

# HOW MANY POWER QUALITY PROBLEMS IN LARGE FACILITIES ARE CAUSED INTERNALLY

The costly effects of power quality problems are most clearly seen in large industrial and commercial facilities when equipment or products suffer damage. Not only is there downtime for the affected equipment, but there are also repair and replacement costs. In addition, loss of product means expensive rework, loss of productivity, and higher overhead costs.

While most people think that power quality problems only affect sensitive electronic components, other aspects, in particular harmonic distortion, also affect normal loads such as motors, and transformers. The entire system, from transmission, to distribution, to utilization, is now subject to damage and destruction from various power quality phenomena.

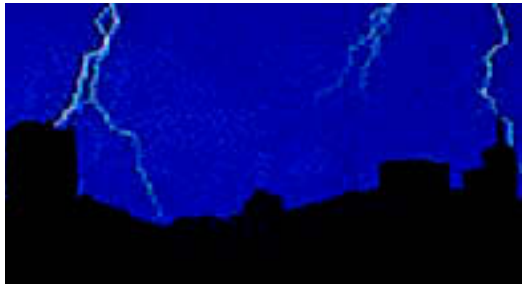
By far the majority of power quality problems happen on a customer's premises. Problems such as equipment damage, loss of product or productivity, and downtime can usually be traced to something happening within the business itself. All types of power disturbances are found on a customer's premises in varying degrees.

## Transients

Transients generated inside a building or office are very common. They come from three sources — electrostatic discharge (ESD), device switching, and arcing.

ESD is like a very small lightning strike. Static electricity builds up between two dissimilar materials. The resulting attraction force is what we commonly call static cling. If the electric field becomes large enough, an arc occurs, discharging the buildup. Humans usually don't feel a static "zap" unless the voltage is above about 1500 volts. But voltage levels as low as 500 volts can disrupt and damage electronic components.

Reactive loads turning on and off generate spikes whether these loads are heavy motors or copy machines. The term "reactive load" is generic. Basically, any piece of equipment can cause impulses. The compressor motor in a soda vending machine is one example.



HVAC and refrigeration equipment can also be culprits.

Another source of transients is arcing. Arcing occurs when there are poor or degraded connections in the wiring system. Arcing is almost always associated with other disturbances. Momentary interruptions, higher voltage distortion, and sags are likely companions to arcing.

Most of the time it is difficult to determine where transients come from. Wherever they originate, most of the solutions are similar. TVSS systems and power conditioners, when properly specified and installed, can reduce transients to non-damaging levels. These devices are usually plugged into a standard outlet, and sensitive devices plugged into them.

By troubleshooting and diagnosing the transient activity, it is possible that the source of the spike can be located. If it is, then three more options exist.

First, if the offending device is failing or there is a bad connection somewhere, get it fixed. Eliminate the source rather than attempt to protect everything else.

Second, try stopping the transient at the source if it cannot be eliminated. Place a power conditioner on the vending machine, for example. This will prevent the normal spike of the compressor motor from traveling to other loads.

Third, relocate the offending device or the sensitive device. The normal wiring system is a great transient reducer. It is far cheaper to address these problems at the source, or side-step them altogether, than to invest time and money into device-based solutions.

## Voltage Sags & Swells

Sags and swells are short duration

changes in the RMS level of the voltage. They typically last for less than a few seconds. Basically, sags and swells occur whenever there is a sudden change in the load current. Ohm's Law tells us that changes in the voltage occur when a changing current interacts with system impedance. If there is a sudden increase in current due to a load turning on, then a sag will result. On single phase circuits, a corresponding neutral-ground swell also occurs. If a load turns off, it produces a momentary increase, or swell, in the voltage. The greater the system impedance, the greater the magnitude of the disturbance.

Swells, including N-G swells, can easily damage equipment. Power supplies controlling all manner of devices are the most common victims of a swell.

Sags, however, do not directly cause damage. They initiate problems indirectly. For example, a sag may cause a laser CNC machine to restart, thus damaging the product it was making.

When internal voltage instability is a problem, the first step in solving it is to identify what is failing or being damaged and why. Where is the load causing the changing current? If that load or group of loads can be located, then a solution may be as simple as relocating either the victim or the culprit.

Since sags and swells are closely dependent on the wiring impedance, another possible solution is to increase the wire size in the distribution path. Increasing the size decreases the impedance, ultimately reducing the magnitude of the disturbance.

If these steps are not possible, then you must introduce voltage regulation to maintain voltage stability and protect

**Continued on page 32**

**Continued from page 31**

equipment.

