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PRACTICAL EXPERIENCE FROM INDUSTRY ON THE LIGHTNING PROTECTION OF SOLAR PV MODULES

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Abstract

This paper reports the practical experience from industry on the performance of the lightning protection of solar PV modules, which are necessarily installed in the open. The conventional practice as per the current industry experience is to use the support frame of the solar PV module for the passage of the lightning current should it be struck. Hence, the support frames are bonded to the lightning protection system installed. This leaves other parts of the PV modules vulnerable to direct lightning strikes with the result of the lightning current flowing through the DC cable rather than the lightning protection tapes that are bonded to the frame. This, therefore, results in the electronic AC/DC invertor being subject to the direct lightning current and against which they are not protected. The paper will provide examples of such incidents and will consider and discuss how best to avoid such penetration of direct lightning in future installations. The paper will also recommend that the industrial experience be considered during the next update of the Standard when referring to protection of solar PV modules against lightning. With the current global initiative to maximise renewable energy systems it is even more important to ensure that the systems are fail safe and can last their economic life thereby delivering the desired savings.

1 Introduction

1.1 Photovoltaic (PV) systems: Solar PV installations are need based. The need to save on energy cost and the aim to cut on carbon emissions are the reasons for most property owners to opt for solar PV systems. Consequently, there is an inherent initiative by the property owners to install solar PV system on the roof top, over carparks, over still water bodies or on open ground [5]. In most situations, the proposed site may not have an existing lightning protection system. By nature, the solar PV arrays occupy a large footprint and are susceptible to direct and induced lightning strikes.

1.2 Lightning Protection systems (LPS): Since the introduction of the Standard BS EN 62305[1-4], installation of lightning and surge protection systems are driven by compliance and safety requirements. Whilst there is a provision to carry out a risk assessment on existing structures there is a requirement for new installations to be equipped with a certified LPS and surge protection system. The standards are elaborate and provide detail guidance on the methods to safeguard life and property from lightning strikes and potential surges.

1.3 Electrical Distribution system: As a statutory requirement the solar PV installation and the lightning protection system are to be integrated into the electrical distribution system. Accordingly, the BS 7671 [6] has stipulated specific requirements for the installation of solar PV systems. The solar PV installation is to meet the requirements of the Electricity Safety, Quality and Continuity Regulations (ESQCR). The installations shall also meet the Engineering Recommendations of the Energy Network Association.

2. Practical situation

2.1 Lightning protection industry: Most lightning protection specialists and manufacturers have suitable products for the protection of the external fabric of the structure and the lives of the people inside the building by channelling the lightning strike energy in a safe and controlled manner, into the earth. The solution takes account of all the potential risks from a direct lightning strike, and incorporates all the elements necessary to deliver full and effective external lightning protection, including;

- Structural lightning protection
- Earth termination
- Equipotential bonding of metallic parts.

2.2 Surge protection industry: Today electronic systems have become central to virtually every aspect of our day-to-day life from data centres to mobile devices. Correspondingly, the surge protection specialists and manufacturers have developed a range of products for the protection of almost all modern electronic systems.

The lightning and surge protection manufacturers have produced ample technical literature, seminars and training modules to translate the need to combine the lightning and surge protection solutions as intended in the BS standard.

