Overvoltage protection

Lightning protection and overvoltage protection

for **SUNNY BOY, SUNNY MINI CENTRAL, SUNNY TRIPOWER**

Content

The PV generator of PV plants is located outdoors, often on top of buildings. Depending on the situation, the inverters are also installed outdoors. For this reason, it is already necessary to examine during planning of the PV plant whether measures against lighting and surges are required. These measures may be required for various reasons. Apart from national technical standards and building regulations, the plant insurer may also demand overvoltage protection. A lightning protection specialist examines which measures are required on the respective PV plant.

This document explains overvoltage protection in general and in connection with inverters. In addition, special features of combining overvoltage protection devices and SMA inverters are described. This document focuses on lightning protection insofar as it is relevant for overvoltage protection.

1 Lightning protection / overvoltage protection

Lightning protection systems are designed to prevent damage to buildings by lightning. For this reason, a distinction is made between external and internal lightning protection.

External lightning protection is intended to attract lightning and divert it into the ground. This way, buildings and plants requiring protection are protected against the effects of a direct strike of lightning. External lightning protection consists of catching devices, conductors and the accompanying ground system.

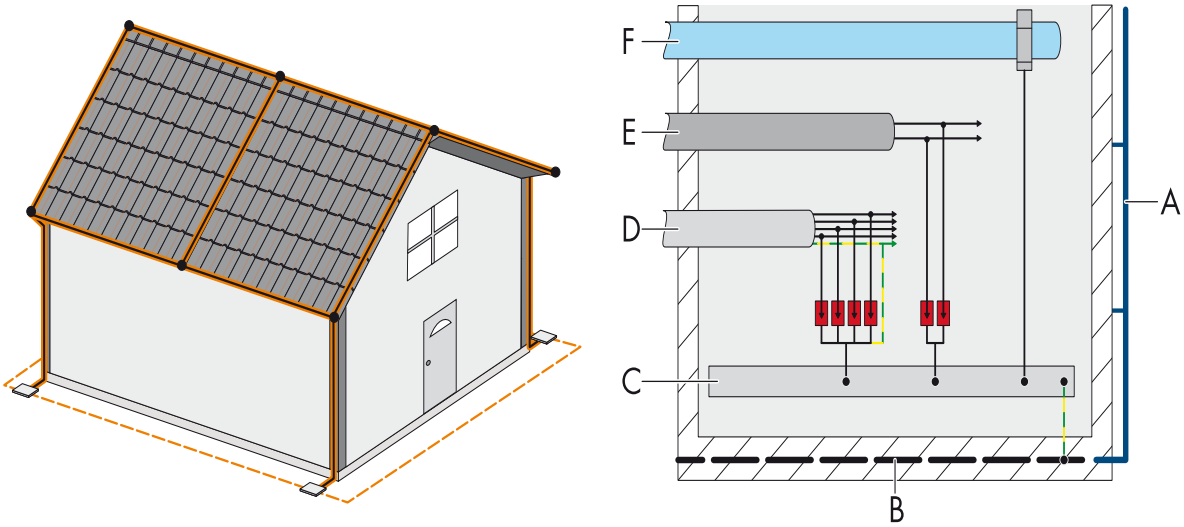

Image 1: external lightning protection (left) and internal lightning protection (right). Legend: A: external lightning protection (with connection to the grounding rod), B: grounding rod, C: equipotential busbar, D: mains connection, E: telephone connection, F: water pipe

Internal lightning protection creates equipotential bonding between metallic installations and cables within a plant. For this reason, metal and conducting plant components, e.g. water pipes, are directly connected. Live cables such as mains connection or telephone lines are indirectly connected to the ground system using the overvoltage protection device.

Overvoltage protection is intended to prevent damage to electrical and electronic devices by excessive voltage. Overvoltage protection devices (abbreviation: SPD) create equipotential bonding between connected conductors. This prevents voltage peaks from destroying connected devices.

2 Reasons for lightning and overvoltage protection

Lightning and overvoltage protection may be required for various reasons. For certain types of buildings or plants, such as hospitals, these types of systems are obligatory. Building proprietors frequently have lightning protection systems installed to achieve lower insurance costs or to be able to insure the objects to be protected at all. The system is then designed according to the instructions by the respective insurer. Nevertheless, we recommend you carry out a risk analysis. Depending on the probability and the resulting damage of lightning striking within the period when the plant is in operation, the costs for lightning and overvoltage protection are lower than the estimated damage.

Please observe the conditions of those buildings where PV plants are retrofitted. If a lightning protection system is already present, corresponding measures must also be taken for the PV plant.

