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Placement Considerations for Surge Protective Devices

White Paper

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Locating SPDs for Optimal Performance and Serviceability

Many factors affect the selection of surge protective devices (SPDs) and the design of surge protection systems. When planning surge protection projects, it is important to consider how installation practices can affect the performance, and serviceability of SPDs. The length of leads connecting SPDs to circuit conductors can impact the clamping voltage of the surge protective devices. In addition, the location and configuration of SPDs and equipment can affect their usability and serviceability. This document identifies several practices for maximizing SPD performance and utility.

USE THE SHORTEST POSSIBLE LEAD LENGTHS

When planning SPD installation, it is important to understand the impact of lead length on SPD performance. Longer leads reduce SPD performance because of inductive effects on conductors, so SPDs should be installed using the shortest possible lead lengths. Because overvoltage transients occur at high frequencies, the associated inductances are high. Inductance limits the propagation of short-duration, high frequency, overvoltage transients. When propagation is limited, high amounts of energy remain in localized areas and can impact nearby equipment. Rule-of-thumb estimates for inductance-related voltage drops range from 100 to 170 volts per foot, which adds to SPD let-through voltage and decreases protection for equipment.

To understand the impact, consider where the effects would occur. An SPD is located between an energized conductor and ground, as shown in the Figure 2. The amount of voltage remaining on the line conductor after an overvoltage is shunted equals the nominal line voltage, plus the voltage drop along the SPD conductors and the let-through voltage of the SPD.

In Figure 2, the diagram at left represents an SPD with short leads, perhaps six inches, while the diagram at right represents a similar circuit with leads that are perhaps two feet long. If the voltage drop is 100V/foot, the difference in lead lengths leaves an extra 300 volts on the line to impact load equipment.

Figure 1: Installing SPDs with long leads results in higher let-through voltages, decreasing protection.

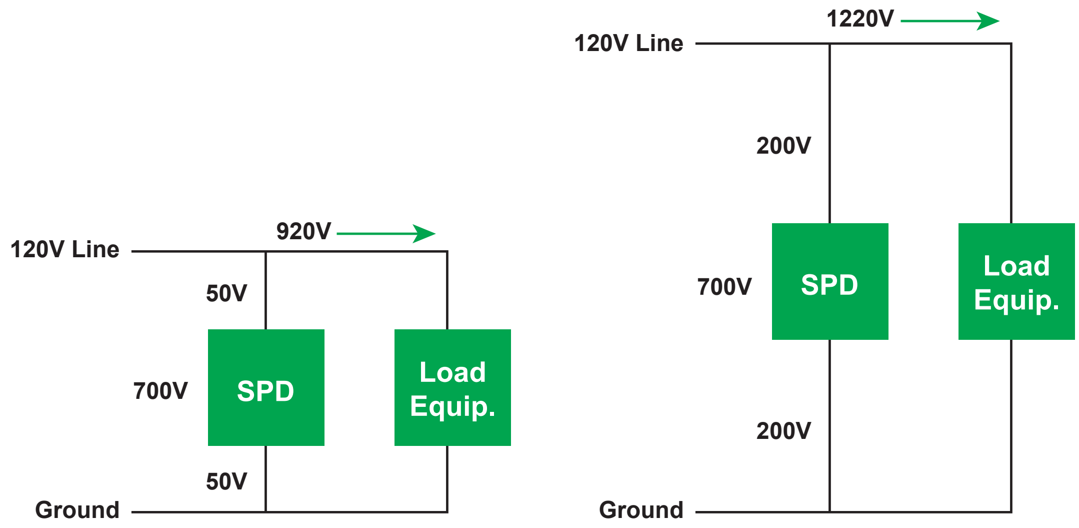

Figure 2: Short leads result in lower line voltages.

For these reasons, the Article 285.12 of 2017 National Electrical Code® requires SPDs to be installed with the shortest possible lead lengths, as follows:

> *"285.12 Routing of Connections. The conductors used to connect the SPD to the line or bus and to ground shall not be any longer than necessary and shall avoid unnecessary bends."*

Whether an SPD is installed within equipment or in a separate enclosure, minimizing lead length will maximize protection from transient overvoltages. Twisting conductors together and avoiding sharp bends can further reduce voltage effects.

