True All Mode Protection

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Abstract--**This document details the use of "True All Mode Protection" to describe the use of individual protection elements in all possible modes within an electrical system. The document investigates what existing IEEE (Institute of Electrical and Electronics Engineers) and NEMA (National Electrical Manufacturers Association) standards state regarding the use of discrete individual protection elements in all modes when protecting electrical systems. Further, additional discussion is provided regarding the benefits of such a protection scheme.**

Keywords – ***protection modes, surge protective device, transient voltage surge suppressors, power quality***

I. Modes of Protection

The number of modes (or protection modes) in any given electrical system depends on the system configuration. As an example, a three-phase, grounded Wye configured system, contains ten possible modes of protection. The possible protection modes include three line-to-neutral modes, three line-to-ground modes, three line-to-line modes and one neutral-to-ground mode.

Transient voltage surge suppression (TVSS) or surge protective devices (SPD) are available in a number of combinations of the above protection modes. Most commonly, these devices offer four, seven or ten modes of protection. Various terminologies are used to describe which of the protection modes are included in the device.

One such phrase is "All Mode Protection." "All Mode Protection" could mean that all ten modes are protected by discrete protection elements; it could mean that seven modes are protected by discrete protection elements and the remaining three modes are protected by the series combination of protection elements purposed for other modes; or, it could mean that four modes are protected by discrete protection elements and the remaining six modes are protected by the series combination of protection purposed for other modes.

Because of this confusion, Surge Suppression Incorporated® has adopted the use of the phrase "*True All Mode Protection*." By definition it means that all ten modes are protected by discrete, individual protection elements purposed for protection of that mode and only that mode. None of the modes of protection depend on protection elements purposed for other protection modes. The intent of Surge Suppression Incorporated in adopting this phrase is to distinguish between its products and others that may claim all mode protection without providing discrete protection elements for all ten modes. The association of the phrase "all mode protection" with an SPD that does not offer individual protection elements in all modes could create confusion. "True All Mode Protection" means just what is implied, that is, all modes are protected by individual suppression elements.

II. Is True All Mode Protection Necessary?

Surge Suppression Incorporated® has continuous success in protecting electrical systems using SPDs with a true all mode protection topology. But, this is a method we have employed based not only on our experience but also on the recommendations and requirements of industry standards from IEEE (Institute of Electrical and Electronics Engineers), ANSI (American National Standards Institute) and NEMA (National Electrical Manufacturers Association).

III. ANSI/IEEE – The Emerald Book

The Emerald Book, IEEE Recommended Practice for Powering and Grounding Electronic Equipment (ANSI/IEEE Standard 1100-1999). In section 8.6.1 of this standard, it states: "*Surge protective devices used for three-phase, four-wire [Wye] circuits are generally recommended to be connected in all combinations of line-to-line, line-to-neutral, line-to-ground, and neutral-to-ground. Surge protective devices for three-phase, three-wire circuits are recommended to be attached in both line-to-line and line-to-ground modes.*"

The above excerpt clearly states that IEEE recommends protecting all possible modes within an electrical system.

IV. ANSI/IEEE – The Trilogy (C62.41 and C62.45)

The IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000V and less) AC Power Circuits (ANSI/IEEE Standard C62.41.2-2002). A review of Tables 2, 3, and 5 from C62.41.2-2002 shows that all modes are affected by transient activity and the standard describes the voltage and current surges for the various "Location Categories". Ring Waves (100 kHz) are shown in Table 2. Combination Waves (the 8x20 µs current impulse) are shown in Table 3. Note that Table 3 specifically calls out the line-to-line, line-to-neutral, line-to-ground modes for electrical systems with more than one phase, with a reference to Table 5 for the neutral-to-ground mode discussion.

In this standard, the IEEE clearly recommends the need for protecting against transient activity in all modes (line-to-neutral, line-to-line, line-to-ground and neutral-to-ground).

V. NEMA – PUBLICATION LS1

NEMA LS1, *Low Voltage Surge Protective Devices*, states in Section 2.2.7 (Protection Modes): "This parameter identifies the modes for which the SPD has directly connected protection elements, i.e. line-to-neutral (L-N), line-to-line (L-L), line-to-ground (L-G), neutral-to-ground (N-G)."

