WHITEPAPER

What are harmonics?

If we could see what a musical melody looks like, we would see a complex shape-wave with no apparent pattern. So, how do we hear the high and low notes? How do we perceive pitch? This paper explains the concept of harmonics and important properties of special harmonics such as triplen. The definitions of some harmonics content indicators are included too.

We can recognize high and low notes because, mixed in the sound wave, are notes of different tones and octaves. Those concepts are closely related to the note's frequency. High notes have greater frequencies, so any given note has twice the frequency than the same note within the previous octave.

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There is an analogous effect in electrical engineering applications. Certain apparatuses, called non-linear loads, demand non-sinusoidal current. This means that a wave form could be split in waves of different frequencies. The fundamental frequency of the wave is the system frequency of 60 Hz in North America. The rest of the waves have a multiple of this fundamental frequency. Those waves are called harmonics and are named according to the multiple of the system frequency they represent. For example, the third harmonic has a frequency of three times the system frequency (3*60=180 Hz). The fifth harmonic has a frequency of five times 60 Hz, and so on.

The fundamental or first harmonic current has a property which is especially important. It is the only fraction of the total current which can produce "useful" work, such as power in a motor or energy to feed a battery charger. The other harmonics use installed capacity and generate energy losses without providing productive power.

In three-phase systems, there are other harmonics with special characteristics. Triplen harmonics are odd-numbered multiples of three (3, 9, 15, etc.). These harmonics are "in phase", which means that the peaks and valleys coincide in time at the three lines. This characteristic is very important at the filtering point of view.

Some examples of non-linear loads that generate harmonics, are servers, PCs, variable frequency drives or printers. Welding machines and arc furnaces are other big harmonics generators.

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01 Distorted shape-wave due to harmonics are very different from the well-known sinusoidal shape as shown at the graph.

As Deming said, “If you don’t measure it, you can’t improve it!” This is especially applicable to the world of harmonics. Some indicators are used to characterize the harmonic content in a specific current or voltage wave; the most common indicators are Total Harmonics Distortion (THD) and K-factor.

Total Harmonics Distortion (THD)
This is the ratio between the effective value of the first harmonic (which provides useful power) and the effective value of the other harmonics (which do not provide useful power).

K-factor
The K-factor is the amplification factor of magnetic losses. Due to the high frequency of harmonics, the losses caused by K-factor are greater than those caused by the current at fundamental frequency.

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