Backroom Technology comes to the Forefront Practical Power Quality Solutions for Convience Stores

W. A. Brown's Bart Mercer discusses serious electric power quality issues, such as dirty power, power surges and swells, as well as how to mitigate internally and externally generated electrical noise.

Educating users on electrical power quality:
The ever-expanding use of electrical equipment and electronic systems in service stations and convenience stores is raising the stakes significantly for owners and operators who may be gambling on whether or not their electrical distribution and power quality systems are up to the task of providing “clean power” with sufficient protection from external and internal power problems. For those who bet wrong, the consequences can be disastrous: long shut-downs, damaged equipment, lost revenue, and diminished customer good will. To help educate and update readers in this critical and dynamic area, we asked several industry leaders to share their knowledge and perspectives in the pages of PE&T. To our delight, four such leaders answered the call: W.A. Brown Electrical Controls’ Bart Mercer, Power Integrity’s Julian Fesmire, Intelligent Controls’ Enrique (Rick) Sales, and Johnson Controls’ Angela Scott. Their stories are similar in certain respects, but we found them sufficiently diverse to warrent special coverage. Bart Mercer’s article, which follows, is a thorough and basic discussion of electrical power quality issues and solutions. The other three will be featured in the February issue.

Electricity has a magical and mystical nature because it is an invisible form of energy that can only be “seen” when converted by an electrical device to another form of energy such as light, heat or mechanical motion. In stark contrast, gasoline and motor oil can be seen and smelled and easily measured by the liquid level in a container or the amount that is pumped and metered through a dispenser. The quality of this gas and motor oil cannot be easily determined without sophisticated testing equipment, but is assumed by the general public (with their brand selection) to be consistently good and readily available.

Determining the quality of electrical power also requires sophisticated testing equipment and is likewise assumed by the general public to be consistently good and readily available. However, this is not always the case. When this invisible electrical power source is disturbed or disrupted, one can definitely see bad things happen to the operation of any business due to equipment damage, down time, unhappy customers and the associated loss of revenue.

Unlike gasoline and motor oil, the quality of electrical power cannot be tightly controlled from the production source, through the distribution channels and all the way to its final point of use. There are many ways that the quality of electrical power can be compromised in each of the stages from the initial production at the electrical utility generator, through the electrical service grid, through the electrical distribution system of the facility and ultimately to its final point of use at the electrical device.

The term “power quality” is a very simple concept, yet the search to achieve it reveals a very confusing combination of unique power problems and equipment technology solutions. The focus of power quality studies should be to provide a matching level of power and protection for each primary electrical and electronic system so that business operations and cash flow are maintained. Matching up the correct solutions with these different problems is the basis for a practical power quality program, which should be one of the primary goals of all business operations.

Basic terms

In an effort to make the mysterious electrical power issues more understandable, several household terms have been adopted to describe the behavior (and misbehavior) of electricity. These terms are not literal or scientific descriptions of electrical patterns. They are simply figurative descriptions of what an oscilloscope looks like when observing the wave forms of electrical voltage and currents.

An oscilloscope is a sophisticated metering device which allows the user to observe these electrical wave forms in extremely short time frames to see both the normal voltage patterns and the disturbed patterns when quality problems occur.

The terms “clean power” and “dirty power” are hopelessly overused metaphors for describing the difference in the desirable pure and uninterrupted voltage sinewave (clean) and the undesirable distorted and/or interrupted voltage sinewave (dirty). Just like the household terms, there are many different types of dirty power requiring different types of treatment to clean it up.

Figure 1 illustrates what an oscilloscope shows when plugged into a standard electrical receptacle in either the home or business facility. In this typical 120 volt, AC circuit, the clean or pure voltage wave form alternates up and down in a cyclical pattern. The AC stands for alternating current that is descriptive of the shape which technically is referred to as a sinewave. This sinewave pattern alternates at a rate of 60 times per second (60 hertz) so the single cycle shown in Figure 1 only takes 1/60th of a second to complete. Note also in Figure 1 that the peak voltage of the sinewave at the top of the cycle is actually 170 volts above the zero crossover point and the voltage actually goes to zero volts on its way to negative 170 volts at the bottom of the sinewave. Then why is it considered 120 volts? Because the net effective voltage of the sinewave form itself (called RMS or root mean squared) is 120 volts, which is well below the peak voltage.

