Applying Surge Protective Devices to Selectively Coordinated Distribution Systems

White Paper 102
In multi-tiered electrical power distribution systems, the characteristics of Overcurrent Protection (OCP) devices may be coordinated to ensure that faults open OCP devices closest to a fault location to avoid unnecessarily de-energizing equipment. Because Surge Protective Devices (SPDs) are often equipped with their own integral OCP, it is important to deploy SPDs in ways that maintain selective coordination schemes.

**SELECTIVE COORDINATION PRINCIPLES**

Article 100 of the National Electrical Code® (NEC®) defines Selective Coordination as:

*Localization of an overcurrent condition to restrict outages to the circuit or equipment affected, accomplished by the selection and installation of overcurrent protective devices and their ratings or settings for the full range of available overcurrents, from overload to the maximum available fault current, and for the full range of overcurrent protective device opening times associated with those overcurrents.*

The key phrase in the definition is “…to restrict outages to the circuit affected.” If the overcurrent condition opens an upstream breaker that feeds more than one branch circuit, the event could de-energize more loads than necessary.

**SPDs AND SELECTIVE COORDINATION**

To protect electrical equipment and systems, SPDs are installed to shunt transient overcurrent away from loads. The SPDs contain voltage-sensitive devices, most often Metal Oxide Varistors (MOVs), that are nonconductive when at nominal voltage. They become conductive during sustained or transient overvoltage events.

If a component such as an MOV fails in a manner that creates a short, the resulting current flow will clear the internal fusing and remove the SPD from the circuit, as demonstrated during UL 1449 testing. However, there are typically breakers located upstream of an SPD. If a short is created at the SPD, the upstream breaker could open, depending on characteristics of the event and the breaker trip curve relative to the SPD’s internal fusing. This, in turn, would de-energize all loads on the protected downstream circuit. For this reason, it’s important to consider the implications of SPD placement in a selectively coordinated system.

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Several industry standards, including IEEE 1100, recommend placing surge protection on main distribution panels, branch distribution panels, and on panels at every voltage level. Figure 1 therefore shows a system with SPD1 on Panel MDP and SPD2 on Panel A. In this instance, the SPDs are connected directly to bus. If SPD1 is not properly coordinated with CB1, failure of SPD1 could result in a short that opens CB1. This would result in an outage across the entire system (Figure 1).

In theory, one option for changing this outcome is coordinating the electrical characteristics of the SPD with the those of the OCP devices. In practice, SPDs are subject to UL 1449 short-circuit testing during product development and verification. The test data produced by this testing is typically insufficient for developing the types of discharge curves need to selectively coordinate devices. Consequently, manufacturers are unlikely to provide sufficient data to develop trip curves for SPDs.

A second option is to place a dedicated, selectively coordinated breaker (CB7) upstream of SPD1, as shown in Figure 2. Doing so forms a circuit where the SPD is the only load. Closing the breaker protects all the circuits on the panel. Opening the breaker takes the SPD offline, potentially easing service or replacement. Where CB5A is properly coordinated, it can clear the fault at SPD2 without impacting the remaining portions of the system (Figure 2).

Nevertheless, in Figure 2, SPD2 is connected directly to the bus.

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in Panel A. As before, this leaves all circuits on this panel susceptible to outage of the SPD fails. Again, installing a properly coordinated breaker (CB7) to isolate the SPD from a short limits the resulting impact of an outage (Figure 3).

**SUMMARY**

SPDs with integral overcurrent protection devices may defeat selective coordination schemes by shorting after overheating. It is typically impossible to selectively coordinate SPDs with circuit overcurrent protection devices because insufficient information exists for developing SPD "trip curves". Instead, selectively coordinated breakers can be placed upstream of SPD. Should a short develop in an SPD in this configuration, a dedicated breaker would remove the SPD from service before an upstream breaker could open and de-energize critical loads.