Power Protection Technology Landscape

Traditional Technologies vs. The Innovolt Technology

INNOVOLT™
powering performance

THE BUSINESS CHALLENGE

New technology advancements are changing the way people interact with electronic equipment. Today, each new device is more sophisticated than its predecessor, delivering a product with advanced functionality and capabilities. In the past, these technologies were only integrated into highly-complex electronic equipment such as an MRI machine. However, over the past decade there has been a rising trend to integrate more advanced components into electronic equipment to support the new technologies. Some examples include:

- Wirelessly connected vending machines
- Whole house DVR set-top-boxes
- 100" interactive corporate boardroom TVs

The rise in sophistication has placed a growing burden on businesses that are responsible for the service and support of these devices. Businesses in all industries face the challenge of managing a wide network of distributed electronic assets. Some of these tasks include:

- Availability & Uptime
- Performance & Reliability
- Customer Satisfaction
- On-Site Maintenance & Repair Visits
- Service Cost & Margin

A large percentage of service and reliability challenges can be attributed to poor power quality at the outlet level. According to The Electric Power Research Institute (EPRI), "power issues cost the U.S. industry as much as $188 billion per year." The increasing complexity of today's electronic equipment makes them more susceptible to the array of voltage and current level fluctuations that cause them to malfunction, operate inefficiently, and require an on-site service call.

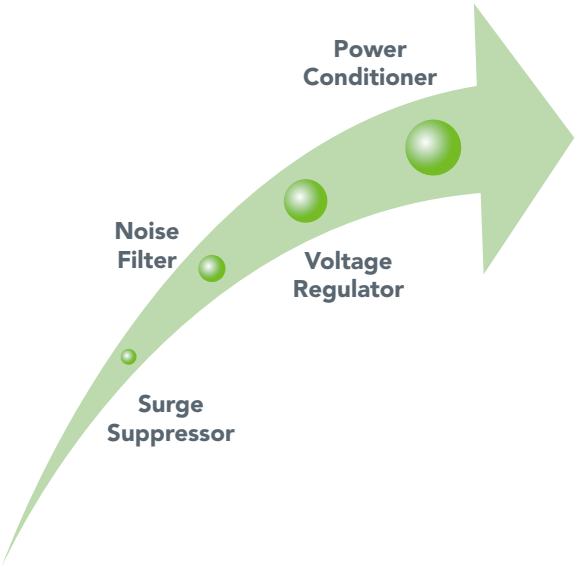
> Sophisticated electronic equipment can be very sensitive to even small, split-second electricity fluctuations
>
> – Pacific Power

Realizing the need to provide the highest level of customer satisfaction and to reduce service costs, businesses integrate a range of power protection technologies to insure the best performance and reliability of their devices. This paper highlights the different power protection technologies by providing an in-depth overview of the technology as well as a comparison to the Innovolt ROC™ (Remote Optimization & Control) Technology.

1. Surge Suppressor
2. Noise Filter
3. Voltage Regulator
4. Uninterruptible Power Supply
5. Isolation Transformer

POWER PROTECTION TECHNOLOGIES

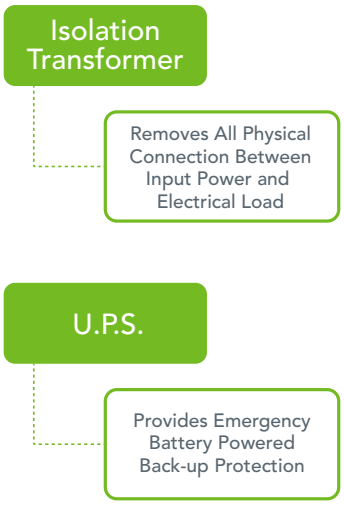
The progression of the power protection industry over the past half century can be viewed as a series of architectural innovations, where certain platforms were built on top of the proceeding technologies, expanding the functionality. As the power conditioner product grew to become a solution that encompassed multiple power protection attributes, the industry's terminology became somewhat interchangeable. Today, the most commonly used technology by owners of sophisticated electronic assets is the power conditioner, which can include any combination of features such as surge suppression, noise filtering, or voltage regulation. IEEE defines a power line conditioner as a device that combines one or more "power-enhancement" attributes.



