Strike Action

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Protecting PV system components, in particular inverters, from the damaging effects of overvoltage surges is both crucial and necessary - what measures should be considered?

In a world seemingly obsessed by risk assessment and analysis, it is ironic that the topic of surge or overvoltage protection seems to be underplayed and, at times, misunderstood.

Yet the need for such protection is largely self-evident as industry and commerce relies more and more on devices that are hugely sensitive to overvoltage events such as surges and lightning currents.

Indeed the protection of critical system components vital to the production, conversion and distribution of electricity, such as inverters, needs to be addressed. It is imperative that protection of these systems is considered during the design stage for effectively managing the damaging effects of the overvoltage events..

The major causes for surges in PV systems are over voltages induced onto the system by inductive or capacitive means deriving from lightning discharges as well as lightning surges. Lightning surges in the PV system can damage PV modules and inverters.

This can have serious consequences for the operation of the system. First, high repair costs, for example, those of the inverter, can be incurred, and, second, the system failure can result in considerable loss of revenue for the operator of the plant due to downtime.

The effects of a lightning strike can induce surges onto electrical systems as far as 2km away from the point of impact. Hence the cause of many system failures is often unknown giving more reason than ever to fit surge protective devices (SPD). SPDs are installed in parallel to the load and they act as pressure relieve valve by taking access voltage and shunting it to ground thus maintaining healthy stream of system voltage to the application.

Obviously coordinating the types of surge protection devices employed is key to combating the damaging and disruptive effects of overvoltages. Typically this involves the following classifications of device;

Class 1 SPD aka Lightning Arresters: this device has the largest impulse current discharge capacity. It is designed to handle the damaging effects on the electrical system from a direct lightning strike to the lightning conducting rod. They are used where lightning currents or fractions of currents are not only diverted via the external lightning protection system but also induced into 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 far enough. Common when an entire roof is covered in PV panels and the mounting frame is equi-potentially bonded to the lightning protection system. In this instance it is a requirement of IEC62305-3 that the DC conductors be protected with class I surge protective devices.

A direct lightning strike to the lightning protection system would, in such a system, induce the damaging overvoltage and voltage spikes onto the DC cables, PV

panels and input to the system inverter. The cost of repairs would be significant without the protection of the correct surge protective device. A class I device capable of handling a current discharge capability of 50kA (10-350µS) would prevent the need for costly repairs.

Class II SPD aka Surge Arresters: these surge protective 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 of the building, but not directly onto the external lightning protection system, electro-magnetic fields develop that may induce dangerously high voltages onto electric circuits.

However, peak values of the current resulting from indirect lightning strike surges are far lower than the corresponding direct lightning strike current. The duration of the pulse and therefore the energy introduced is lower. Class II SPD are used to protect from this type of surge. Typically these devices can handle surge pulses of 8-20µS and a discharge current of 12.5kA.

Class III SPD aka Surge Arresters: these devices have the lowest impulse current discharge capacity. They protect sensitive electronic devices from impact by lightning striking far away or more commonly localised switching surges. Typically they are installed as a supplement to Class II devices and are designed to reduce the overvoltage at the terminals of sensitive equipment. Their current discharge capacity is very limited. As a consequence they should not be used alone.

It is important to understand that a Class I device will provide protection against the high surge voltages and currents induced by direct lightning strikes, but will not protect against the smaller surges of indirect strikes or switching surges.

Attention should be paid to the voltage protection level of the device being used as this is the point at which the device will start to protect as the surge rises in amplitude. e.g. in Class I SPD, the protection level is mostly higher than the dielectric strength of the device to be protected. In such cases an Class II SPD and possibly an Class III SPD must be connected downstream to reduce the protection level to a value suitable for the device.

In terms of inverter protection there are several important points to take into account. For instance in inverters with maximum power point tracking (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.

Another important point to consider when selecting a Class II SPD is that most Class II SPD devices use a thermal disconnects which in DC applications can generate a DC arc. Once the DC arc is generated it is hard to extinguish thus creating more damage than protection. In this case the ideal solution is using the SPDs that in addition to MOVs also use a fast acting DC fuse to extinguish the arc and safely disconnect the SPD. This combination of MOV with fast acting fuse is often time referred to as Short Circuit Technology (SCI).

Due to the nature of the PV installation which can be in remote locations, it is advisable to use SPDs with remote contacts which can alert the user should a SPD sustains a strike and goes offline.

Along with SPDs used on the DC side, SPDs are also required on the AC side due to differences in potential and earthing of the system beyond this point. Unlike on the DC side, several inverters can be protected by one SPD because they are connected to the same (mains) voltage. On the AC output side of the inverter it is important that the SPD device being used is rated according to the system configuration. It is advisable to consult the relevant IEC standard for the possible system types.

When using string circuit protectors and SPDs, the SPD must be installed at the linkage point (combiner box) of the PV strings downstream of the fuses. If the SPD was only to be connected to one PV string between string output and string fuse, the remaining PV strings would be unprotected if the fuse operated.

In addition there would be no protection to the inverter if the surge occurs on the remaining live PV strings. In this event, there would be no protection to the input of the inverter from the remaining strings. Hence it is imperative that the DC SPD devices are positioned in the correct circuit position to provide secure system protection.

It is often said that prevention is better then cure and given the big investments necessary for PV system build and operation, it seems prudent to invest what is a relatively small amount of money in SPDs to achieve system safety and security.