The terms “spikes” or “surges” are used to describe a condition when this smooth sinewave pattern is disturbed with a high amplitude and short duration pulse. Figure 2 shows an example of this. On the oscilloscope, it appears to look like a spike in the voltage pattern. The technically correct term for this type of event is a voltage transient. This type of transient is definitely an unwelcome visitor to your business and can damage or destroy both electrical and electronic equipment in very short order.

The terms “swell” or “over voltage” are used to describe a condition when the voltage rises above the nominal 120 volts by 10 percent (132 volts) for more than one cycle. This is not to be confused with the previously mentioned surge, spike or transient, which is a very short pulse that lasts only milliseconds and has a much higher amplitude of at least 30 percent above the nominal 120 volts (156 volts). The term “sag” or “brownout” is used to describe a condition when the voltage drops below the nominal 120 volts by 10 percent (108 volts). Figure 3 shows both a swell and a sag relative to the normal amplitude of the 120 volt sinewave.

The term “dropout” is used to describe a condition when voltage goes to zero, or “flat lines,” for less than one cycle. The term “blackout” or “outage” is used to describe a condition when the voltage flat lines for more than one cycle.

The term “noise” is used to describe a condition when this smooth sinewave pattern is disturbed with a lower amplitude and high frequency voltage that “rides” on top of wave form. Figure 4 shows an example of this pattern which creates a fuzzy appearance (not a technical term) on the oscilloscope. This type of noise is not audible, but it can make you yell if it locks up your POS terminal in the middle of a transaction.

A tale of two problems

The source of the power problems described above can be divided into two primary categories that are distinctly different and require various types of defensive strategies:

A. Externally generated disturbances from the electrical utility power distribution grid. In general, the quality of electrical power provided from the electrical utilities in the United States is excellent. The upcoming deregulation of electricity to provide a selection of providers may change this somewhat, but in reality, this will be more of a marketing and billing issue as opposed to a change in the operation of the electrical power grid.

The electricity produced at the output of a utility’s generators is rarely a problem. However, in the transmission of electricity across the country, the hardware that distributes this power (such as cable, wire, transformers, towers and poles) is subject to the effects of temperature, water, lightning strikes and accidental damage, which can disturb and/or disrupt the normal flow of electrical power.

The electrical power grid, which connects all electrical generation facilities to each other and ultimately to all end users, also has huge switches to direct power to where it is needed the most. The power switching process can disturb the normal flow both when these switches are turned on and turned off.

By the time the electricity reaches the user’s facility, there can be significant voltage transients, swells, sags, dropouts and blackouts. The frequency of these events is directly dependent on weather patterns, proximity to heavy construction and substation switches and unpredictable events such as accidents that damage the power distribution lines.

However, blaming the electrical utility and its incoming power as the source of all problems is misguided, because many other culprits can impact the power quality in every user’s facility.

B. Internally generated disturbances from the electrical equipment and/or wiring inside the users’s facility. The other source for power disturbances is the electrical equipment and wiring that is operating inside the user’s facility itself. Internally generated events are more frequent, although often less dramatic, than externally generated disturbances.

Much of the electrical equipment inside the user’s facility is defined as an “inductive load,” which means at least part of the device’s function involves passing electrical current through a coil of wire that induces an electromagnetic field. Inductive loads draw more current when they are turned on and release energy when they are turned off. This type of load can generate voltage transients, noise, swells and sags that couple directly with the entire electrical distribution system in the facility.

Examples of inductive loads are refrigeration compressors, heating and air conditioning compressors and fans, fluorescent lighting ballasts, submersible turbines and car wash motors. The majority of these types of loads also cycle on and off during their normal operation which generates more power disturbances than a continuously running load.

The electromagnetic fields that are generated by inductive loads can also create problems with other equipment wiring that is run in close proximity to it, such as in the same conduit or wireways. These electromagnetic fields can easily penetrate the plastic insulation of wire to induce unwanted currents on the secondary wiring. An example of this would be running data cabling above the ceiling tiles directly on top of the fluorescent light fixtures. The ballasts in these fixtures can induce currents on the data wiring which can disrupt the proper operation of the communication equipment at both ends of the wire.

Improper electrical distribution and wiring in the user’s facility can also lead to problems due to overloading, overheating and improperly grounded equipment or receptacles. The number one rule of thumb with a persistent data communication problem on a single piece of equipment is to check for proper system grounding and induced currents from other equipment.