At the same time, there were also radical innovations that solved the previously unaddressed concerns. In order to fulfill the remaining unmet needs within the marketplace, two specialized technologies were developed for specific purposes - the isolation transformer and the uninterruptible power supply. Today we see state-of-the-art products such as a double conversion online UPS combine all of the functionality of the power conditioner with an auxiliary power source.

After utilizing the traditional power protection technologies, businesses have to ask themselves:

- Is my electronic asset fully protected?
- Have the implemented products reduced my expenses on service and maintenance?
- What is the equipment downtime costing me in lost revenues?
- Can I accurately manage the power that is input into these machines?
- How do I successfully monitor all of the tools that I have deployed in the field?



SURGE SUPPRESSION TECHNOLOGY

Definition

Whenever a business first considers a power protection solution, the initial technology option is usually the well-known surge suppressor. These commoditized products have been in the marketplace since the early 1950's and have therefore garnered the most mind-share with the public. They are referred to as surge protection devices (SPD) or transient voltage surge suppressors (TVSS). They are utilized to protect electronic assets from dangerous voltage spikes, caused by lightning or power line transformer damage. At the outlet level, a surge suppressor is typically the third level of defense, coming after the utility company's robust surge protection measures and the building or whole-house protective device.

Technical Overview

The surge suppression device attempts to limit voltage spikes through a series of specialized electrical components or by shorting the surge directly to ground. A simplistic arrangement of various components can be used to achieve surge suppression. These include transient voltage suppression (TVS) diodes, gas discharge tubes (GDT), or metal oxide varistors (MOV). These components typically have a finite lifetime and an associated joule rating that gives the user a theoretical estimate of the maximum protection against a single surge event. Response time and let-through voltage level, or clamping voltage, are important factors to consider if outlet level protection is installed as the primary surge defense.

Business Use

Businesses that utilize surge suppression technologies aim to shield their electronic assets from the rare but damaging power disruption, a voltage spike or surge. A single event can cause irreparable damage to a business's entire fleet of electrical equipment. The SPD is common in the home, office, and industrial environments. Devices installed at the outlet level provide a surge suppression solution for all connected electronics on that particular outlet. Devices installed at the circuit breaker box protect the entire branch circuit.

Applications & Form Factors

Surge suppression products are seen as vital additions to applications in many environments. Home entertainment systems, home office equipment, and home kitchen appliances are oftentimes connected to a surge suppression power strip. Offices have their data servers, printers, copiers, and conference room equipment shielded by SPDs. Industrial research, manufacturing, and shipping divisions rely on surge suppression to protect their high-priced equipment from unforeseen disruptions. The surge suppression technology is most commonly seen today in the form of a power strip with multiple outlets. These can be either free standing, wall or ceiling mounted, server rack mounted, or attached to the electronic asset. The solution's circuitry is also embedded into other products such as power conditioners or uninterruptible power supplies.

Drawbacks

Surge suppression devices have a drawback in that they only offer one power protection capability. According to the Electric Power Research Institute (EPRI), the surge is the most damaging single event that can occur; however, voltage surges only account for approximately 0.5% of all of the measurable power disturbances that occur globally. The inability to protect equipment from overvoltages, undervoltages, voltage sags, and power outages place the technology at a disadvantage. Additionally, surge suppressor's main method of functionality, MOV-based protection, has shortcomings due to its limited functional life span. An unprotected MOV degrades over time as it is continually exposed to overvoltages, thus depleting it of the limited energy absorbing capabilities.

NOISE FILTERING TECHNOLOGY

Definition

The line filter, EMI/RFI filter, and noise filter are all terms that refer to the simplistic device that minimizes electrical noise. The basic tool is intended to filter the incoming power supply, attenuate the electrical noise, and improve the quality that is delivered to the electrical load equipment.

