Overvoltage Protection

Lightning Protection and Overvoltage Protection for Sunny Boy and Sunny Tripower

Content

In PV systems, the PV arrays are outdoors, frequently on buildings. Depending on the situation, the inverters are also installed outdoors. For this reason, even at the planning stage of the PV system, you should determine whether measures need to be taken to deal with flashes of lightning and overvoltage. These measures can be required for various reasons. In addition to national technical standards and building regulations, the system insurer can also require overvoltage protection. An expert on lightning protection must determine for each PV system which measures are necessary.

This document explains overvoltage protection in general and in the context of inverters. Also, special features of combining overvoltage protection devices with SMA inverters are described. The document covers lightning protection in as far as it influences overvoltage protection.

1 Lightning Protection / Overvoltage Protection

Lightning protection systems are intended to prevent damage to buildings from lightning strikes. We distinguish here between internal and external lightning protection.

The external lightning protection serves to collect the lightning and conduct it into the ground. In this way, buildings and systems to be protected are saved from the effects of a direct lightning strike. The external lightning protection consists of air-termination systems, conductors, and the associated grounding arrangement.

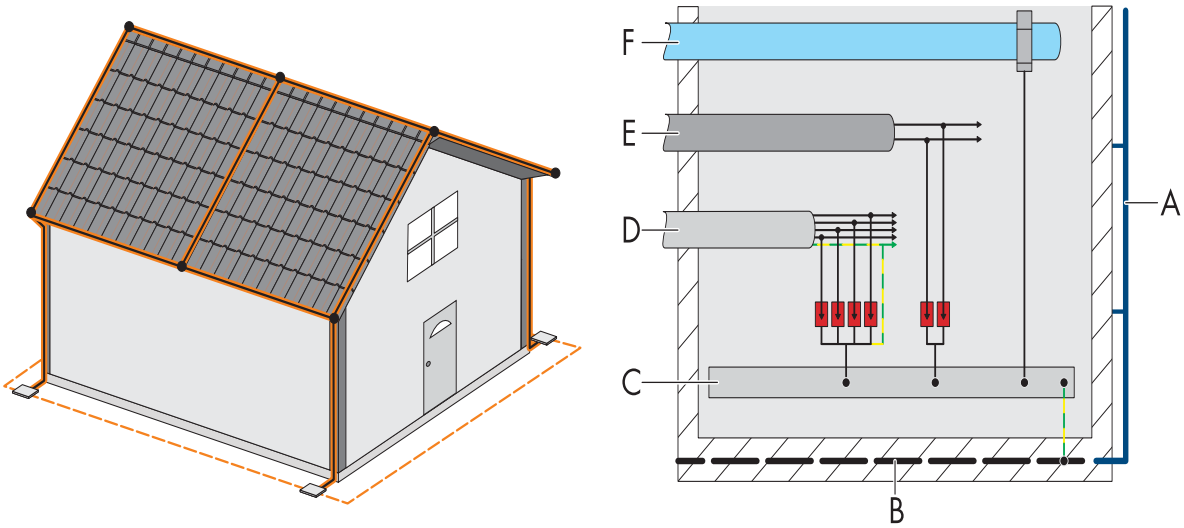

Fig.1: External lightning protection (left) and internal lightning protection (right). Legend: A: external lightning protection (with connection to foundation ground electrode), B: foundation ground electrode, C: grounding busbar, D: grid connection, E: telephone connection, F: water pipe

The internal lightning protection provides equipotential bonding between metal installations and cables within the system. Metal and conductive system parts, e.g. water pipes, are connected directly with each other for this purpose. Live cables such as the grid connection or telephone lines are connected indirectly to the grounding arrangement using an overvoltage protection device.

Overvoltage protection serves to prevent damage to electrical and electronic devices as a result of excessive voltages. Overvoltage protection devices (surge protection devices, or SPD for short) generate equipotential bonding between the connected conductors when excessive voltage is applied. This prevents voltage peaks from destroying connected devices.