3 SPD type classes [1]

Overvoltage protection devices (SPD) are divided into three classes.

- **Coarse protection (SPD type I):** SPD type I have the largest impulse current discharge capacity because they are designed to withstand a strike of lightning. These systems are used where lightning currents or fractions of currents are not only diverted via the external lightning protection system but also via the electrical cables. This is likely if the plant to be protected is directly connected to the external lightning protection system or, for example, the separation distance between DC cables and external lightning protection is not large enough. The volume of lightning current fractions results from the division of currents across the number of arresters of the lightning protection system and the number of cables. The overvoltage protection device can be selected according to this current value and the lightning protection category. While costs for SPD type I for AC are relatively low, costs for DC overvoltage protection devices with the capacity to carry lightning currents can rapidly reach amounts that make the operation of a PV plant uneconomical. Adapting the lightning protection system to increase the distance of separation is frequently the more economic solution.
- **Medium protection (SPD type II):** these overvoltage protection devices have a lower impulse current discharge capacity and protect from the indirect effects of lightning. In the event of lightning striking in the vicinity, e.g. into the external lightning protection system, electro-magnetic fields develop that may introduce dangerously high voltages into electric circuits. However, peak values of the current resulting from surges are far lower than the corresponding lightning current. The duration of the pulse and therefore the energy introduced is lower. SPD type II are used to protect from this type of surge.
- **Fine protection (SPD type III):** SPD type III have the lowest impulse current discharge capacity. They protect sensitive electronic devices from impact by lightning striking far away. SMA inverters are designed in such way that SPD type III are not required.

1. according to EN 61643-11 / IEC 61643-1

Normally the higher the remaining residual voltage in SPDs, the so-called protection level, on devices to be protected, the higher the pulse load capacity of the SPD. For this reason, e.g. in SPD type I the protection level is mostly higher than the dielectric strength of the device to be protected. In such case an SPD type II and possibly an SPD type III must be connected downstream to reduce the protection level to a value suitable for the device.

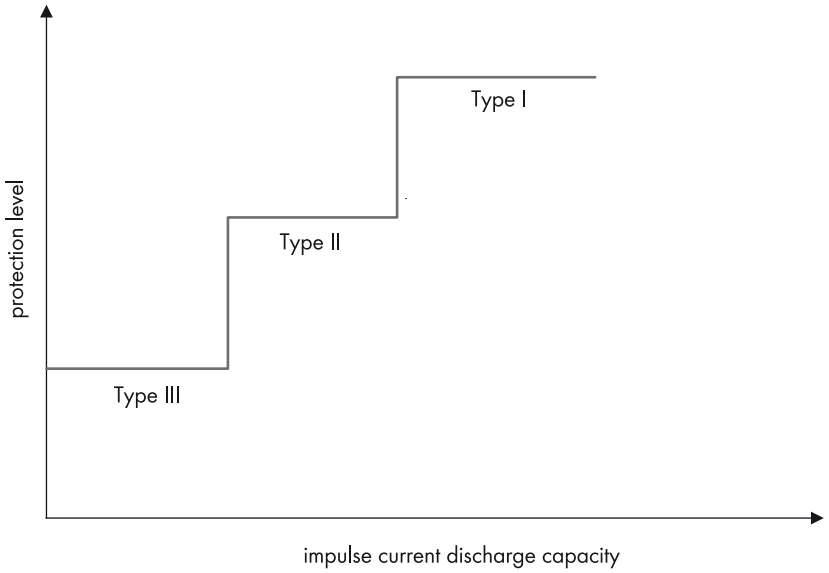

Image 2: protection levels of SPDs with different impulse current discharge capacity

If you require to protect an SMA inverter against introduced surges, an SPD type II is sufficient. Use an SPD type I with an SPD type II connected downstream if fractions of lightning currents are anticipated.

4 Combining SPD with Inverters

In inverters with an MPPT, PV strings are combined upstream of the inverter and the SPD(s) is/are connected to the linkage point. In inverters with several MPPTs, each input must have an SPD or an SPD combination. This applies to devices such as the SMA Multistring inverters Sunny Boy 4000TL-20 and Sunny Boy 5000TL-20 and Sunny Tripower inverters.

