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# How to determine the best fix for VFD harmonic issues

## Application Note

Several options exist to mitigate harmonic problems in plants. Unfortunately, there is no one solution that fits all applications. Finding and choosing the correct option for your needs is the key. Otherwise, failure to reduce these unwanted electrical currents can result in problems ranging from overheating neutral conductors and transformers to inefficient operation of electronic equipment. Spurious alarms on VFD's, PLC problems and computer lock-ups are common issues resulting from excessive harmonics in a distribution system.

To determine the best solution for mitigating unwanted harmonics, start by investigating the equipment suspected of producing the bulk of the harmonic currents. Most often these are Variable Frequency Drives (VFD's). Use measuring equipment to measure and analyze the frequencies and amplitudes of the harmonics. This is much simpler than it sounds. Power quality analyzers and recorders measure and record these values, calculate the distortion of the original 60 Hz sine wave created by the harmonics, and then allow for a data download to a PC for further analysis. The key parameter calculated by the analysis equipment is Total Harmonic Distortion (THD). THD is calculated for both voltage and current. Once the measurement process is complete, the VFD manufacturer will help bring about a solution.

What is the best way, then, to go about measuring the needed values? Simply measuring the amount of THD at one point in time and then purchasing a filter to mitigate these harmonic currents is probably not the best solution. The reason: the frequency and magnitudes of the harmonic currents being created by the VFD will typically vary as the load changes on the drive. For example, a certain VFD may create many harmonics of relatively low magnitude when lightly loaded, but produce more prominent harmonic frequencies under heavy load. If harmonic data is recorded only once for a relatively short duration of time, chances are you will miss the data you need.

Filters, chokes and other devices used to mitigate harmonics are designed for certain harmonic and operational conditions. Selecting a filter to mitigate harmonics generated while the VFD is lightly loaded would most likely result in purchasing the wrong harmonic filter. You may find your most severe problems are generated at other times during plant operation.

If you want to increase mitigate harmonic issues, follow these steps:

1. Identify any suspected nonlinear equipment, (VFD's are typical), you think may be causing unwanted harmonics to flow into your distribution system.
2. Setup a power quality analyzer or recorder to record data. Connect the tool at the point at which the VFD connects to other system loads. This point is referred to as the Point of Common Coupling (PCC) in industrial facilities. While some recorders can be permanently installed, it makes sense to use a portable analyzer connected and safely placed inside of the appropriate electrical cabinet for the duration of the recording study.
3. Always ensure proper electrical safety precautions are used when connecting and disconnecting this equipment!
4. Record data for at least one plant cycle to ensure your data will capture the most severe harmonic occurrences. Obtain logs of plant operations and processes during this cycle, to compare against your recorded data.
5. Download data to a PC for analysis using the analyzer software. Then, observe the harmonics created at various times during drive operation. Compare the harmonics data to operational data in the plant. Ask questions, such as, "During what plant events and operations are the harmonics creating the greatest distortion?" "What is the output load of my VFD at that point?" This will most likely be the VFD operational point at which you will correct for harmonics.
   IEEE recommends that Total Harmonic Distortion of the fundamental 60 Hz frequency at this PCC does not exceed 5 % for voltage. Any THD values throughout the plant operating cycle approaching these limits should be carefully considered for corrective action.
6. If possible try to correlate any plant problems experienced during the recording of harmonic data with the THD values and harmonic levels at that time. For example, if a PLC produces a spurious high temperature alarm on equipment at the same time the load changes on the VFD and a large motor starts in the plant, you may have just uncovered your harmonics problem! A filter designed for that particular VFD load may be your answer.
7. Finally, to select the best harmonic mitigation solution, work with the manufacturer of the problem VFD. Through a series of questions and engineering analysis your VFD supplier will help you determine and supply you with the best solution to mitigate the unwanted harmonics.

Harmonic frequencies are identified by their Harmonic Number. The 1st Harmonic is the fundamental system frequency of 60 Hz. Sequence indicates the direction of magnetic field (phasor) rotation.

| Harmonic (partial list) | Frequency (Hz) | Sequence |
|---|---|---|
| 1 | 60 | Positive |
| 2 | 120 | Negative |
| 3 | 180 | Zero |
| 4 | 240 | Positive |
| 5 | 300 | Negative |
| 6 | 360 | Zero |
| 7 | 420 | Positive |
| 8 | 480 | Negative |
| 9 | 540 | Zero |

## Typical harmonic effects:

All harmonics tend to distort the original fundamental 60 Hz sine wave creating operational problems with electrical equipment such as, PLC's, automation equipment, machine tools, and computers.

Odd triplen harmonics, (3rd, 9th, 15th, etc.), do not cancel each other, but add together in neutral conductors of 3-phase, 4-wire systems to cause overheating in panels, neutral conductors, terminations and transformers.

3rd harmonics generated by the transformer secondary loads in the 3-phase delta-wye distribution transformer are reflected back into the delta primary resulting in circulating primary currents and overheating.

5th harmonics of sufficient magnitude result in motor inefficiencies and overheating. The negative sequence may produce sufficient counter-torque to cause excessive motor vibration.

Generalized harmonic effects include: unexplained operation of protective devices, audible noise interference on telephone circuits, blown fuses on power factor correction capacitors and, erratic operation of generators with solid-state controls.

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Printed in U.S.A. 7/2009 3511184A A-EN-N

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