INDUCTANCE-RELATED VOLTAGE DROP

Transient overvoltages occur and decay in milliseconds. As a result, the associated frequencies are high. So is the corresponding inductance, which limits the propagation of surge currents. The formula for estimating inductance-related changes is

$$V = L\, di/dt$$

Where:
V = voltage
L = inductive reactance
i = current
t = time

$$V = (0.75\mu H/m)\,(10{,}000V/8\mu s) = 938V/m$$

Using a simple algebraic estimation, voltage differentials exceeding 900 volts per meter could theoretically occur along SPD leads. In practice, manufacturers offer rule-of-thumb estimates from 330 to 560 volts per meter or 100 to 170 volts per foot.

Figure 3 below shows how SPD placement can result in conductor leads of various lengths. In any installation, SPDs should be located to minimize lead lengths. Engineers and facility managers should specify this practice when planning surge protection systems or retaining installation providers. Contractors should promote this practice by minimizing lead lengths, avoiding coiling of leads, and avoiding sharp bends. Keep in mind that the total length of all wires (N-G and Lines) need to be kept as short as possible.

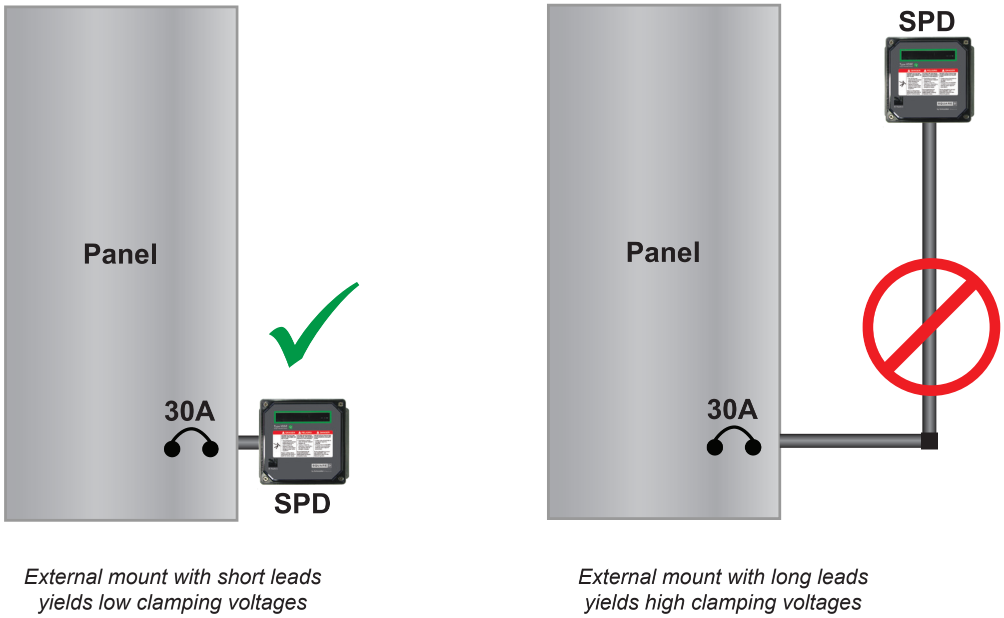

Figure 3: Whether externally or internally mounted, the shortest lead lengths minimize let-through voltage and maximize protection from transient overvoltages.

ENSURE SERVICEABILITY

SPDs can require service or replacement. The location and configuration of SPDs can affect serviceability. For SPDs located outside of electrical equipment, installing a shut off switch or breaker between the SPD and the protected load allows for maintenance of the SPD. SPDs located internal to electrical equipment may offer serviceability challenges because power may need to be shut off to some or all of the electrical components, depending on how the SPD is installed.

SUMMARY

Installation practices can affect the performance and usefulness of surge protective devices. To ensure that SPDs provide full protection, use the shortest possible lead lengths, provide visual access, and provide switching to enable removal of SPDs from service.

References

1. National Fire Protection Association, NFPA 70 - National Electrical Code, Fourteenth Edition, 2017. Quincy, Massachusetts, 2016

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