# *Lightning protection of photovoltaic plants*
# *Tips and hints for the mounting system*

*(kindly supported by DEHN + SÖHNE, Dipl.Ing. Brigitte Schulz)*

## *1 Preliminary notes*

*When planning and mounting a photovoltaic plant many points have to be considered. But there is hardly any other topic on which there are so many different and maybe unclear opinions as on lightning protection and potential equalisation.*

*Basically it's the installer's responsibility to see that all regulations and guidelines regarding lightning protection are followed. As a qualified manufacturer of mounting systems we want to offer you a suitable range of component parts and furthermore give you some hints.*
*Please note that this compilation is non-binding and that no responsibility is taken for the correctness of this information.*

## *2 References*

*Please also have a look at the information given in the following documents:*
*(available for download on the internet at www.solar.schletter.de):*

- *Protection proposal „Lightning and overvoltage protection for photovoltaic plants" (DEHN + SÖHNE)*
- *Pictures of damages (www.solar.schletter.de – picture gallery)*
- *Inspection report „Grounding tests"*

*Furthermore you have to note:*

- *DIN V VDE V 0185 with the respective paragraphs*
- *Guideline VdS:2010 : 2002-07 (01) „Risk orientated lightning and overvoltage protection"*

## *3 Shock-hazard protection and potential equalisation*

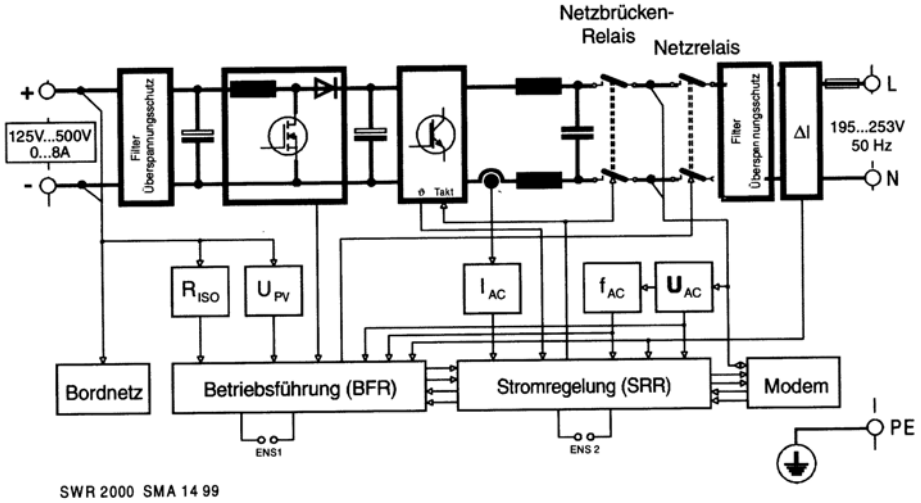
### *3.1 Potential equalisation in general*

*Potential equalisation for all metal parts of a plant that could be touched is compulsory according to DIN VDE 0100, part 712. This especially concerns mounting systems and module frames. It must be pointed out that there can be potential differences in a plant for example because of malfunctions of the inverter. So you have to prevent damages to persons by potential equalisation!*
*Primary damages by electric strokes are especially dangerous on roofs because they can easily lead to heavy secondary damages (falling off the roof...). Roofs are not really open to the public, but the plants have to be maintained and for example the chimney sweeper could touch the plant. So a complete contact protection has to be warranted.*

## *3.2 Potential equalisation when using an inverter without transformer*

*Even if there are no malfunctions, a capacitive charging to high voltages at the module cannot be excluded if a inverter without transformer is used. So a potential equalisation is especially important in this case.*

*Explanation:*
*An example of an inverter without transformer (source: SMA) shows a high-frequency boost converter for the MPP adaptation at the input. The next part is a high-frequency clocked bridge that copies the line frequency. Boost converter and bridge work together so that at the input of the inverter a voltage because of shifting charges can be built up. The input of the inverter cannot be brought to earth potential because of the bridge circuit. So capacitive charges at the module possibly cannot flow off.*




*Because this voltages are usually highly resistive and the charges are limited there is normally no direct danger. But especially on roofs discharges can lead to perilous secondary damages (e.g. falling off the roof).*

*For this reason the manufacturers of inverters without transformers specify that the module frames have to be grounded (example instruction manual SMA):*

