

# Power Quality Issues for Large Commercial Facilities: Voltage Surges and Spikes

As businesses, we don't think twice about conditioning and filtering incoming air or water for our buildings, or about setting up filters for computer and e-mail security. Why not consider the same treatment for electrical equipment? Service reliability and quality of power have become growing concerns for many businesses, because they depend on power to run their operations. Few businesses today are immune to the impact of power problems. You may want to take charge of protecting and conditioning your electronic equipment from the effects of power surges, sags, and other disturbances.

## The Power Quality Bottom Line

Electric utilities continuously strive to improve their systems so that they provide the most reliable and consistent electric power possible. In the course of normal utility operations, however, voltage will inevitably fluctuate as loads come on to or leave the power system or as the utility switches among various sources of electricity supply. With the advent of microprocessor controls on equipment, even a deviation of a couple of volts is enough to cause that equipment to reset or fail, yet most utility tariffs call for specified voltage levels plus or minus 5 or even 10 percent.

The bottom line is that it is not possible for a utility to maintain perfectly constant voltage 100 percent of the time, because many power quality (PQ) events occur for reasons that have nothing to do with the utility. Lightning strikes, storms, motor-vehicle accidents, falling tree limbs, and even squirrels can cause major power disruptions and surges. Utilities can provide "four nines," or 99.99 percent reliability, which translates into approximately 53 minutes of total outage time per year, and that may be as good as it gets. The only way to improve reliability beyond that level is to focus

on sensitive equipment and potential problem areas inside a specific facility.

Subtle PQ problems often originate within the facility's walls and can usually be traced to things like the starting and stopping of refrigeration compressors or air-conditioner motors, circuit overloads, harmonic currents created by electronic equipment, or grounding and wiring problems. Industry experts estimate that 70 to 85 percent of all voltage transients are generated within commercial and industrial facilities and not by some problem on the grid.

But whatever the origin of an electrical disturbance, the outcome can be expensive, distracting, and downright irritating.

## Should I Install Surge-Suppression Devices?

When electronic equipment is exposed to a surge or a spike, your lights flicker, equipment gets disrupted or locks up, garbled data may come up on computer screens, and system components such as power supply rectifiers or integrated chips may deteriorate.

If you have equipment that is sensitive, vital to your operations, or expensive, or that contains critical data, then you should strongly consider a surge-protection device. If you incur significant outage costs from lost productivity, lost business opportunities, or other outage-related costs—such as damaged equipment, new materials, repairs, and restarts—then you should definitely protect your business from PQ disruptions.

The purpose of surge-suppression or surge-protection devices is to mitigate or minimize the impact of surges or spikes so that they will not damage equipment or interrupt processes. However, these devices are *not* designed to lower energy consumption or electrical demand. Be leery of any

## Power Quality Glossary

Although specialists use complex equations for precise descriptions and analysis, the following definitions are adequate for most discussions with your local utility account managers, distribution engineers, and PQ consultants and vendors.

- *Harmonic distortion.* Continuous or sporadic distortions of the 60-hertz (Hz) voltage sine waveform, usually caused by microprocessor-based loads in the building such as computer power supplies, lighting ballasts, and electronic adjustable speed drives. Harmonics can also be transmitted from an energy user down the block. These can cause telecommunications or computer interference; overheating in motors, transformers, or neutral conductors; decreased motor performance; deterioration of power-factor correction capacitors; or erratic operation of breakers, fuses, and relays.
- *Interruption, momentary.* A very short loss of utility power that lasts up to 2 seconds, usually caused by the utility switching operations to isolate a nearby electrical problem.
- *Interruption, temporary.* A loss of utility power lasting from 2 seconds to 2 minutes, caused by a nearby short circuit due to something like animals, wet insulators, or accidents. Corrected by automated utility switching.
- *Long-term outage.* A loss of utility power lasting more than 2 minutes due to major local, area, or regional electrical events.
- *Noise.* Sporadic voltage changes consisting of frequencies higher than the normal 60-Hz power frequency due to any number of causes, including arc welders, loose wiring, and nearby radio and TV transmitters.
- *Sag.* A short-term decrease in voltage lasting anywhere from milliseconds up to a few seconds. Sags starve a machine of the electricity it needs to function, causing computer crashes or equipment lock-ups. Usually caused by equipment start-up—such as elevators, heating and air-conditioning equipment, compressors, and copy machines—or nearby short circuits on the utility system.
- *Spike.* A very brief (nanoseconds to milliseconds) change in voltage ranging from tens to thousands of volts. Can be produced by utility and customer equipment operations, nearby lightning strikes, falling tree limbs on power lines, and even static discharges.
- *Surge.* A short-term increase in voltage, lasting up to a few seconds. They are due either to customer equipment operation, such as air conditioners or motors switching on and off, or to utility activities, such as capacitor switching.
- *Transient.* A sudden momentary change in voltage. Also called a spike.
- *Undervoltage.* A decrease in voltage lasting longer than a few seconds. Usually due to undersized wiring at the facility but can also be caused by overloaded utility circuits and result in brownouts.

claims of energy or demand savings from surge-protection devices.

### How Do I Protect Against Voltage Surges and Spikes?

Consider protecting your equipment from surges or spikes at the following locations in your facility:

- At the service entrance, where utility lines come in. This is a crucial first line of defense from the outside and will divert major incoming surges.
- At electrical distribution panels, where hard-wired devices help suppress internal voltage transients from spreading to other circuits in your facility.
- At telecommunications and cable local area network circuits, which are extremely vulnerable to voltage transients.
- At branch-panel locations that feed sensitive equipment like fire, security, or energy management systems.
- At the point of use, where sensitive equipment connects to electrical outlets.

