Harmonics and THD Roles in Improving Power Quality

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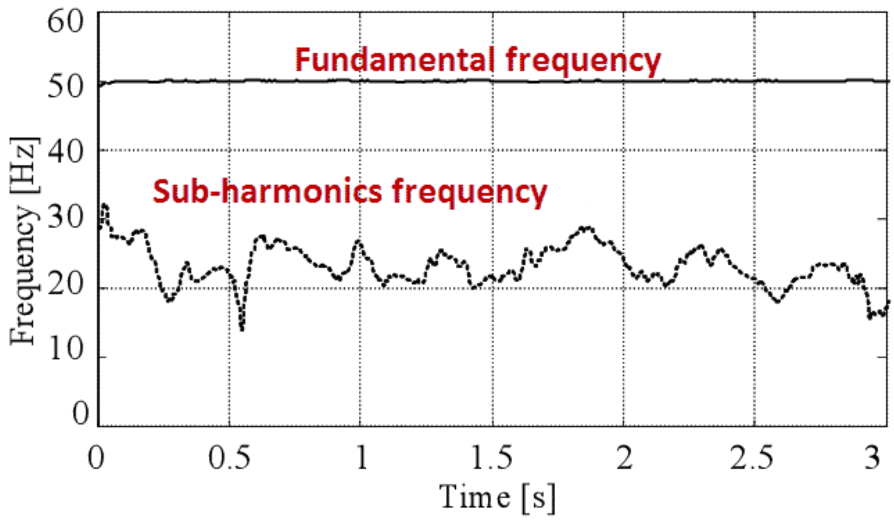
Removing harmonics to Lower Hazards Associated with Them

Today's modern life is impossible without electricity, So having a safe and stable supply is very important for peace of mind. The existence of harmonics is one of the main issues with distribution and transmission networks. Electronic systems with harmonics experience distortion and sinusoidal wave deviation in current and voltage. There are several causes of harmonics, including the use of inverters, switched-mode power supplies, and other components in the electrical system. We will learn about the basic definition, reasons for occurrence, damaging consequences, and ways to eliminate harmonics in this post.

What Is Total Harmonic Distortion (THD) to Eliminate harmonics

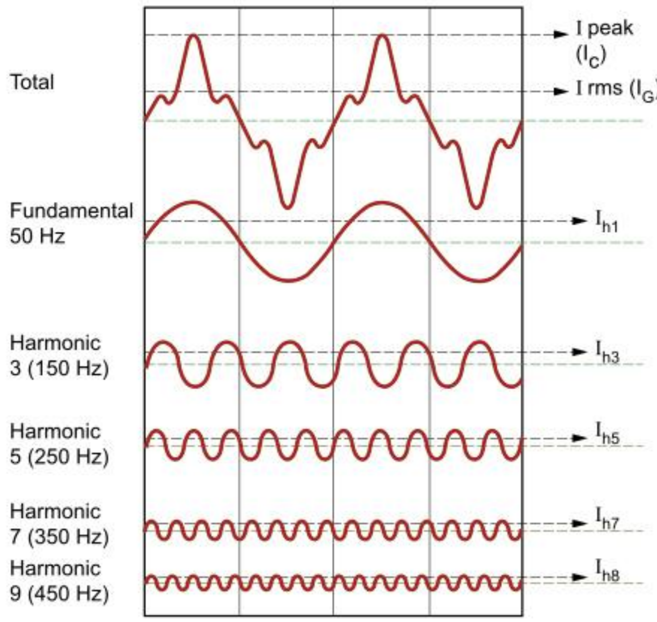
You must first comprehend the meaning of harmonic and THD in order to eliminate harmonics.



Sub-Harmonics in Power system

The ideal power supply waveform is a pure sine wave without any noise, but in reality having the ideal power source is impossible. A harmonic is, in general, a wave whose frequency is an integer multiple of the fundamental frequency. The fundamental frequency is the lowest frequency that may be generated. The harmonic has a frequency that is twice the fundamental tone's frequency, and its third harmonic has a frequency that is three times the fundamental tone's frequency. For instance, the basic power frequency in the power distribution system is 50 Hz, and the harmonics are multiples of 50, such as 100 or 150, etc.

The existence of harmonics in the system may manifest itself in a variety of ways, including the overheating of transformers, the flashing of lights, and the destruction of circuit switchers and breakers. Harmonics, in general, may be very harmful owing to overloaded electrical devices because they may result in transformer saturation, nuisance circuit breaker tripping, aging, and degradation of the electrical distribution system, etc. So, we need to figure out how to eliminate harmonics in our distribution system.



In general, the state of the harmonics in the system may be checked out using a variety of various approaches. The total harmonic distortion (THD) approach is one of these ways. It reflects the collection of harmonic effects. Total harmonic distortion (THD) is a qualitative measure that is used in this procedure. It demonstrates how well the wave conforms to the sinusoidal waveform. The value of this qualitative measure is represented as a percentage, and the THD percentage will be smaller the better the network sine waveform is. As a consequence of this, the power system will endure for a more extended period of time and experience less loss of energy if the THD is lower.

