A Field Engineer's Guide to Power Quality Problems

How power line noise gets into and damages computerized equipment.

Plugging any piece of modern electronics directly into the commercial AC power system means connecting it to all kinds of transient noise, such as spikes, surges, notches and other electrical disturbances. This power pollution downgrades the performance and shortens the life of any system exposed to it.

What are the sources of electrical disturbances?

The Utility Grid

No matter where you go, the commercial AC power system is polluted with spikes, surges and other disturbances generally called "electrical noise." Power-line noise has always been a part of the electrical utilities. It is a natural by-product of the distribution and use of electric power.

If demand for power increases beyond the capacity of the utility company's generator in one area, or if heavy industrial use overloads the power system, the corrective actions by the utility company can cause spikes and transients to appear on the power line.

Lightning

Lightning strikes are not the most common source of power-line noise, but they are certainly devastating. Even when the strike is many miles away, surges and spikes measuring thousands of volts may show up at your electrical outlets.

In-House Electrical Equipment

Dramatic events like lightning may get all the attention when it comes to power line disturbances, but on a day-to-day basis, much more electrical noise is created right in your building by noisy electrical loads.

Copiers, heating, ventilating and air conditioning, coffee makers, power tools, vending machines, and the like all throw noise back into the electrical system when they operate. Computerized systems and their peripherals are frequently part of the problem. Disk drives and printers, for example, use motors that often have large start-up current requirements that can cause transients to travel to and from the peripheral.

Why are today's systems so much more sensitive than they used to be?

Changing Power Supply Technology

Today's computers use switchmode power supplies. Because switchmode power supplies operate by switching on and off rapidly and draw a large amount of current during each cycle, they can generate a lot of noise if they are not connected to a very low-impedance source of power.

ONEAC®
A CHLORIDE POWER PROTECTION COMPANY
ONEAC Corporation • 27944 N. Bradley Rd. • Libertyville, IL 60048-9700 • (847) 816-6000 • Fax (847) 680-5124 • www.oneac.com
TT0402 Rev. -

tech tips

The Complexity Of The Chips

Semiconductor chips themselves are more vulnerable to noise than they used to be. In each new generation, more transistors are packed into the same microscopic space. As the individual transistors get smaller, the amount of electrical overstress they can survive gets lower and lower. Modern semiconductor devices can now be disrupted by as little as 1/2 volt of electrical noise. Over 10 volts of noise starts to destroy them.

The vulnerability of computerized systems to power problems is well-documented. Several studies have shown that up to 80% of all computer failures are power-related. Removing noise from the electrical environment is one of the most important things you can do to improve a system's reliability.

Over their lifetime, we expose computerized systems to higher levels of disruption, degradation and destruction by connecting them directly to raw AC power. Power conditioning, to eliminate electrical noise, is the best way to ensure uninterrupted performance and the longest life from electronic systems.

What does effective power conditioning do?

There is a lot of confusion over the meaning of the words “power conditioning” or “power conditioner.” People confuse power conditioners with other devices, such as surge suppressors, voltage regulators, spike arrestors, EMI/RFI filters and so on. Most of these devices are designed to treat one or two symptoms of noisy power. A true power conditioner, however, should protect your system completely from damaging power-line disturbances.

What are the four basic power conditioning functions?

There are four basic power conditioning functions that are essential in order to give your system the total protection it needs.

1. Reducing All Electrical Disturbances

Most computerized systems have some level of noise immunity built into them. But the equipment manufacturers can’t predict how well their noise rejection will perform in the field because of the wide variety of system configurations in which their equipment is used. Add-ons, accessories and peripherals all change a system's sensitivity to electrical noise. Even more unpredictable is the electrical environment in which the equipment will have to perform.

In order to be effective under all circumstances, a power conditioner must reduce the worst possible electrical noise levels to levels that are harmless to semiconductors before entering the system. Only then is it certain that systems are protected. Anything less is a gamble.

2. Providing a Single-Point Reference Ground

Noise on the ground wire is either directly or capacitively coupled into the systems logic ground. More than half a volt of noise here will almost surely disrupt the system's operations. It is, therefore, crucial to provide a clean, single-point, all-purpose reference ground.

