White Paper

Surges and SPDs Defined

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Understanding Surge Challenges Starts with Comprehending Common Terms

INTRODUCTION

In February of 2013, the National Football League's 47th Super Bowl was played at the Superdome stadium in New Orleans, Louisiana. The most popular sporting event in the United States, the game between the Baltimore Ravens and the San Francisco 49ers became even more dramatic when play was interrupted for 34 minutes because of power problems that affected lighting, communications, and other systems. During a television broadcast, a league official stated that "… a power surge caused the outage." Subsequent investigation traced the actual cause to the mis-operation of a relay in the stadium's power distribution system.

The official's choice of words is understandable because he presumably is not an electrical power expert. Nevertheless, his word choice reflects a common misunderstanding of an important power quality term, one that is often reflected in communications about power conditions and surge protective devices. To promote proper understanding, this paper defines the term "surge" together with the term "Surge Protective Device" (SPD).

DEFINING SURGES

In popular use, the term "surge" might be used to describe the presumed cause of electrical disturbances including the brightening, dimming, or flickering of lights or momentary losses of electrical power. However, the term actually describes an overvoltage condition, and in the context of surge protection, applies to overvoltages of very short duration.

Surges Defined

The Institute for Electrical and Electronic Engineers (IEEE) ***C62.42.2 - IEEE Recommended Practice on Characterization of Surges in Low-Voltage AC Power Circuits*** states that a surge is "a transient wave of current, potential, or power in an electric circuit". Section 1.1 of this document also states that the standard applies to "… surges that "do not exceed one half-cycle of the normal mains waveform in duration." The Underwriter Laboratories (UL) ***Standard 1449 - Standard for Safety- Surge Protective Devices*** states that "… surges do not include temporary overvoltages consisting of an increase in the power frequency [or] voltage for several cycles." Consequently, sub-cycle overvoltage events are aptly described by the term ***transient overvoltages***. A transient overvoltage is shown in Figure 1.

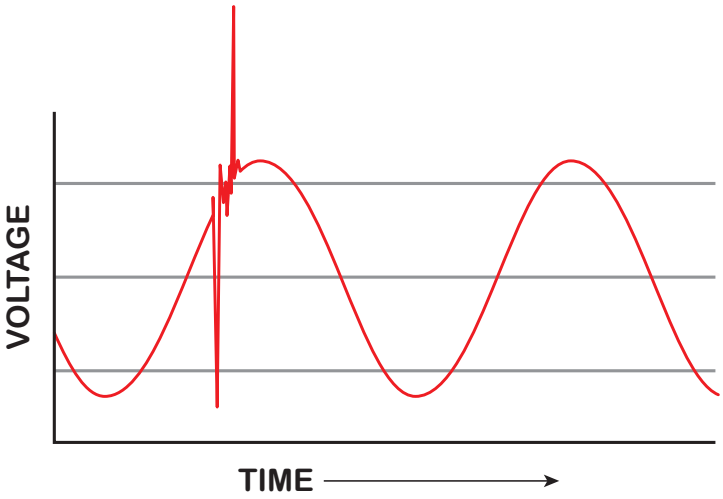

Figure 1: An example of a sub-cycle transient overvoltage

Transient overvoltages in building power distribution systems result from both external and internal events. External events such as atmospheric lightning and switching on utility grids and internal events such as capacitor and motor switching produce sub-cycle overvoltages like the example shown in Figure 1. While events such as lightning are the most recognizable sources of transient overvoltages, the majority originate from power events inside buildings.

Exceptions

The term “surge” is sometimes used to describe phenomena unrelated to transient overvoltages. For example, two ratings are typically provided for light-duty generators. While Running or Continuous Watts indicates the maximum operating load, Starting or Surge Watts is the measure of power that a generator can supply for a few seconds. This second rating is necessary to account for inrush currents when starting motor-driven devices. However, in this context, the use of the term “surge” relates to amperage, and is unrelated to voltage aberrations that require surge protection.

