No Margin for Error: The Case for Internal Surge Protection

April 2011 / White paper 9910-0002

Revision A

Schneider Electric

Summary

Executive summary

As the demand for energy increases and our appetite for electronics continues to grow, the need to provide protection from voltage transients, also known as surges, that damage these investments also grows. Power-related problems cost US companies more than $80 billion a year and brings power-quality discussions to the forefront. A surge protective device (SPD) is designed to suppress voltage transients, but they are only effective when installed properly. This is an element that is out of the specifying engineer's control—and yet so critical to customers.

Without question, external SPDs have their place. However, for many projects, using internal SPDs that are installed in the electrical distribution equipment takes the guesswork out of SPD installation and gives specifying engineers the control they need over the execution of their project. This white paper discusses important considerations for surge protective device selection and explores important trends in the marketplace.

Power-related problems cost US companies more than $80 billion a year.

Introduction

It's a scenario that's all too familiar to specifying engineers. You carefully consider each product selected for the customer. You understand that protecting their investment from energy surges and disruptions is dependent on the surge protective device (SPD). Yet, the contractor hired to perform the actual installation doesn't understand negative effects of added lead lengths. To him, an SPD is just another piece of equipment and he mounts it in the most convenient place, or the only available space on the wall.

In a perfect world, SPDs would be installed exactly according to manufacturer specifications and industry best practices. But the reality is that how and where the device is installed is completely in the hands of the installer, who may or may not understand SPDs. Poor placement of the device and excess wires being looped instead of shortened—standard wiring practices—significantly impacts the performance of the SPD. Today, when surge and other power-related problems cost companies billions of dollars, it's not enough to hope the product is installed correctly. Specifying engineers, installers, and customers need to know that the SPD is going to work as designed and specified. Internal SPDs are built to do just that: ensure the right device is used and installed properly.

Internal SPDs are typically mounted inside the electrical distribution equipment during the manufacturing process. Switchgears, switchboards, motor control centers, panelboards, and busways, among other equipment, are currently available with internal SPDs. External SPDs will continue to be a viable solution, particularly in existing installations; however, changes in the market are creating new demand for the advantages internal SPDs provide.

40% of data loss at computer installations can be attributed to surges.[i]

Market drivers impacting the SPD landscape

It is widely accepted that power surges and other power-related issues are a high-cost problem for businesses—a problem with costs well into billions of dollars. The cost of repairing or replacing damaged equipment is just part of the overall expense. The impact on business includes maintenance costs, delays, decreased productivity, and data loss. In fact, Frost & Sullivan estimates that 40% of data loss at computer installations can be attributed to transient voltage spikes.[i]

A study by the Lawrence Berkeley National Laboratory put an $80 billion price tag on the effects of power interruptions on businesses. This study was conducted in 2004.[ii] As our dependence on energy and electronic devices continues to grow, we can expect that figure to rise.

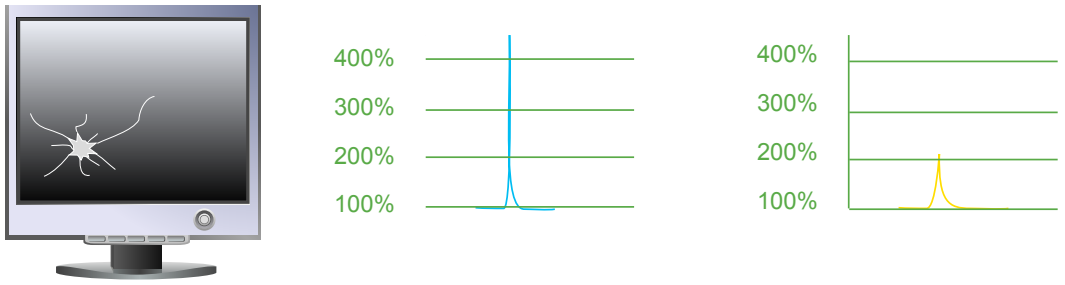
"Transient voltages and surges can impact productivity and profitability."