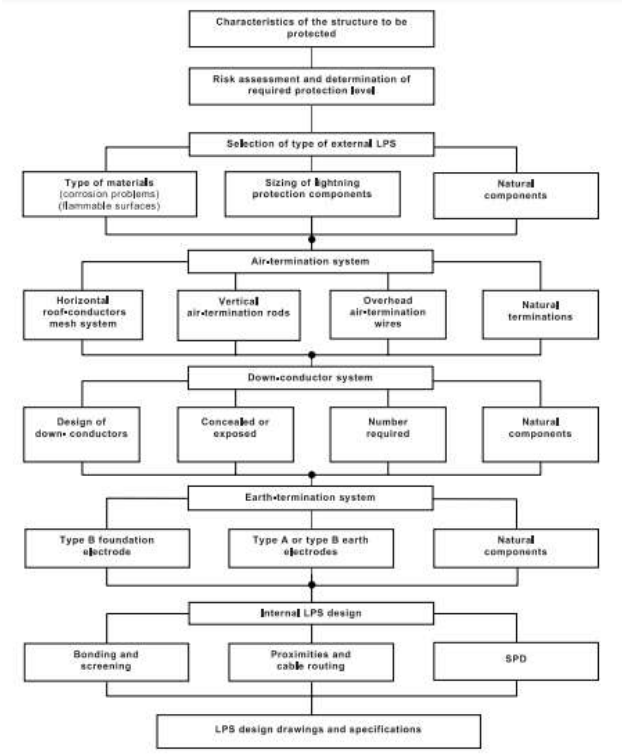

Fig. 1. LPS Design Flow Diagram, [3]

However, there has been only a few guidelines from the industry on the specific protection of solar PV systems from direct and indirect lightning strikes. Although the LPS design flow diagram is explicit it is seldom referred to.

2.3 Academic situation: Whilst the industry has been in the forefront on the implementation and delivery of the lightning and surge protection solutions there have been several further research on the subject of protection of solar PV systems from lightning and surges by the academics. [7-11]
The distinction between isolated and non-isolated lightning protection and additional earthing systems for solar PV installations is modelled and assessed in the research as shown in the Fig 2 and 3 respectively.
The academic research highlights the benefit of providing additional earth electrodes to enhance the earthing system, thereby reducing the energy dissipated. This in turn reduces the load on the surge protection devices.
From these valuable findings it is clear that the lightning protection, surge protection and earthing system of large-scale solar PV systems needs to complement each other. These findings provide the designers sound advice even before the standards are released.
Further research on factual on-site experience from installations will validate the current simulated models.

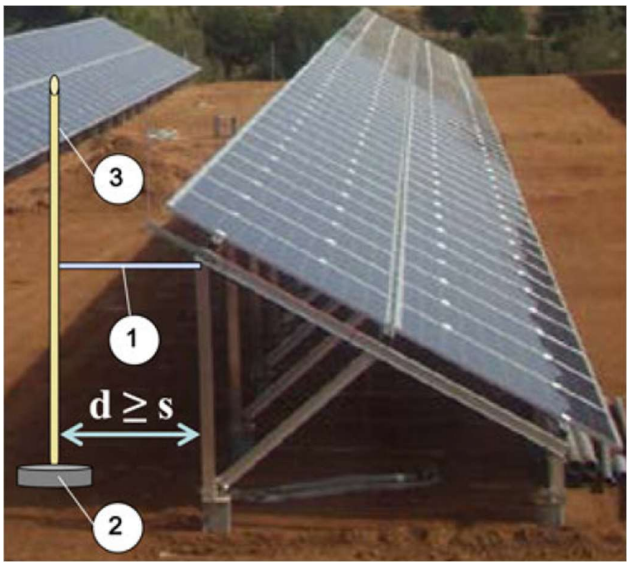

Fig. 2. Isolated LPS, [7]

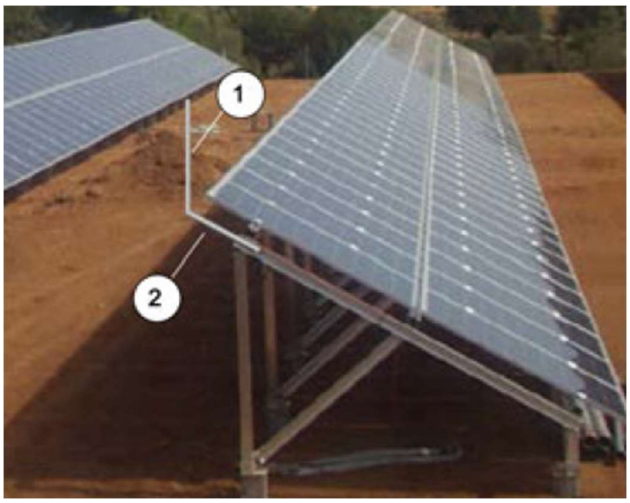

Fig. 3 Non-isolated LPS, [7]

In depth analysis have also been carried by the academics on Lightning-Induced Voltages Effect with surge protection devices(SPD) Placement in Solar PV installations. [8].
The recommendation to install multiple surge protection devices is to be considered by designers.