Voltage regulators may be stand-alone devices, or used with other technologies such as transformers to add to their capabilities. Once again, please remember that to properly provide a solution means you must understand the problem and ensure the solution is appropriate.

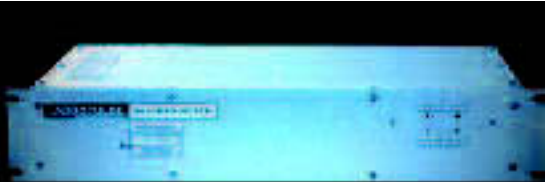
**EMI**

Electromagnetic interference, or EMI, is a high frequency, low voltage signal on the power lines. EMI is seldom damaging in and of itself. But, like voltage sags, EMI indirectly causes damage and loss of product.

EMI can cause disruption in sensitive devices. An example would be in a process control computer regulating gasoline dispensing. EMI may confuse the computer, causing it to pump more gasoline than requested.

Should EMI be a problem, there are three typical solutions, the last one being very complex and expensive. The first solution is to locate where the interference is coming from and remove or relocate the victim or culprit. The second is to isolate the victim or culprit by using an EMI filter.

The final solution is very complicated. It is possible that the interference in the power lines began as interference in the air, or what is called radiated EMI. If this is the case, then steps must be taken to identify and locate the source, identify its frequency, and then provide protection — this protection often takes the form of placing a conductive shield around the effected device. Obviously this is complex and costly.



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**Harmonic Distortion**

Harmonic distortion is found in both the voltage and the current waveform. Most current distortion is generated by electronic loads, also called non-linear loads. These non-linear loads might be single phase loads such as point-of-sale terminals, or three-phase as in variable speed drives.

As the current distortion is conducted through the normal system wiring, it creates voltage distortion according to Ohm's Law. While current distortion travels only along the power path of the non-linear load, voltage distortion affects all loads connected to that particular bus or phase.

Current distortion affects the power system and distribution equipment. It may directly or indirectly cause the destruction of loads or loss of product. From the direct perspective, current distortion may cause transformers to overheat and fail even though they are not fully loaded. Conductors and conduit systems can overheat, leading to open circuits and downtime.

On three-phase wye systems, current distortion causes higher than expected currents in shared neutrals. A shared neutral is one that provides the return path for two or three phases. Currents as high as 200 per cent of the phase conductors have been seen in the field. This large level of current can easily burn up the neutral creating an open neutral environment.

This open neutral creates voltage swells and overvoltages. These voltage conditions easily destroy equipment, particularly power supplies.

Another indirect problem introduced by current distortion is called resonance. Certain current harmonics may excite resonant frequencies in the system. This resonance can cause extremely high harmonic voltages, possibly damaging equipment.

There is one additional comment about current distortion. When the current is non-sinusoidal, our conventional ammeters and voltmeters will not respond accurately. To accurately measure currents that are harmonically distorted, you must use a True-RMS meter. This applies equally to distorted voltages.

Voltage distortion, on the other hand, directly affects loads. Distorted voltage can cause motors to overheat and vibrate excessively. It can also cause damage to the motor shaft. Even non-linear loads are prey to voltage distortion. Equipment ranging from computers to electronically-ballasted fluorescent lights may be damaged by voltage distortion.

If damage occurs due to current distortion, except for high neutral current, then one solution is to reduce the distortion. There are three methods for this. First, a passive filter can be used to reduce the current from one or two specific harmonics.

In the second method, an active filter reduces all the harmonic currents. It is more costly and complex to use, but it works better than passive filters.

The third method involves the use of transformers. Delta-wye transformers reduce certain harmonics, particularly what are called zero sequence harmonics. Zig-zag transformers can also be used to reduce zero sequence harmonics, but without changing the system type between delta and wye. In addition, they can help reduce high neutral currents.

If there is concern that these special transformers or the regular distribution transformers may overheat, then transformer derating, or the use of K-rated transformers, is recommended.

If high neutral currents are the culprit, then the first step is to eliminate shared neutrals wherever possible. Where this cannot be done, try oversizing the neutral wire so it won't overheat. If this doesn't work, then the distortion must be

reduced as described above.

There are two ways to reduce voltage distortion. Remember that internal voltage distortion is the result of the business's non-linear loads interacting with the wiring. The first way to reduce the distortion is to reduce the harmonic current. The second way is to reduce the impedance of the wiring. This is done by increasing the size of the conductors.

Where the total voltage distortion is the sum of internal and external distortion, these techniques reduce the internal contribution.

