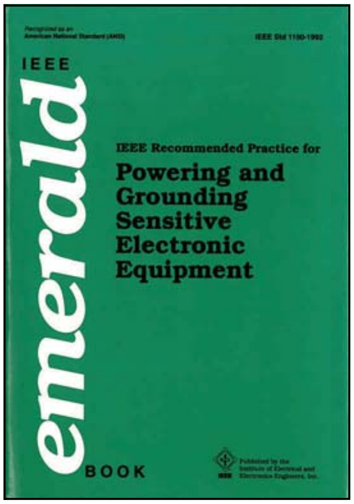
Tech Byte 10: Cascaded TVSS Design

Effective, Facility-Level Surge Suppression Strategies

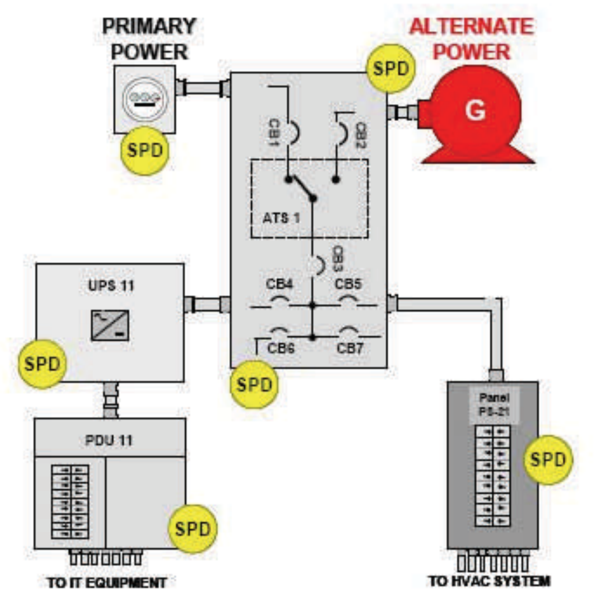
In today's commercial and industrial facilities, the reliance on electronic equipment to support and perform business critical functions continues to increase. However, electrical infrastructure design continues to lag behind in its efforts to provide a reliable and functional environment for this electronic equipment. A new focus for electrical design needs to be on understanding the factors that affect the longevity and operational performance of electronics, and the most effective ways to address them. It is common knowledge that power quality has a significant effect on longevity and performance, and a major power quality concern for electronic equipment is transient activity. Transients have the ability to affect performance of electronics, as we will show later in this article, and they also have the ability to decrease the operational life of electronics. Today's new electronic and information technology (IT) equipment is smaller, more adaptable, and more powerful than its predecessors. As a consequence of this, the newer equipment is also more susceptible to power fluctuations and transient conditions. The focus on this article is to identify the best design practices for applying transient voltage surge suppression to offer the best protection for electronic equipment.



To account for the increased needs for electronic equipment, infrastructure design best practices have become a critical topic addressed by the engineering community. The Uptime Institute has qualified this by denoting four levels of infrastructure design and their anticipated availability for a given AC power system. These levels are denoted as Tier 1, Tier 2, Tier 3, and Tier 4. Each level is based on specific redundancies and design requirements for the systems used to operate a computer room. For a system to be compliant to a specific level, all subsystems are required to meet the specifications for that particular tier. This includes the power system, the heating ventilating and air condition (HVAC) system, and the fire alarm system. For simplicity sake the Tier 1 Power System will be the focal point of this article.

The Tier 1 power system (Figure 2) is composed of two power sources: primary and alternate, an uninterruptible power supply (UPS), a power distribution unit (PDU), a switchgear for the incoming power, and a distribution switchgear for the HVAC system. In Figure 2, the primary source is derived from the local utility and the alternate power source is derived from an engine generator. Non-standard sources of AC power (e.g. wind turbines) can also be used to provide primary power with the utility providing the alternate power source. In addition, a separate utility feed can also be used for alternate power.