As in the Super Bowl example, popular usage of the word “surge” often extends to phenomena other than the sub-cycle transient overvoltages. Terms such as ***swell***, ***sag***, ***interruption***, ***outage,*** and ***harmonics*** represent power events that can affect loads, but none represent the transient overvoltages that surge protection devices are designed to mitigate. ***Sags*** are undervoltage events and thus are not surges. ***Swells*** are overvoltages that last for several cycles or more, and are better described as temporary overvoltages. While ***interruptions*** can cause momentary power losses and ***outages*** result in sustained downtime, they involve absence of voltage and thus are not surges. Furthermore, ***harmonics*** are distortions of normal electrical sinusoidal waveforms, generally produced by effects from nonlinear loads and are unrelated to voltage conditions. Switch-mode power supplies, variable speed motors and drives, office equipment, and uninterruptible power supplies are examples of nonlinear loads. Figure 2 below illustrates waveforms for these terms.

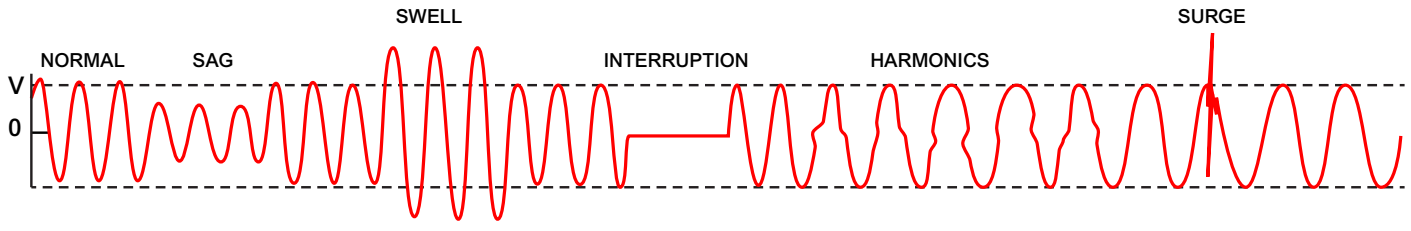

Figure 2: Waveforms for common power disturbances

SURGE PROTECTION DEVICES DEFINED

Transient overvoltages can degrade or damage electronic equipment or affect equipment operation. In order to protect equipment, SPDs are used to mitigate potential impacts. The following sections define and describe SPDs.

SPD Definition

Safety testing measures for SPDs are described in ***UL-1449 – Standard for Safety – Surge Protective Devices***. Section 3.42 defines an SPD as "A device composed of at least one non-linear component and intended for limiting surge voltages on equipment by diverting or limiting surge current and is capable of repeating these functions..." Typically, the "non-linear component" is a voltage-sensitive element that becomes conductive only when voltages exceed nominal values. SPDs thus begin to redirect current when the voltage level exceeds the device's Maximum Continuous Operating Voltage, or MCOV.

Exceptions

The UL definition notwithstanding, SPDs are often referred to as ***surge protectors***, ***surge suppressors***, or ***transient voltage surge suppressors***. However, surge protectors actually refer to any device for controlling electrical voltage surges, regardless of duration. While the terms surge suppressor and transient voltage surge suppressor can both refer to SPDs, the modern term for devices used to mitigate sub-cycle transient overvoltages is ***surge protective device***. Underwriters Laboratories discontinued using transient voltage surge suppressor when it issued the 3rd Edition of UL 1449, which became effective in September of 2009.

Operating Description

Installed between a grounding conductor and other conductors in a circuit, SPDs shunt voltage exceeding their MCOV to a grounding system. Figures 3 and 4 illustrate conceptual SPD operation for a single-phase system. In Figure 3, current of nominal voltage does not trigger a response by the SPD. However, Figure 4 shows that the SPD shunts voltage to ground when excess line voltage is present. In that instance, the load equipment receives current at the "let-through" voltage of the SPD, a level that is relatively close to the nominal voltage of the circuit.