A double-edged power sword

Convenience stores are one of the most challenging retail environments for power quality because of the tremendous growth in the use of electronic equipment in close proximity with a large number of inductive loads that are the primary source for internally generated disturbances.

Typical electronics at the user's facility include computers, POS terminals, scanners, card readers, Multi-Product Dispensers, data interfaces, automatic teller machines, telephone and satellite communications equipment, security systems and tank monitoring systems. With many of these systems networked together, additional problems can arise from the routing of the network cables and the possible disturbances on multiple power receptacles. Convenience stores combine this high density electronic environment with a high density inductive load environment, which produces a double whammy on the pursuit of power quality.

No magic bullets

Another reason that power quality is so badly misunderstood is that different types of building equipment require different types of power protection from different types of power disturbances. However, most manufacturers promote the quick-fix magic bullet that doesn't always address the proper application of equipment at the right place.

Hopefully, if you have made it this far through the article and have gotten a feel for the challenges in developing a power quality program in the convenience store environment, you will also realize that there are definitely no magic bullets. Different types of electrical disturbances require different kinds of electrical technology applied in the correct manner.

One of the most important platforms for beginning a power quality program, or for solving some specific problems that already exist, is to verify the grounding system in the facility. Single point grounding refers to the National Electrical Code requirement for a single ground reference at the electrical service entrance to the facility, where the neutral and ground terminals are bonded together and then bonded to a driven ground rod or other approved grounding method. Multiple ground rods should never be used unless they are all bonded together. Not having the proper neutral-to-ground bond at the service entrance is a Code violation and can cause problems with equipment operation.

Isolated ground receptacles (the infamous orange receptacle) on dedicated circuits are required by most electronic equipment manufacturers in an attempt to provide some isolation from the other building circuits. However, these isolated ground receptacles often get installed incorrectly and rarely provide true isolation.

Verifying a proper grounding system typically will require the services of a licensed electrical contractor, but this is money well spent because the other types of equipment that are used to provide power quality solutions will not operate properly without a good grounding system in place.

Surge protection

The most recognizable, yet most misunderstood, category of hardware solutions is Transient Voltage

Surge Suppression (TVSS). The term “suppression” is a little misleading because this type of equipment doesn’t really suppress the transient voltage but instead diverts it away from the protected load to another electrical location. The most commonly used phrase for TVSS equipment is “surge protection,” for which there are many different technologies and applications available.

The most common electrical component used for surge protection is the Metal Oxide Varistor (MOV). The MOV is installed in parallel with the protected load and when normal voltage is present, the MOV has an extremely high impedance which makes it appear electrically to be an open circuit. When a large voltage transient appears on the wave form, the MOV is designed to rapidly become a short circuit and divert the transient away from the protected load. The voltage at which the MOV begins to become a short circuit is designed with the AC voltage sinewave in mind and is typically 25 percent above the nominal voltage, which, for the 120 volt RMS example, would be 150 volts RMS.

The advantage of MOVs is that they can conduct large amounts of current when they divert voltage transients, which is a very important factor when designing a surge protection system. MOVs come in many different sizes with regard to the design voltages where they begin to conduct and the maximum amount of current that they can carry. Typically, MOVs are used in parallel arrays to increase the surge current rating for the entire system.

Other component technology that is used in some hybrid designs are Silicone Avalanche Diodes (SADs) and gas tube diodes. These components complement MOVs by increasing response time and providing high end current capacity. Inductive chokes, which look like ring shaped magnets, are also used around the primary conductors of surge protection equipment to resist rapid changes in current and to assist the other components in the system.

These components begin to conduct at the design voltage levels, but the only way to determine the effectiveness of surge protection equipment is to know the “clamping voltage” of the entire system. This is essentially the maximum voltage that the surge protection system will limit to the load. The only way to determine this is by testing in the lab under live conditions where specific wave form transients are intentionally produced.

Surge protection can be packaged in either parallel or series configurations, but they all utilize this parallel component technology even if they are wired in series to the protected load. In selecting surge protection equipment, be sure that it has been tested to UL 1449 (2nd Edition) standards and that it has a high surge current rating for the application and a low clamping voltage rating (330 volts is the lowest possible category).

This is worth repeating: a higher surge current rating is better and a lower clamping voltage rating is better when comparing products.