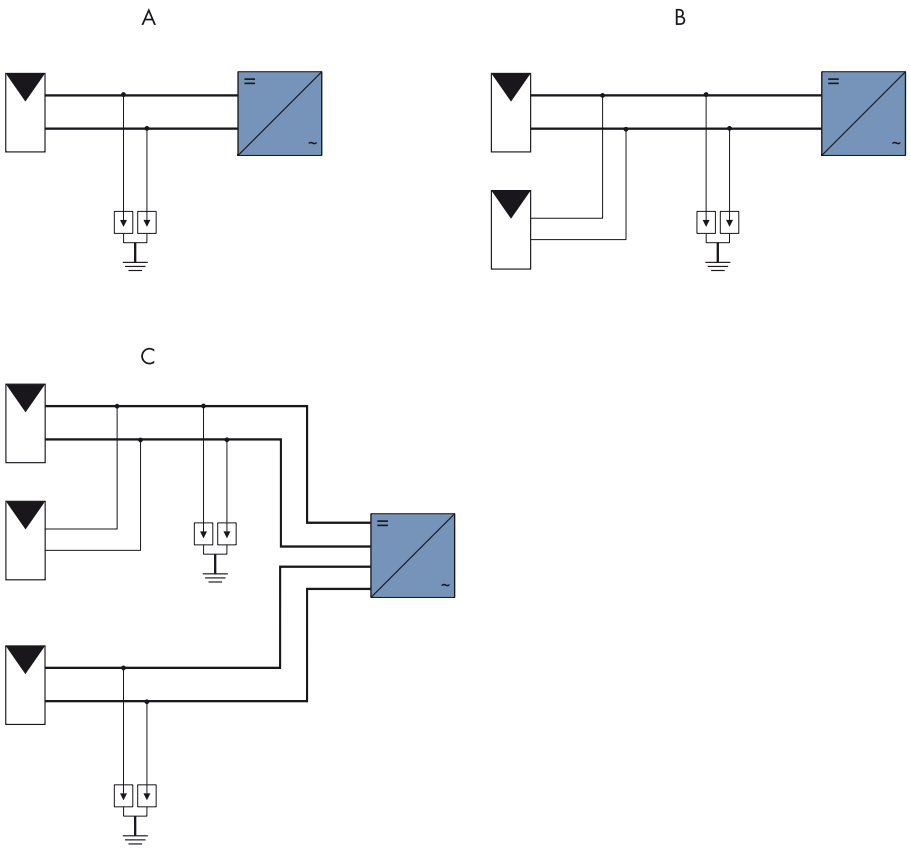

Image 3: a PV string connected to an inverter with an MPPT (A), several PV strings connected to an inverter with an MPPT (B), several PV strings connected to a Multistring inverter with several MPPTs (C)

If SPDs are used on the DC side, SPDs are also required on the AC side due to differences in potential. Contrary to the DC side, several inverters can be protected by one SPD because they are connected to the same (mains) voltage. An integration of SPDs on the AC side is not intended for SMA inverters because several inverters are frequently installed next to each other. Separate installation of an individual SPD for all inverters is then far more cost-effective.

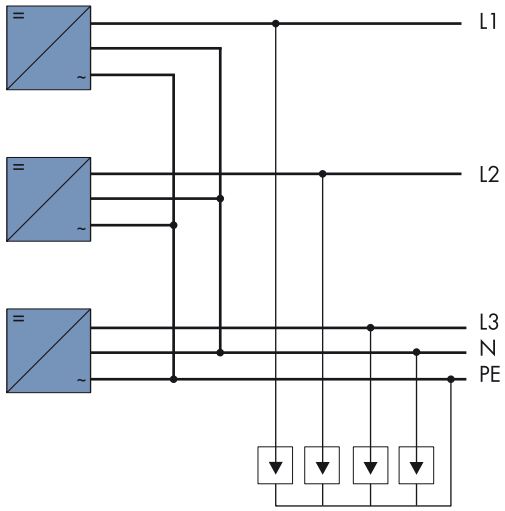

Image 4: connection of several inverters on the AC side to a 3-phase SPD

When using string protectors and SPDs, the SPD must be installed at the linkage point of the collected PV strings downstream of the fuses (cf. Image 5 A). If the SPD was only to be connected to one PV string between string input and string fuse, the remaining PV strings would be unprotected if the fuse triggered (cf. Image 5 B).