A combination of panel-mounted—also called “hard-wired”—and plug-in devices will provide the greatest level of protection. The capabilities and performance of surge-protection devices vary widely by type, size speci-

cations, and manufacturer. In many cases, devices are designed for specific applications and should be used accordingly. You can request test results from the manufacturer that verify the product's claimed surge ratings and then match the product to your application. It is important to remember that proper installation is critical to performance. Good sources of information include your utility representative, standards C62.11 and C62.41 from the American National Standards Institute (ANSI) and the Institute of Electrical and Electronics Engineers (IEEE), Underwriters Laboratories (UL) 1449 recommendations, and qualified installers.

Plug-in surge suppressors provide affordable but somewhat limited protection for sensitive equipment. Often designed as power strips with multiple outlets, they protect only the devices that are plugged into them. Not all power strips provide adequate surge protection. Look for devices that are UL 1449 Listed, meaning that samples have been found to meet the Underwriters Laboratories standard for surge suppressors. Further, an Industrial Organization for Standardization (ISO) 9001 rating adds assurance that the manufacturer is in compliance with the international quality system standard.

Associated with the UL listing is a number indicating the maximum voltage the suppressor will allow your equip-

ment to be exposed to. The lower this "let-through" voltage rating is, the better the surge-suppression device will work. Also note that plug-in surge protectors can degrade over time, depending on the strength and frequency of surges that they receive. Higher-quality units have indicator lights to notify the user when maintenance or replacement is necessary.

**Table 1** shows some selection criteria for plug-in surge suppressors. The more effective units combine several different surge-protection components. Sine-wave tracking is advisable only if you have equipment that is particularly sensitive to harmonic distortion. Note that many uninterruptible power supplies (UPSs) are not designed to provide surge protection, and even the UPSs themselves should be protected.

Not all solutions to surges and spikes require the addition of protection equipment. Your building's wiring may not be sufficient to handle current operating loads and may need to be upgraded. Certain equipment loads that contribute to voltage transients may have to be isolated and moved to separate circuits. And, lastly, device grounding may be inadequate or redundant; by using connections to a common ground, unsafe conditions are avoided, and short circuits can be quickly cleared by protective equipment.

**Table 1: Choosing plug-in surge suppressors**

The more-effective surge-suppression units combine several different protection components. Sine-wave tracking is a sophisticated feature that is advisable only if you have equipment that is particularly sensitive to harmonic distortion. And the lower the device's let-through voltage rating is, the better it will work.

	Surge-suppression rating	Durability	Protection method	Additional features
Good	UL Listed at 500 volts	1,000 surges at 2,000 volts and 1,000 amps	Surges are diverted to ground.	None.
Better	UL Listed at 400 volts	1,000 surges at 4,000 volts and 2,000 amps	Surges are absorbed and not diverted to ground circuit.	Indicator lights (showing that surge suppression is working, not just that the device is plugged in).
Best	UL Listed at 330 volts or below	1,000 surges at 6,000 volts and 3,000 amps	Surges are absorbed by multiple, redundant internal components.	Data-port protection, sine-wave tracking, phone/fax/coaxial plug-ins, metal housing, space to accommodate transformer plugs, and warranties offered to cover damage to equipment connected to the suppressor.

Note: UL = Underwriters Laboratories

Source: Platts

## Do I Need Protection from Lightning?

A lightning strike—which packs as much as 100 million volts and can hit with a degree of force comparable to 10 tons of TNT—can easily damage buildings, destroy equipment, and kill or injure people.

If you have facilities that are located in areas prone to storms and lightning, or if you have sensitive electronic equipment, consider installing a UL-certified lightning-protection system that complies with current nationally recognized standards (ANSI/IEEE standard C62.41-1991 and C62.45-1992) and other electric codes. Lightning-protection systems consist of lightning rods that are connected by heavy aluminum or copper cables to grounding equipment (usually metal rods driven into the earth), providing a path for the lightning current to travel safely to ground.

Even though large surges—above 70 kiloamperes (kA)—are rare, a service-entrance surge-protection rating of 100 kA 8/20  $\mu$ s (a measure of energy tolerance) should provide sufficient protection for most exposed areas. Plug-in surge suppressors should also be used to further protect electronic systems and equipment.

Surges caused by lightning can also enter buildings through power lines and the underground circuits that supply electricity for sprinkler systems, pole-mounted lights, pool pumps, outbuildings, telecommunications cables or other external equipment. A surge received on one of these circuits could damage wiring and equip-

ment on other circuits unless a suppressor at the electrical panel can block it.

## Additional Protection for Your Facility and Equipment

Here are some further actions you can take to protect your facility and help to pinpoint problem areas and solutions.

- Talk to your electric utility company about PQ monitoring services. Using monitoring devices in critical areas can avoid or reduce downtime by rapidly pinpointing sources of noise, spikes, sags, and harmonic distortion.
- If possible, before you commit to a purchase of controls or other sensitive equipment, make sure that the specifications on the equipment you are considering are compatible with the expected facility power supply.
- Ask what electrically “noisy” customers are nearby, such as welding shops. You may need special filters to protect sensitive equipment.
- Keep a careful log of all known power disturbances at your facility. This will come in handy in finding effective solutions without unnecessary analysis costs.
- For analysis and specific solutions, you may need the services of a PQ specialist or consultant. Your electric utility company may have available resources or a list of reputable independent providers.