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Application considerations for surge protective devices when used with generators and automatic transfer switches

Introduction

The purpose of this paper is to address the subject of how to properly apply surge protective devices (SPDs) to systems using transfer switch equipment and generators, and to avoid common pitfalls associated with the application of surge protection to these systems.

SPDs are widely used in virtually all modern electrical systems. The use of electronic and computer controls in almost every aspect of industrial, commercial, institutional, and residential applications makes surge protection practically a necessity. However, improper application of surge suppression can result in suboptimal performance and reduced SPD life.

What is the purpose of a surge protective device?

The purpose of an SPD is to protect electrical and electronic equipment from damage and degradation due to short duration, high-energy transients. Typical voltage transients have a duration of microseconds to a few milliseconds. IEEE® C62.41 describes a number of transient waveforms that might be found on an electrical system. They range in magnitude up to 10 kV, 10 kA with a duration of 20 microseconds.

Sustained overvoltage, also called temporary overvoltage (TOV), is another power quality event. A TOV is an overvoltage that lasts at least one 60 Hz cycle, or 17 milliseconds. Typically, TOVs have a much lower magnitude, 1.7 to 3.0 times the nominal system voltage, but a much longer duration, from seconds to minutes to hours.

While SPDs do an excellent job of mitigating voltage transients, they are not designed to provide continuous sinusoidal voltage regulation. When an SPD is subjected to a sustained overvoltage, there is a very real danger of the SPD going into a thermal runaway and being permanently damaged. Modern surge suppressors that have passed UL® 1449 2nd Edition, including the February 2007 update, or have passed UL 1449 3rd Edition testing should pose no external threat of damage even when exposed to a sustained overvoltage. When exposed to a sustained overvoltage, the SPD should safely disconnect itself from the circuit.

What is thermal runaway?

Thermal runaway describes a condition where an increase in temperature causes a condition that further increases the temperature and can quickly lead to the destruction of the device. The main building block of an SPD is a metal-oxide varistor (MOV). An MOV is a non-linear device that has a very high impedance when the applied voltage is below the threshold voltage, and a low impedance when the applied voltage is above the threshold voltage. An increase in voltage past its threshold causes an increase in current flow that, in turn, causes an increase in the temperature of the MOV. An MOV that sees an increase in temperature will decrease in impedance, and a further increase in current flow and rapid thermal runaway will occur. An MOV can quickly and safely recover from a short-duration voltage transient; however, when an MOV is subjected to a sustained overvoltage, the MOV goes into thermal runaway and can not recover. **Figure 1** shows a graph that indicates typical threshold levels of time and voltage above which an MOV will go into thermal runaway.

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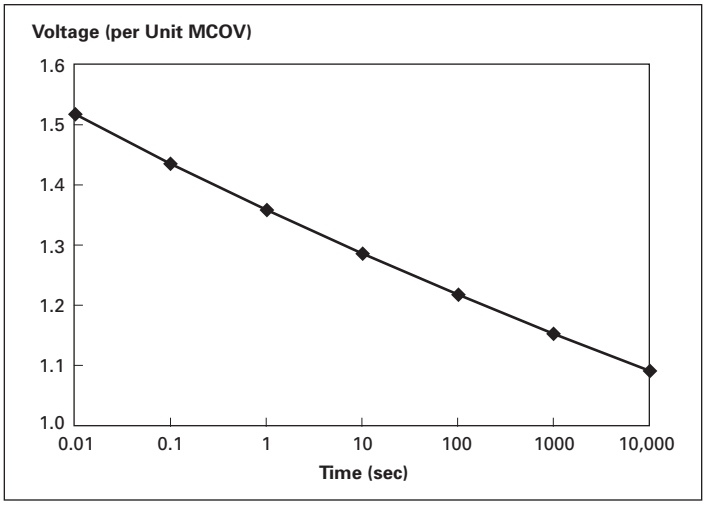

Figure 1. Typical Sustained Overvoltage Damage Curve for an MOV

Overvoltages in generators

Overvoltages in generators can occur for a number of reasons:

- Initial startup overshoot
- Poor voltage regulation
- Step change in load
- Single-phase ground fault
- Excitation control failure
- Overspeed

As described above, sustained overvoltages, even those that last only a few cycles or seconds, can have a devastating effect on MOVs. Power obtained from the electrical utility typically has very good voltage regulation due to the large size of the generators, or most often multiple generators, versus the relative size of the individual loads. Utility generators also have very precise regulators and sophisticated protection schemes to ensure that the voltage stays within a very tight band, even down to a few cycles duration.

Standby or emergency generators, however, typically have poorer voltage regulation. Voltage overshoot at startup and during a step change in load is very common. Also, for cost considerations, many voltage regulators do not regulate well in the short term, for example, cycles-to-seconds time frame. Most standby power or emergency power generation systems are designed with the purpose of keeping critical loads, such as emergency lighting, sump pumps, and critical loads, operating "no matter what" with power quality as a secondary consideration.

It is not uncommon that the voltage fluctuations of a typical standby generator exceed the limits of the voltage damage curve of an SPD. The failure of SPDs due to a sustained overvoltage is typically not covered under manufacturers' warranties, as this is clearly outside of the designed operating parameters of an SPD.

Solutions to overvoltage damage to SPDs caused by generators

1. On an automatic transfer switch (ATS), apply surge protection only to the Normal side of the switch. Do not apply surge protection to the Emergency or Load side of the automatic transfer switch. This will ensure that during the vast majority of the time, when the system is operating on utility power, the electronics in the ATS and the downstream electrical and electronic loads are protected.
2. Invest in a high-quality voltage regulator for the generator. Mechanical governors and low-cost electronic regulators may be a tempting option in cost-sensitive applications; however, the long-term effects of damage to SPDs and other equipment due to sustained overvoltages often quickly outweigh the cost savings of a low-cost regulator.
3. Make sure that the generator is sufficiently sized. Take into account any motor loads or other loads that have a high inrush current. Electric motors typically draw 6 to 10 times their full load current when started. Make sure your generator is sufficiently sized to handle the startup of these motors. An undersized generator is prone to severe undervoltages as connected motors are started followed by a severe overvoltage when the motors reach their operating speed. Most generator manufacturers offer software that will assist in sizing the generator properly.

Conclusion

SPDs offer many positive benefits and can successfully prevent damage and disruption to electrical and electronic equipment. However, it is highly recommended that SPDs only be applied on the Utility side of the emergency power system in order to prevent damage to the SPDs from sustained overvoltages.

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