This statement makes it clear that if a mode of protection is claimed, then the SPD must contain a directly connected protection element. In turn, according to this definition, a protection mode cannot be claimed unless directly connected protection elements exist in that stated mode. That is, if a manufacturer claims "all mode protection" and does not provide directly connected protection elements in each of the ten modes (including the three line-to-neutral modes, three line-to-ground modes, three line-to-line modes and one neutral-to-ground mode), then that manufacturer is not in compliance with NEMA LS1.

VI. SURGES AND TRANSIENTS WITH REDUCED MODE PROTECTION

Outside of the recommendations of IEEE, ANSI, and NEMA, there are other reasons why true all mode protection should be employed. Consider what happens when an electrical system is subjected to a line-to-line transient. The difference in potential exists in the line-to-line mode. In the situation where true all mode protection is utilized, the directly connected protection elements in that mode create a bond between those conductors; therefore, the only voltage that the connected equipment is exposed to is the let-through voltage that exists after the transient has been mitigated.

In contrast, if an SPD with only seven modes of protection is utilized and the line-to-line protection mode is protected by the series combination of the line-to-neutral and neutral-to-line modes or the line-to-ground and ground-to-line modes, then those modes (line-to-neutral or line-to-ground) are intentionally exposed to unnecessary and undesired transient voltages. In essence, the SPD is sharing the line-to-line transient with the line-to-neutral and line-to-ground modes and creating voltages on those modes that would not be present with the use of a true all mode protection SPD.

VII. SURGE EQUALIZATION VERSUS SURGE DIVERSION

Another concept that is often overlooked or misunderstood is that the function of the SPD is not to merely divert or shunt surges to ground via the path of least resistance; but, to create a condition of voltage equalization. In the example cited above with a line-to-line transient, the voltage potential difference exists from one line to the other and not from each line to ground; therefore, the function of the SPD is to equalize and stabilize the voltage and remove the difference of potential between the lines. In doing so, the lack of difference of potential in that mode prevents surge current from flowing to the load being protected.

Even in the earliest publications of surge component manufacturers such as Harris/General Electric it was noted that "The logical approach is to connect the transient suppressor between the points of potential difference created by the transient. The suppressor will then equalize or reduce the potentials to lower and harmless levels." This statement not only affirms the concept discussed above but also recommends connection of suppression elements between any points that could have a voltage potential difference created by a transient and, thus, recommends true all mode protection.

VIII. SUMMARY

In the discussion of modes of protection above, it is evident the use of individual suppression elements in all possible modes of protection is strongly supported by such agencies as IEEE, ANSI, and NEMA. Also, this type of design has been successfully utilized by Surge Suppression Incorporated® throughout its history. The use of the phrase "True All Mode Protection" has been adopted purely to distinguish between an SPD that provides discrete, individual suppression elements for each and every possible mode versus an SPD that provides suppression elements only for selected modes.

Regardless of the phrase used to describe the design method, the goal of Surge Suppression Incorporated is to provide the customer with the best possible surge suppression solution through "True All Mode Protection."

IX. REFERENCES

1. The Emerald Book, *IEEE Recommended Practice for Powering and Grounding Electronic Equipment (ANSI/IEEE Standard 1100-1999).*
2. The Institute of Electrical and Electronic Engineers, *IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000V and less) AC Power Circuits (ANSI/IEEE Standard C62.41.2-2002).*
3. NEMA Publication LS1, *Low Voltage Surge Protective Devices*, *1992*
4. Harris/General Electrical Product Catalog and Application Notes

Ronald W. Hotchkiss is the Vice President of Product Engineering for Surge Suppression Incorporated® and has been involved in the design, development and certification testing of one-port and two-port surge protection devices for since 1990. Ron also manages engineering, safety agency, and compliance and quality operations. He is a member of IEEE's Power Engineering Society and is an active participant and contributor to several IEEE SPD working groups for the development of standards and the Underwriters Laboratories Standard Technical Panel for Transient Voltage Surge Suppressors. He is a member of the IEEE Standards Association balloting group for the approval of IEEE standards. Ron received his Electrical Engineering degree with Honors from the University of South Florida in Tampa.