Surge protection for photovoltaic systems

Surge protection for photovoltaic systems  Photovoltaic application example  F.2
Surge protection prevents damage

Photovoltaic (PV) facilities for exploiting renewable energy are at great risk from lightning discharges because of their exposed location and large surface area. Damage to individual segments or the failure of the entire installation can be the consequence.

Lightning currents and surge voltages often cause damage to inverters and photovoltaic modules. These damages mean more expense for the operator of the photovoltaic facility. Not only are there higher repair costs but the productivity of the facility is also significantly reduced. Therefore, a photovoltaic facility should always be integrated into the existing lightning protection and grounding strategy.

To avoid these outages, the lightning and surge protection strategies in use must interact with one another. We provide you with the support you need, so that your facility functions smoothly and delivers its expected yield!

That’s why you should safeguard your photovoltaic installation with lighting and overvoltage protection from Weidmüller:

- To protect your building and PV installation
- To increase system availability
- To safeguard your investment
Standards and requirements

The current standards and directives for overvoltage protection must always be taken into account in the design and installation of any photovoltaic system.

The European draft standard DIN VDE 0100 part 712/E DIN IEC 64/1123/CD (Erection of low voltage systems, requirements for special equipment and facilities; photovoltaic power systems) and the international installation specifications for PV facilities – IEC 60364-7-712 – both describe the selection and installation of surge protection for PV facilities. They also recommend surge protection devices between the PV generators.

In its 2010 publication on surge protection for buildings with a PV installation, the Association of German Property Insurers (VdS) requires > 10 kW lightning and overvoltage protection in accordance with lightning protection class III.

To ensure that your installation is future-safe, it goes without saying that our components fully comply with all requirements.

Furthermore, a European standard for surge voltage protection components is in preparation. This standard will specify to what extent surge voltage protection must be designed into the DC side of PV systems. This standard is currently prEN 50539-11.

A similar standard is currently already in force in France – the UTE C 61-740-51. Weidmüller’s products are currently being tested for compliance with both standards so that they can provide an even higher level of safety.
Superior surge protection from Weidmüller

Our surge protection modules in Class I and Class II (B and C arresters) ensure voltage occurrences are quickly limited and that the current is safety discharged. This allows you to avoid expensive damages or the potential for complete power failure in your photovoltaic facility.

For buildings with or without lightning protection systems – we have the right product for every application! We can deliver the modules as you require – fully customised and pre-wired into housings.

Deploying surge protection devices (SPDs) in photovoltaic systems

Photovoltaic energy is a vital component of the overall energy production from renewable energy sources. There are a number of special characteristics that need to be considered when deploying surge protection devices (SPDs) in photovoltaic systems. Photovoltaic systems have a DC voltage source, with specific characteristics. The system concept must therefore take these specific characteristics into consideration and co-ordinate the use of SPDs accordingly. For instance SPD specifications for PV systems must be designed both for a maximum no-load voltage of the solar generator (VOC STC = voltage of the unloaded circuit under standard test conditions) as well as with regard to ensuring maximum system availability and safety.

External lightning protection

Owing to their large surface area and generally exposed installation location, photovoltaic systems are particularly risk from atmospheric discharges – such as lightning. At this point there is a need to differentiate between the effects of direct lightning strikes and so-called indirect (inductive and capacitive) strikes. On the one hand the necessity for lightning protection depends on the normative specifications of the relevant standards and on the one hand, the necessity for lightning protection depends on the normative specifications of the relevant standards. On the other hand, it depends on the application itself, in other words, depending on if it is a building or a field installation. With building installations a difference is drawn between the installation of a PV generator on the roof of a public building – with an existing lightning protection system – and the installation on the roof of a barn – without a lightning protection system. Field installations also offer large potential targets due to their large area module arrays; in this case, an external lightning protection solution is recommended for this type of system to prevent direct lightning strikes.

