

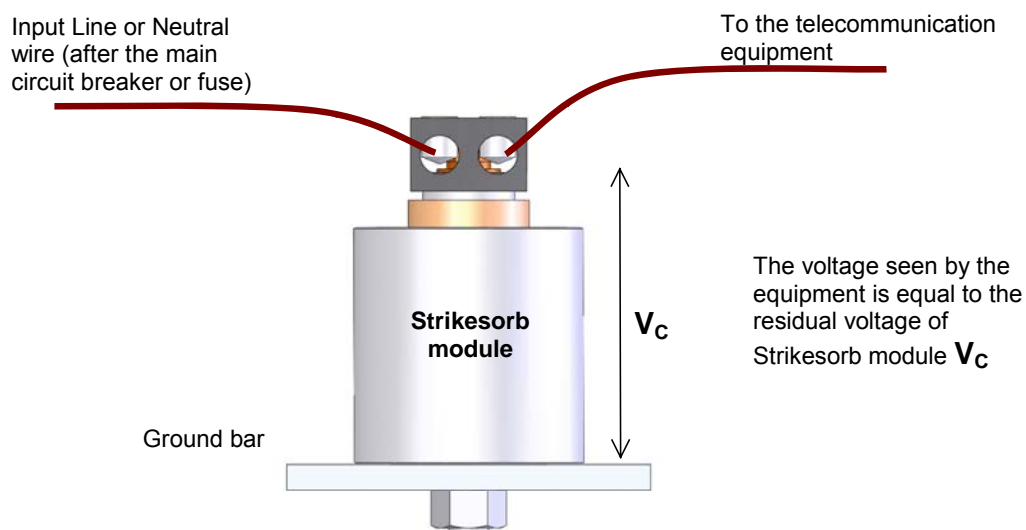
# DIRECT (IN-LINE) CONNECTION vs T-CONNECTION

## A. BACKGROUND

There are two options to install surge suppression systems:

- **Direct (In-line) Connection** – The surge suppression system or SPD modules are installed directly on the power system.
- **T- Connection** – traditional method of connection to the electrical system through a branch fuse or circuit breaker.

The fuseless design of Strikesorb modules allows the direct installation of Strikesorb and Rayvoss products on the power lines, without the need for additional interconnection wires or branch fuses. The principle of direct connection is shown in fig. 1.

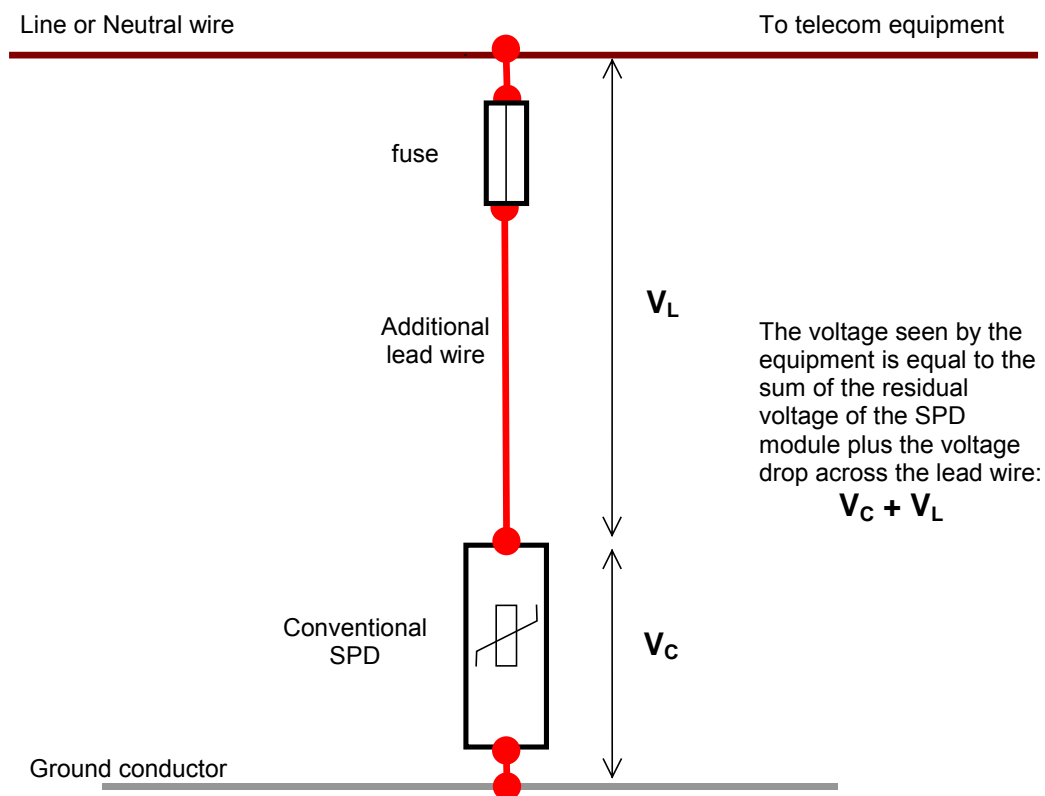


**Figure 1: Direct (in-line) connection of Strikesorb module between a phase (or neutral) wire and the ground without additional lead wires.**

### Key advantages of the direct connection:

- **Zero lead length** – The modules are directly connected to the electrical system offering the lowest possible let-through voltage. 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 the above diagram. Therefore, no additional lead wires are used, thus providing the lowest possible clamping 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 clamping voltage due to the self inductance of the lead wires, as this will be explained below.