Harmonic and THD calculation formula

$$hf_n = \frac{A_n}{A_1}$$

$$A_n = \sqrt{a_n^2 + b_n^2}$$

$$a_n = \frac{2}{T}\int_{t_1}^{t_1+T} f(l)\ \cos nw_0\, l\ dl$$

$$b_n = \frac{2}{T}\int_{t_1}^{t_1+T} f(l)\ l\ dl$$

Harmonics
A_n - value of nth harmonic
A_1- value of first harmonic
n = 1,2,....
w_0 - angularfundemental frequency= $2\pi f_0$= $2\pi/T$
nw_0- nth harmonic angular frequency

$$\mathrm{THD}V_{phase}(\%) = \frac{\sqrt{\sum_{n=2}^{63} V_{Phase\ n}{}^2}}{V_{phase\ 1}} * 100$$

Phase voltage THD(Total Harmonic Distortion)
V_1 - value of first harmonic
n - number of harmonic

$$\mathrm{THDI}(\%) = \frac{\sqrt{\sum_{n=2}^{63} I_n{}^2}}{I_1} * 100$$

Current THD(Total Harmonic Distortion)
I_1 - value of first harmonic
n - number of harmonic

$$\mathrm{THD}V_{Line}(\%) = \frac{\sqrt{\sum_{n=2}^{63} V_{Line\ n}{}^2}}{V_{Line\ 1}} * 100$$

Phase-to-phase voltage THD(Total Harmonic Distortion)
V_1 - value of first harmonic
n - number of harmonic

What Causes Harmonics In Electronic Systems

Harmonics are produced when a power system is subjected to non-linear loads. Sine waves are the most common form in which electric current is generated. These loads use electricity that is not a sine wave, which causes them to emit harmonics as a consequence of their power consumption. If the power distribution and transmission system have a low impedance, then the quantity of harmonic voltage distortion will likewise be relatively low. Harmonic may be thought of as a term that is used to characterize the distortion of the sinusoidal waveform caused by frequencies that are not identical.

The presence of harmonics in a distribution system may have a deleterious effect, not only on the equipment that makes up the system but also on the loads that are linked. Electronic equipment such as printers, computers, TVs, servers, and telecommunications systems are examples of non-linear loads that have the potential to create harmonics. Other non-linear loads that may cause harmonics to include rectifiers, switching power supplies, and transformers. To eliminate harmonics, you have several options to do.

The Hazardous Effects of Harmonics

You might think that you don't need to eliminate harmonics of your distribution system. But it must be said that harmonics have very destructive effects on your distribution system. For example, harmonics can significantly increase the heat of transformers and thus cause the equipment to fail. In the following, we examine some of the harmful effects of harmonics:

- **Surging excessive current into the system**: In electrical systems, the presence of harmonic currents causes an increase in the r.m.s current and a deterioration in the quality of the supply voltage. This is because harmonic currents distort the fundamental frequency of the supply voltage. They place a load on the electrical network and may possibly cause damage to the apparatus because of their presence. They could make it more difficult for the equipment to perform correctly, which would result in an increase in the cost of operating
- **Making transformers overheated**: The main effect of harmonic currents is an increase in power losses inside the transformer's internal parts. In addition to shortening the transformer's lifespan, this results in an increase in the amount of heat produced
- **Shortening Capacitor Banks' Lifespan**: Any of the harmonic frequencies have the potential for resonance, and when it happens, the system experiences high voltages and high currents. This might impair capacitor banks across the whole electrical distribution system, which could lead to their failure and a higher risk of fire
- **Making Magnetization Harder In the Motor's Stator and Rotor**: The presence of harmonic content makes it more challenging to magnetize the copper and iron that are found in the stator and rotor of the motor, which results in more significant eddy current and hysteresis losses. It makes the motor become overheated and run into the malfunction

Ways to Eliminate Harmonics

There are five strategies that may be used in order to eliminate harmonics and their adverse effects in a circuit or power distribution system. Harmonic filters are used by utilities to reduce harmonics that are present on their distribution networks. It is also possible to utilize filters on the inside of the plant. In most cases, harmonic filters fall into one of two categories: active or passive. Additionally, some transformer connections have the ability to lessen the number of harmonic currents in three-phase systems. Altering the capacity of the system capacitor is another low-cost option that is applicable to both residential and industrial projects.

Utilizing Power Analyzers to Eliminate Harmonics

One of the best ways to eliminate harmonics is to utilize a power analyzer tool. In order to conduct a comprehensive examination of the power quality in the facility, the ideal piece of equipment to use is a harmonic analyzer (Power analyzer in general). This allows for the determination of the waveforms of the current and voltage over their respective frequency spectrums. Harmonic analyzers are valuable tools that may provide a comprehensive study of the potential source of voltage to eliminate harmonics.

In order to offer a comprehensive investigation of the possible culprit source, a harmonics analyzer is used. The harmonic ratio function generates a number between 0% and 100% to reflect the deviation of non-sinusoidal and sinusoidal waveforms based on this data. The existence of harmonics may be determined from this measurement.