It is important to protect the building and the PV array from damage by fire (as the result of a direct lightning strike), and the electrical and electronic systems (inverter, remote diagnostics system, generator main line) against the effects of lightning’s electromagnetic impulses (LEMP).

Air-termination system and down conductor system
For protecting the PV array against direct lightning strikes, it is necessary to arrange the solar modules in the protection zone of an isolated air-termination system. Its design is based on a lightning protection system class 3 for PV systems greater than 10 kW in compliance with the relevant guidelines. According to the class of lightning protection system, the height and the quality of the air-termination rods required is determined by means of the rolling sphere method. Furthermore, it has to be ensured that sufficient separation distance is kept between the PV supporting frames and the air-termination rods in compliance with the standard. The building housing the electrical and electronic systems is to be equipped with an external lightning protection system. The down conductors are to be connected to the earth-termination system by means of terminal lugs. Due to the risk of corrosion at the point where the terminal lugs come out of the soil or concrete, these have to be made out of corrosion-resistant material such as stainless steel or galvanised steel, in which case they have to be protected by corresponding measures, including the application of sealing tape or heat shrinkable sleeve.

Earth-termination system
The earth-termination system of the PV system is designed as a ring earth electrode (surface earth electrode) with a mesh size of 20 m x 20 m. The metal supporting frames, onto which the PV modules are fixed, should be connected to the earth-termination system approximately every 10 m. The earth-termination system of the building is to be designed as a foundation earth electrode. The earth-termination system of the PV system and the building have to be connected with each other via at least one conductor (30 mm x 3.5 mm steel strip, stainless or galvanised steel). The interconnection of the individual earth termination systems reduces the total earthing resistance considerably. The intermeshing of the earth-termination system creates an equipotential surface which reduces the voltage load of lightning effects on the electric connecting cables between PV array and the building. The surface earth electrodes are to be laid in at least 0.5 m depth of soil. The meshes are to be interconnected with four-wire connectors. The joints in the soil have to be wrapped with an anticorrosive band. This also applies to stainless steel strips laid in the soil.

Lightning equipotential bonding
In principle, all conductive systems entering the operation building from outside have to be generally included into the lightning equipotential bonding. The requirements of this bonding are fulfilled by the direct connection of all metal systems and by the indirect connection of all live systems via lightning current arresters. Bonding should be performed preferably near the entrance of the structure in order to prevent partial lightning currents from penetrating the building. In this case the low voltage power supply in the operation building is protected by a multi-pole combined lightning current and surge arrester. Furthermore, the DC lines entering the PV inverter have to be protected in the building by a suitable spark-gap-based lightning current arrester.

Surge protection measures in the PV array
In order to reduce the load on the isolation inside the solar modules at a lightning strike into the isolated air-termination system, thermally monitored surge protective devices are to be installed in a generator junction box as close as possible to the PV generator (Fig. 1). On the DC side, a surge protective device is to be installed in each generator junction box. In this case class 2 surge protective devices are sufficient because the PV modules are within the protective area of the external lightning protection. In practice, it is a proven method to use surge protective devices with floating contacts to indicate the operating state of the thermal disconnection device. Thus, the intervals between the regular onsite inspections of the protection devices are extended. The surge protective devices in the generator junction boxes assume the protection for the PV modules locally and ensure that no spark overs caused by conducted or field-related interferences come up at the PV modules.

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**Fig. 1: Earth termination system.**
Surge protection measures for IT systems

The building provides a remote diagnostics system, which is used for an easy and quick function check of the PV systems. This allows the operator to recognise and remedy malfunctions at an early stage. The remote supervisory control system provides the performance data of the PV generator constantly in order to optimise the output of the PV system. Measurements of wind velocity, module temperature and ambient temperature are performed via external sensors at the PV system. These measurements can be read directly from an acquisition unit which provides an Ethernet interface, and which is connected to a PC and/or modem for remote enquiry and maintenance. In this way the service engineers can determine the cause of a malfunction by tele-diagnosis and then directly eliminate it. The modem can be connected to the network termination for ISDN basic rate access (NTBA).

The measuring sensors for wind velocity and module temperature are also installed in the same zone protected against lightning strikes as the PV modules. Thus, no lightning currents come up in the measuring leads. Transient surges resulting from induction effects in the event of lightning strikes are conducted into the isolated air termination system. In order to provide a reliable trouble-free and continuous transmission of the measured data to the measuring unit, it is necessary to lead the sensor cables entering the building via surge protective devices.

Conclusion

When choosing protective devices, it has to be ensured that the measurements cannot be impaired. Safety in the forwarding of the measured data via the telecommunication network's ISDN modem must be provided as well in order to provide a continuous monitoring and optimisation of the performance of the installation. For this purpose, the Uk0 interface upstream of the NTBA, which the ISDN modem is connected to, is protected by a surge protective adapter. This adapter ensures additional protection for the 230 V power supply of the NTBA.

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