2 Reasons for Lightning Protection and Overvoltage Protection

Lightning and overvoltage protection can be required for various reasons. For some types of buildings or systems, e.g. hospitals, such systems are mandatory. Building owners frequently have lightning protection systems installed to avail of lower insurance rates or to enable the protected objects to be insured in the first place. The systems are then installed to the insurer's specifications. In any case, it is recommended to carry out a risk analysis. Depending on the probability of a lightning strike during the operating time of the system and the destruction that would occur as a result, the costs for lightning and overvoltage protection measures are lower than the damage to be expected.

In the case of PV systems that are erected on existing buildings, the specifications for these buildings must be taken into account. If a lightning protection system is already present, appropriate measures must also be implemented for the PV system.

3 SPD Type Classes[1]

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

- **Broad protection (SPD Type I):** SPD type I have the highest value for admissible surge current resistance since they have been designed to handle a direct lightning strike. They are deployed where lightning currents or lightning partial currents are not only conducted via the external lightning protection system but can also be conducted via electrical cables. This can be the case if the system to be protected is directly connected to the external lightning protection system or if, for example, the distance between the DC cables and the external lightning protection is too small. The level of the lightning partial currents is determined by the current distribution with the number of conductors in the lightning protection system and the number of cables. In accordance with this current value and the lightning protection class, you can select the surge protection device. Whereas the costs for SPD type I for alternating current are relatively low, the costs for DC overvoltage protection devices which can carry lightning current can quickly reach dimensions which render a PV system uneconomic. In many cases, adapting the lightning protection system to increase the separation distance is the most economical solution.
- **Medium protection (SPD Type II):** These overvoltage protection devices have a lower value for admissible surge current resistance and protect against the indirect effects of lightning. In the case of local lightning strikes, e.g. to the external lightning protection system, electromagnetic fields arise which can couple dangerous high voltages into electric circuits. However, the peak values from the currents resulting from the overvoltage are much lower than the lightning current in each case. Also the duration of the impulse and therefore the coupled energy is lower. SPD type II are deployed to provide protection against this type of overvoltage.

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

- **Fine protection (SPD Type III):** SPD type III have the lowest value for admissible surge current resistance. They protect sensitive electronic end devices from impact by lightning strikes that occur further away. SMA inverters are designed in such a way that SPD type III are not necessary.

Typically in the case of SPD, the level of residual voltage, the protection level of the device to be protected is proportional to the value of admissible surge current resistance of the SPD. For example, in the case of SPD type I, the protection level is usually higher than the dielectric strength of the device to be protected. In this case, an SPD type II and, possibly, an SPD type III must be connected downstream to lower the protection level to an appropriate value for the device to be protected.

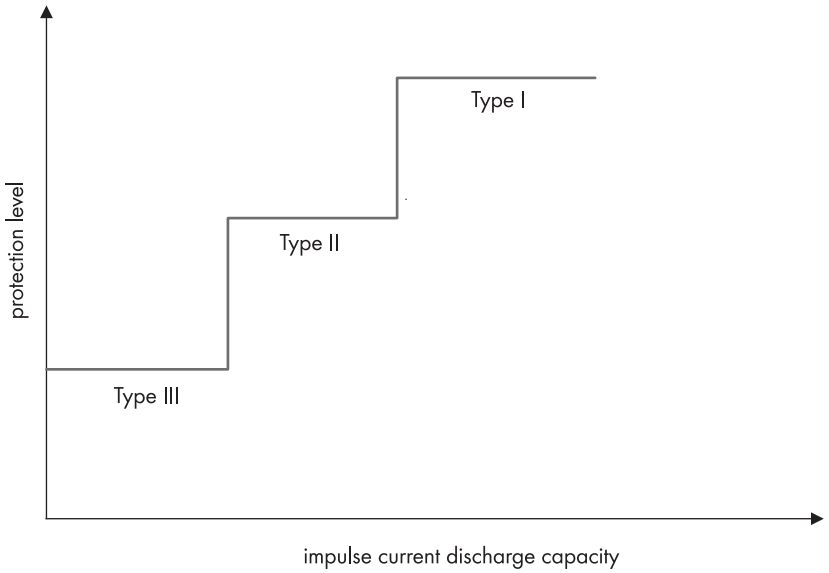

Fig. 2: Protection level of SPD with different values for admissible surge current resistance

If you wish to protect an SMA inverter against impacting overvoltages, an SPD type II is sufficient. If lightning partial currents are expected, an SPD type I with connected SPD type II should be used.

