Best Practices for Dealing with the Aging Power Infrastructure

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Introduction

There may be a glimmer of hope in a recent Federal Government initiative to improve America's aging infrastructure, including our outdated, aging, and inadequate electrical grid. But unfortunately, for the foreseeable future it seems we will be stuck with it, according to a University of Pennsylvania lecturer in electrical systems engineering. A 20-year electric industry veteran, he described our nation's electricity grid as "a third-world electricity system that really needs to be upgraded".

The current age, complexity, and nature of the electrical supply system in the United States has a big impact on the quality of the electrical power delivered to users. For example, it is in the nature of the electrical grid that it must largely operate in a "just in time" manner – always increasing and decreasing supply in response to demand changes, because there is no efficient way to store large amounts of electrical power instantaneously. The grid switching required to adjust supply to meet demand is a tremendous source of electrical disturbances that affect users in every state.

In this paper, we will review some of the implications of our aging power infrastructure, and explore what businesses and individual facilities can do to minimize the effects of electrical system disturbances on their critical business systems.

The Nature of Today's Electrical Grid

Today's electrical supply grid is enormous in both size and complexity. Within just the United States of America, there are more than 3,100 electrical energy providers – and nearly 150 million customers of all shapes and sizes. Connecting all these providers to all these customers, and constantly switching energy on and off throughout this complex system, creates a lot of electrical power disruptions, surges, and spikes even when everything is working correctly.

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Much of the electrical distribution system that connects sources of energy to the users is located outdoors, exposing it to a full range of environmental conditions across the country. In addition, it is exposed to sources of disruption ranging from direct and indirect lightning activity, to wind-induced contacts and shorts from trees and other vegetation. Additional unexpected hazards include car accidents knocking down poles, kites or hang gliders getting tangled in power lines, and rockslides. In 2003, an unexpected contact between a distribution line and a tree started a chain of events that resulted in a total electrical blackout of Southeastern Canada and eight Northeastern U.S. States – but fortunately most disruptions are much smaller!

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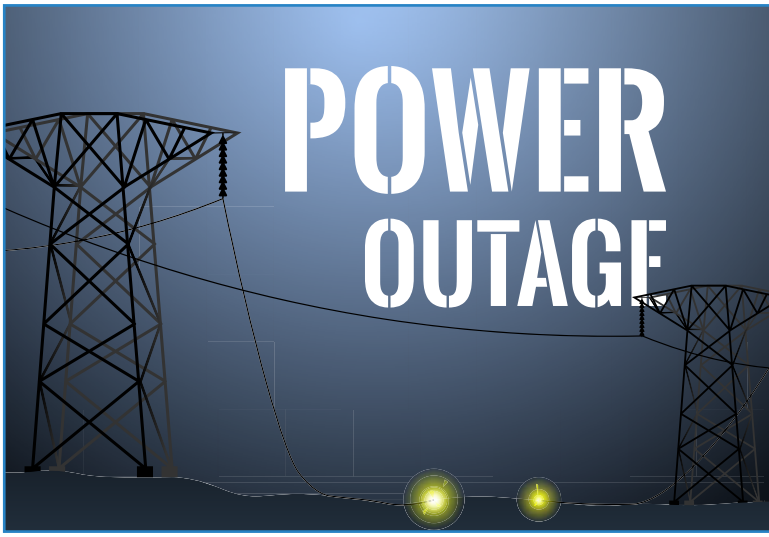
New uses of electrical power – such as the current push for electric vehicles – will place substantial new strains on the nation's electric supply grid. Because it is not easy to predict or control the location, timing, or size of these new demands, there may well be increases in outages and disruptions due to these factors.

The aging of the system is one more factor that cannot be overlooked. While the lifetime reliability of our current electrical system is extraordinarily high, it is also true that much of the current system was installed decades ago and this age has an impact on small and large local failures that can have ripple effects across wide parts of the entire grid.

Effects of Electrical Disruptions

No matter what the source of the disturbance, it is a fact that electrical outages, surges and spikes can affect, and damage, any kind of electrical cable systems including power, phone, cable, and data/internet systems. Moreover, disturbances that originate on one kind of cabling can have indirect effects on other nearby systems, and even jump from one kind of cabling into another to cause damage when those systems are not protected.

