Troubleshooting the Most Common Power Quality Problems

Application Note

Tools and tips for issues with voltage distortion and harmonics

Troubleshooting is a systematic process of finding and eliminating problems. To the untrained eye, problems in electrical distribution systems may not be recognizable as power quality problems. For example, a tripped thermal-magnetic circuit breaker typically indicates a short circuit, ground fault, or overload. When no immediate problem is apparent, it may be written off as s "just an old breaker that needs replacing."

Instead, the power quality technician or engineer asks, "Maybe we should look at the types of loads on the system and monitor for harmonics; perhaps we should monitor for unbalance?"

Knowing and recognizing the most common power quality symptoms and how to troubleshoot them is a first step in solving power quality issues.

What tools do you need for the job?

As with any troubleshooting task, you need the right tools. When it comes to power quality troubleshooting, these tools may not be what you think.

First, you need a good set of up-to-date drawings. Then, use a power quality analyzer to measure and record the specific parameters associated with power quality. Other tools, such as a data logger, thermal imager, infrared thermometer, and recording digital multimeter, can also aid in troubleshooting.

A Fluke 435 Series II Power Quality and Energy Analyzer in use. Power quality analyzers are one of the necessary types of tools for troubleshooting power quality problems.

What kinds of problems will you find?

Common power quality problems are grouped into two broad areas: voltage anomalies and harmonic distortion issues. Voltage anomalies can cause several problems, many easily corrected. The key is to spot the symptoms.

Voltage dips or sags are responsible for up to 80 percent of all power quality issues. A dip or sag occurs when the system voltage drops to 90 percent or less of nominal system voltage for a half-cycle to one minute. Common symptoms of dips include incandescent lights dimming if the dip lasts more than three cycles, computer lockup, spurious shutdown of sensitive electronic equipment, data (memory) loss on programmable controls, and relay control problems.

To troubleshoot potential dip problems, begin by monitoring at the load where the dip symptoms first occur. Compare the time of the equipment's operational failure to the time at which the voltage dip occurred; if there is not a correlation, the problem is most likely not voltage dip. Continue troubleshooting by monitoring farther upstream until the source is located. Use plant one-line drawings to help determine whether starting large motors is creating the dip, or whether there are other sudden increases in current requirements in the plant.

Voltage swells or surges occur only about half as often as dips. However, increases in system voltage for short periods up to a cycle or more can cause problems. As with all power quality problems, you must monitor parameters for a period of time, then observe and interpret.

Symptoms of swells often include immediate failure of equipment, typically the power supply section of electronics. However, some equipment failures may not occur immediately, because voltage swells can occur over a period of time and prematurely break down components. If analysis of electronic equipment reveals faulty power supplies, monitor voltage trends on the feeders and

The Fluke 1750 Three-Phase Power Quality Recorder is one of the tools that can be used to help detect voltage unbalance. In reality, voltage differences between phases vary as loads operate. However, motor or transformer overheating, or excessive noise or vibration, can merit troubleshooting for voltage unbalance.

branch circuits feeding this equipment. Where possible, compare failure rates of similar equipment operating on portions of systems known not to be experiencing swells.

When analyzing power quality survey results, look for any sudden line-to-ground faults on a single-phase line. This type of fault causes the voltage to suddenly swell on the two non-faulted phases. Large plant loads suddenly dropping offline, and power factor correction capacitor switching, can also cause voltage swells.

Voltage transients can cause symptoms ranging from computer lockups and damaged electronic equipment to flashover and damaged insulation on distribution equipment.
Transients, sometimes referred to as spikes, are substantial increases in voltage— but only for a matter of microseconds. Lightning strikes and mechanical switching are common causes. Equipment failure during a storm is often rightfully attributed to transients and no power quality monitoring is performed.
Other causes of transients include switching of capacitors or capacitor banks, reenergizing systems after a power failure, switching of motor loads, turning off or on fluorescent and HID lighting loads, switching transformers, and sudden stoppage of certain equipment. For these transient conditions, monitor at the load and correlate equipment operational problems or failure with distribution system events.