4 Combining SPD with Inverters

For inverters with one MPP tracker, the strings are combined before the inverter and connected to the SPD(s) at the point of interconnection.

For inverters with multiple MPP trackers, an SPD or SPD combination should be planned for each input. This applies, for example, to all Sunny Boy and Sunny Tripower inverters with multi-string inputs. The same applies for inverters with only one MPP tracker but multiple inputs, each with their own string code or fuse, such as the inverters from the STP XX000TLEE series. An SPD must be used for each input fused with a string diode.

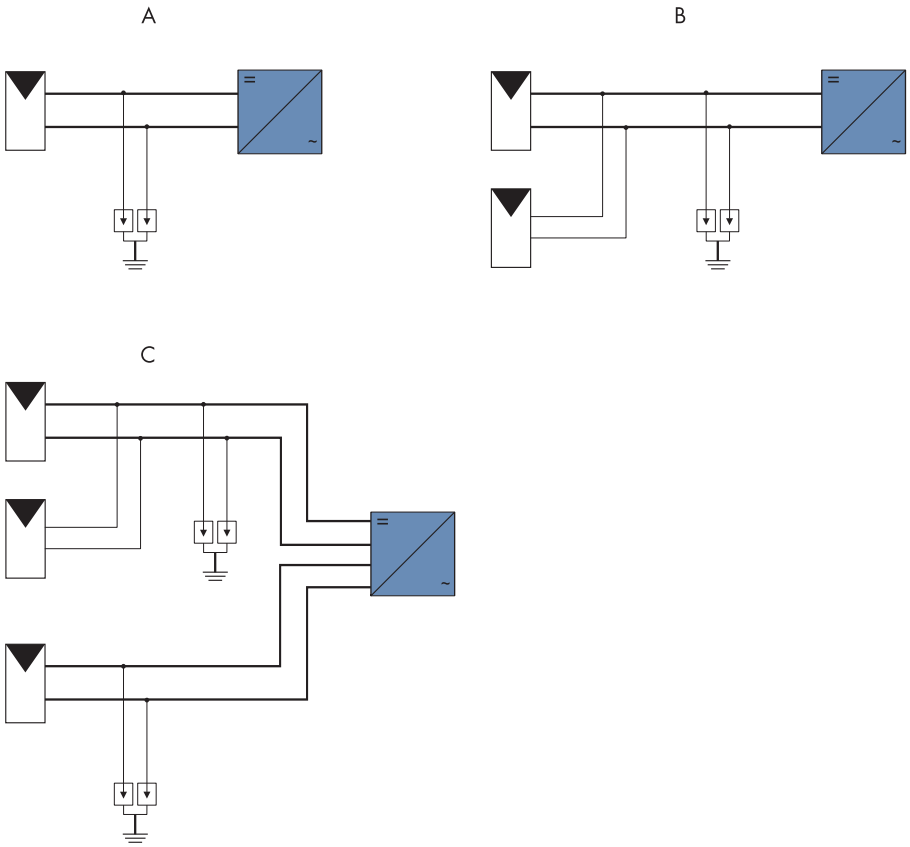

Fig. 3: A string connected to an inverter with one MPP tracker (A), multiple strings connected to an inverter with one MPP tracker (B), multiple strings connected to a multi-string inverter with multiple MPP trackers (C)

If SPDs are deployed on the DC side, SPDs are required on the AC side due to potential differences. In contrast to the DC side, multiple inverters can be protected with one SPD on the AC side since they are connected to the same (grid) voltage. Integration of AC-side SPDs is not planned for SMA inverters as in many cases, multiple inverters are mounted next to each other. The separate installation of a single overvoltage protection device for all inverters is in this case significantly more cost-effective.

If there is wired communication in place (e.g. RS485, Ethernet), these connections must also be protected by means of overvoltage protection devices. Otherwise, damage could be caused to the interfaces in the inverter, to the inverter itself, and to the connected communication device due to potential differences.