For example, within almost every commercial office building are businesses stocked with sensitive devices that store important information and data, along with network communication systems vital to business operations such as sales, customer service, inventory, and financials. All these devices and systems are susceptible to electrical disturbances that can deliver subtle power surges and spikes. Even though such events may not create any staff concern and often occur unnoticed, these events can exceed normal capacity for the building's electrical line voltage and cause serious damage to any connected devices.



What kind of damage can occur? In short, the damage can fall into one of two categories. The first is catastrophic damage that immediately causes a device or network to fail. In the worst cases, this type of damage can even start fires. The second is a slower degradation of the electrical components of connected devices. This case is more like rust damage on a structural steel member. Every instance of damage may be small and even unnoticed, but over time the equipment is destined to fail. This slow damage is insidious, making any unprotected sensitive electronic system less reliable and resulting in shorter equipment life.

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The problem, of course, is that this equipment is vitally important to the operations of the organization, and decreased equipment life and reliability can be a significant problem – even to the point of causing significant indirect losses in addition to the equipment or system damage.

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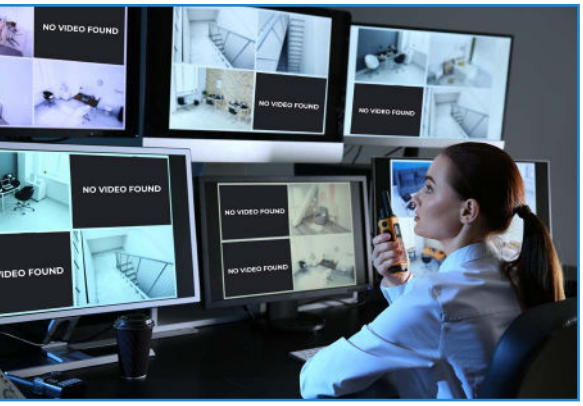

For example, in a recent situation described in Delaware Online, a concerned mother came to her daughter's school to review surveillance video that would confirm or dispel her fears about whether her daughter might have been harmed at school. School staff reported that there had been a power surge in the days just after the alleged incident that wiped data from the hard drive of the school's surveillance system, deleting the video in a "freak accident". This situation clearly shows the potential for significant cost exposure, above and beyond any potentially damaged equipment. The school's computers were not protected by a standard battery backup system or surge protection. By neglecting to provide even basic protection for their video surveillance system, school officials created a situation where a parent was unable to confirm if her daughter had been harmed at the school, but also the school might not have been able to protect itself or its staff from liability had a jury found that damages had occurred.

Aging Power Infrastructure Concerns

Let's look a little closer at some specific concerns about our aging electrical infrastructure system. Each of these factors, or trends, will have a significant impact on the performance and stability of the electrical grid:

1. High-voltage Power Transformers

- Transformers are used in the high-voltage transmission portions of the system to raise the generated electricity voltage high enough for efficient transmission, and then to lower the voltage at destination sites.
- These transformers are massive (in the 400 ton range) and expensive (millions of dollars each). Needless to say, they are not available at the local electrical supply shop when they need to be replaced.
- Many, or even most, of these existing transformers in the electrical supply system are near the end of their designed lives, increasing the chances of electrical disruptions in the case of malfunctions or failures.

2. Increasing Use of Renewable Energy Sources

- There are many positive factors regarding an increase in the use of renewable energy sources, and many benefits for society.
- However, the nature of renewable energy sources such as wind or solar power is inherently intermittent. That is, neither of these sources is constant, controllable, or perfectly predictable.
- This intermittent nature will result in an increasing stress on the electrical grid, requiring an increase in control functions, and possibly an increase in reserve generation capacity as well to ensure the capability to meet demand at all times.

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3. Increasing Need for Smart Grid Technologies

- There are several factors that support the implementation of increased automation and controls in the electrical grid – that is, a greater use of 'Smart Grid' technologies. Increased automation has the promise of improving on older, electro-mechanical switches and other devices, replacing them with smart control systems and electronic devices.
- While these changes promise to improve the operation and efficiency of the electrical grid, there is also a concurrent increase in the risk of cyberattacks and disruptions. This is because the operation of smart control systems necessitate an increase in internet-connected devices and communications that can be vulnerable to such attacks.