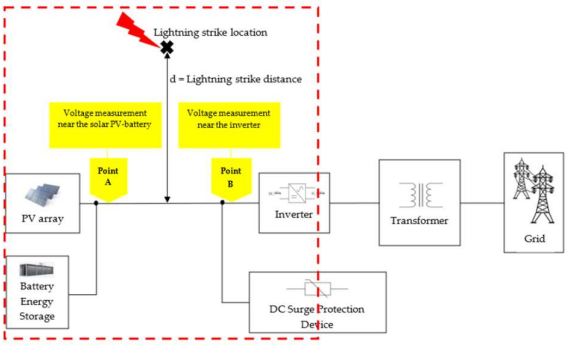

Fig. 4 SPDs on DC side, [8]

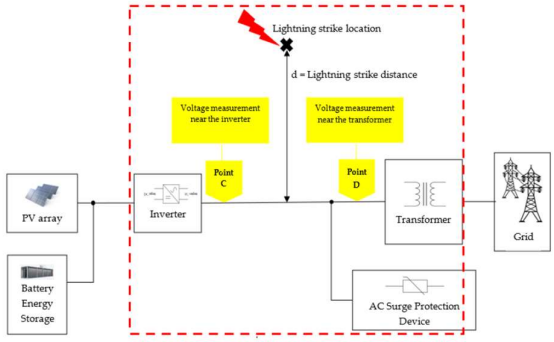

Fig. 5 SPDs on AC side, [8]

3. Practical experience

3.1 Concept stage: Most property users would tend to call the solar PV specialists/installers initially for a design proposal and price quote. While the solar PV specialists are quick in submitting a snap proposal with modelling of energy parameters and return of investment projections, the need for lightning protection is often not included in the costing unless specifically asked for by the owners.
It must be noted here that both the solar PV system and Lightning Protection System are different sectors with very different skills and competence. Although the Standards are specific and clear, there is a 'blind' spot in terms of the design methodology at concept stage.

3.2 Schematic stage: As the detail design progresses there are further grey areas that are often not considered. If the structure has an existing lightning protection system, then PV installers would bond the PV array frames on to the lightning protection air termination tapes. See Fig. 6.

Fig. 6

This leaves the entire solar PV array exposed to direct lightning strikes.

Furthermore, the DC wiring beneath the solar PV panel is either clipped below the PV module or taken through PVC containment to the inverter. Although the DC wires are shielded, they will seldom withstand the high induced lightning surge current.
Some comfort will be provided by the installer that the inverters have inherent AC and DC surge protection. This comfort is short lived, as the LPS and surge protection systems are to be annually checked and certified by an approved LPS installer. The integral surge protectors within the invertor will normally not get checked as the units are sealed by the manufacturer for warranty purpose.

3.3 Post handover: As per industry standard most PV installations come with the installers warranty of 12 months. Very seldom do faults and failures occur during this period.
The inverters usually have a 10–12-year warranty and the solar panels come with a performance warranty of 25 years.
Inverter failures usually occur after five years, and it is usually cumbersome to get a replacement of the inverter from the overseas manufacturer. This nullifies the return of investment and defeats the objective.

4 Practical suggestions

4.1 At concept stage: Ensure that the solar PV proposal covers the protection of the solar PV panels from direct and induced lightning. The design of the lightning and surge protection should be carried out by a certified LPS specialist.

4.2 At schematic stage: It is advisable to install a DC isolator at proximity to the PV array. This will allow the termination of DC wiring at the DC isolator enclosure. The termination point shall also accommodate the connection of long runs of cable to the inverter by multi core steel wire armoured cable in metal heavy duty cable tray with protective metal cover. As a result, the system will be fully protected from induced surge current. See Fig 7.

Fig. 7

It is a good practice to install additional DC and AC surge protection devices out with the inverter. So that they can be tested annually by the LPS specialist without opening the

sealed invertor. This will enhance the life of the inverter and solar PV system.

5 Conclusion

With the number of solar PV installations on the rise it would be extremely important to ensure that the installations are well protected. Although the current standards are useful it is not sufficiently cross referenced between different sectors. Further study needs to be carried out to ensure that the blind spots are removed, and the systems can perform until the end of their economic life span.

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