- Frost & Sullivan

Frost and Sullivan reports, "As the use of electronic equipment increases in manufacturing facilities, corporations, and the residential sector, the need for power-quality protection equipment is essential. Surge protection for both the entire facility and individual equipment is gaining significance as transient voltages and surges can impact productivity and profitability."[iii]

Costs like these have not escaped notice. The average industrial consumer experiences 13.3 power-quality events per year.[iv] The equipment most impacted by power quality includes computers, controls, and motors. This awareness is driving demand for surge protection. Consequently, the SPD market continues to grow.

Impact of large surges and short, repetitive surges



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Large surges can cause immediate damage while small, repetitive surges can cause damage over time.

External SPDs: A look at where traditional solutions fall short

The installation of external SPDs by experienced installers will continue to provide excellent protection and remains the only option for protecting existing electrical distribution equipment. But there are three core areas of concern in using external SPDs that must be addressed: lead length, installation mistakes, and the added cost of installation.

Problem 1. Lead length impacts SPD performance

It is no secret within the surge industry that lead length is critical to overall performance. Most industry experts agree that for every foot of wiring there is a minimum increase of 100v that can reach down-line equipment.

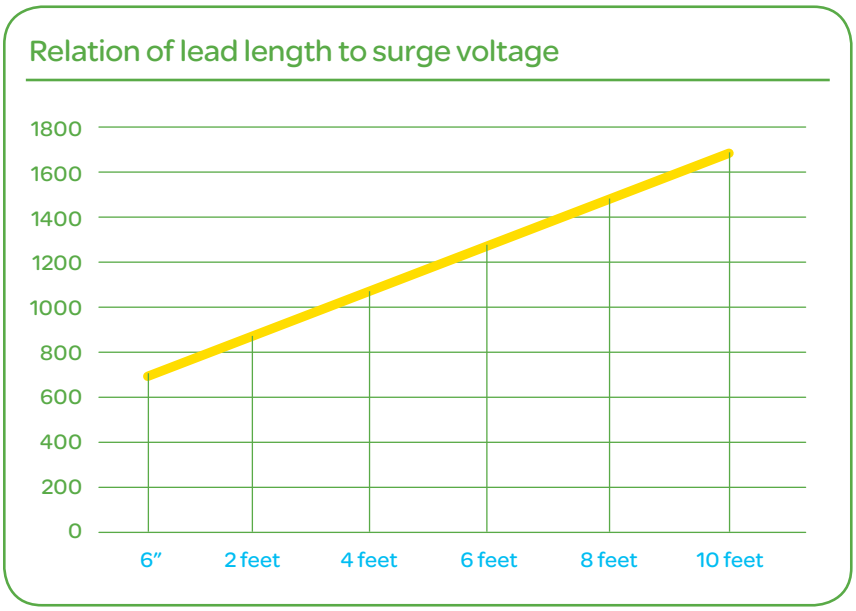
The Underwriters Laboratories (UL) has a defined test procedure for SPDs. The UL 1449 3rd Edition standard subjects the SPD to 6000 volts and 3000 amps. UL then measures the let-through voltage from a cable length of six inches. This means that a SPD with a 700v voltage protection rating (VPR) provides that level of protection with six inches of lead wire. If the device were installed with a 10-foot lead wire, the voltage left in the system could reach 1700v (minimum) under this same test. This is the amount of damaging let-through voltage headed to down-line equipment.

When SPDs are wall-mounted, there can be a wide variance in the lead length depending on the placement of the device and the wiring technique employed by the contractor. The impact of lead length on let-through voltage is documented in an IEEE study.[v]

Problem 2. Planning and Installation Mistakes

External or wall-mount devices are typically installed after the distribution equipment is in place and systems are up and running. In these types of installations, the SPD is more of an afterthought and little planning may have been put towards proper surge protection installation methods. Issues that arise include:

- Limited panel access
- Limited wall space
- Installer's experience or inexperience with SPDs



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For every foot of wiring, there is a minimum increase of 100v that can reach down-line equipment.

It is not uncommon for externally mounted SPDs to be installed into an electrical system and fail on startup. Upon further investigation, it's often discovered that the wrong product was installed for the system configuration. For example, a product rated for 120v was installed in a 277v system, or a WYE-configured SPD was used in a DELTA application. These are costly mistakes because the damage they cause are typically not covered under warranty.