Normative references can be found in IEC 62305-3 (VDE 0185-305-3), Supplement 2 (interpretation according to lightning protection level or risk level LPL III) [2] and Supplement 5 (lightning and surge protection for PV power systems) and in the VdS Directive 2010 [3]. (If PV systems > 10 kW, then lightning protection is required). In addition, surge protection measures are required. For instance, preference should be afforded to separate air-termination systems to protect the PV generator. However, if it is not possible to avoid a direct connection to the PV generator, in other words the safety separation distance cannot be maintained, then the effects of partial lightning currents must be taken into consideration. Fundamentally, shielded cables should be used for the main lines of generators to keep induced overvoltages as low as possible. In addition, if the cross-section is sufficient (min. 16 mm² Cu) the cable shielding can be utilised to conduct partial lightning currents. The same applies to the utilisation of closed metal housings. Earthing must be connected at both ends of cables and metal housings. That ensures that the main lines of the generator fall under LPZ1 (Lightning Protection Zone); that means that a SPD type 2 suffices. Otherwise, an SPD type 1 would be required.

Utilisation and correct specification of surge protection devices

In general, it is possible to consider the deployment and specification of SPDs in low voltage systems on the AC side as standard procedure; however, the deployment and the correct design specification for PV DC generators still remains a challenge. The reason is firstly a solar generator has its own special characteristics and, secondly, SPDs are deployed in the DC circuit. Conventional SPDs are typically developed for alternating voltage and not direct voltage systems. Relevant product standards [4] have covered these applications for years, and these can fundamentally also be applied to DC voltage applications. However, whereas previously relatively low PV system voltages were realised, today these are already achieving approx. 1000 V DC in the unloaded PV circuit. The task is to master system voltages of that order with suitable surge protection devices.

The positions at which it is technically appropriate and practical to position SPDs in a PV system depends primarily on the type of system, the system concept and the physical surface area. Figures 2 and 3 illustrate the principle differences: Firstly, a building with external lightning protection and a PV system mounted on the roof (building installation); secondly, an expansive solar energy system (field installation), also fitted with an external lightning protection system. In the first instance – because of the shorter cable lengths – protection is merely implemented at the DC input of the inverter; in the second case SPDs are installed in the terminal box of the
solar generator (to protect the solar modules) as well as at the DC input of the inverter (to protect the inverter). SPDs should be installed close to the PV generator as well as close to the inverter as soon as the length of cable required between the PV generator and the inverter extends beyond 10 meters (Figure 2). The standard solution to protect the AC side, meaning the inverter output and network supply, must then be achieved by using type 2 SPDs installed at the inverter output and – in the case of a building installation with external lightning protection at the mains feed-in point – equipped with an SPD type 1 surge arrester.

Special characteristics on the DC solar generator side

Until now, protection concepts on the DC side always used SPDs for normal AC mains voltages, whereby L+ and L- respectively were wired to earth for protection. This meant that the SPDs were rated for at least 50 percent of the maximum solar generator no-load voltage. However, after a number of years, insulation faults can occur in the PV generator. As a consequence of this fault in the PV system, the full PV generator voltage is then applied to the non-faulty pole in the SPD, and results in an overload event. If the load on SPDs based on metal-oxide varistors from a continuous voltage is too high, this can potentially result in their destruction or trigger the disconnecting device. In particular, in PV systems with high system voltages, it is not possible to completely exclude the possibility of a fire developing due to a switching arc that is not extinguished, when the disconnection device is triggered. Overload protection elements (fuses) used upstream are not a solution to this probability, as the short-circuit current of the PV generator is only slightly higher than that of the rated current. Today, PV systems with system voltages of approx. 1000 V DC are increasingly being installed to keep power losses as low as possible.

To ensure that SPDs can master such high system voltages the star connection consisting of three varistors has proven reliable and has become established as a quasi-standard (Figure 4).

If an insulation fault occurs two varistors in the series still remain, which effectively prevents the SPD from being overloaded.
To summarise: protective circuitry with absolutely zero leakage current is in place and an accidental activation of the disconnecting mechanism is prevented. In the scenario described above, the spread of fire is also effectively prevented. And at the same time, any influence from an insulation monitoring device is also avoided. So if an insulation malfunction occurs, there are always two varistors still available in the series. In this way, the requirement that earth faults must always be prevented, is met. Weidmüller’s SPD type 2 arrester VPU II 3 1,000 V DC to UCPV mode +/-, -/+PE, +/PE = 1,000 V DC provides a well tested, practical solution and has been tested for compliance with all current standards (UTE C 61-740-51 and prEN 50539-11) (Figure 4). In this way, we offer the highest degree of safety available for use in DC circuits.