This may only be accomplished with a transformer-based power conditioner that safely and legally ties together line, neutral, and ground on the secondary at noise frequencies.

3. Preventing Interaction Between Noise Generating Loads

We mentioned that the switching power supplies used in today's computerized systems and peripherals sometimes create a fair amount of noise themselves. This can be a problem if the noise generated by the printer, for example, finds its way into the computer plugged in right next to it.

The situation will be made worse if the computer and printer are both plugged into an older-technology power conditioner. Ferroresonant and high-isolation type power conditioners are not compatible with systems using switching power supplies. The high output impedance of these older design conditioners will act like an induction coil, turning low-level switching noise into higher level noise that travels into everything connected to the conditioner.

A power conditioner must, therefore, have a very low-impedance output that prevents disruptive interaction between noise generating loads.

4. Providing Peak Current On Demand

Another characteristic of switching power supplies is that they have a very high current draw during the portion of each AC cycle that they turn on. Ferroresonant and high-isolation conditioners cannot meet these peak current demands unless they are considerably oversized for the job. Oversized units cost more and are less efficient, meaning higher electric bills, among other problems.

A low-impedance conditioner, on the other hand, will provide peak current on demand, without having to be oversized.

The four power conditioning functions that we have covered here are all basic features that are essential to any truly effective power conditioner. Any conditioner that cannot meet this standard for performance will only offer partial protection, and, in many cases, will be incompatible with your system.

How to recognize power-related problems

Power-line noise causes Disruption, Degradation, and Destruction - the 3 Ds. Some problems may be intermittent, and are almost impossible to trace on a service call. This results in frustration for the service technician and the end user. Other times, parts may be irreparably damaged and require replacement.

Disruption

Even low-level electrical noise will sometimes cause a system to “hang” or “lock-up” causing a loss of all the data in memory. More common than a “lock-up” is receiving error messages. The most common messages concern disk drive errors. Communications between the CPU and peripherals are also very vulnerable to noise, particularly if they are placed some distance apart. Garbled printouts, for example, are a common symptom of power problems.

Some electrical noise won’t cause the computer to crash, but will change or erase data in memory. This results in problems such as inconsistent results, erroneous calculations, lost or changed letters or words, missing paragraphs, missing files, and more.

Degradation

Regularly occurring electrical noise causes hardware degradation. Electrical overstress will gradually eat away at the microcircuitry until it no longer performs consistently. The symptoms will remain the same, but they will last longer, so there is a greater chance they’ll be caught on a service call.

Destruction

After being exposed for a long time to low-level noise, or after a catastrophic event like a lightning strike, some or all of the hardware may fail completely. Then the problem is finding the true extent of the damage. Even after all damage is repaired, there will probably be additional failures for months as other weakened parts slowly give up.

tech tips

How do I determine if a location has poor power quality?

A traditional line monitor can be used to record the site's electrical noise activity, but such devices are expensive, time-consuming to use and the results are often difficult to interpret.

An easier, more direct approach is to use the ONEGraph® to monitor power. The ONEGraph allows electrical disturbances to be observed on the screen as they happen, or will also monitor the power over a period of time and record electrical noise activity on its journal tape for interpretation at the conclusion of the test. The ONEGraph will clearly illustrate if the power quality is poor.

How do I illustrate that power conditioning is the solution for electrical noise?

Even after the ONEGraph test, the decision to install power conditioning may be a difficult one for the end user to make. You can help the end user realize the benefits of power conditioning, right there, on the spot, by simply installing a power conditioner to demonstrate how power conditioning reduces noise to levels that are safe for electronic systems. You can also help the end user here, if you point out the business value of power conditioning. Maximum System Uptime, Lower Service Costs, Reduced Spare Parts Inventory, Maximum Productivity, Longer Equipment Life, Increased Customer Satisfaction — all of which translate to increased profits for the end user's business. This simple demonstration of power quality and the power conditioning solution will usually convince even a skeptic.