Panelboard Power... The Power Quality Battlefront!

Understand It And Win!

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Businesses of all types and sizes, experience the pressure of the increased level of reliance on electronic equipment. It seems most of us hardly go a day without running into a situation where our ability to complete a task, make a purchase or complete a transaction is compromised by misoperation of electronic equipment that we depend upon.

The challenge for the consumer, electrician, electrical engineer and electrical distributor alike, has been to determine what power quality product do I use to protect electronics? The decision becomes more difficult as we turn to power quality equipment manufacturers that furnish detailed information on the product they build. So generalists and engineers alike are left to sort through marketing information with the hope of finding the right product to protect their application and their equipment.

If this process sounds familiar to you and you have been frustrated by it, you are not alone. The reason is that this process is flawed, since it is product driven. Regardless of the equipment and the application, the process of deciding how to protect electronics from power quality problems needs to be driven by the requirements of the equipment and the application you are protecting.

New technologies have made it possible to protect against harmonic distortion and voltage transients with panelboards that feature designs that incorporate integral protection circuits. With the exception of industrial equipment connected to a buss bar, most electronic equipment gets its power from a circuit breaker panel or panel board. While computers and other types of microprocessor controlled devices or electronic equipment come in many different forms, panelboards supply the power supply. The device that is used nearly 100% of the time inside the equipment, is referred to as a switch mode power supply. These two pieces of information are fundamental to the process of deciding how to protect your electronics.

With few exceptions, electronic equipment utilizes switch mode power supplies & the application invariably involves panelboard power.

We intend to furnish a broad overview of information related to power quality problems and products designed to protect electronics from power quality problems. We will begin with some of the industry recommended practices for addressing a power quality problem. Then we will review some of the attributes associated with switch mode power supplies, electronic equipment and power quality products. Next a brief discussion reviewing the relative importance of certain types of power disturbances and finally some general recommendations for addressing power quality concerns at the panelboard or circuit breaker panel level in a power distribution system.

Wiring and grounding are frequently overlooked when evaluating a power quality concern.

Industry standards can serve as guidelines to assist you in determining how to address a power quality concern. For example, the Electrical Power Research Institute (i.e. EPRI) published a handbook on power conditioning equipment that contained a flow chart suggesting the proper steps to take when trying to address a power quality concern. This flowchart is depicted below in figure 1.

E.P.R.I.-RECOMMENDED P.Q. ANALYSIS STEPS

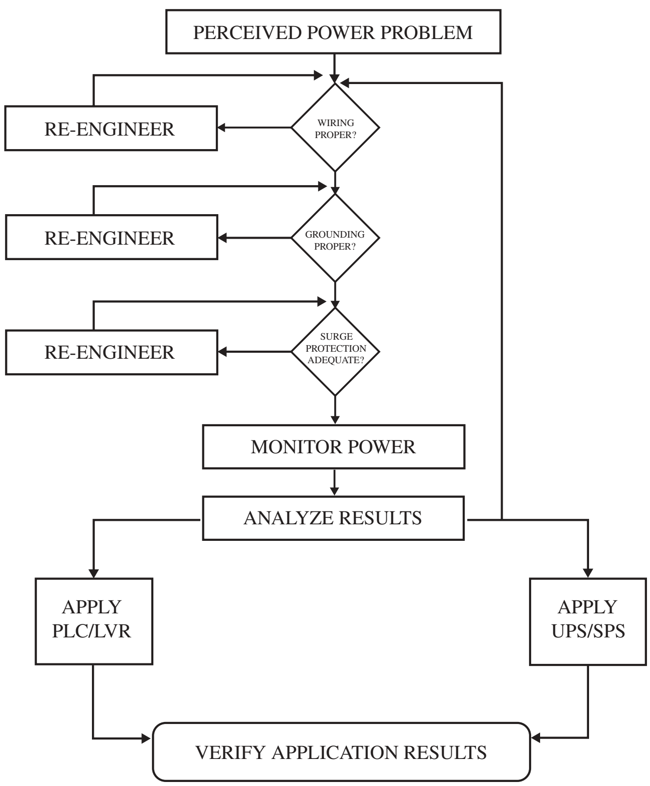

Figure 1.