- **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. Conventional SPDs on the other hand are always T-connected using additional lead wires and branch fuses, as shown in fig.2. The operation of the fuse will disconnect the SPD from the power lines, thus leaving the equipment without protection.



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

### **The Effect of Lead Length on the Protection Level**

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

$$V_L = L \times (di/dt) + I \times R$$

where L is the self inductance of the wires  
di/dt is the rate of change of the surge current  
R is the resistance of the lead wire.

This results in residual voltages that are higher than desired, potentially leading to equipment damage. Assuming a typical example where the inductance of the wire is 0.255µH/m and its resistivity is 1mΩ/m, then, for a total wire length of 1m and for a relatively low surge current of 10kA (8/20 waveform), the residual voltage is increased by approximately 115V.

## **B. DIRECT (IN-LINE) APPLICATIONS OF STRIKESORB MODULES AND RAYVOSS TVSS**

Strikesorb modules and Rayvoss TVSS products have been widely used in numerous applications offering the highest level of protection to critical equipment worldwide. In this section we will provide a brief description of some key applications where Strikesorb and Rayvoss systems are directly connected to the power system.

### **Vestas Wind Systems**

Vestas (the worldwide leading manufacturer of wind turbines) has chosen Strikesorb modules for the protection of its new series of wind turbines. Several Strikesorb modules are directly connected on the bus bars at several locations inside the wind turbine to protect the transformer, the generator, control electronics, and motion control systems.

Wind turbines are high-rise metallic structures which are prone to lightning strikes. When damage induced by surges interrupts the wind turbine from producing energy, profits are significantly impacted. In addition to the loss of revenue one needs to consider the cost of replacement parts, transportation costs to service the remote installation sites, and the labor cost to perform the repairs.



The low residual voltage offered by the directly-connected Strikesorb modules, the maintenance-free operation and the high surge current capability were key factors that differentiate Strikesorb technology from conventional TVSS devices when protecting wind turbines.

## Federal Aviation Administration

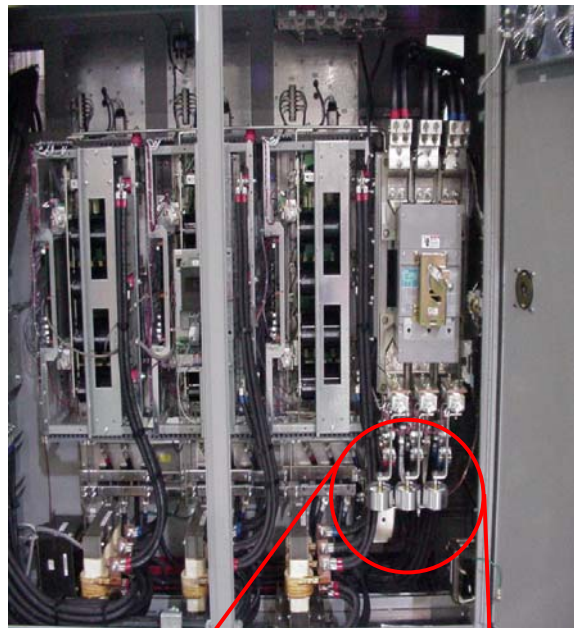
FAA is using TVSS products for the protection of critical equipment used in airports, including radars, ILS systems and Critical Power Centers, runway and airport lighting equipment. The operation of these systems is critical to ensure the safety of flights.



FAA has conducted extensive testing on different TVSS technologies. Strikesorb was the only device to pass all FAA requirements and has been chosen as its preferred technology. Rayvoss and Strikesorb systems fully meet the requirements of FAA's 019-E standard for the lightning protection of its sites. Rayvoss systems have been directly installed in many FAA sites and have been operating successfully for more than 4 years without any sign of failure.

## Schlumberger

Schlumberger uses variable speed drives manufactured by Toshiba for the motion control of its electrical submersible pumps (ESP) used in the oil industry. The oil well installations are normally remote sites and are highly exposed to frequent power surges. Schlumberger is exclusively using Strikesorb modules integrated into 6-pulse and 12-pulse drives, directly mounted on the input power busbars of the drives, on the load side of the fuses, as shown in the following picture.



## Mobile Telecommunication Operators

Wireless Telecommunication companies have been installing Rayvoss TVSS systems for more than 5 years worldwide. All Rayvoss applications in radio base station sites are in-line (direct) installations.

Users of Rayvoss include leading operators like:

- Cingular Wireless/AT&T
- Vodafone Group
- Telefonica Movistar Group
- America Mobile Group
- TIM (Telecom Italia)
- Bell Canada
- Telus Mobility