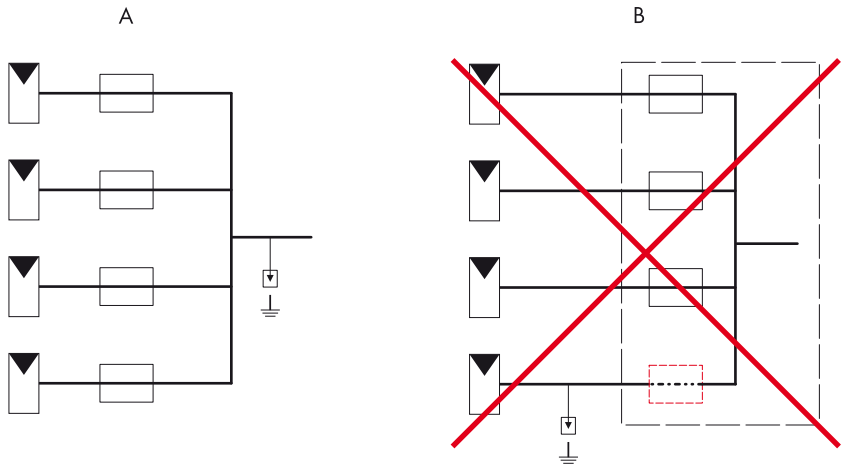

Image 5: several PV strings with string fuses and a single SPD at the linkage point (A), several PV strings with string fuses and an SPD at one PV string with triggered string fuse (B)

In addition the protection level at the inverter would be increased if the surge occurs at a different PV string. Additional voltages are discharged through cable inductance in the event of load. In the event of unfavorable arrangement, the protection level at the inverter is increased (cf. Image 6).

5 Combining SPD with Sunny Mini Central 9000TL / 10000TL / 11000TL

In SMA inverters of type SMC 9000TL-10, SMC 10000TL-10 and SMC 11000TL-10, brackets for string fuses have been integrated. This enables simple and cost-effective retrofitting of string fuses. However, if string fuses and SPDs are planned, the string fuse brackets in the inverter cannot be used because in this case the string fuses have no common overvoltage protection device that can be connected downstream. There would be the possibility to connect an SPD to each individual PV string but this is not realistic due to costs. Additionally it would be also possible to connect an SPD to a string input and replace the fuse on this string with the copper bolt included in the scope of delivery. The resulting additional cable length would in turn increase the protection level at the inverter input. For this reason, there is the risk that the inverter is damaged despite overvoltage protection devices.

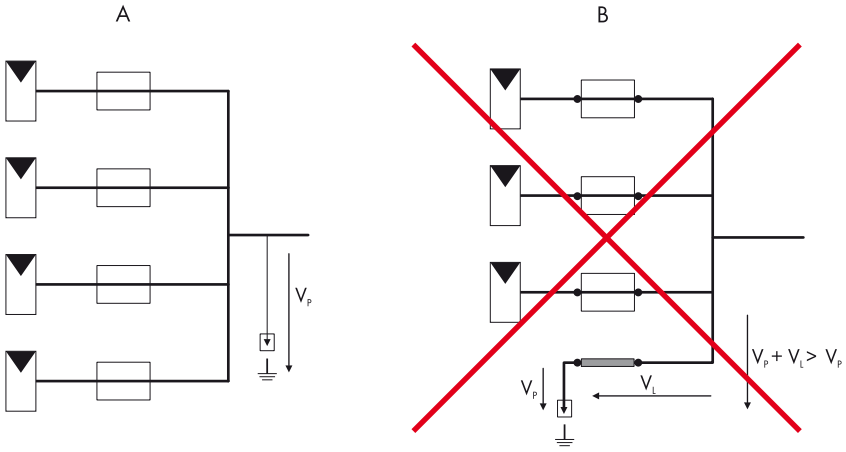

Image 6: SPD connected downstream of the string fuses (A), SPD connected to a string input, its string fuse has been replaced with a copper bolt (B)

6 Combining SPDs with Sunny Tripower

The previously mentioned issue was resolved for SMA inverters of the Sunny Tripower product range by overvoltage protection that can be integrated into the component. The overvoltage protection device was connected downstream of the integrated electronic string fuse. This makes it possible to comply with the protection level at the inverter. However, SPDs may cause issues on the inside of inverters. For this reason, damage may be caused by the correlation with the EMC filter. Due to the strong current inside the SPD in the event of load, currents can additionally be diverted to circuits inside the inverter. This was taken into account as from the initial steps during the development of Sunny Tripower. On the one hand, the EMC filter and the SPD have been phased. On the other, the overvoltage protection devices are located in a separate, shielded area so that no currents can enter the inverter circuits.

