# Waves

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Writing while listening to the sounds of the ocean surf can be therapeutic. The rise and fall of the waves is like the sine wave of the ac voltage waveform that is often used as the basis to compare with as a means to determine the quality of the supply. Deviations from the pure sine wave can be the result of harmonics, interharmonics, and, impulsive or oscillatory transients. Changes in the amplitude of the sine wave can be classified as a sag, swell, sustained over/undervoltage. While changes in frequency aren't very common in North America except under extreme fault conditions, phase shifts during sags or swells do occur. With all of these different type of power quality phenomena, the RMS calculation is used to attempt characterize or describe the sine wave. While useful in many cases, it can be inadequate and even misleading in others.

What is RMS ? RMS stands for Root Mean Squared, which is a mathematical process used to calculate a single value from a series of numbers. It is a way to compare one cycle to the next, or one phase to another. The RMS voltage is "the effective value of a varying or alternating voltage. That value which would produce the same power loss as if a continuous voltage were applied to a pure resistance". [1] In today's world of sampled waveforms processed by digital signal processor (DSP) chips, it is one of the simpler calculations to make. Each data sample value over a pre-defined period (usually one cycle) is multiplied by itself (squared), all of them over the period are then averaged (sum them up and divide by the number of samples), and then the square root of that value is taken.

For a stable DC signal, each sample would have the same value, therefore, each sample's value would be the equivalent of the RMS value. With a sine wave, the values get larger for the first quarter of the cycle, then get smaller until they cross zero and get more negative before heading back to zero in the last quarter cycle (see Figure 1). The RMS value of a pure sine wave would be equal to 70.7% of the peak value. With a distorted waveform, this is not true, which is why non-true-RMS meters may read differently with different levels of distortion and should not be used when harmonics are present. Those that just take the peak value and scale it down to 71% would give an incorrect value for the current waveform in Figure 1. This is the classic current waveform from a single phase, full wave rectified power supply, found in many consumer electronic devices. This waveform with 108% THD has a peak value of 3.6A and a true RMS value of 1.4A, (not 0.707 * 3.6 or 2.55A).

Power quality monitors that only trigger on RMS values can also be tricked into missing data. Some monitors calculate the RMS value over multiple cycles. These monitors will most likely not record the multi-phase, single cycle sag in Figure 2. Such a sag is typical when the fault is cleared by a protective fuse blowing (as it is designed to due). In Figure 3, the single cycle sag resulting from a flashover at the peak voltage (possibly due to insulator failure or lightning strike) would have a different RMS value for each of the three cycles. Depending on the triggering mechanism and the thresholds, it may not recognize the sag until the third cycle shown, as the faulted cycles RMS value may be above the trigger threshold. A phase-shifted fault can have an identical RMS value from one cycle to the next, even though the amplitude of the waveform changes. This is where power quality monitors with multiple triggering mechanisms, such as transient and

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waveshape faults, can provide a significant advantage.  Remember, just because the
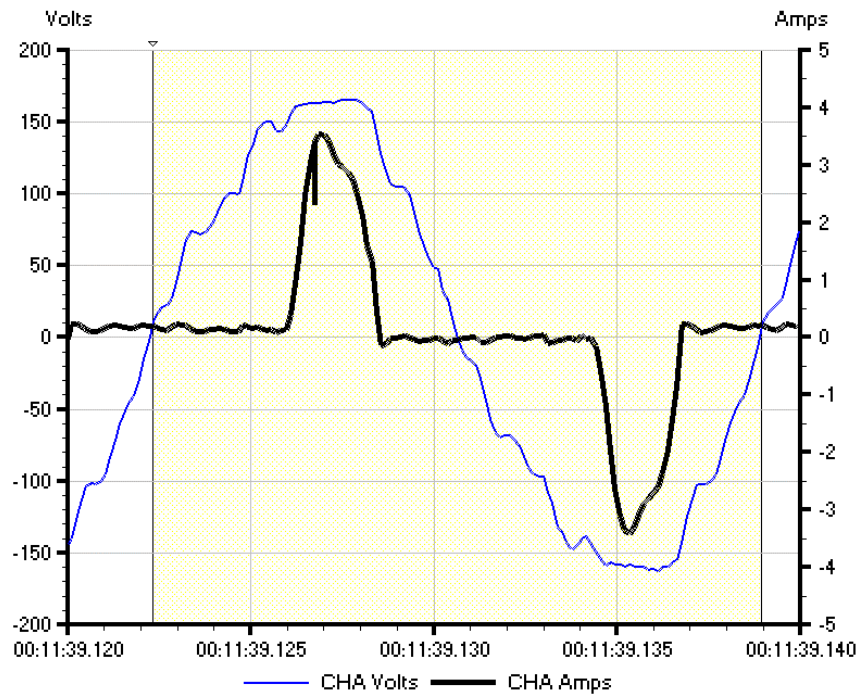


