

Harmonics

Overview

Harmonics are a mathematical way of describing distortion to a voltage or current waveform. Harmonic voltages and currents in an electric power system are a result of non-linear electric loads. Harmonic frequencies in the power grid are a frequent cause of power quality problems. High levels of harmonic distortion can cause such effects as increased transformer, capacitor, motor and generator heating, mis-operation of electronic equipment, and mis-operation of protective relays. Examples of non-linear loads include common office equipment such as computers and printers, fluorescent lighting, battery chargers and variable frequency drives (VFD). Reduction of harmonics is considered desirable.

In the United States for normal alternating current power systems, the current varies sinusoidally at a specific frequency of 60 Hertz. When a linear electrical load is connected to the system, it draws a sinusoidal current at the same frequency as the voltage (though usually not in phase with the voltage).

Current and Voltage Harmonics

Current harmonics are caused by non-linear loads. When a non-linear load is connected to the system, it draws a current that is not necessarily sinusoidal. The current waveform can become quite complex, depending on the type of load and its interaction with other components of the system. The waveform starts at the power system fundamental frequency and occurs at integer multiples of the fundamental frequency. Voltage harmonics are mostly caused by current harmonics. The voltage provided by the voltage source will be distorted by current harmonics due to source impedance. If the source impedance of the voltage source is small, current harmonics will cause only small voltage harmonics.

Steady-State Distortions

Harmonics are steady-state distortions to current and voltage waves and repeat every cycle. They are different from transient distortions to power systems such as spikes, dips and impulses. Total harmonic distortion (THD) is a common measurement of the level of harmonic distortion present in power systems. THD is defined as the ratio of total harmonics to the value at fundamental frequency.

Power System Harmonics

One of the major effects of power system harmonics is to increase the current in the system. This is particularly the case for the third harmonic, which causes a sharp increase in the zero sequence current, and therefore increases the current in the neutral conductor. This effect can require special consideration in the design of an electric system to serve non-linear loads.

Harmonics Problems

Although the likelihood of harmonic problems is very low, the cases in which they do occur can result in decreasing power system reliability. An understanding of the causes, potential effects and mitigation means for harmonics can help to prevent harmonic related problems at the design stage and reduce the probability of undesired effects occurring during the life of the building. It should be kept in mind that if the harmonic producing loads are small in relation to the total plant load, then harmonics are not an issue. When the non-linear loads become a substantial portion of the total load, it becomes worthwhile to give some consideration to harmonics. In these cases, harmonic modeling analysis is recommended to predict harmonic levels and identify potential problems.

Mitigation for VFDs

For proactive harmonic mitigation for VFDs, NIH states the following prescriptive harmonic allowance limits:

Motor Horsepower	Allowable THD at drive input ^{1,2} terminals	Allowable iTHD at drive input ² terminals	Allowable vTHD at drive input ² terminals	Maximum Individual allowable distortion at any individual harmonic
< 10 Hp	10%	10%	5%	5%
10 Hp to < 25 Hp	8%	8%	5%	4%
25 Hp to < 75 Hp	5%	5%	5%	3%
≥75 Hp	5%	5%	5%	3%

- (1) All VFD are required to comply with IEEE519 Table 10.3 for Total Demand Distortion at the Point on Common Coupling (PCC).³
- (2) Compliance shall be shown for motors loaded between 50% - 100%.
- (3) The NIH defined location for the PCC shall be the load side of the building transformer - essentially the switchgear (or main switchboard) bus.

Reference: Rockwell Automation, Allen-Bradley – Power Systems Harmonics: A Reference Guide to Causes, Effects and Corrective Measures. 2001