Normal arcing across contacts by interrupting large loads can be a cause of transients. Use the facility one-line to move the monitoring farther upstream in the distribution system until you find the source.

Voltage interruptions can last anywhere from two to five seconds or more. The symptom is usually quite simple: the equipment stops operating. Interruptions for longer than five seconds are typically referred to as *sustained interruptions*. Most motor control circuits and process control systems are not designed to restart even after a brief interruption of power.

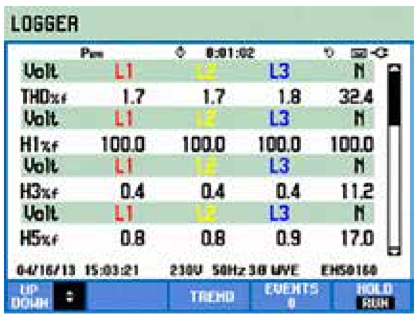
If a voltage interruption occurs when equipment is unattended, the cause of the equipment shutdown might not be properly identified. Only monitoring equipment and correlating the time of any power interruptions to the time of equipment issues will help identify voltage interruptions.

Voltage unbalance is one of the most common problems on three phase systems, and can result in severe equipment damage, yet it is often overlooked. For example, a voltage unbalance of 2.3 percent on a 230 V motor results in a current unbalance of almost 18 percent, causing a temperature rise of 30 °C. While a digital multimeter (DMM) and some quick calculations can be used for averaging voltage readings, a power quality analyzer provides the most accurate information about unbalance.

Unbalance can occur at any point throughout the distribution system. Loads should be equally divided across each phase of a panelboard. Should one phase become too heavily loaded in comparison to others, voltage will be lower on that phase. Transformers and three-phase motors fed from that panel may run hotter, be unusually noisy, vibrate excessively, and even suffer premature failure.

Monitoring over time is the key to capturing unbalance. In a three-phase system, the maximum variation in voltage between phases should be no more than 2 percent (the Vneg % value on the analyzer), or significant equipment damage can occur.

Harmonics are voltages and currents whose frequency is said to be an integer multiple of the fundamental frequency. For example, the third harmonic is the voltage or current that is occurring at 180 Hertz (Hz) in a 60 Hz system (3 x 60 Hz = 180 Hz). These unwanted frequencies cause numerous symptoms, including overheating in neutral conductors and the transformers supplying these circuits. Reverse torque creates heat and efficiency losses in motors.



When each harmonic is identified and compared to the fundamental 50 Hz frequency in this case, you can make decisions about the severity of each harmonic that appears in the system. For example, in this power quality analyzer screenshot, on Phase A, the total harmonic distortion is 1.7 %. Of this total the 3rd and 5th harmonic are 1.2 % of the total (0.4 % and 0.85 % respectively)

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The most severe symptoms created by harmonics are typically the result of the harmonics distorting the fundamental 60 Hz sine wave found in facilities. This sine wave distortion results in improper operation of electronic equipment, spurious alarms, data losses, and what are often reported as "mysterious" problems. When symptoms of harmonics occur, troubleshoot by observing total harmonic distortion (THD). Significant increase in THD under varying load conditions warrants a percentage comparison of each individual harmonic current level as compared to the total fundamental current flow in the system. Knowing the effects created by each harmonic current and comparing them to identified symptoms will aid in troubleshooting. The source of the harmonic must then be isolated and corrected.

Summary

Voltage problems and the creation of harmonic currents are the two broad areas under which power quality problems occur. Dips and swells, voltage transients, power interruptions, and voltage unbalance all can be monitored, analyzed, and compared to equipment operation histories to determine the cause and severity of the power quality problem. The same can be done with the various harmonic currents in a system.

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