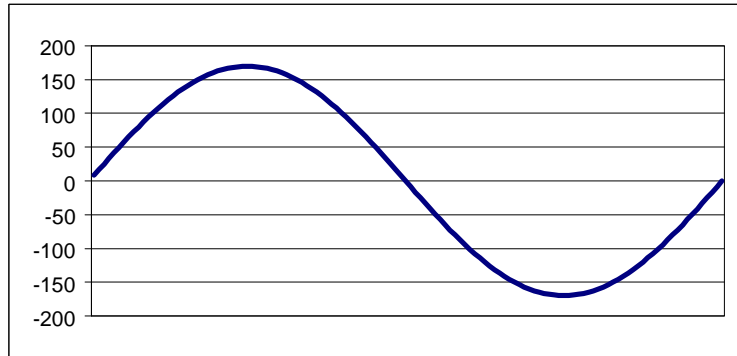


## The Sign of the Sine

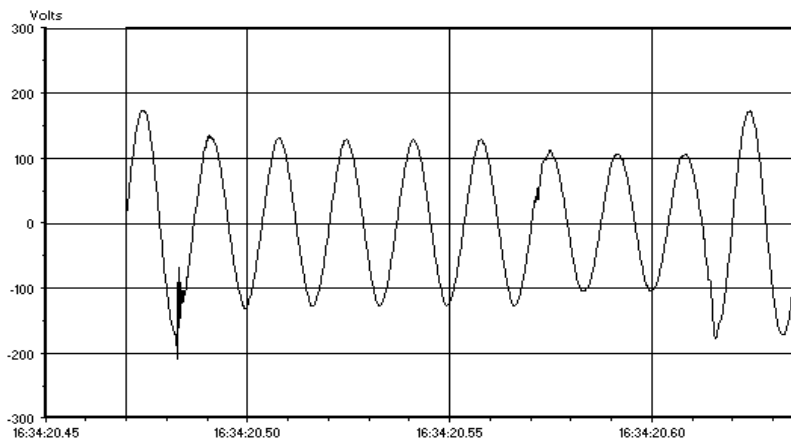
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There are certain phenomena that occur in nature which show up in so many different places that it is a bit eerie. The sine wave is one of those signs that the universe wasn't just randomly put together. If one plots the speed of the pendulum as it swings back and forth, the graph would be a sine wave. At the top of the arc, the speed is zero. Then it begins to travel faster and faster until the bottom of the arc. After reaching the bottom, it begins to slow down until it hits the other top of the arc and the speed goes to zero. The process reverses as it begins to accelerate in the opposite direction. The resulting graph is shown below of the speed of the pendulum versus time.