monitor didn't capture it, doesn't mean that it didn't happen.

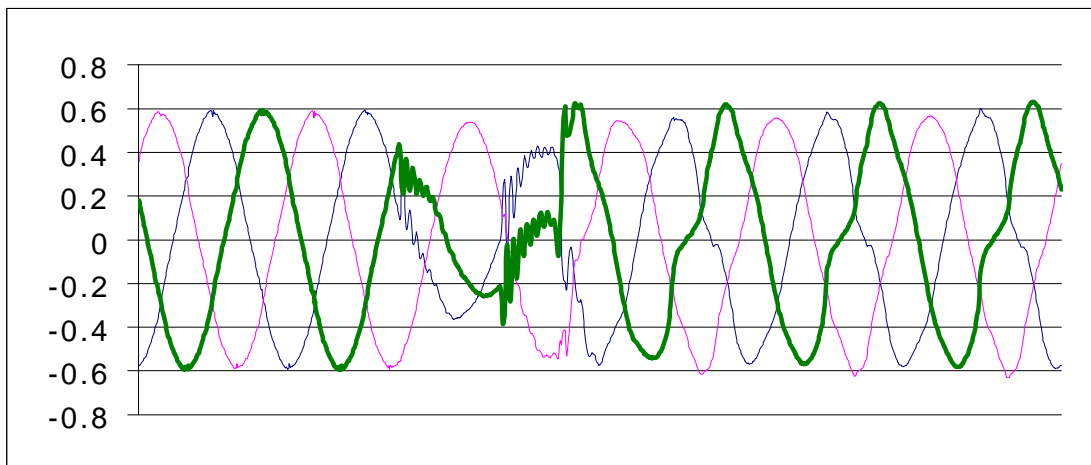Figure 1.  Waveforms from a Single Phase, Full Wave Rectified Power Supply Load



Figure 2. Single Cycle Sag on Two Phases.

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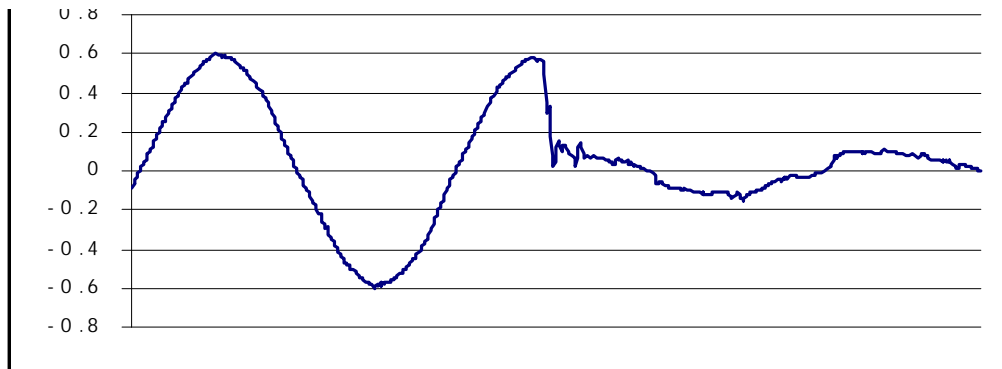
Figure 3. Single Phase Sag from Flashover at Peak Voltage.

[1] Unabridged Dictionary of Electronics, edited by Rudolf. F. Graf, Howard W. Sams & Co, Inc., Indianapolis, 1972. pg 504.

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