However, if surge protection equipment is not installed properly, these ratings that worked in the lab will not perform up to the rating in the field application. The key here is that the surge protection equipment should be installed as close to the protected load as possible, with a minimum amount of wire. The impedance of the wiring used to install surge protection can directly diminish the performance of the system by increasing the actual voltage that gets to the protected load.

Depending on the size of the conductor used, the net clamping voltage can increase by 20 to 80 volts per foot of wire. Just 10 feet of wire can increase the net clamping voltage by 200 to 800 volts. This means that your 330 volt rated system now only performs at 530 to 1130 volts. The lower the clamping voltage the better; so be sure to install the surge protection equipment as close as possible to the load that you are protecting.

Externally generated voltage transients, such as lightning strikes on the power grid, can best be stopped right at the source, which, in this case, is the electrical service entrance to the facility. Install a circuit breaker in the main distribution panel of the facility and install the surge protection as close to this breaker as possible using the minimum amount of wire. Any wire bends that are required should be a smooth radius and not a sharp right angle bend. This application protects the entire facility from the external transient by diverting most of it to ground before it enters the building. Figure 5 shows a typical service-entrance-type surge protection system installed on the main panel.

Electrical subpanels, which provide power to outside loads, such as dispensers, submersible turbines and exterior lighting, are also good candidates for surge protection to create a fire wall between the inside loads and the exterior loads to limit the magnitude of transients going in either direction. Install a circuit breaker in each subpanel feeding exterior loads and install the surge protection as close to this breaker as possible using the minimum amount of wire. Ditto on the wiring practice. Typically, this subpanel application doesn’t require as high a surge current rating as the one used at the electrical service entrance. Figure 6 shows a typical subpanel type surge protection system installed.

Plug-in surge protection strips and hardwired surge protection boxes are designed for individual loads within the facility and are normally designed in series wiring configurations for convenience only. (Remember they are still using parallel surge protection technology with the addition of a fuse or breaker for overcurrent only.) However, the electronic loads that typically get plugged into or wired to these devices usually have more clean power needs than just protection from basic voltage transients.

Power conditioning and uninterruptible power supplies

Surge protection systems, when applied properly, provide excellent protection from the large scale voltage transients that come from the electrical utility grid or that are generated internally. However, surge protection doesn’t do much for other power disturbances such as noise, sags, dropouts and outages. These types of problems require another set of tools from the power quality workshop

generally known as power conditioning and uninterruptible power supplies.

Power conditioners are true series-installed devices because they rely on the use of an isolation transformer that carries the full load that is connected to it. The purpose of the transformer is to isolate the connected load from the rest of the electrical system and to allow for the re-establishment of the neutral/ground bond on the output to eliminate common mode voltages and noise that can disrupt communication in networked electronic systems.

Older power conditioner technology used ferroresonant-type transformers that were good voltage regulators but were very inefficient and generated a great deal of heat. The latest computer and POS technology has switch-mode power supplies that are now very tolerant of voltage sags and swells but much more susceptible to common mode disturbances. For this reason, most power conditioner manufacturers now use low impedance-type transformers which are very efficient in operation and are well matched with the switch mode power supplies used in the protected electronic equipment.

Power conditioners also use some surge protection and line filtering technology on the output of the transformer to enhance the performance of the connected equipment. Since they are true series-connected devices, power conditioners are sized according to the load that is connected and are available in both plug-in and hard-wired configurations. Figure 7 shows both the plug-in and hard-wired types of power conditioners.

Load ratings are typically in volt-amp (VA) sizes and must be calculated on the total rating of all connected equipment along with a safety factor. To calculate VA, multiply the amp draw of the equipment times the voltage. For example, a 3-amp connected load at 120 volts would be 360 VA; with a 10 percent safety factor, it would be a 400 VA unit.

Applications for power conditioners include in-store electronics, such as computers, POS terminals, scanners, card readers, data interfaces, automatic teller machines, telephone and satellite communications equipment, security systems and tank monitoring systems. Noticeably absent from this list is Multi-Product Dispensers (MPDs), which are not good applications due to their large load requirements and the long wiring distances from the backroom electrical panels to the MPDs in the yard.

MPD power requirements have increased dramatically over the years and contain such equipment as lights, heaters, solenoid valves and vapor recovery systems that add to the load but do not really warrant power conditioning. A typical dispenser that might have a total peak draw of 12 amps would require a 1440 VA power conditioner (12 amps x 120 volts) and for a site with 8 MPDs would require almost a 12,000 VA unit (8 MPDs x 1440 VA each). This gets way too big and way too expensive to be practical and, even so, would not be effective in protecting the MPDs because of the long distances involved.

