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# IEC 61312 Surge Protective Device Coordination

## *Four coordination variants*



*The purpose of SPD coordination is to successively reduce the lightning threat, in stages (SPD 1, 2 & 3) down to the surge-withstand capability of the vulnerable equipment, without exceeding surge current and voltage ratings of individual SPDs.*

## Background

Lightning surges contain significant amounts of energy that needs to be diverted away from vulnerable equipment, which is the system that is to be protected from surges. CE-marked electronic equipment is designed with a certain built-in surge voltage immunity in accordance with IEC 61000-4-5. This level of immunity will be sufficient for the majority of office buildings where the vulnerable equipment is located far away from the electric service entrance. Therefore, equipment that carries the CE mark will work well without surge protection in many environments.

However, when the vulnerable equipment is installed close to the electric service entrance or in an outdoor enclosure, particularly in areas with a poor physical ground such as dry sand or rock, it is often necessary to add external surge protective devices (SPDs). IEC recommends (IEC 61024) that lightning protection zones (LPZ) are established to successively reduce lightning currents in stages, down to the built-in immunity of the vulnerable equipment.

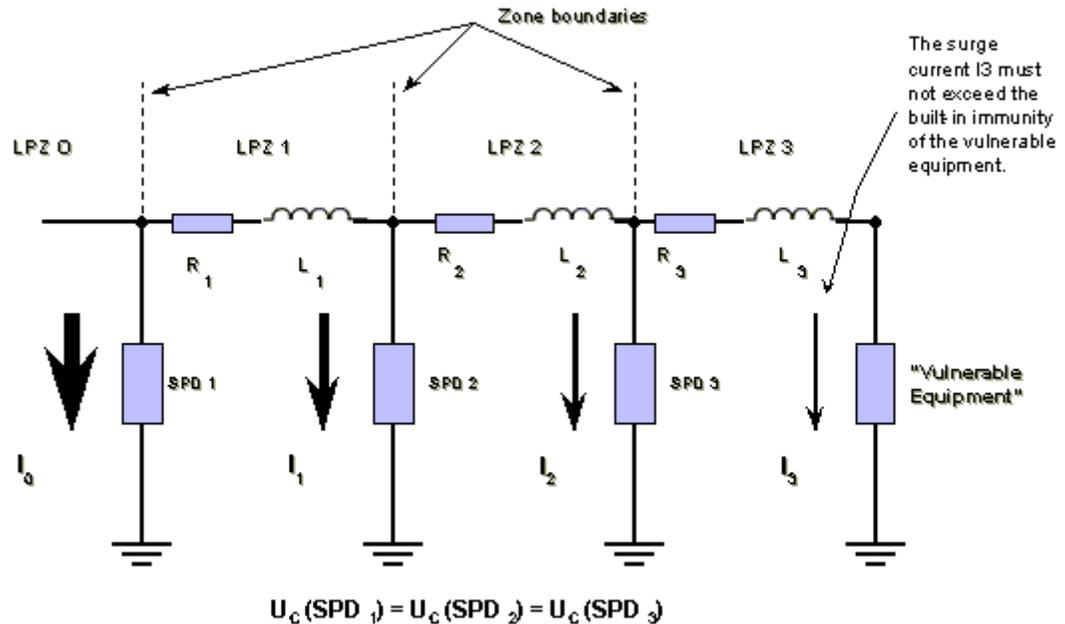
The number of zones required depends on the structure containing the installation and the vulnerable equipment. IEC 61024 requires that an SPD is installed at each zone boundary and the surge current and voltage ratings of individual SPDs must not be exceeded.

This paper explains the purpose and concept of surge protective device (SPD) coordination in accordance with the IEC 61312 standard.

## Purpose of coordination

To successively reduce the lightning threat, in stages (SPD 1, 2 & 3) down to the surge-withstand capability of the vulnerable equipment, without exceeding surge current and voltage ratings of individual SPDs.

### Variant 1



*Variants I, II & III utilize individual single-port SPDs. Variant IV is a two-port hybrid design.*

Figure 1

## Coordination concepts

### Variant 1

Shown in Figure 1, the rated voltage of SPDs is identical and coordination is achieved by separating each SPD by means of series impedance. Variant I is not recommended by the IEC, probably because it would require approximately 30' (10 m) of wire or separate inductors between each SPD, which is not practical when installing equipment close to the electric service entrance or in outdoor enclosures.