Problem 3. Additional Cost for Installation

This challenge is inherent in the external SPD's design. A wall-mounted device requires that a contractor install it; therefore, additional materials and labor are required.

In addition, some external SPD manufacturers have introduced specialized wiring that uses the mutual inductance of the cables to help reduce the effects of their added lead lengths. These specialized cables do provide better performance when compared to standard wire and standard wiring practices but create additional cost. And, they still cannot provide the same level of performance as the internal solutions with minimized lead lengths.

SPDs should be installed as close to the protected equipment as possible, and cable lengths should be as short as possible.

Guidelines for providing surge protection at commercial facilities clearly state, "Only surge protection that is properly sized and grounded can be successful in preventing equipment damage. For maximum protection, SPDs should be installed as close to the protected equipment as possible, and cable lengths should be as short and straight as possible to minimize the resistive path of the circuit to ground. Anything less than a low grounding and bonding impedance will cause surge energy to be diverted throughout the facility, with potentially hazardous effects."[vi]

Internal SPDs: Increasing performance and protection

The alternative to external SPDs is internal SPDs. These devices are built in-line with the electrical distribution equipment. Their success at addressing the lingering problems in surge-protection installation has prompted a steady increase in demand. The primary advantage in quality internal SPDs is the assurance that the device is the right rating, uses minimal lead lengths, and is installed correctly.

Solving the Lead Length Dilemma

When an SPD is internal, it can be installed very close to the conductor. The design allows manufacturers to minimize lead length and wire bending, which should ideally be eliminated. As a result, the lead length between the SPD and the conductor is often much shorter than the connection to an external SPD. An article in the IEEE Transactions on Industry Applications publication compared the effectiveness of SPD types.

"There are two methodologies that can be employed to protect industrial equipment. One method is to connect the SPD externally to a power distribution panel. This method of installation does not provide a sufficient level of protection to the equipment at high surge currents. The second method is to integrate the SPD devices within panelboards, switchboards, switchgear, motor control centers, VSDs, or other electrical equipment. Integration of SPD devices ensures the lowest clamping voltage, thus the highest level of protection to the equipment."[vii]

Eliminating Installation Mistakes

Installed SPDs are tested for their proper system application and configuration. With internal SPDs in the distribution equipment, there is no need for any additional external space for accommodating surge protection. This allows better utilization of what little space is allocated within these electrical rooms. And, since the SPD is already installed, labor and materials costs are reduced.

Future Outlook

The IEEE and other organizations, along with consulting and specifying engineers, have realized that keeping the conductor lead length connecting an SPD as short as possible is critical in maximizing surge-protector performance. For this reason, and the other benefits internal surge protection provides, the popularity of installing SPDs inside electrical distribution equipment has greatly increased over recent years and is expected to continue.

Analyst Projections

Frost & Sullivan reported that internal SPDs made up 37.3% of the total hardwired SPD market in 2009. They predict this share is likely to increase to 45.6% in 2016. Conversely, external SPDs accounted for 62.7% of the market in 2009. This share is likely to decrease to 54.4% in 2016.[viii]

Industry Support

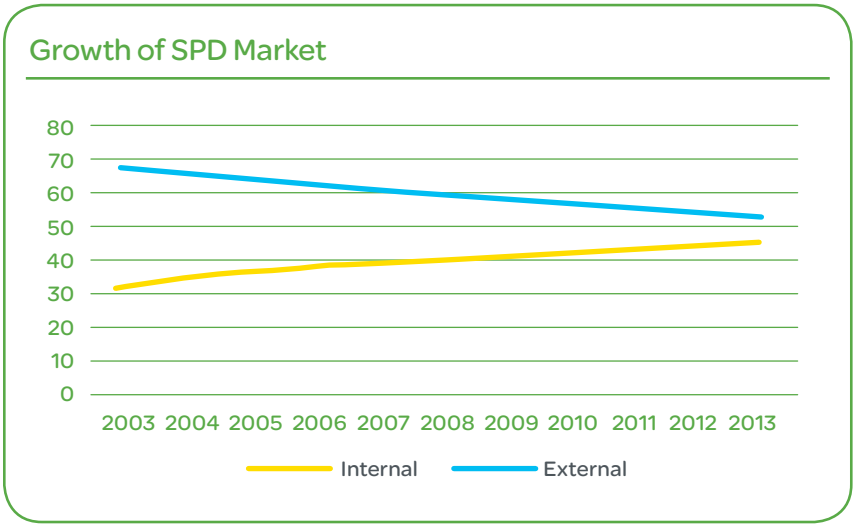
The designs, the applications, and the installation of surge protection are highly influenced by different organizations within the industry such as IEEE and UL. Their job is to publish articles, write standards, and recommend best practices. They have recognized the performance benefits of internal surge protection.