Many times, when people think they need to address a power quality issue, they assume that they need a UPS or that they need to monitor the power with a Power Line Disturbance Analyzer. According to EPRI, the process should begin with determining 1) whether the wiring is correct, 2) whether the ground is adequate and 3) whether the surge protection is adequate. If they are, then monitor the power and determine whether the application requires some type of voltage regulator or UPS.

This flow chart is important because oftentimes, power quality problems occur as a result of premise wiring and/or grounding problems. The significance of this is, by and large, ignored or underestimated. For example, despite the fact that IEEE introduced Standard 1100 calling for an impedance level on the ground and neutral conductor of branch circuits serving sensitive electronics of <0.25 ohms back in 1992, very little effort is made to test branch circuits for compliance with this standard. This is significant, since two circuits, each with a ground impedance that complies with IEEE recommended impedance of 1 ohm or less for safety, may not comply with the IEEE Standard for reliable power to electronics. This frequently results in ground loop issues. In addition, harmonic distortion issues can be helped by making sure that the impedance on the neutral conductor is rated at < 0.25 ohms.

EPRI is sending a message about the relative need for surge protection by placing the need for it ahead of monitoring power. This makes sense if you consider the source of voltage transients. While most people think of the large power surge that can occur from outside their building from a source like lightning, this type of event is not a frequent occurrence for most facilities.

Engineering and coordinating surge protection properly is one of the more involved areas of power quality. Products are frequently mis-applied.

The real risk most people face is from voltage transients that result from switching electrical equipment on and off. Equipment switching is a daily occurrence and as result, so are switching transients. While internally generated switching transients are typically smaller in magnitude than externally generated transients, they occur on a daily basis and are the result of normal operation equipment. Voltage transients cause disruption to electronics and cause stress to semi conductor material. In addition, transient voltages are much more difficult to protect against, since exposure to this type of disturbance typically involves multiple paths and involves a solution that requires some technical expertise. Unless someone engages the services of specialist that really understands how to implement the industry recommended practices for surge protection, most generalists will implement TVSS equipment in a configuration that still leaves the application vulnerable. This reinforces why EPRI feels that the need for adequate surge protection is so important.

Early in this article, we commented on the significance of switch mode power supplies and panelboard power. Since most microprocessor controlled equipment operates with a switch mode power supply, it exhibits all of the strengths and weakness of this type of device. This includes a relatively robust level of tolerance to line voltage fluctuation. However, this comes with a price. Switch mode power supplies are much more likely to pass a voltage transient through to a microprocessor than a linear power supply. Combine this with the increased number of distributed power processing environments, differences in ground potential issues, faster processor clock speeds, lower chip voltages and higher component density on boards and chips, and it helps to explain the increased level of sensitivity of modern electronics to power surges.

The vast majority of the time, electronic equipment derives power from a receptacle/branch circuit connected to a electrical panelboard or circuit breaker panel as its source of power. While microprocessor controlled equipment is easily affected by voltage transients, the same microprocessor controlled equipment is also a major source of harmonic distortion. The panelboard or other upstream electrical distribution equipment can become a point of common coupling for harmonic distortion and thus a point where equipment operational problems can occur.

Armed with knowledge of the various types of power problems, how they occur, how likely they are to occur and the fact that electronic equipment is very susceptible to some types of power disturbances, we can begin to categorize power disturbances into three groups.

Group One includes disturbances that are less likely to occur, and less likely to disrupt electronic equipment. Examples include EMI/RFI and fluctuating line voltage. Group Two includes disturbances that are less likely to occur, but more likely to affect microprocessor controlled devices if they occur. Examples include a power failure. Group Three includes disturbances that are very likely to occur and very likely to disrupt or damage electronic and electrical equipment. Disturbances such as voltage surges and harmonic distortion fall into Group 3.

Voltage regulating products are often applied in applications that require little need for voltage regulation.