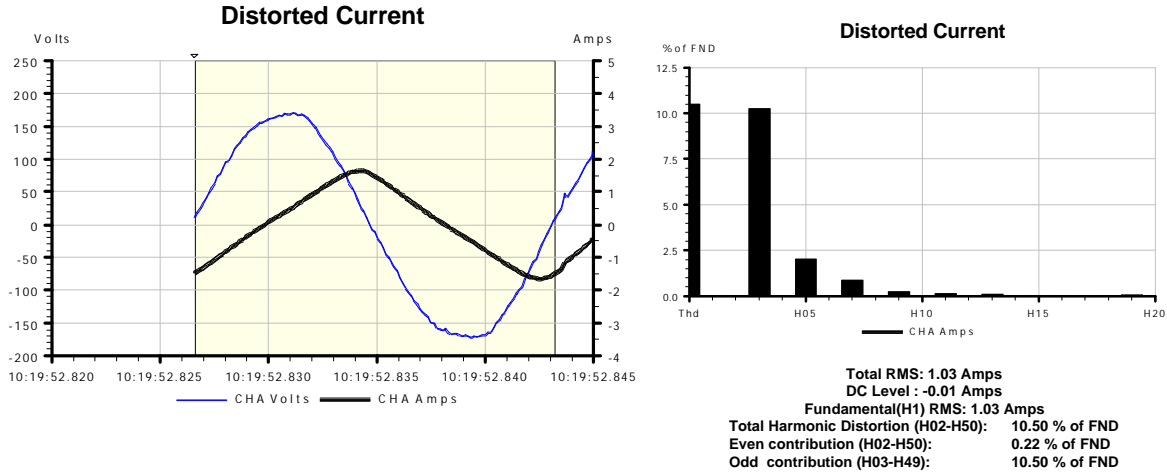


The same curve represents the change in electrical current induced in a coil of wire as it rotates past two magnetic poles, which is the basis for an alternating current electrical generator. Not wanting to restart the debate between Edison and Westinghouse over whether AC or DC is the best way to transmit electrical energy, AC is how most electrical energy is transferred between electrical suppliers and the loads. Within loads, some devices change the voltage into DC, such as those typically called electronic loads. Integrated circuits within personal computers, VCRs, or clock radios typically run off of either 5 or 12 Vdc (though newer circuits run on lower voltages (3.3 Vdc or smaller). But it is the AC voltage, or the sine wave, around which most of power quality phenomena is measured.

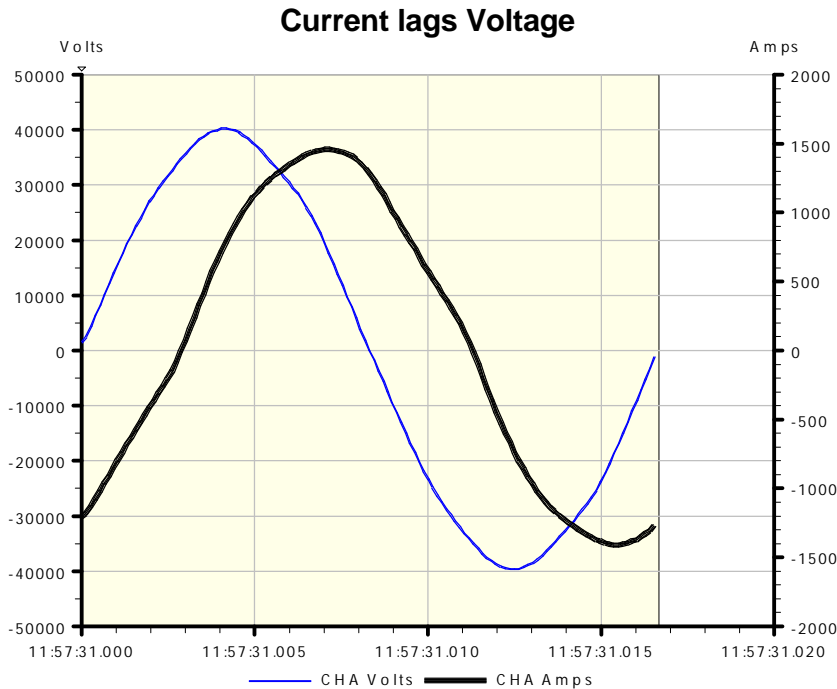
A sag or swell is determined by a variation in the amplitude of the sine wave. A sag is a reduction in the RMS value of the sine wave, typically below 90% of nominal, whereas a swell is an increase, typically above 110% of nominal. A seven cycle, two stage sag is shown below.



Harmonic distortion is a series of sine waves superimposed on each other. A transient, such as a PF cap switching generated event, can be decomposed into a series of sine waves. The oscillation following the initial negative going transient usually has a frequency between 400 and 1500 Hz, compared to the fundamental power frequency of 50 or 60 Hz. As Fourier's Theorem states, any periodic waveshape can be represented by the sum of a series of sine waves. Even square wave and sawtooth waves are but a series of sine waves.



Power factor is based on sine waves. The method of measuring PF in the past was based on the difference in time or phase angle between the voltage and current. This is referred to as displacement PF. Electrical motors, which make up 60% of the load in the United States, have a current sine wave that lags behind the voltage sine wave, as a motor is mostly a coil of wire, which is an inductor. Unfortunately in today's harmonic rich electrical environments, this method no longer works. Today, true power factor is defined as watts divided by voltage amperes, or how much work is done versus the energy transferred.



Though the sine wave is really magical, most designers of equipment to be powered from the AC voltage waveform have made the assumption that the shape of the waveform will be basically sinusoidal, with the amplitude between certain limits (typically +/- 10%) and frequency stable. When events, such as large motor starts or downed wires, cause the sine wave to exceed these limits, it is usually a sign that a power quality event has occurred and possibly equipment malfunction has resulted.