### Variant II

Shown in Figure 2, the rated voltages of SPDs are stepped. The SPD in the vulnerable equipment has the highest-rated voltage and SPD 3, 2 & 1 have progressively lower rated voltages, assuring that each upstream SPD would divert progressively higher currents. Variant II is difficult to implement since most power supplies, uninterruptible power systems and telecom rectifiers, rated for 230 V, use input SPDs with a 275 V rating. Therefore, stepping down rated voltage would cause SPD 1 and 2 to be destroyed by normal line voltage fluctuations. Experience has shown that fluctuations of plus 10%, resulting in 250 V, are not unusual.

### Variant II

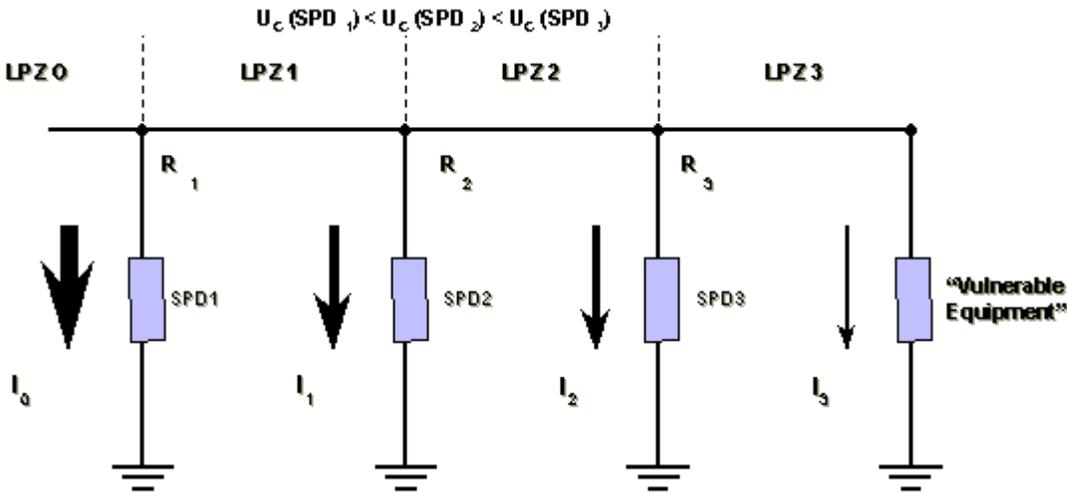


Figure 2

### Variant III

Shown in Figure 3, Variant III includes a component with a non-linear current/voltage characteristic, such as a spark gap. The SPD 1 spark gap would divert the majority of the surge current and output a combined wave (similar to ANSI/IEEE C62.41-1991, Category B3, Combination Wave, 3000 A, 6000 V) to downstream SPDs 2 and 3. The voltage ratings of SPD 2 and 3 are identical, but each device will handle considerably less current thanks to the much higher energy handling capability of spark gap SPD 1. Variant III is a better choice than I or II because the spark gap is insensitive to fluctuations in line voltage. However, spark gap follow-on, short-circuit current may be an issue and the Metal Oxide Varistors (MOVs) will still be sensitive to line voltage fluctuations.

