Technical Paper

Meeting IEEE 519-1992 Harmonic Limits

Using HarmonicGuard® Passive Filters

Written By:
John F. Hibbard
Michael Z. Lowenstein

Abstract

With the advent of IEEE 519-92, the increasing demand by utilities for power factor improvement, and the proliferation of non-linear loads in industrial power distribution systems, specification of harmonic mitigation has become common. Questions arise regarding the performance of passive harmonic trap filters in removing harmonic distortion.

Data from a number of TCI HarmonicGuard® trap filter installations have been collected which illustrate how closely IEEE 519-92 limits can be met. HarmonicGuard® filters have been installed, both for power factor improvement and to meet harmonic distortion limits based on IEEE 519-92.

A computer model has been developed to help predict the harmonic reduction that can be expected for specific load-filter combinations and the model has been verified with field data. This paper outlines and explains the computer model and details the application of harmonic trap filters.

Computer generated design curves are provided which can be used by a system designer to predict success in meeting harmonic specifications using HarmonicGuard® trap filters.

IEEE 519, 1981

IEEE 519, "Recommended Practices and Requirements for Harmonic Control in Electric Power Systems," was published in 1981. The document established levels of voltage distortion acceptable to the distribution system. This document has been widely applied in establishing needed harmonic correction throughout the electrical power industry. However with the increase in industrial usage of adjustable speed drives, rectifiers, and other non-linear loads, it became apparent that a rewrite of IEEE 519, treating the relationship of harmonic voltages to the harmonic currents flowing within industrial plants, was necessary to support control of harmonic voltages. The new IEEE 519, published in 1992, sets forth limits for both harmonic voltages on the utility transmission and distribution system and harmonic currents within the industrial distribution systems. Since harmonic voltages are generated by the passage of harmonic currents through distribution system impedances, by controlling the currents or system impedances within the industrial facility, one can control harmonic voltages on the utility distribution. Unfortunately, there is some user confusion regarding the application and intent of the information included in IEEE 519, 1992. Section 10, "Recommended Practices for Individual Consumers" describes the current distortion limits that apply within the industrial plant. Consulting engineers and applications engineers may not be clear as to the proper use of Table 10.3, which outlines the limits of harmonic distortion as a function of the nature of the electrical distribution system. This paper will explain, with examples, the proper use and interpretation of this table. Using a computer model, we have outlined the level of distortion one might expect to encounter for various types of loads and distribution systems and the level of correction obtainable through the use of line reactors and passive harmonic trap filters has been detailed. It is hoped that the readers of this paper will come away with a better understanding of the meaning and application of IEEE 519, 1992.

Generation of Harmonic Currents

Power electronic equipment is called non-linear because it draws non-sinusoidal current. Fig. 1a shows the linear relationship between voltage and current for one phase of a 3-phase induction motor connected to the line, while Fig. 1b shows the nonlinear current drawn by the same motor powered by an adjustable drive. IEEE 519, 1992 defines a harmonic as, “A sinusoidal component of a periodic wave or quantity having a frequency that is an integral multiple of the fundamental frequency.”

Linear Current

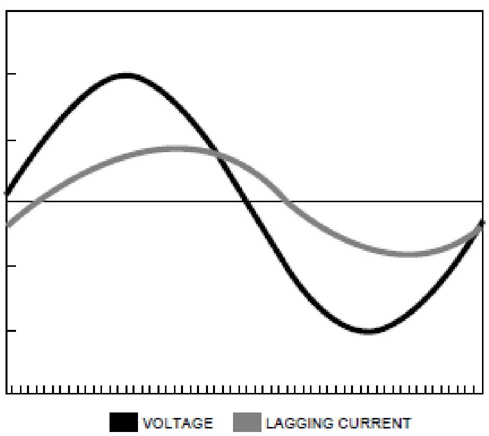

Figure 1a

Non-Linear Current

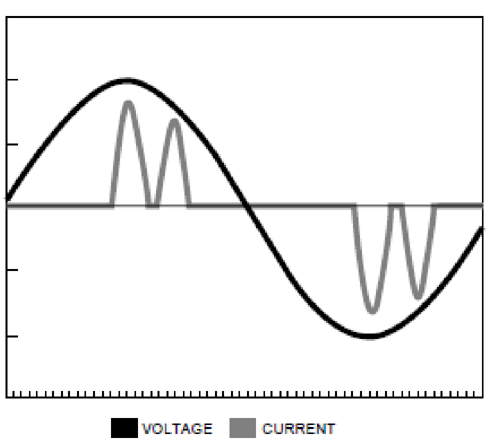

Figure 2a

Fig. 2a illustrates the frequency relationship of a number of harmonics. As the graph clearly shows, the 5th harmonic has five complete waves for each complete fundamental wave. It is important to remember that harmonic phenomena are “periodic” which indicates their continuous nature. While impulses or spikes in the power system may contain multiples of the fundamental frequency, it is the continuous phenomena which are addressed in the IEEE document and in this paper. Currents drawn by non-linear loads are rich in harmonics. The harmonics present are a function of the distribution system and the circuit configuration of the distorting load. Typical industrial power systems are:

- 3-phase delta with loads connected phase-to-phase
- 3-phase 4-wire wye with loads connected phase-to-phase
- single phase loads connected phase-to-neutral

Summary

From the information presented in this article, one can see that the distortion of line current and voltage can be effectively reduced to acceptable levels using harmonic trap filters. A basic understanding of how distortion is created and the effects of circuit impedances on the levels of distortion helps in resolving the problems created by distortion. Don't be fooled by those who suggest that adding line reactors or transformers ahead of a distortion load will reduce the level of distortion (voltage or current) to acceptable levels in all instances. Realizing the role of the distribution system impedance in any installation is necessary to accurately predict the level of distortion attainable through the use of filtering or other harmonic-reducing products.

TCI, LLC
W132 N10611 Grant Drive
Germantown, WI 53022
(414) 357-4480
FAX (414) 357-4484
PQ Helpline (800) TCI-8282
www.transcoil.com