The best application for MPDs would be to install some combination of power conditioning and surge protection in the MPD electronics head to put the protection as close to the load as possible. This would require close coordination with all the manufacturers of MPDs and would be driven by the willingness of ownership to pay for the additional costs that would come with the additional protection and operating benefits. As more internet technology is added to MPDs, this change is inevitable.

Using properly applied surge protection equipment in conjunction with power conditioners provides both the macro and micro electrical views for the majority of power quality problems. However, neither technology can provide protection from the power failure problems previously defined as “dropouts” or “outages.”

Uninterruptible Power Supplies (UPS) provide a battery backup for these types of power disturbances by converting the power from DC batteries to some form of AC power to operate the equipment for a limited time (5 to 10 minutes) which is long enough to close out the transaction and turn the load off.

Like power conditioners, UPS systems are also true series-installed devices, because all the equipment load passes through the system. For this reason, sizing the UPS is done in the same manner by calculating the connected load in VA and adding a safety factor.

There is a huge disparity in the quality and functionality (and cost) of UPS systems. Not every piece of electronic equipment requires a battery backup for the operation of the business, but if it does, it is best to consider both of these items in system design and product selection:

• Most UPS systems are battery backup only and do not have any built-in power conditioning.

• Most UPS systems do not generate a pure sinewave voltagen the battery backup mode creating noise problems.

Products are available in the marketplace that have power conditioning built into the UPS and that provide a pure sinewave output during battery backup. Figure 8 shows a photograph of a plug-in type conditioned UPS system.

Products are also available that have the orange isolated ground receptacles built into the back of the power conditioners and the UPS systems with power conditioning that eliminates the need for wiring the orange receptacles into the building wall. This is done by adding a controlled impedance to the ground leg ahead of the power conditioners neutral/ground bond. This essentially provides a portable isolated ground receptacle circuit along with the power conditioning.

Be sure to lock the back door

Verifying proper system grounding and installing surge protection and power conditioning equipment on the electrical system provides a solid foundation for a power quality program. There are, however, a few other items to consider that are not directly related to the electrical system.

These other links to the outside world include data and communications wiring which can also be the source for voltage transients that can enter the back door of your electronic equipment and damage modems and data ports, even when the power sources are properly protected. Don’t forget these other sources for possible problems:

• Telephone lines

• Cable TV
• Satellite networks

Beware of the red flags

This important quest for power quality has provided a major market opportunity for manufacturers with a broad range of hardware solutions. Hundreds of manufacturers are involved in developing and distributing products. This competitive marketplace has yielded some excellent technology and outstanding value to the end user.

However, as in any market, there is a segment of marginal players who peddle a great deal of hype, fear and misleading claims. Even legitimate manufacturers can have overly zealous sales reps who will look for any opportunity to sell their products ahead of the competition. There are a couple of “red flags” in this business that should provide just cause to investigate product claims a little further before making purchasing decisions:

• One size fits all. This goes along with the magic bullet theory that one box fits all applications and will solve all problems. Be very careful about this sales approach. It may sound good and be easy to understand but usually is only a partial solution and usually not a good one.

• Vague UL listings and test ratings. When evaluating different equipment, insist on published UL listings and appropriate test data. If this is not readily available, the legitimacy of the product is questionable at best. Surge protection equipment falls under UL 1449 (2nd Edition), with the critical ratings being clamping voltage and surge current. Stand-alone power conditioning systems fall under UL 1012, with the critical ratings being common mode and normal mode voltage let-through. UPS systems (with or without integral power conditioning) fall under UL 1778, with the critical ratings being voltage tolerance range before switching to battery and full load run time.

• Equipment damage insurance packages. Some manufacturers include insurance policies that guarantee payment if any equipment is damaged when using their power quality system. Most of these programs are marketing gimmicks to make you feel better about making a decision and the insurance cost is built into the product cost. Making claims on this type of invisible-third-party insurance program requires extensive documentation that is nearly impossible to obtain. You are better off discussing the existing comprehensive policy on the facility with your existing insurance agent to see what coverage is provided from lightning damage. You may also get a discount for installing some preventive measures. If you insist on going with third-party insurance, at least request a copy of the claim form up front so you can be aware of what documentation will be required from you should a claim ever be required.