Technical Overview

The sinusoidal waveform of A.C. electrical power fluctuates as it passes through the power grid, enters the office building, and cycles to all of the various tools plugged into the outlets. The filter can provide a means to smooth out these fluctuations. This technology attempts to minimize the radio frequency interference (RFI) and electromagnetic interference (EMI) between the electrical power line and the connected equipment. These interferences commonly occur internally within the building due to noise caused by other electronic equipment or wireless signals. Noise filters are rated based on their reduction capability, measured in decibels (-dB).

Business Use

Typically, businesses realize the need for noise filtering after experiencing significant static interference within their electrical equipment. This can be noticed as continued issues such as delayed response time, erratic behavior, audible static, or wavering performance levels. Noise can affect systems more significantly when equipment exposure to wireless signals or pulsing electrical signals is more frequent. Sensitive electrical equipment housed in these environments most commonly requires not only noise filtering technology but also interference shielding methods such as cable sheaths and robust enclosures.

Applications & Form Factors

Noise filters are commonly found in audio and video tools where the interference is most obviously realized. Measurement equipment can also be significantly impacted by static and noise. Laboratories and manufacturing environments have multiple pieces of sensitive electrical equipment, and therefore high-performance noise filtering or shielding is crucial for these applications. The technology is embedded within the power supply of many machines, so businesses must realize the potential for adding redundancy to their systems when incorporating additional filters. For example, the switch-mode power supplies, used with sophisticated electronic assets which contain microprocessors, are required to incorporate noise filters because they generate interference on their own. Most form factors are combined with other power protection technologies such as power conditioners or uninterruptible power supplies.

Drawbacks

This technology addresses only a small fraction of the power performance issues. The filtering technology is most effective at reducing internal disruption and does not shield any of the grid-based disturbances. Overreliance on only a noise filter solution can lead to damaged electronic equipment. Not all loads are susceptible to noise, and the technology is not needed nearly as much as it is used. Identifying and shielding the noise generator rather than filtering every other piece of equipment is oftentimes more impactful for businesses.

VOLTAGE REGULATION TECHNOLOGY

Definition

The voltage regulator is designed to provide a constant voltage level to connected equipment from an oftentimes wavering voltage supply. The device can regulate multiple voltages, either AC or DC. Some manufacturers incorporate only electrical components into a design, while others build an electromechanical system to achieve voltage regulation. Automatic voltage regulators (AVR) and constant voltage transformers (CVT) are the commonly used solutions in the industry today. The effectiveness of the devices can be determined by the line regulation ratio which compares the input and output voltage levels.

Technical Overview

Voltage regulation is utilized to ensure that input power, which might be inconsistent and range from +/- 25%, will be constrained to a more acceptable +/- 5%. The range of voltage regulation significantly varies depending on the degree of functionality and cost. The AVR acts as a negative feedback control loop where the comparator, a threshold-based electrical component, determines the tuning necessary to remediate the input and output voltage level mismatch. Capacitors or transformers are used to store voltage in AVRs, enabling supply for the voltage shortages or absorption for the overvoltages. The CVT is a ferroresonant transformer where electrical saturation of a pair of coupled coils and an internal capacitor is required to form a tank circuit in order to store voltage for regulating power disruption. With this technology, output power can be regulated in a tighter range of +/- 1%. Additionally, surge suppression, step-down voltage capability, and harmonic filtering are possible with some transformer-based voltage regulation products. When fully loaded, the CVT can achieve up to 90% efficiency. Though power backup is not offered with this product, the CVT can provide power hold-up for up to 3mS, which is often long enough for a disruption to be remediated.

Business Use

Voltage regulation is common for businesses in large office buildings that experience many internal disruptions as heavy equipment such as HVAC systems and elevators come online and consume large amounts of power. The automatic voltage regulator and the constant voltage transformer are highly reliable solutions for power management. The top-of-the-line power conditioner solutions incorporate voltage regulation attributes along with noise filtering and surge suppression features and are used by businesses in all industries to attempt to provide comprehensive power protection ability.