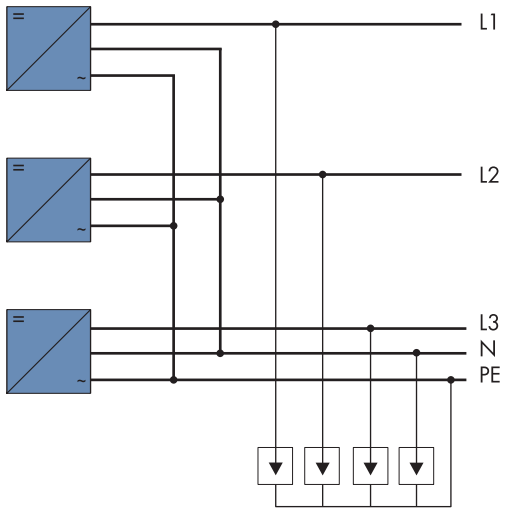

Fig. 4: AC-side connection of multiple inverters to a three-phase overvoltage protection device

If you are using string fuses and an SPD, the SPD must be installed at the point of interconnection of the combined strings after the fuses (see Fig. 5 A). If the SPD was connected to only one string between the string input and the string fuse, the remaining strings would be unprotected if the fuse tripped (see. Fig. 5 B).

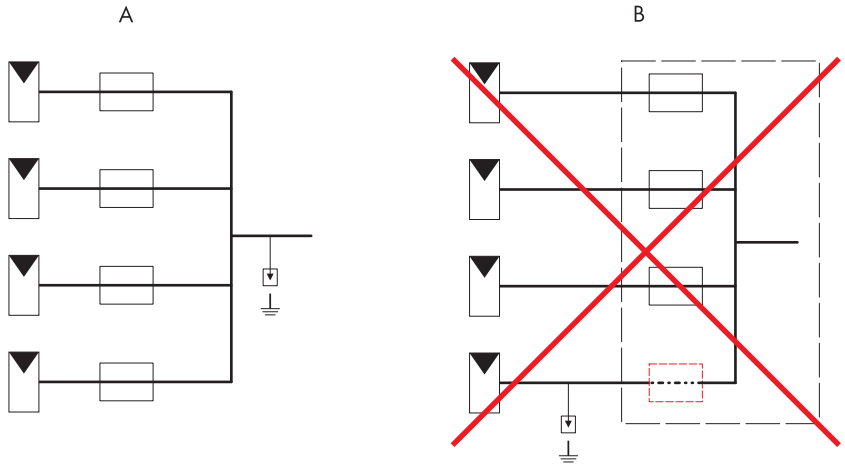

Fig. 5: Multiple strings with string fuses and a common SPD at the point of interconnection point (A), multiple strings with string fuses and an SPD connected to a string with tripped string fuse (B)

In addition, the protection level at the inverter is increased if the overvoltage occurs at one of the other strings. When excessive voltage is applied, voltage falls via the cable inductance. If the arrangement is not ideal, the protection level at the inverter is increased (see Fig. 6).

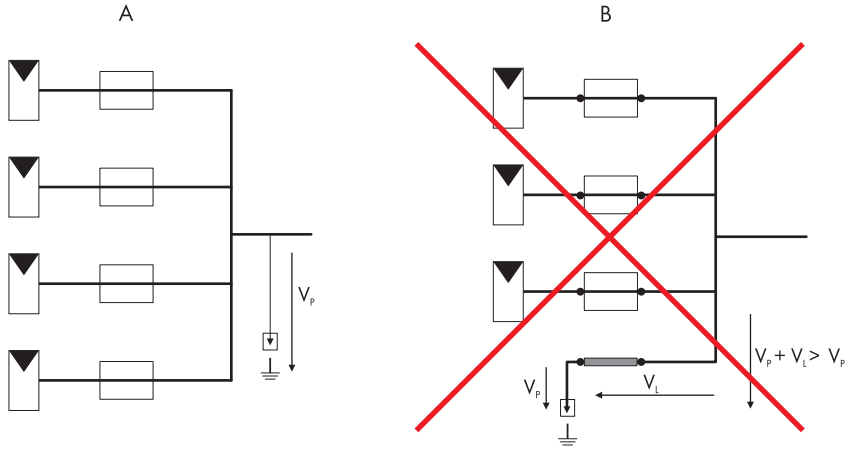

Fig. 6: SPD downstream of string fuses (A) and SPD connected to a string input where the string fuse has been replaced by a copper bolt (B)

