The benefits of Direct (inline) SPD connection

Technical Note

A. BACKGROUND

There are two options to install surge suppression systems:

- **Direct (or In-line) Connection** – The surge suppression system or SPD modules are installed directly on the power cables/conductors feeding the load.
- **T (or branch) Connection** – conventional method of connection to the power cables through a branch protected by a fuse or circuit breaker.

Strikesorb modules like any other SPD device can definitely be connected in a T-connection. However, the **fuseless design** of the Strikesorb module in combination with its unique **robustness** and **energy handling** capabilities, also allow its **direct** installation on the power lines, without the need for additional interconnection wires or branch fuses/breakers.

In this document we present the advantages of this **exclusive** feature of Strikesorb.

The principle of direct connection is shown in fig. 1.

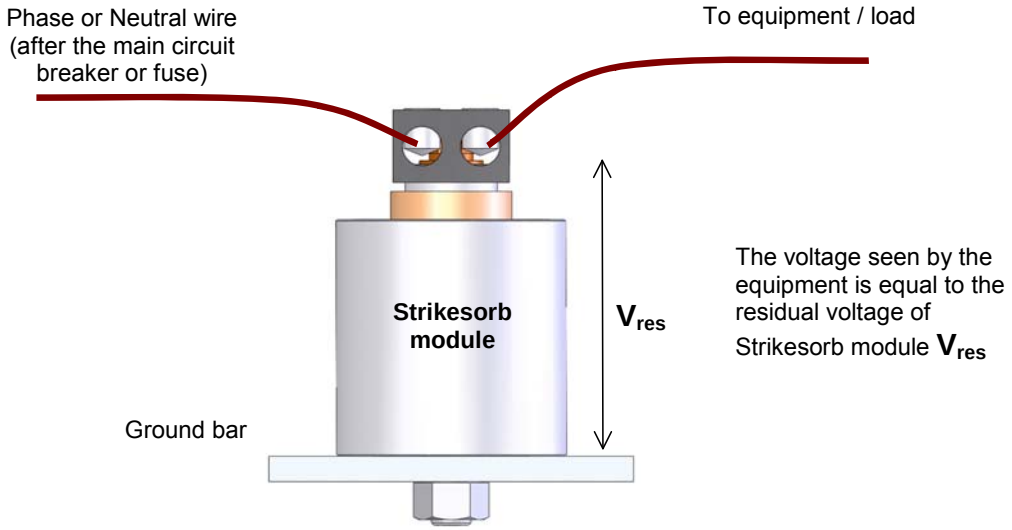

Figure 1: Direct (in-line) connection of Strikesorb module between a phase (or neutral) wire and the ground without additional lead wires.

B. Key advantages of the Direct Connection:

- **Load is always protected** – The exceptionally high energy handling capability of Strikesorb modules ensures that they will not be destroyed by surge currents caused by either lightning strikes or by surges generated inside an electrical installation. Should a Strikesorb module operate to a short as the result of a problem on the utility grid (MV/LV transformer fault, loss of neutral, prolonged temporary overvoltage) then the upstream overcurrent protection device will operate. In this way the equipment is taken off-line, protecting it from subsequent exposure to damaging conditions.

  Considering as a typical example the case of a prolonged overvoltage condition, it is easy to understand the benefits of direct SPD connection. In case the SPD is connected to the power lines in a T-connection with a fuse in series to the protection modules (MOV) as shown in fig. 2 – the fuse can be either internal to the SPD or external – then the exposure of the SPD to the overvoltage (typically above 25-30% over the nominal operating voltage) will short the MOV and consequently will force the fuse to open.