UL 1449 3rd Edition recognizes the importance and growth of internal surge protection and created tests and UL categories specifically for internal surge protection which ensures that internal surge protection meets or exceeds the safety requirements for external surge protection. There is no need to be concerned about adverse effects of SPD failure when installed internally.

Recent articles discuss the merits of internal SPDs. “Panelboards are available that contain integrally mounted SPDs that minimize the lead length of the SPD conductors, thus optimizing the effectiveness of the device.” IEEE 1100-2005, Section 8.4.2.5

“Design engineers are taking into account the integration of SPDs with panel boards or with switch-gear at the design stage rather than at the implementation stage. Also, internal SPDs are smaller in size and require less space than their external counterparts.”

— Frost & Sullivan



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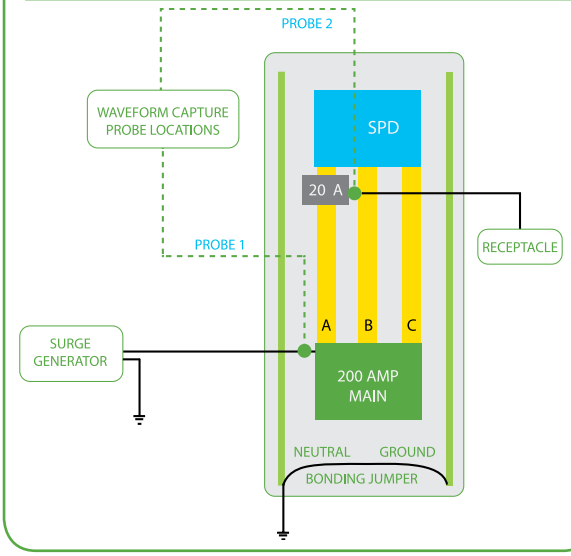
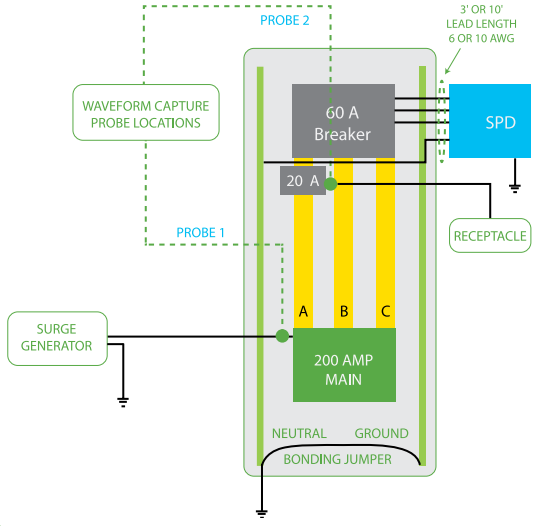
The market share for internal SPDs continues to grow. It is projected to increase to 45.6% in 2016.

Another article published by the IEEE reported the results of independent SPD testing performed by R&B Labs. These tests confirm, "That the effectiveness of a SPD is directly related to connection method, type, and length of wire leads. Surge protection devices mounted integral to the electrical distribution equipment was demonstrated to be the best surge mitigation approach without exception."[ix]

Internal SPD Test: Probe Placement



External SPD Test: Probe Placement



Figures at Left

The UL-SVR values shown in the table reflect UL-1449 second edition values. The third edition uses a Voltage Protection Rating (VPR) with increased let through values.