5 Sunny Tripower with Integrated SPD

In some SMA inverters[1] of the Sunny Tripower product family, the problem above has been solved through integrated overvoltage protection. However, some problems can be caused by the presence of SPDs inside inverters. Firstly, damage can be caused by interaction with the EMC filter and secondly, in the case of excessive voltage, the high current within the overvoltage protection device can also lead to voltages impacting electronic circuits inside the inverter. During development of the Sunny Tripower, these difficulties were taken into account right from the beginning and appropriate countermeasures were taken. The EMC filtering device and the SPD have been made compatible. Also, the overvoltage protection devices are located in a separate shielded area so that no voltages can impact on the circuits of the inverter.

The overvoltage protection devices can be retrofitted by plugging them into the base which is standard on all devices. In the Sunny Tripower, the medium protection can be retrofitted quickly and cost-effectively thanks to the SPD type II which can be integrated. Due to space constraints, installation of an SPD type I is not possible. In addition, in order to reduce costs, the PV system should be planned in such a way that an SPD type I is not required.

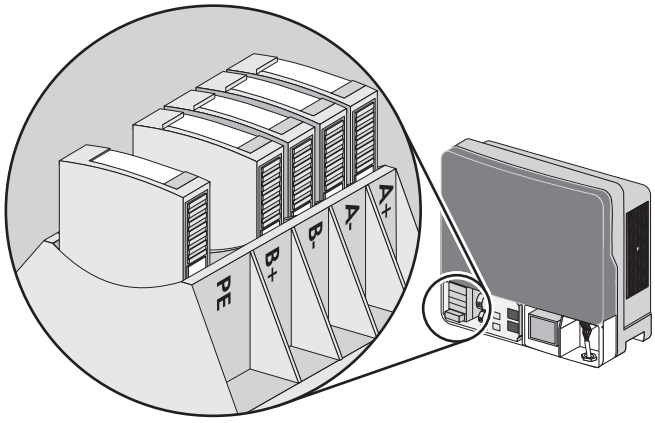

Fig. 7: Installation site of the SPDs with the STP XX000TL-10 device family as an example

Depending on the situation on site, it may be more appropriate to install the SPDs in a different location (e.g. at the entrance to the building, if a lightning protection 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. Whether this is the optimum position, with regard to the protection of the PV system, must be determined by a lightning protection expert taking account of local conditions.

1. STP 8000TL-10, STP 10000TL-10, STP 12000TL-10, STP 15000TL-10, STP 17000TL-10, STP 20000TL-30, STP 25000TL-30

6 Additional Information

You can find more information on lightning protection and overvoltage protection in the following publications:

- DIN EN 62305-3 / VDE 0185-305-3 Protection against lightning - Part 3: Physical damage to structures and life hazard (2006)
- DIN EN 62305-3 / VDE 0185-305-3: Protection against lightning - Part 3: Physical damage to structures and life hazard; Supplement 5: Lightning and overvoltage protection for photovoltaic power supply systems (2009)
- Bundesverband Solarwirtschaft (German Solar Industry Association), Zentralverband der Deutschen Elektro- und Informationstechnischen Handwerke (2008): Merkblatt für PV-Installteure - Blitz- und Überspannungsschutz von Photovoltaikanlagen auf Gebäuden (Information sheet for PV Installers - Lightning and Overvoltage Protection of PV Systems on Buildings). (this can be downloaded in the Info area at www.zveh.de)
- Beer, Michael (2009): Blitzschutzfibel für Solaranlagen - Ratgeber für Solarinstallateure und Blitzschützer, 4. völlig überarb. u. erw. Auflage, Wagner & Co Cölbe/Marburg. (www.wagner-solar.com)
- Dehn + Söhne (2007): Blitzplaner, 2. aktualisierte Auflage, Dehn + Söhne GmbH + Co. KG. Neumarkt i.d.OPf. (can be downloaded at www.dehn.de)
- VdS 2010 - Risikoorientierter Blitz- und Überspannungsschutz, Richtlinie des Gesamtverbandes der Deutschen Versicherungswirtschaft e.V. (can be downloaded at http://www.vds.de/verlag/files/vds_2010_web.pdf)
- Specialist information from the manufacturers of overvoltage protection devices