The need for tightly regulated voltage isn't as great as it was 20-30 years ago when linear power supplies were widely used in electronic equipment. Since linear power supplies were easily affected by line voltage fluctuations, the industry needed a more robust power supply. This gave rise to the development of the switch mode power supply. In most cases, the switch mode power supply is able to maintain its output within specifications with input voltage as low as 105 volts AC.

EMI/RFI noise is often a non-issue.

In a similar sense, several other types of power quality disturbances are a predictable by-product of operating electrical equipment. For example, noise (i.e. EMI/RFI) is present in almost every electrical system. While noise is very prevalent, its effect in most cases is pretty minimal, due in part to the widespread use of bi-directional EMI/RFI filters on the AC input of most electronic equipment and equipment enclosures that have been designed as Faraday Shields.

The fact that electronic equipment is able to perform reliably even when exposed to fluctuating input voltage and EMI/RFI helps to explain why these disturbances are in Group One. Group Two disturbances, while infrequent, are relatively easy to address. The power goes off, equipment goes down. If the degree of economic loss is great enough to offset the cost of a UPS, you buy one. Group Three disturbances like voltage transients and harmonic distortion occur daily in most business. They are hard to identify. They can damage equipment and disrupt applications.

Harmonic distortion, is present wherever non-linear loads are operating.

Harmonic distortion is a predictable by-product of the normal operation of certain types of equipment referred to as non-linear loads. Examples of non-linear loads include electronic ballasts, V.F.D.'s and electronics that internally use a switch mode power supply. Non-linear loads create harmonic distortion just as predictably as equipment switching can create a voltage transient.

Harmonic distortion is present in virtually every business that operates non-linear loads. As the amount of non-linear load in a building increases, so will the level of harmonic distortion. If harmonic distortion is not properly managed in a facility, equipment operational problems are to be expected.

The operational problems associated with harmonic distortion can be placed in two categories. The first category, harmonic current distortion will cause thermal stress on transformers, breakers and neutral conductors in a building. If harmonic current distortion is left to increase in a building as more non-linear load is added, it is likely that nuisance tripping of circuit breakers will occur, overheating and premature failure of distribution transformers will take place and in severe cases, with older buildings, possible failure of the neutral conductor and electrical fires may occur.

The second category is harmonic voltage distortion. Excessive levels of harmonic voltage distortion will cause disruption to the operation of electronic equipment. Once again, the normal operation of non-linear loads will create this type of disturbance.

Application guidelines can assist with selecting power quality product solutions.

All power distributions systems need some level of surge protection. When selecting TVSS for a panelboard, the peak surge current rating of the TVSS should be selected based on the level of protection you desire. The higher the peak surge current rating, the larger the disturbance that a device is rated to handle. You should decide if the amount of protection is enough for the application based on information like the table shown in figure 2.

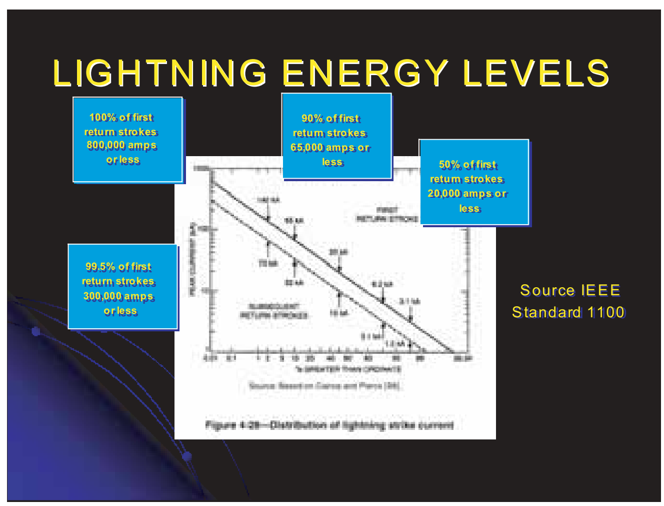

Figure 2.

While lightning impulse energy levels have been documented close to one million amps, selecting a TVSS device with higher peak surge current ratings clearly produces diminishing returns. Proper TVSS selection involves coordinating the energy handling capacity of multiple devices designed to provide layers of protection at the panelboard, main distribution panel and service entrance.