The change in testing and terminology does not have a direct effect on the measured values defined by Probe 1 and Probe 2.

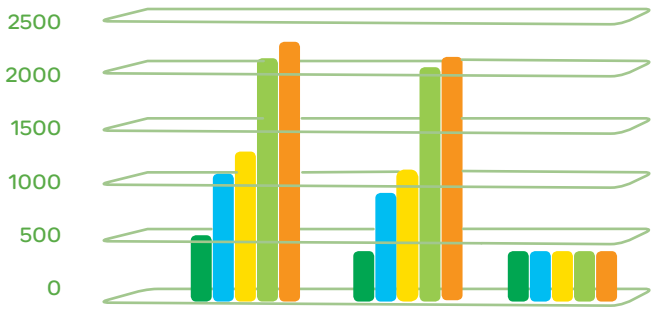
Figure Below

Independent lab tests demonstrated that internal SPDs are the best surge mitigation approach without exception.

Note

The peak voltage measurement without SPD connected are 7,420V at Probe 1.

B3/C1 Impulse Test Results



	Probe 1	Probe 2	UL-SVR
Internal SPD	583	427	400
Wall Mount 3ft 6awg	1110	917	400
Wall Mount 3ft 10awg	1301	1163	400
Wall Mount 10ft 6awg	2255	2052	400
Wall Mount 10 ft 10awg	2267	2160	400

Conclusion

Consulting and specifying engineers should consider internal surge protection to provide maximum protection against surge events. This paper identified the following key benefits that internal SPDs provide and that should be taken into consideration when specifying surge protection:

- Performance – minimized lead lengths provide maximum performance and equipment protection
- Proper location of the installed SPD along with installation
- Proper SPD is installed for the application (voltage and configuration)
- Eliminates additional installation costs that are required by external SPDs .
- Eliminates additional space requirements for external mounted SPDs
- Industry accepted and growing popularity make it the preferred method of installing surge protection

About Surgelogic

With the Surgelogic™ line of surge protective devices, Schneider Electric offers world-class solutions for electrical distribution systems. From simple applications to mission-critical implementations in commercial and industrial environments, the Surgelogic line provides a surge protective device for every need. Each Surgelogic SPD is designed, tested, and manufactured in-house, confirming that your solution is:

- Built to the highest standards
- Features the most advanced technologies
- Meets the industry's most rigorous testing criteria
- Backed by 100 years of experience in electrical distribution .
- Made in the USA

We have the knowledge and resources to help you select the system that's right for your specific needs. This is critical when considering that choosing devices with a higher level of suppression than you need can be unnecessarily costly, while too little suppression can result in serious equipment damage and power outages.

Learn more at www.surgelogic.com or call our Technical Assistance Group at 1-800-577-7353.

References

[i] "World Transient Voltage Surge Suppressor Market," Frost & Sullivan, August 2010

[ii] "Understanding the Cost of Power Interruptions to U.S. Electricity Consumers," Kristina Hamachi LaCommare and Joseph H. Eto, September 2004.

[iii] "World Transient Voltage Surge Suppressor Market," Frost & Sullivan, August 2010

[iv] "European Power Quality Survey Report," European Copper Institute and Leonardo Energy, Jonathan Manson and Roman Targosz, November 2008.

[v] "The Use of Surge Protection Devices in the Petroleum/Petrochemical Industry" IEEE Paper No. PCIC-97-9

[vi] "Guidelines for providing surge protection at commercial, institutional and industrial facilities." 2008 The Hartford Steam Boiler Inspection and Insurance Company

[vii] Electrical Surge-Protection Devices for Industrial Facilities—A Tutorial Review. IEEE Transactions on Industry Applications Vol. 43. No 1. January/February 2007

[viii] "World Transient Voltage Surge Suppressor Market," Frost & Sullivan, August 2010

[ix] The Influence of Cable Connections on TVSS Performance Marshall, E.; Hander; Valdes, M.; Britton, J.; Jones, T.; Whitehead, J.; McIntyre, B. Industrial and Commercial Power Systems Technical Conference, 2005 IEEE Volume, Issue, 8-12 May 2005 Page(s): 212-217

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Document Number 9910-0002

April 2011