Applications & Form Factors

Applications that require high power loads with known disturbance issues are prone to utilize voltage regulation technology. Office equipment, self-service kiosks, vending, professional audio-video systems, and medical equipment have all implemented this technology into their systems. The tool is installed between the outlet and the asset in an attempt to remediate disruption. Form factors for voltage regulators cover both free standing tools and printed circuit boards. Over the past decade, many power conditioners and uninterruptible power supplies have integrated voltage regulation technology.

Drawbacks

This technology solution experiences disadvantages in the marketplace due to its high cost, size, and weight. The device is also electrically wasteful as it consumes electricity even if it is not actively regulating voltage levels. This contributes to the finite lifespan of the internal electrical components. Though the voltage regulator can protect from the input voltage level fluctuations, additional components and devices are required to shield equipment from surges, current inrushes, and electrical noise. Another drawback is the efficiency varies greatly with varying electrical loads. Typically the unit performs inadequately with light loads when compared to heavier loads because there is a requirement for near-constant power to maintain the transformer or capacitor saturation. Additionally, the device lacks the ability to collect data which makes it difficult for the user to manage their power.

UNINTERRUPTIBLE POWER SUPPLY (UPS) TECHNOLOGY

Definition

When the electrical power supplied by the utility company fails, the only means to ensure that an electronic asset does not shut down improperly is an emergency battery backup system. This device is known as the uninterruptible power supply (UPS) because it ensures a constant stream of electrical power is provided no matter what disruptions come through the grid. The UPS system primarily serves as an emergency battery backup device that delivers stored energy when called upon. It can support electrical load equipment that has suffered from a lapse in the primary power supply. Various versions of the UPS system support loads for varying amounts of time. Typically this time period is relatively brief, but the pause is usually more than enough to allow the equipment to properly close out all programs, save all important data, and power down. This solution is different from electrical generators because of the near-instantaneous response time of the UPS.

Technical Overview

The technology is specialized because it is applied on a needs basis when the business cannot afford to improperly shutdown the electronic equipment. There are three main types of UPS systems available on the market today: 1. Standby 2. Line Interactive 3. Online. Each version of the solution contains a different circuitry design and distinct performance capabilities. However, the basic functionality is similar in that each circuit offers power to the electrical load via two different paths – either direct from the power supply or indirect from the back-up battery. When the mains power is active and stable, the UPS will draw some current into the battery cell in order for recharging. When the mains power fails, the load is supported from the charged battery.

Business Use

The uninterruptible power supply sufficiently provides emergency backup power to electronic assets in all industries. Businesses that depend on a steady and reliable power supply rarely can afford to not have backup battery systems installed. Computer malfunction, data loss, and service and re-calibration expenses are moderate ramifications when compared to the personal injury and potential fatality concerns that stem from many electrical systems. The expanded functionality of UPS systems provides businesses with the added value of power conditioning and voltage regulation.

Applications & Form Factors

Industries where UPS usage is most common include medical, telecommunications, data center, financial services, and large scale manufacturing. These industries install the units onto various applications such as robotic surgery equipment in hospitals, computer server centers in banks, and semiconductor fabrication tools in manufacturing clean rooms. Typically the UPS device is plugged directly into the AC power outlet before the electronic asset and before the power supply. The size of the tool ranges from that similar to a power strip to a desktop computer tower to, in some applications, a small automobile.

Drawbacks

This technology solution experiences disadvantages in the marketplace due to its high cost, size, and weight. The on-battery runtime that the UPS can provide varies greatly over the form factor and price ranges. Up-time is inversely proportional to current draw making it a challenge for a smaller UPS to keep high current loads operational for more than a few minutes. Matching the backup systems specifications with the load and the system environment is crucial before utilizing a UPS Additionally, the UPS itself incurs service expenses as their batteries need to be replaced every 2-4 years. Disposal of these batteries also requires a significant fee. Overall, the high cost of implementing and utilizing uninterruptible power supplies make them a good fit only when the electronic asset requires backup support.