Of similar importance is the need to insure that a TVSS device has a discrete circuit of protection for each mode. Simply selecting a device that claims all mode protection DOES NOT ensure this. Many products claim all mode protection via series circuits and do not have a discrete circuit of protection for L-G or L-L. For example, let's assume a surge occurs in a specific mode, and you compare two devices with equal peak surge rating per mode, both with all mode protection. If one, does not have a discrete circuit of protection for L-L, the summation of the energy handling capacity of each mode will be half the total of the device with a discrete circuit of protection for each mode. This will result in substantially less energy handling capacity for the TVSS if a surge occurs.

Lack of an industry standard results in many products that exhibit little capability to do much more than filter EMI/RFI.

In addition, while nearly 100% of products applied at the panelboard should feature sinewave tracking, most claiming this capability only include an EMI/RFI filter that essentially addresses noise. These filters usually provide marginal improvement relative to reducing voltage switching transients. The absence of an industry standard that properly defines this term results in many products that were specified or purchased to track the sinewave, exhibit little capability to do much more than filter EMI/RFI. Bid specifications frequently require sinewave tracking, feature a list of approved manufacturers and fail to specify what sinewave tracking means. Over 90% of the specs we see, include "approved manufacturers" that are unable to contain an IEEE ringwave, applied at any phase angle on one side of the zero crossing, from exceeding the peak of the sinewave on the other side of the zero crossing. This is because they are fixed clamping products.

Be sure to insist on the manufacturer furnishing let-thru voltage or measured limiting voltage test results based on IEEE test waveshapes, that include ringwave and impulse tests for all modes. Test parameters, such as phase angle, lead length and mode must be detailed. Without test parameter information, test results are meaningless. Measured limiting voltage is the most important TVSS specification.

Be careful when manufacturers only list their UL 1449, suppressed voltage ratings (SVR). UL SVR specs do not include any ringwave testing. UL SVR data is based entirely on impulse testing. Ringwaves from switching are the most likely transient to occur. Therefore, looking at UL SVR specs gives you no idea of how well a device will attenuate a switching transient.

Application pitfalls abound in the power quality industry. It is not unusual to find products that were selected improperly.

If you truly need to protect from a power failure, you must select a UPS. If you really need to protect your equipment from fluctuating line voltage, you can select either a UPS or a power conditioner. But applications to protect electronics from transients and harmonics can be addressed at the panelboard level. At this level UPS or power conditioner can be cost prohibitive or overkill.

Solutions that protect electronics at the branch circuit and panelboard level from harmonic distortion, fall into two categories, harmonic mitigating power conditioners and harmonic mitigating panelboards. A variety of harmonic mitigating technologies are manufactured today. Most UPS and power conditioning products provide little to no protection against harmonic distortion. It is important to select either a harmonic mitigating power conditioner or a harmonic mitigating panelboard to control this disturbance before it becomes a problem.

Recent advancements in harmonic mitigation technology have resulted in the development of panelboards that incorporate integral TVSS protection and harmonic mitigation.

The benefits of a panelboard that can reduce harmonic distortion and voltage surges in a pre-engineered package, include space savings and reduced cost over installing a separate harmonic power conditioner to supply power to a panelboard and selecting a TVSS device for the panelboard.

In summary, this article is not a replacement for the type of knowledge that is typically found with individuals who make a living as power quality specialist. With the mass commercialization of the power quality industry, a significant amount of product is selected and applied today by people who are experts in other fields and generalists when it comes to power quality. Frequently these choices work well when a moderate power quality problem occurs, but fail to measure up when a more significant power quality disturbance occurs.

Seeking the services of a trained power quality specialist can pay substantial dividends by integrating product into a facility that is based on achieving your design criteria. In addition, an informed choice can often reduce the overall cost of protection for your facility and equipment.

For every power quality application, product and recommendation, there is the exception. There is no replacement for the years of experience that a trained power quality specialist can offer when it comes to avoiding the pitfalls associated with product mis-application and improper engineering.

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