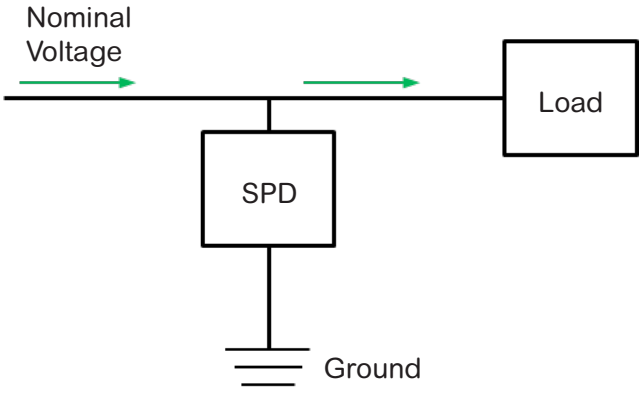

Figure 3: Circuit activity under nominal conditions

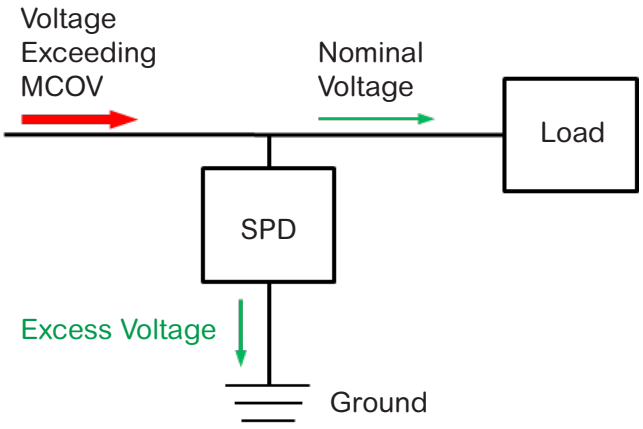

Figure 4: Circuit activity during overvoltage conditions

Additional surge pathways are available when SPDs serve three-phase electrical circuits. For additional information about surge pathways in three-phase systems, see our document entitled *Per Mode and Per Phase Ratings Defined*.

Proper Application

SPDs can effectively protect load equipment from damage by overvoltage transients. To properly apply SPDs, it is important to understand the types of functions that they cannot provide.

1. SPDs do not protect against temporary or sustained overvoltages. SPDs are designed to shunt sub-cycle transient overvoltages. When overvoltages occur over a longer duration, SPDs will attempt to shunt current until the voltage decreases below the MCOV. However, longer durations subject SPD components to additional heating, which could result in failure of the unit and risk of fire. For this reason, many SPDs are available with thermal mechanisms to disconnect the SPD from a circuit when sustained overvoltages occur. While this returns the load equipment to an unprotected state, it nevertheless averts safety hazards associated with overvoltage conditions.

2. SPDs are not power quality monitors. While SPDs offer a range of indication and annunciation features, they are not designed to monitor power quality. While ASCO offers a separate, voltage-based, surge monitoring system that offers many unique advantages, surge protection devices simply shunt current when excess voltage is present.

3. One SPD cannot protect an entire power distribution system. In most applications, SPDs are necessary at the utility service entrance. This can provide effective mitigation of transient overvoltages from external sources such as lightning that enter along utility services. However, a service entrance SPD will not protect load equipment from internally generated transient overvoltages. A single SPD also cannot fully protect against transients that enter a building along other conductors, such as grounding conductors or conductors powering loads on the roof, exterior walls, and grounds. For example, if lightning strikes the ground near a building's grounding point, voltage could enter into the building and damage load equipment without ever reaching the service entrance SPD. For this reason, SPDs should be installed at the service entrance, distribution panels, and critical load equipment using a cascaded approach.

SUMMARY

Surges are overvoltage conditions that are sustained for one-half cycle or less, and are best referred to as ***transient overvoltages***. While ***swells*** and ***sags*** both refer to voltage conditions, ***swells*** are multi-cycle overvoltages, and ***sags*** refer to undervoltages. ***Interruptions*** and ***outages*** refer to absence of voltage, events that can have causes other than power surges.

The modern term for a transient voltage surge suppressor is ***surge protective device***. ***SPDs*** are devices that can repeatedly limit surge voltages on equipment by diverting or limiting surge current. SPDs do not protect against temporary or sustained overvoltages. Thermal protection devices prevent SPDs from overheating and mitigate associated fire risks.

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