PHASE SHIFTING FOR HARMONIC CANCELLATION

General
In a three-phase power distribution system, the 5th and 7th harmonics are the most predominant causes of distortion and heating problems. These harmonics will easily cause standard distribution transformers to overheat, burn neutral conductors and naturally fail at the worst possible time.

Scrambling to replace a transformer in the middle of production, whether that production is data processing or an assembly line, is exceptionally costly. Aside from expedition fees, premiums, etc., the unforeseen downside is that the first transformer available is the one that gets installed. Efficiency of the transformer cannot be considered; time just doesn’t allow it. So… you continue to pay extra year after year, and most likely have not addressed the original problem that caused the transformer to fail in the first place… the harmonics!

Elimination
The damaging harmonics are the odd order frequencies of the fundamental 60Hertz. Electronic nonlinear loads are the reason for the generation of harmonics. Nonlinear loads range from the little plug-in power sources to the massive automation equipment in factories. Harmonics slowly erode the electrical environment causing high maintenance, premature failures and fires. It is important that they are addressed.

The elimination or attenuation of harmonics can be accomplished through a variety of techniques, costs and applications. First, know that power factor correction capacitors do not remove harmonics. They need to be de-tuned requiring some engineering and a custom design. Later changes in the load may require the engineering process to be repeated. Active filters are good, but are the most expensive and complex. Active filters digitally create and control reactive power to cancel the harmonics. Some other benefits can be achieved with this technology, but all at a substantial cost.

Procedure
An effective, basic method to take harmonics “head-on” is through the use of phase shifting transformers. This method is clear and fundamentally easy to understand. The principal is to take harmonics generated from separate sources, shift one source of harmonics 180° with respect to the other and then combine them together; this will result in cancellation.

Picture a sinewave, which contains the 5th and 7th order harmonics within the waveform. The Ultra-K shifts the 5th harmonic 150° and shifts the 7th harmonic 210°. When the shifted harmonics return back onto the line, The shifted 5th will be approximately 30° away from a perfect 180° with respect to the non-shifted 5th. Likewise the shifted 7th will be 30° from 180° with respect to the non-shifted 7th. This is an excellent blend for these two most corruptive harmonics. Now, within the electrical distribution system, the shifted 5th harmonics are opposite in phase and cancel with each other, as do the shifted 7th harmonics.
The triplen harmonics, (3, 9, 15 etc.) are captured in the delta primary of the transformer, preventing any effects reflected to the electrical distribution system. Unlike dual secondary mitigation transformers that require absolute load balancing between 6 outputs and two load centers, the Ultra-K handles all the harmonics without the need for load balancing through one load center.

Both Ultra-K and mitigating transformers require equal and opposite magnitudes of harmonics for complete cancellation. However, the Ultra-K's design handles all harmonics whether equally opposing or not, without the side effect of heating.

Mitigating Transformer

UltraK Transformer

Shifting the Fundamental 30° will shift the 5th harmonic 150°
Here is a numerically embellished example of a typical application:

Load (A) generates 15% of the 5th harmonic, Load (B) generates 6% of the 5th harmonic. Shifting the fundamental 30° places the unequal 5th harmonic of loads (A) and (B) 150°. A resultant of approximately 9% of the 5th harmonic remains. With no other loads, this is the best condition attainable.

Summary

The 5th and 7th harmonics are typically the major causes of distortion and heating problems. The most cost-effective method to eliminate these harmonics is through the use of phase shifting transformers. The Ultra-K's shielded transformer resolves the harmonic problems by shifting the 5th and 7th harmonics to cancel them, without the side effect of heating. The low output impedance helps maintain stability in the electrical system. The Ultra-K's high efficiency coupled with the electrostatic shields provide years of cost-effective, quality noise and spike-free power.