Surge Protection Solutions

What can responsible organizations do to protect themselves and their constituents from all the negative effects of these power system disruptions?

The simple answer is that organizations cannot depend on the electrical distribution system, or electricity providers, to reduce or eliminate electrical supply disruptions. The only available prudent, proactive action firms can take is to install appropriate surge protection on power systems and every other wired data and communication device.

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Surge protection technology limits transient voltages by diverting or limiting surge currents. Surge protective devices (SPDs) are a cost-effective solution to prevent downtime, improve system and data reliability, and eliminate equipment damage due to transient surges entering through both power and communication lines. The use of SPDs is often specified by the end-user or mandated by code or local requirements.

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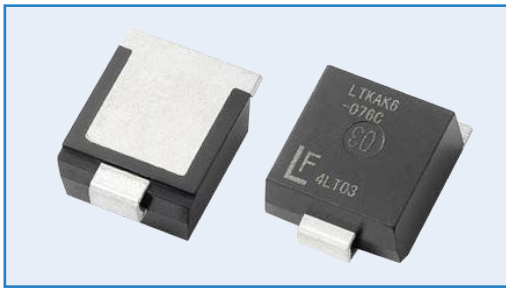
Types of surge protection technology

The three most common solutions for voltage transients are Metal Oxide Varistors (MOV), Silicon Avalanche Diodes (SAD) and Gas Discharge Tubes (GDT). Here is a brief overview of the three technologies:

- A **Metal Oxide Varistor** (MOV) is a bipolar, ceramic semiconductor device used in power supply circuits. MOVs are the most commonly used technology for surge protection and are most often found in the widely available surge protection power strips. MOVs cannot handle sustained overvoltage – they can only be used for short duration surge protection. And while MOVs are fairly sturdy components, capable of absorbing strong surges at the beginning of life, they do degrade over time and eventually must be replaced.

- **Silicon Avalanche Diodes** (SADs) are the most commonly used surge protection technology for high-speed data transmission, low-voltage DC applications and networked devices. This SPD has a faster response time than MOVs and are built to experience avalanche breakdown, which is a type of electric current multiplication that causes a sudden and swift increase in current-diverting capacity.



- **Gas Discharge Tubes** (GDTs) are traditionally the most rugged surge protection component available. They provide a connection between the power line and the ground line, with an inert gas as the conductor between the two lines. When the line voltage is below a certain level, the gas does not conduct electricity. But when there is a power surge or spike, the gas molecules will break into positive and negative ions and the now-ionized gas becomes an extremely effective conductor. The surge current will be passed through to the ground line, diverting the surge away from the device it is protecting. Once the surge has passed, the ions recombine to become gas molecules. While the GDT is ideal for protecting against extremely large surge events, it is less effective reacting to fast traveling and sudden surges.

Layered Strategies for Protecting Power and Communications

Best practice protection strategies are based on a layered approach. The starting point is to protect the first layer of incoming power to the facility because this is the primary entry point for power surges and spikes that originate outside the facility.

The second protection layer should be to protect the network equipment power connections that can shield against power surges that are generated from within the facility, as well as providing extra protection from external and accidental sources.

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A third layer of protection should include all other electrical pathways into the organization's systems, especially cables that pass outdoors and could carry damaging power surges into interior systems. Examples of these include wired connections to networked devices such as outdoor surveillance cameras, signaling line circuits, and telephone lines that are connected to fire alarm panels, ATMs, and point of sale devices to enable communication and notification.

Protect Both Ends!

With a more network-centric approach to most vital facility systems, the increased risk of damaging surges migrating to other parts of a facility necessitates putting surge protection in place at both ends of these connections, and especially at locations where the network moves from outside the facility to the inside. Taking these steps can help prevent surges from spreading across a network and damaging or destroying multiple devices and systems.