ISOLATION TRANSFORMER TECHNOLOGY

Definition

An isolation transformer enables a business to isolate a sophisticated electronic asset from a disruptive power environment. It is a less commonly employed protection device. The primary issue that is remediated by isolation transformers is neutral to ground voltages, also known as common mode voltages.

Technical Overview

An isolation transformer provides a method to transfer electrical power from the source input to the electrical equipment while eliminating the physical connection between the two circuits. Voltage and current are inducted over the transformer rather than conducted through hard-wire connections. This design addresses the frequent disruption called neutral to ground voltage.

Business Use

Businesses that utilize many computer controlled operations frequently have issues resulting from common mode disturbances. The ability to control the neutral to ground voltages that are confusing and disrupting microprocessors remains a priority for businesses in many industries. Clean power is essential for these sophisticated tools to perform accurately and as intended.

Applications & Form Factors

Isolation transformers are best suited for systems such as HVACs, elevators, data centers, and automated manufacturing tools. Specifically, any machines that utilize three-phase power supplies and have microprocessor-based control are susceptible to common mode disruptions. The isolation transformer solution comes in a stand-alone unit that must be implemented into the system. Some manufacturers also integrate the isolation transformer into power conditioners.

Drawbacks

An isolation transformer, like a UPS, is a specialized tool that is required when the need or issue arises. Many electronic assets are not affected by common mode disruptions. The isolation transformer product can be costly and lacks the ability to protect assets from all power disturbances. Additionally, the size limitations of this technology prohibit many electronic assets from implementing them into a design. Being iron and copper-based, isolation transformers are heavy and expensive. Both weight and cost rise exponentially with load current requirements.

INNOVOLT ROC™ TECHNOLOGY

What is the unmet need in the marketplace?

When gauging the strengths and weaknesses of the power protection devices in the marketplace, there appears to be a significant unmet need. Protecting electronic assets from the full array of damaging power disruptions that occur in less than a few milliseconds requires quick and repeatable diagnosis and remediation. Currently, the Innovolt ROC™ (Remote Optimization & Control) is the only solution that utilizes microprocessor based algorithms to predict and prevent power anomalies from damaging your electronic assets.

As mentioned previously, the failures of power conditioner devices that contain line filtering or threshold-based components happen when response times are either too fast or too slow. These devices struggle with identifying and remediating the various anomalies because no two power anomalies have the exact same voltage signature. Nuisance trips frustrate users when reaction occurs too fast after the disruption was improperly identified. Reaction to the disruption that is too slow causes internal circuitry damage that leads to machine failures. The shortcomings of power conditioners that contain voltage regulation circuitry happen when electrical loads fluctuate. Electronic assets frequently experience high load periods followed by low load periods. The inability to protect assets throughout the course of varying electrical load periods dramatically decreases the product's efficiency.

Another drawback of the industry leading power conditioners is that they lack the ability to protect the asset's internal components from the full onslaught of power anomalies. Specifically, the basic devices cannot fully protect against current inrushes due to voltage sags, brownouts, and post-blackout reclose sequences. Some of the competitive devices successfully handle current inrushes during equipment start-up scenarios, but after the machine has been running for even a few minutes, this protection circuitry is disabled and a current inrush would flow directly into the machine and damage vital hardware.

Additionally, surge protection offered from power conditioners can have a short effective time frame. This is because the most widely used protective component, metal oxide varistors (MOV), are commonly damaged and rendered dysfunctional because of repeated overvoltage or surge events. Many of the alternative products lack both a protection component for the MOV array and a method of alerting users that the MOV has been degraded to the point of failure. Once this component expires, surges can unabatedly enter into the electronic asset. Overall, power conditioners require additional circuitry, and accordingly additional size, weight, and cost in order to address each of the specific power anomalies.