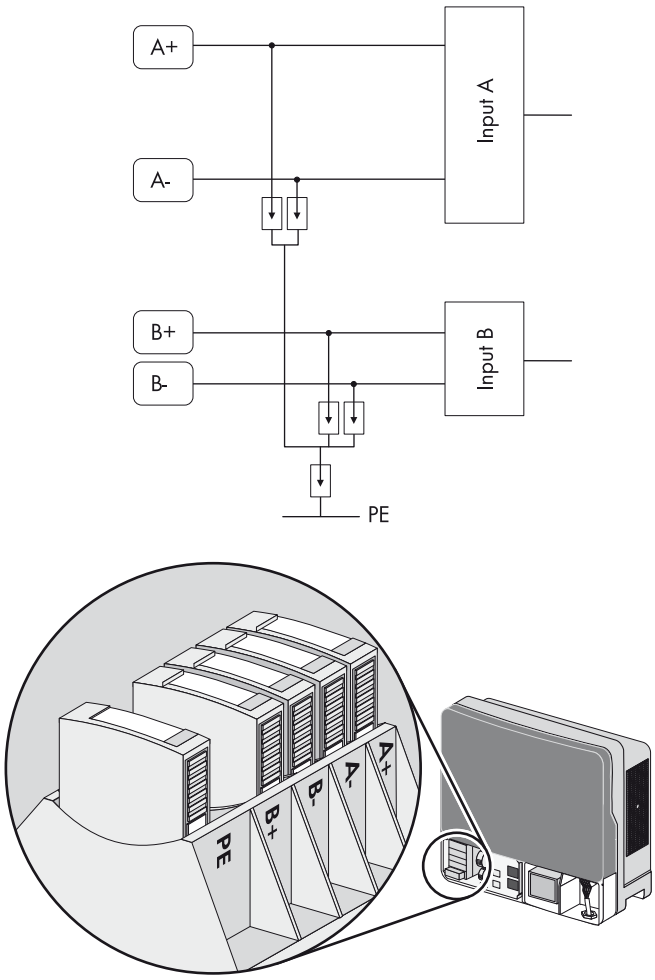

Image 7: arrangement of SPDs type Sunny Tripower inverters in a block circuit diagram (top), connector plinth of the SPD in shielded enclosure (bottom)

The overvoltage protection devices can be retrofitted by connecting them to the standard plinth. The failure of an SPD module is detected by the inverter and displayed on screen as well as reported by the monitoring devices, if required. If input A is used, the 3-pin set (DC_SPD_KIT_1-10) is sufficient. If you are using both inputs, the 5-pin set (DC_SPD_KIT_2-10) must be selected. In the Sunny Tripower, medium protection can be retrofitted fast and cost-effectively thanks to the SPD type II that can be integrated. Installing an SPD type I is not possible for reasons of lacking space. Additionally we recommend to plan the PV plant so that no SPD type I is required to keep costs low.

Depending on the on-site installation, it may be more advisable to install the SPDs in a different position (e.g. at the building input, if a lightning protection zone concept is to be implemented). The solution that can be integrated makes the installation of SPDs in a separate enclosure in the immediate vicinity of the inverter obsolete. Considering the on-site conditions, a lightning protection expert must evaluate whether this position is ideal to protect the PV plant.

7 Additional Information

For more information on lightning and overvoltage protection please see:

- DIN EN 62305-3 / VDE 0185-305-3 Lightning Protection Part 3: protecting buildings and structures and persons (2006)
- DIN EN 62305-3 / VDE 0185-305-3 Lightning Protection Part 3: protecting buildings and structures and persons – Supplement 5: lightning and overvoltage protection for PV power supply systems (2009)
- Bundesverband Solarwirtschaft (German Association of Solar Industries), Zentralverband der Deutschen Elektro- und Informationstechnischen Handwerke (Central Association of German Crafts in Electrical Engineering and Information Technology) (2008): Merkblatt für PV-Installateure - Blitz- und Überspannungsschutz von Photovoltaikanlagen auf Gebäuden (instructions for PV installers – lightning and overvoltage protection of PV plants on buildings). (can be downloaded from the Info section at www.zveh.de)
- Beer, Michael (2009): Blitzschutzfibel für Solaranlagen – Ratgeber für Solarinstallateure und Blitzschützer, 4th completely revised and extended edition, Wagner & Co Cölbe / Marburg. (www.wagner-solar.com)
- Dehn + Söhne (2007): Lightning Protection Guide, 2nd updated edition, Dehn + Söhne GmbH + Co. KG. Neumarkt i.d.OPf. / Germany (can be downloaded at www.dehn.de)
- VdS 2010 - Risikoorientierter Blitz- und Überspannungsschutz (VdS 2010 – risk-oriented lightning and overvoltage protection), guideline of the Gesamtverband der Deutschen Versicherungswirtschaft e.V. (umbrella association of German insurers), (can be downloaded at http://www.vds.de/verlag/files/vds_2010_web.pdf)
- Specialist information of overvoltage protection device manufacturers