### Power System and Large Industrial Facilities

Large industries require large amounts of power. To satisfy this need, the utility typically provides a higher service voltage to these industries than they do to smaller businesses. Service voltages ranging from 12 kV to 138 kV are common in heavy C/I facilities. This higher voltage changes the complexity of what goes on at the service entrance.

Instead of simply being the point of marriage between the utility and the facility, several substation type activities take place at the service entrance. Voltage regulation and power factor correction capacitor banks may be used to control the incoming voltage.

Large facilities commonly have two sets of distribution lines brought in from the utility. This enhances power reliability. Facility switchgear selects which line the building connects to. When these control systems are operated, momentary interruptions and transients are generated and sent into the building.

Due to this increased complexity, it is also common to find some form of power monitoring or control equipment at the service entrance. This equipment may range from simple strip chart voltage recorders, to advanced digital monitoring systems, to Supervisory Control And Data Acquisition systems, known as SCADA. While all of these may help prove the presence of power disturbances, they also require the expertise to know how to use them and their data effectively.

By the very nature of large industries, the larger the overall power system, the greater the risk for error and failure. Problems can easily arise from having so many conductors, panels, transformers, and even service drops. The hot conductor for a load may come from one panel while the neutral comes from another. Loads from different panels may all share the same neutral. Wires get crossed, panel schedules quickly become outdated, recommended color codes are ignored, and what is expedient usually replaces what is appropriate. The larger the facility, the more critical it is to comply with Code.

### Grounding

Anytime sensitive loads are used, great care should be taken to ensure that the wiring and the grounding are appropriate. Every aspect of the power system should meet, or exceed, code requirements.

The impact of improper grounding cannot be understated. Poor grounding can significantly affect the performance and reliability of devices such as process control computers, variable speed drives, and electronic machinery.

Proper grounding practices take on a whole new dimension when ensuring good ground connection between multiple service drops. Ground loops between a computer on one system and the control mechanism it communicates with on another must be prevented.

### Multiple Buildings

The fact that many businesses are housed in multi-build-

ing facilities makes matters more complex because each building may not have its own service entrances. Some may be fed through outdoor branch circuits from these buildings. In these situations, grounding and voltage stability become key areas of concern.

If data communication between buildings is required, then the use of modems, or better yet, fiber-optic cables, will prevent ground loop problems. If modems or direct cable connections are used, be sure to provide data line transient protection.

Where modems or direct cable connections exist, take care to minimize picking up high frequency interference (EMI) on the signal or ground conductors, or on the outer cable shield itself. This, coupled with grounding concerns, can become so troubling that many experts strongly discourage using direct cable connections between buildings.

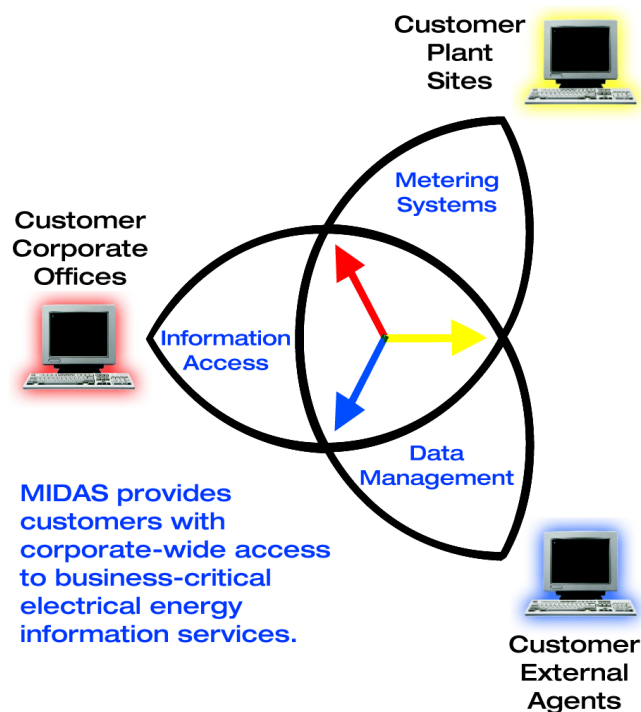
If wiring is found that violates the Code, it should be fixed immediately. Often, bringing the electrical system up to Code resolves many power quality problems.

If poor grounding is a concern, the use of isolated ground receptacles, isolated ground busses in the panel, and isolated ground conductors will alleviate most problems.

If an isolated ground conductor is used, it should be run in the same raceway as the power conductors, and terminated at the neutral-to-ground bond of the power source. This source is the transformer or service entrance directly feeding the loads.

*With material from the Niagara Mohawk Power Corporation website. For more information visit [www.niagamohawk.com](http://www.niagamohawk.com). ET*

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