FIGURE 2
TIER 1 POWER SYSTEM



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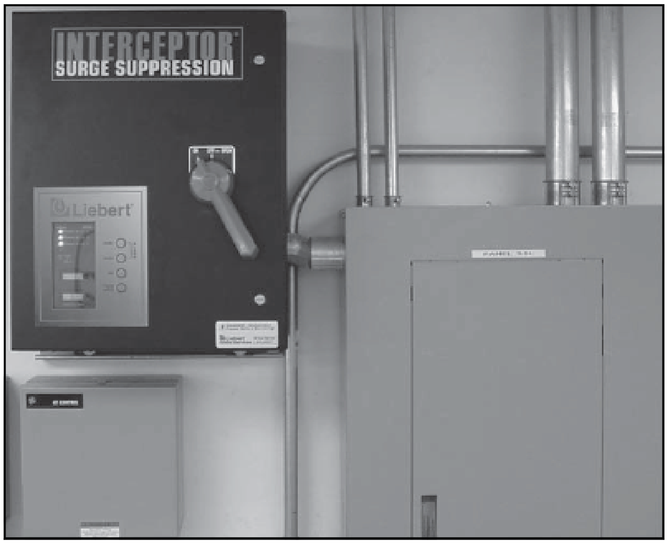
When a utility service is used for both the primary and the alternate AC power, it is up to the authorities having jurisdiction (AHJ) to determine its applicability.

What is important to note is that even the Tier 1 design, which is the most basic of the four tier levels, requires power to be conditioned. While the term “conditioned power” has different meanings to some, it generally implies that the AC power is free from transients, noise, is at a constant voltage, and is at a constant frequency. AC power for the HVAC system is provided through the distribution switchgear PS21. To provide transient protection to a Tier 1 system, surge protective devices (SPDs) are required at all levels within the electrical distribution. The levels within the facility include the service entrance, the distribution panels, and the point of use equipment. In Figure 2, the service entrance location is the input to the switchgear where primary AC power is supplied from the utility service, and alternate AC power is supplied from the generator. The branch panel location is identified as the input and output locations of the UPS11, and PDU11 for conditioned power to the IT equipment. For the HVAC system, branch panel location is PS21.



Main or Secondary Electrical Panel
Example TVSS Install

Significant focus on surge suppression should be made when designing the electrical infrastructure that will support IT equipment. Computer rooms provide critical support to a variety of business functions. To ensure that the ac power system has high levels of availability to meet the demands of the business, specific levels of redundancy have been established by the Uptime Institute. The basic level of reliable infrastructure design is denoted as a Tier 1 system, **and in a Tier 1 system, cascaded TVSS design is recommended**. These basic requirements for TVSS protection will carry over to each of the higher Tier levels as well. The IEEE recommends that SPDs be installed at:

- Each service entrance location
- Each distribution level switchgear, UPS, or PDU
- All point of use locations (specific IT and HVAC equipment)
- Any system (HVAC, fire alarm, security) that requires components to be located external to the structure of the facility

The IEEE also recommends ac power that is supplied from external locations (utility) or ac power that feeds external components (HVAC, fire alarm, security) be capable of protecting these systems from Category C type transient conditions. Additionally, one should consider that Category C transient conditions can occur many times over the life span of the equipment and the facility.SPDs perform an important function by reducing transient conditions so that processes can operate as designed. Using scientific processes, best engineering practices, and various codes and standards will create safer, more efficient, and more profitable processes and installations.

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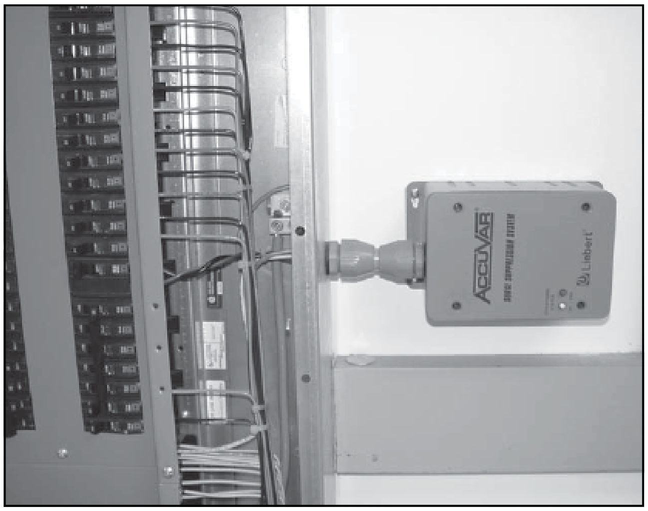
Because of the recommendations by IEEE and the Uptime Institute, a common question becomes, "why the need for cascaded TVSS protection if we have TVSS protection at the service entrance?". This question can be addressed by reviewing industry research on the topic of TVSS, such as the findings of the 2006 Frost and Sullivan World TVSS Markets Report. In this report, Frost and Sullivan's findings include information about transient activity and where the activity commonly takes place. The report makes the following conclusions:

- It is estimated that 50% of data loss at computer installations is due to power quality problems
- Approximately 40% of the data loss problems are due to transient activity, with the remaining 10% due to other factors
- ***More than 60% of all transient voltages and surges originate within the facility, and the remaining 40% is caused outside of the facility due to weather and utility switching***



Branch Distribution Panel - Example TVSS Install

Additional valuable information on the topic of cascaded TVSS protection comes from an IEEE paper from the 2006 Transmission and Distribution Conference. The paper, titled "*Cascade Protection with Transient Voltage Surge Suppressors (TVSS) in Variable Speed Drive for Electro-Submergible Pumps*", addresses another benefit of cascaded TVSS design:

"*Cascaded TVSS protection also offers added protection against residual voltage and current that passes through a service entrance SPD during an externally generated surge event. The principle of the cascade protection scheme relies on the fact that the primary service entrance device – first line of defense unit – will absorb and dissipate the bulk of the transient energy and the residual voltage/current will flow downstream to the second and third level devices. In a lightning type of surge event this residual voltage may be several thousand volts, depending on the design characteristics of the TVSS and the method of installation. If another TVSS is connected in the electrical system – as in a secondary distribution panel, the residual surge of the primary unit is reduced significantly, and so on, until the resulting surge activity and resulting damage threat is virtually eliminated and the impulse is below the equipment nominal voltage*."

Why does "residual current and voltage" exist downstream of the service entrance device? The answer is because although the service entrance TVSS component is designed to provide a low resistance path to ground for transient activity, that path never reaches zero resistance. Therefore there is a split of surge energy distribution. A majority of the surge will be addressed by the service entrance device, while the remainder of the surge will continue to travel into the facility. If the facility TVSS design meets IEEE recommendations, the secondary TVSS devices downstream will address this residual energy.

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Conclusion:

Even today, common design approaches to TVSS protection are to apply a service entrance device and consider the job complete. We can see from IEEE and the Frost and Sullivan report that this is a flawed approach. The majority of surge activity is not being addressed with service entrance only designs. The risk of improper protection continues to elevate with the proliferation of microprocessor controlled equipment and other electronic equipment into facilities of all shapes and sizes. As previously stated, electronic equipment, especially in the IT arena, continues to become smaller and more powerful, and likewise more affected by transient activity. Surge activity within a facility may not be of the magnitude that causes immediate destruction of this equipment, but lower level surges will significantly affect longevity and performance. Cascaded TVSS design is a best practice for ensuring proper performance and longevity of electronic equipment.

IEEE Standard 1100-2006 (Emerald Book), Section 8.6.3 (p. 300) *“Facilities housing electronic load equipment of any type should have service entrance equipped with effective lightning protection in the form of a listed Category C SPDs…”* Section 8.6.4 (p. 301) *“In addition to SPDs installed in the service entrance equipment, it is recommended that additional SPDs…be applied to downstream electrical switchboards and panelboards, and panelboards on the secondary of separately derived systems…* Section 8.6.8 (P. 304) *“All exterior mechanical systems (e.g. cooling towers, fans, blowers, compressors, pumps, and motors) that are in an area not effectively protected by lightning protection per NFPA 780 should be considered as targets for a lightning strike. Therefore, it is recommended to practice to individually provide SPD protection…to all such equipment.”*

Liebert TVSS Products: http://www.liebert.com/product_pages/SecondaryCategory.aspx?id=6&hz=60