How do we address it?

The Innovolt ROC™ technology performs with optimal speed which allows for a unique functionality that sets our solution apart from other competing power management products. Using a series of patented algorithms and protocols, the technology is able to recognize potential power concerns and quickly remediate the issues before damaging effects occur. The Innovolt solution compares real-time power signatures to profiles of scenarios known to inflict damage to electronics. The central microprocessor system, with its algorithms based on 25 years of power research, then determines the most effective steps for remediation and activates the core protection circuitry. This diagnosis is performed in microseconds and damaging power is prevented from reaching the connected equipment. This predictive processing technology is unique to Innovolt.

Addressing the perceived drawbacks of alternative technologies in the power protection marketplace, Innovolt ROC™ operates at peak efficiency no matter what load fluctuation is experienced. The patented algorithm remediates the electrical path within 2 milliseconds after a voltage sag event to limit current inrush and prevent possible damage. When a catastrophic overvoltage occurs, the mechanism reacts in less than 4 milliseconds to remove connected electronics from the power grid. Nuisance trips and an asset's internal circuit damage are eliminated because the Innovolt microprocessor can accurately identify power anomalies. Multi-stage MOV components are common for surge suppression capabilities. Innovolt utilizes not one set of these components, but a pair of multi-stage MOVs on either side of our core protection circuitry. This shields both the electrical asset as well as the surge suppression components from overvoltage and surge damage.

What are our proven results?

Over 25 years of research has built the foundation that Innovolt is based on today and we have amassed a catalog of success stories in each new market that we enter. Our customers have documented improvements in equipment uptime which has resulted in decreased service calls, improved customer satisfaction and increased revenue.

Innovolt guards expensive and sensitive technology against the damaging effects of power disturbances while simultaneously giving businesses the tools they need to predict, measure, and maximize the performance of assets across the distributed enterprise. The value our proven solutions deliver includes:

- Protecting, optimizing and managing your assets
- Extending the life of electronics equipment and reducing cost of ownership
- Increasing productivity and performance
- Increasing asset uptime and lowering service calls
- Improving customer satisfaction and brand loyalty
- Providing a holistic view of the asset environment

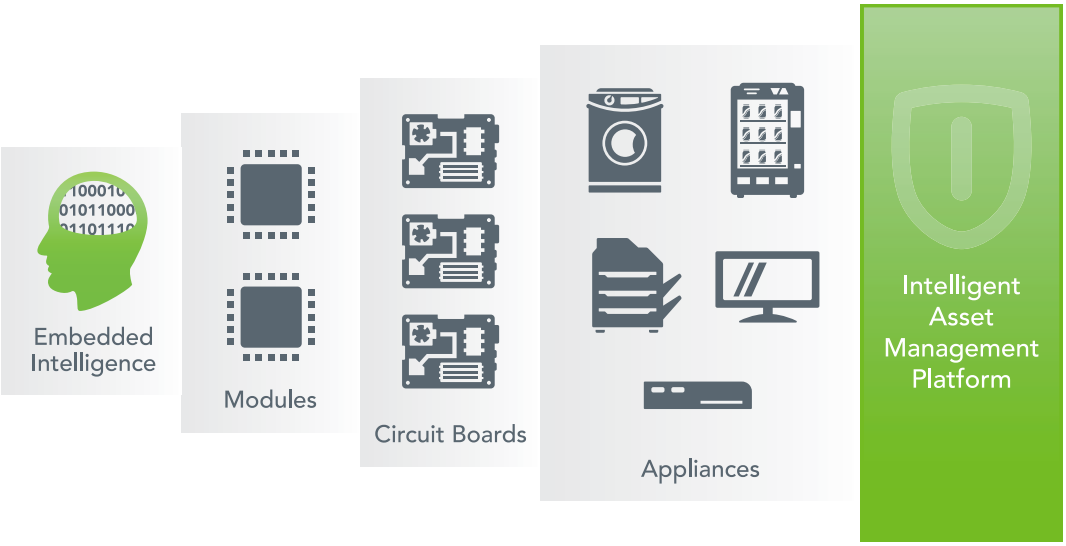
What type of form factors does Innovolt offer?

