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LINE NOTCHING ATTENUATION

General

Any electrical device that converts AC into DC for any purpose is called a static power converter (SPC). A SPC is basically a rectifier that uses power semiconductors. The most widely used SPC is the adjustable speed drive (ASD), or variable frequency drive (VFD). This device adjusts the speed of synchronous motors by varying the frequency. VFD's are becoming more and more popular because of their impact on energy savings, and because they are easier to control. Although VFD's are more efficient than the old process of controlling motors by valves, vanes, or dampers, the trade off is they have detrimental affects on power quality. VFD's produce harmonics, electrical noise, and drastic line voltage notching.

Rectification

The basic VFD uses a 6 pulse rectifier to convert AC to DC. Rectifiers are made up of diodes or silicon controlled rectifiers (SCR). Most VFD's are three phase devices. In three phase circuits, when the voltage in one phase reaches its peak and starts decreasing, another phase voltage starts increasing. There is a brief moment when the two voltages have the same magnitude, creating a momentary short between the phases. This short imposes mechanical stress on the upstream transformer and causes it's secondary voltage to drop. The result is a notch in the waveform. The number of notches per cycle is equal to the number of pulses or SCR's in the circuit. The total notch area is determined by the impedance of the circuit and the magnitude of the short circuit current. As the inductive reactance of the circuit increases, the magnitude of the notch decreases. Although too much inductive reactance increases the amount of impedance to a level where it has an adverse effect on voltage distortion. The design goal is to obtain a level of impedance that corrects for both notching and voltage distortion.

Effects of Notching

Line voltage notching as seen in *Figure 1* has disastrous affects in the commercial and industrial industries. Notching causes CPU's to shut down, laser printers to fail, synchronization problems, UPS output voltage oscillation, and some digital clocks to run fast. Most of this equipment use electronics that detect zero crossing of the voltage wave to determine its process of operation. Severe notching near the base line creates unwanted zero crossing detection, causing the electronic components to perform irregularly. The end result is component stress and eventual failure of that particular piece of equipment leading to downtime and repair cost.

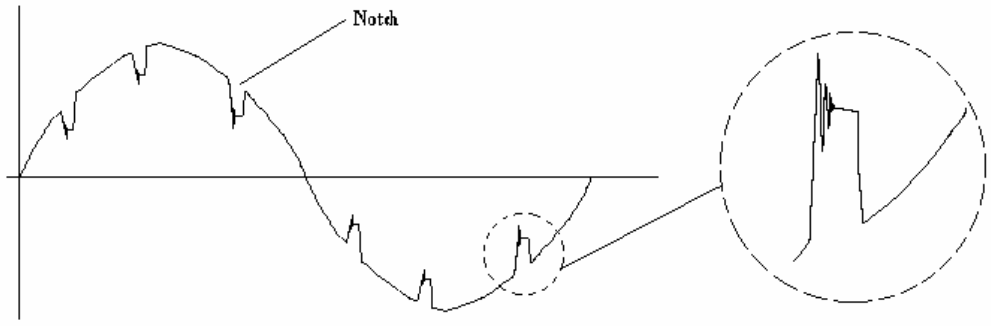

Figure 1

Solutions

The secret to getting rid of line voltage notching is inserting inductive reactance in the line. Inductive reactance tends to oppose the change in current which is directly related to the voltage. This assures a less severe notch depth and lowers the notch voltage distortion. Inductive reactance is obtained by adding inductance ahead of the notch producing equipment (VFD). This is accomplished with a low impedance isolation transformer.

Isolation transformers are basically large inductors that provide a certain amount of inductance. Low impedance transformers provide the correct amount of inductive reactance to minimize notching without distorting the waveform. These special transformers minimize the notches and also provide voltage transformation, electrical noise attenuation, and are able to cope with harmonics when the transformer is K-rated.

K-rated transformers are designed to handle the heat generated by the non-linear loads. Generic isolation transformers are unable to cope with the mechanical stress imposed by the short circuit condition of the SCR's because they are not built with the necessary bracing. This reduces the life of the transformer. What is needed is extra bracing for the coils.

Ultra-K

The *Ultra-K* manufactured by Controlled Power Company is a low impedance shielded K-rated isolation transformer. It is offered in K-factors of K-4, K-7, K-13, and K-20 to handle the heat generated by harmonics. The *Ultra-K* has double or triple shielding for optimal electrical noise attenuation, and comes with the option of a high frequency filter and TVSS for surge suppression. The *Ultra-K* provides the appropriate amount of inductive reactance for combined attenuation of line voltage notching and voltage distortion, and is ruggedly built to deal with mechanical stress.

Summary

Rectifiers found inside of VFD's create line voltage notching, electrical noise, and harmonics wreaking havoc on electronic devices. Inductive reactance is needed to minimize line notching. Low impedance shielded K-rated isolation transformers, such as the *Ultra-K*, provide the appropriate amount of inductive reactance for attenuation of line notching while attenuating electrical noise and protecting against the heating effects of harmonics. The *Ultra-K* is built strong to handle the mechanical stress imposed by the SCR's.

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