• Claims that equipment is protected from a direct lightning strike. No surge protection system can protect you from a direct lightning strike. Claiming this is a sign of sales desperation. The only option here is to look at installing lightning rods on top of the user’s facility or canopy. Lightning rod systems provide an array of sharply pointed rods pointed skyward which are all bonded together and to earth ground. These systems are intended to prevent the accumulation of static electrical charges on the facility which is the root cause of lightning strikes. If there is a direct strike, it will theoretically hit the rod and go directly to the ground without going through the building's electrical system. However, the effectiveness of lighting rod systems are unproven and are very expensive; in the range of tens of thousands of dollars.

• Claims that surge protection saves money on electric bill. This type of claim and related ones about installing power factor correction capacitors are without merit in the convenience store environment. The voltage transients that surge protection diverts are only milliseconds in duration and are not even registered by electrical utility meters because kilowatt demand (KWD) readings are typically averaged over a 15 minute or 30 minute time period by the meter. Voltage transients are invisible to the meter and do not increase the kilowatt demand charges on the electric bill.

Similar claims about installing a standard bank of capacitors to correct power factor and save kilowatt demand costs are also unfounded and a poor application of technology (this is also a variation of the one-size-fits-all claim). First of all, putting a fixed capacitance on a variable inductive load environment is not the right approach, because when the inductive loads are not on, the only result is a leading power factor instead of a lagging power factor. However, the most suspect claims are about yielding savings on kilowatt demand charges. Most electrical utility meters read true kilowatt demand of power (not the higher KVA associated with leading or lagging power factor), so even if the power factor was perfectly corrected at all times to unity, it still wouldn't reduce demand charges or dollars.

Some utilities charge their big industrial customers a power factor penalty where special meters are installed, but not their small commercial convenience store customers. Be sure to understand the local electrical utility rates and metering systems when analyzing these claims and ask the opinions of the electrical utility representatives.

Finding the balance point that works

The primary goal of a power quality program is protecting the investment in electrical and electronic equipment and maintaining continuous business operations. It is important to find a balance point on the equipment cost versus the risk that works for the business. Divide weekly sales by the weekly hours of operation to come up with an average hourly cash flow—this can help gauge the hourly cost of downtime to the business. Estimate the cost of repairing or replacing all of your major electronic systems—this can help to determine the value of protecting this investment and what should be budgeted for this. Check existing insurance policies on electrical damage, deductibles and discounts that may be available for power quality equipment.

It would be impractical and very expensive to put surge protection or power conditioning on every single load in the building. The law of diminishing returns states that, past a certain point, incremental investments bring a reduced return. A better approach is to install high quality, heavy duty systems at key points. Established manufacturers with quality products will be around longer to support their products and warranties. Ask for test results when comparing the ratings of different manufacturers.

Analyze the power patterns in your facility with plug-in metering equipment. There are some excellent data recording meters on the market that plug into the wall, record information for a week or two and then download to laptop computers for processing.

A power quality program is usually a low priority compared to running the day to day operations and investing in other equipment that provides a more tangible and immediate return. However, it only takes a milli-second to be shut-down and out of operation for hours or days on end with unhappy customers and negative cash flow. Don’t wait until disaster strikes to develop a power quality program because it is much more difficult to analyze options and make decisions while doing a disaster recovery program at the same time.

“Common mode” disturbances

Common mode noise and voltages are one of the primary reasons for communication problems with networked electronic systems. Common mode refers to voltage measurements between the neutral conductor and ground. At the electrical service entrance to the facility, the neutral and ground are bonded together so that the voltage difference is 0 volts. However, further inside the facility, low magnitude voltages and noise can build up on the neutral conductor due to neutral current voltage drops, induced currents and unbalanced electrical systems.

Common mode disturbances are a significant problem because all networked electronic equipment defines the ground reference as the zero reference point (for the stream of 0s and 1s) in digital communications and these disturbances can corrupt the integrity of the signals and cause lockups and parity errors. The best way to address common mode disturbances is with low-impedance transformer based power conditioners which are available with or without battery backup.

Unfortunately, there is no single fix for all these different types of electrical power disturbances. Diagnosing the source and type of problem is vital in devising solutions that address the unique requirements of the different types of electrical equipment in the facility.

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