### Variant III

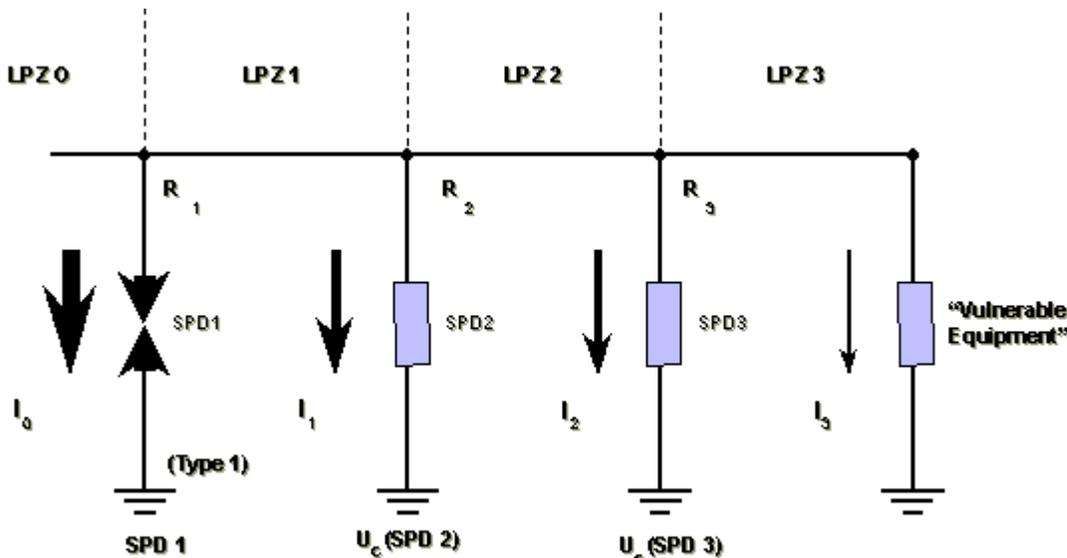


Figure 3

*Variant III is a better choice than I or II as the spark gap is insensitive to fluctuations in line voltage.*

## Variation IV

Figure 4 shows a two-port hybrid device that incorporates cascaded stages of SPDs internally coordinated with series impedances. A hybrid device can be designed to maximize performance while reducing the undesirable characteristics of spark gaps and SPDs based on varistor or silicon-avalanche-diode technology. The use of a hybrid device eliminates the need to coordinate surge protective devices, but does not eliminate sensitivity to prolonged line over voltage.

## Variation IV

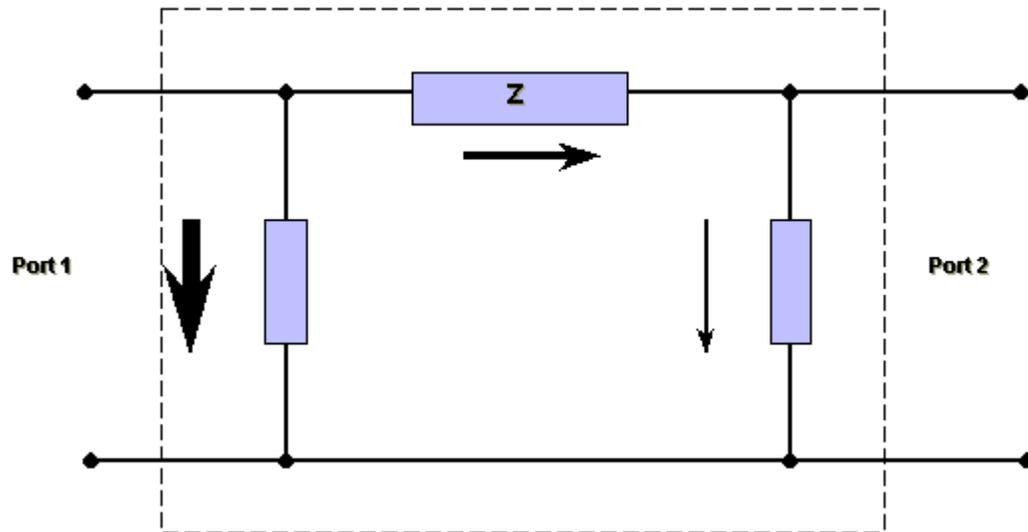


Figure 4

## Summary

Equipment designed to conform to CE requirements has a built-in surge immunity level that is sufficient in most office applications. However, equipment installed close to the electric service entrance or in an outdoor enclosure, particularly in areas with a large number of lightning days, requires additional protection – especially if the physical ground is poor.

Surge protective devices require coordination to perform well. The remnant voltage of the SPD closest to the vulnerable equipment, shall not exceed its built-in immunity level. Coordination of surge protective devices is not always easy and the best solution may be a two-port, hybrid device, which will simplify the planning and installation process. Because high line voltage will destroy varistor and silicon-avalanche devices that are rated too close to the line voltage, this must be considered when planning for protection in areas with unstable power lines.

## About the Author

Peter Nystrom is the president of TSi Power Corporation and has been in the power protection industry for over 30 years. He can be reached at: [peter@tsipower.com](mailto:peter@tsipower.com).

TSi Power specializes in manufacturing indoor and outdoor UPS, line conditioners, precision automatic voltage regulators, automatic transfer switches and DC-AC inverter systems designed to meet the challenging international power conditions.



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