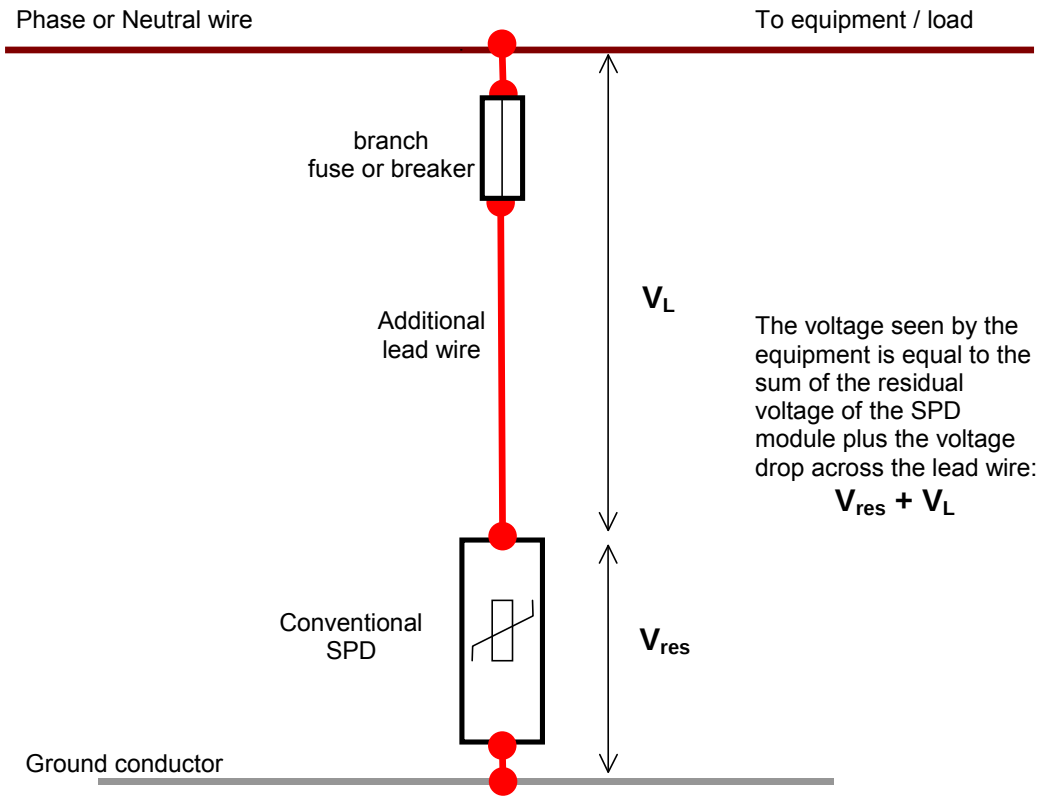

Figure 2: T-Connection of conventional SPD devices. In this case, an additional lead wire is required together with a branch fuse or breaker, which results in significant increase in the residual voltage to the equipment.

Therefore, the SPD is disconnected from the power lines and is no longer exposed to the overvoltage. However, the overvoltage is still applied to the "protected" load – which is no longer protected. The exposure of the load to the overvoltage will lead it to failure. So, the role of the SPD fuse (internal or external) in a T-connection is just to prevent catastrophic failure of the SPD and the way it opens, exposes the load to the overvoltage.

In the case of T-connected SPD's under prolonged overvoltage conditions, the SPD is taken offline but the load is damaged!

In case an SPD like Strikesorb is approved/listed for direct connection on the power lines behind the main breaker or fuse of the circuit, there is no reason to connect it in series with a fuse. Its listing certifies that even if its MOV is shorted, the SPD is able of handling the short circuit current generated without failing catastrophically. In a similar prolonged overvoltage condition (as above), the MOV inside the Strikesorb SPD will become a perfect short circuit and it will allow the short circuit current to flow through it, forcing the upstream main breaker to operate, trip and disconnect the circuit. This way the load behind the Strikesorb is isolated from the prolonged overvoltage.

The benefit in this case is that the direct connection of Strikesorb prevents any damage to the protected equipment.

- **Zero lead length** – In the case of direct connection the SPD is directly connected to the power cables/conductors offering the lowest possible residual voltage to the load. The input wires (line and neutral wires) are directly connected to one of the two Strikesorb connector ports. The second port of each connector is used to connect the corresponding wires that feed the equipment, as shown in Figure 1. Therefore, no additional lead wires are used, thus providing the lowest possible residual voltage to the equipment. The majority of conventional TVSS devices can only be installed in T-connection. One major drawback of T-connection is the increased let-through voltage due to the self inductance of the lead wires, as explained in the next section.

C. The Effect of Lead Length on the Protection Level

Conventional SPDs require the use of extra wires and fusing or branch breakers to connect in parallel (T-connection). The length of the wire adds impedance to the circuit and increases the residual voltage. The residual voltage that will be applied to the equipment is increased by:

$$V_L = L\left(\frac{di}{dt}\right) + IR \quad \text{(V)}$$

where L is the self inductance of the wires (H)
dI/dt is the rate of change of the surge current (A/s)
I is the peak value of the surge current

R is the resistance of the lead wire (Ω)

The self inductance depends on the length and diameter of the cable:

$$L = l\left[\ln\left(\frac{4l}{d}\right)-1\right]\cdot 200\cdot 10^{-9} \quad \text{(H)}$$

where *l* is the length of the cable and *d* is its diameter, both in meters.

As an example, in the following we calculate the values of V_L that can be created on typical copper cables of sizes 4/0AWG, 2AWG and 6AWG and for lengths of 1ft, 2ft, and 3ft. For the calculations we assumed that the surge current follows a 8/20μs waveform with peak values of 20kA and 100kA. The typical resistance of a 4/0AWG, 2AWG and 6AWG copper cable is 0.164mΩ/m, 0.523mΩ/m, and 1.322mΩ/m respectively.

The values of V_L at a surge current of 20kA (8/20) for various copper cables sizes and lengths			
Size (AWG) \ Length (ft)	1	2	3
4/0	446V	1060V	1739V
2	519V	1206V	1958V
6	580V	1329V	2142V

The values of V_L at a surge current of 100kA (8/20) for various copper cables sizes and lengths			
Size (AWG) \ Length (ft)	1	2	3
4/0	2229V	5302V	8695V
2	2593V	6031V	9788V
6	2900V	6645V	10709V

These results show the significant effect that the voltage V_L developed on the lead cable of a T-connection under various installation types and conditions has on the residual voltage to the equipment. These voltages (V_L) are applied to the load in addition to the residual voltage of the SPD.

D. Conclusion

In conclusion, the combination of the fact that Strikesorb is listed[1] to be connected directly on the power lines with the fact that it does not contain internal fuses[2], makes it the **ideal protection for the equipment / load.**

[1] Listed SPD devices conform to UL 1449 2nd edition standard

[2] Strikesorb is the only fuseless listed SPD featuring unique high energy handling capabilities