Practical applications

As already stated, a difference is drawn between building and field installations in practical solutions. If an external lightning protection solution is fitted, the PV generator should preferably be integrated into this system as an isolated arrester device system. IEC 62305-3 specifies that the air termination distance must be maintained. If it cannot be maintained then the effects of partial lightning currents must be taken into consideration.

On this point the standard for protection against lightning IEC 62305-3 Supplement 2 states in Section 17.3: ‘to reduce induced overvoltages shielded cables should be used for the main lines of the generator’. If the cross-section is sufficient (min. 16 mm² Cu) the cable shielding can also be used to conduct partial lightning currents. Supplement (Figure 5) - Protection against lightning for photovoltaic systems – issued by the ABB (Committee for Lightning Protection and Lightning Research of the (German) Association for Electrical, Electronic and Information Technologies) states that the main lines for the generators should be shielded. This means that lightning current arresters (SPD type 1) are not required, although surge voltage arresters (SPD type 2) are necessary on both sides. As Figure 5 illustrates, a shielded main generator line offers a practical solution and achieves LPZ 1 status in the process. In this manner, SPD type 2 surge arresters are deployed in compliance with standards specifications.
Ready-to-fit solutions

To ensure on-site installation is as straightforward as possible Weidmüller offers ready-to-fit solutions to protect the DC and AC sides of inverters. Plug-and-play PV boxes reduce the installation time. Weidmüller will also perform customer-specific assemblies at your request. More information is available at www.weidmueller.com

Note:
Country-specific standards and guidelines must be observed

Literature
[1] DIN VDE 0100(VDE 0100) part 712: 2006-06, Requirements for special installations or locations. Solar photovoltaic (PV) power supply systems
[2] DIN EN 62305-3 (VDE 0185-305-3) 2006-10 Lightning Protection, Part 3: Protection of facilities and people, supplement 2, interpretation according to protection class or risk level III LPL, Supplement 5, lightning and surge protection for PV power systems
[5] IEC 62305-3 Protection against lightning – Part 3: Physical damage to structures and life hazard
[7] prEN 50539-11 Low-voltage surge protective devices – Surge protective devices for specific application including d.c. – Part 11: Requirements and tests for SPDs in photovoltaic applications
[8] French product standard for surge protection in the DC area UTE C 61-740-51

VPU II 3 1000 V DC PV

- A 1,000 V surge voltage arrester for use on the DC side
More information in Chapter C.

VPU II 4 280 V / 40 kA

- 230/400-V surge protection arrester
- Suitable for TN-CS power system
- High energy absorption with I_max: 40 kA per element
More information in Chapter C.

VPU-I-LCF-Serie

- 230/400-V “Combined lightning current and surge arresters”, free from leakage current
- 1-pole version
- High energy absorption
- Option for V-shaped conductor connection
More information in Chapter C.
Modular use of our surge protection components

If a lightning protection system is already present on the building, this must be at the highest point of the entire system. All modules and cables of the photovoltaic installation must be installed below the air terminations. Separation distances of at least 0.5 m to 1 m must be maintained (depending on risk analysis from IEC 62305-2).

The external Type I lightning protection (AC side) also requires the installation of a Type I lightning arrester in the electrical supply of the building. If no lightning protection system is present, then Type II arresters (AC side) are sufficient for use.

1. **VPU II 3 1000 V DC PV**
   - Y-coupling

1\* **VPU II 3 1000 V DC PV**
   - For long distances > 10 m between the PV generator and inverter

2. **VPU II 4 280 V / 40 kA**
   - For long distances > 10 m between the inverter and the house power feed

3. **VPU-I-LCF-Serie**
   - In the event of an existing lightning protection system