It is critical to remember that every networked sensor that provides input to a security system requires power and some form of communication, whether it is wired or wireless. Even wireless networks require power at the access points and depend on wired connectivity to function. Any networked system is vulnerable to the damaging effects of surges and spikes from the supplied electrical power. These systems are also susceptible to electrical disturbances transmitted via communications and signaling cables that can carry unwanted voltages directly to sensitive electronic circuits.

Protecting Sensitive Electronic Systems: Where sensitive security, communications, business and data systems are concerned, the same rules apply– use the layered approach. Any unprotected electronic system including fire and life safety, access control, surveillance and intrusion detection is likely to suffer some damage during its lifetime from power surges and spikes. Many of these unprotected systems will ultimately fail as a result, or at least have their useful lives shortened. A proper surge protective device should be an automatic expenditure for all essential security and life safety systems.

When designing a surge protection plan for any facility, matching the application and need is a key element to mitigating power surge issues. Here are three examples of matching the protection devices to the need:

- **Access Control:** An access control system is an essential component of any business or facility safety and security program. The reasons for controlling access points vary from facility to facility. One facility might be looking at the safety aspects by keeping people away from hazardous machinery or chemicals. In other cases, it might be to prevent theft, provide a secure workspace, keep non-residents out, or to make sure members have paid their fees. In every case, these systems are implemented to ensure that only authorized people can enter these protected areas.

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Best practices dictate that every access control system have surge protection to its supplied power connection as well as to the facility power entry point. Include surge protection at both ends of all connected network equipment, as the network cabling provides a conductive path for electrical power surges. This is especially critical for cabling paths that run to exterior areas including outdoor access control readers, gate control panels, electronic locks, or any other networked electronics or sensors.

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- **Convenience Stores:** As direct customer-facing small businesses, convenience-store operators may spend tens of thousands of dollars providing customers a seamless buying experience with enhanced functionality and upgraded systems striving for the ultimate in customer satisfaction and repeat business. Unfortunately, all it might take is a nearby lightning strike and an undetected power surge to ruin that experience. It is these types of surges that gradually degrade and damage expensive equipment until a system finally fails.

The impact of a power surge or spike in a retail environment can be catastrophic. Business operations dictate that crucial systems like point of sale (POS), refrigeration, food and beverage machines, fire and security systems, fuel pumps, ATMs and back office and inventory management systems stay online at all times. Investing in surge protection for all network-centric systems is a smart investment.

- **Schools:** Public and private schools are keenly aware that as active shooter incidents and on-campus violence continue to rise, secure entrances, visitor management, and video surveillance systems have an important role to play in providing safe places for students to learn. It makes good financial and practical sense to protect all safety and security systems to ensure they will work when needed.

School districts that have installed surveillance systems report that maintenance issues are a recurring problem and increase multiple risks. Not only do troublesome systems become a drain on maintenance resources, but if either access control or video surveillance systems fail during an incident, districts are putting staff and students in danger and facing potential liabilities. Protecting safety and security systems from power surges and spikes is a small but highly effective investment.

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Ongoing Maintenance and Monitoring

Surge protective devices function by sacrificing themselves to protect the organization's systems and devices, and eventually they wear out and require replacement. The lifespan of your SPD will depend on how often they are called upon for this protection, along with the severity of the applied power surges. Some SPDs are designed with visual and/or audible indicators, such as LED lights and sounds, that alert you when a device is no longer functioning and needs to be replaced. Some SPDs can also provide remote notification of surge protection status to your systems. It is important that a periodic maintenance program is in place to inspect SPDs regularly, otherwise protection will cease when the SPDs reach end of life.

Conclusion

We must recognize the current state of the electrical supply grid, and acknowledge that while improvements are in the offing, they are not likely to be fully implemented anywhere for quite a long time. Thus, taking proactive steps now to protect sensitive electronic systems against the effects of electrical system disturbances is a prudent and sensible step that will provide valuable reliability and equipment longevity benefits – protecting all kinds of businesses and organizations in many ways.

The cost of a proactive surge protection plan is usually less than the sales tax on the system. When you think about how much it will cost to replace a full system, or even just certain elements of a system, it becomes clear just how cost-effective a proactive surge protection plan really is. Surge protection should be an integral part of the design process from the start with collaborative efforts from the end-user, consultant, systems integrator and a qualified electrical power solutions vendor.

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