The diagram below illustrates the deployment options which include:

Embedded Intelligence: Work with our team of experts to license and incorporate Innovolt's proprietary microprocessor-based algorithms.

Modules or Boards: Integrate our system-ready chip modules or boards into your electronics.

Appliances: Get immediate protection with our plug-and-play appliances you can purchase today.



INTELLIGENT ASSET MANAGEMENT

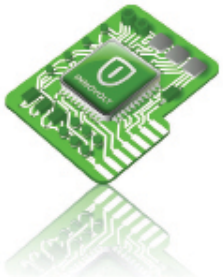
How can we change the way your business operates?

While the Innovolt ROC™ technology provides the highest level of electronics protection, it is also part of a broader Intelligent Asset Management (IAM) platform. IAM is a proactive solution that ensures the performance of electronics and enables a company to holistically and accurately manage its entire fleet of electronics. Through the combination of the ROC technology and the Innovolt Management Cloud (IMC), companies have access to a complete Intelligent Asset Management offering.

The Innovolt Management Cloud (IMC) is a platform for offering a consolidated view of a company's electronic devices and the power-related data they deliver. This allows a company to track the performance history of an entire fleet of devices—recording such data as power disturbances, etc.—and identify its trends. Rather than retrieving information piecemeal—device by device—the IMC presents a holistic perspective of how all devices are performing across a broader spectrum and empowers a company to formulate a proactive plan for managing those devices. Like all cloud technologies, the IMC is hosted on the Web. A user simply opens a browser to access the information from anywhere with an internet connection. More details about IAM and the IMC are available in additional whitepapers: Defining Intelligent Asset Management & Its Business Impact and Why Innovolt's Management Cloud is Business Critical.

Monitoring

Microprocessor- based real-time monitoring for over a billion dollars in protected assets.



Remediation

Patented technology and algorithms for electronics resilience.

Management

SaaS powered analytics and management engine providing data and remote control.

Sources

[1] Bendre A., Divan D., Kranz W., and Brunsickle W., "Equipment Failures Caused by Power Quality Disturbances", IEEE-IAS 2004 0-7803-8486-5/04

[2] Imam A., Divan D., Harley R., and Habetler T., "Electrolytic Capacitor Failure Mechanism Due to Inrush Current", IEEE 2007 0197-2618/07

[3] N.K. Medora, A. Kusko, and M. Thompson, "Impact of line voltage sag on switch mode power supply operation", presented at Industrial Electronics and Applications, 2008. ICIEA 2008. 3rd IEEE Conference, 2008

[4] A.J. Collin, S.Z. Djokic, "Voltage Disturbances and Inrush Current of DC Power Supplies", presented at International Conference on Renewable Energies and Power Quality, 2010.

[5] S.Z. Djokic, J. Desmet, G. Vanalme, J.V. Milanovic, and K. Stockman, "Sensitivity of personal computers to voltage sags and short interruptions", Power Delivery, IEEE Transactions, vol. 20, pp. 375-383, 2005.

[6] A. Mohamed, H. Shareef, M.F. Faisal, "Performance comparison of voltage sag source detection methods for power quality diagnosis," IEEE 2012 1827-6660

About Innovolt

Innovolt® combines patented electronics protection technology with comprehensive monitoring and analytics applications to deliver the leading Intelligent Asset Management platform. Significantly reducing the cost of electronics ownership, Innovolt intelligently protects and manages the productivity and usable life of the technology that powers today's digital world. The company's proven solutions guard expensive and sensitive electronic assets against the damaging effects of power disturbances while simultaneously giving businesses the tools they need to predict, measure, and maximize their performance across the distributed enterprise. For more information, visit www.innovolt.com.

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INNOVOLT™
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