**In diesem Zusammenhang achten Sie bitte unbedingt darauf, daß berührbare leitende Teile des PV-Generators (z.B. Metallrahmen, aluminiumhaltige Folien der Module, Tragkonstruktion etc.) geerdet sein müssen, damit im Betrieb auftretende Verschiebungsladungen abgeleitet werden können.**

*Translation: „In this regard please see that all touchable conductive parts of the photovoltaic generator (e.g. metal frames, module foils containing aluminium, mounting frames…) have to be grounded so that occurring shifting charges can be discharged."*

*Even the manufacturers of inverters with transformers partly recommend to ground the modules.*

### 3.3 Involvement of anodised module frames into the potential equalisation

*When building a photovoltaic plant this compulsory grounding of the modules is often neglected in practice. Often no grounding connections are looped through from module frame to module frame. The modules with their anodised frames are only clamped to the mounting rack. Measurements made by Schletter GmbH Solar-Mounting Technology show that a no reliable grounding in reached with this method (q.v. inspection record). Our measurements proof a reliable grounding with grounding middle clamps (new product of Schletter GmbH).*

# 4 Regulations for lightning protection measurements Hints for the building of photovoltaic plants

## 4.1 Lightning protection concepts to protect photovoltaic plants

*According to VdS2010 a lightning protection concept of the protection category three has to be provided for photovoltaic plants above 10kW. That means that the plant has to be protected – independently from the protection of the building.*
*In which cases a lightning protection concept for the plant ultimately must be provided has to be checked with the concerned client respectively with the responsible insurance agency.*

## 4.2 Duty of care when mounting photovoltaic plants on buildings with existing lightning protection concepts

*The installer of a photovoltaic plant has the duty to take care irrespective whether a new lightning protection concept is made for the plant or an existing concept is used or adapted. So he has to inform the owner if he damages the lightning protection system or notices existing damages to it.*

## 4.3 Protection concepts if mounting photovoltaic plants on buildings with existing lightning protection concepts

*Possibly it's the decision of the owner or insurance companies whether a new photovoltaic plant has to be secured with additional lightning protection measures. But the existing lightning protection of a building can be affected or disabled by a photovoltaic plant. In this case big liability claims could be made to the installing company!*
*Here also keep in mind especially secondary damages (for example damages because of inductive coupling into power supply or data grids).*

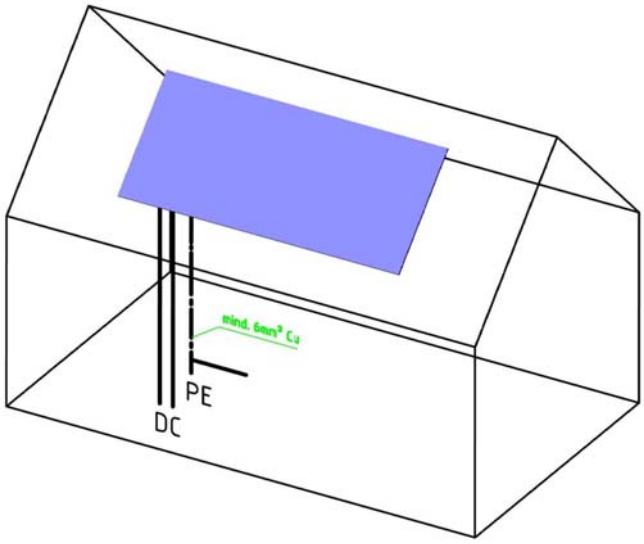
### 4.4 Legal protection of status quo for lightning protection systems

*Existing lightning protection systems on buildings might be obsolete or not any more conforming to standards. But there is legal protection of status quo for this systems as long as the building or roof are not changed. But when a house is equipped with a photovoltaic plant, this protection for possibly obsolete lightning protection systems expires!*

# 5 Technical hints for lightning protection measures

## 5.1 Photovoltaic plants on buildings without lightning protection

*A photovoltaic plant does not increase the risk of a lightning strike for buildings without lightning protection. The potential equalisation in the whole generator according to VDE 0100 is necessary in any case (minimum cross section 6mm$^2$). You can often hear that leaving out the potential equalisation leads to a reduced risk of a lightning strike into the then ungrounded frames. That is not true! In fact the PE conductor discharges the DC conductors in case of a direct strike. So damages to the low voltage grid or to the inverters can be limited.*



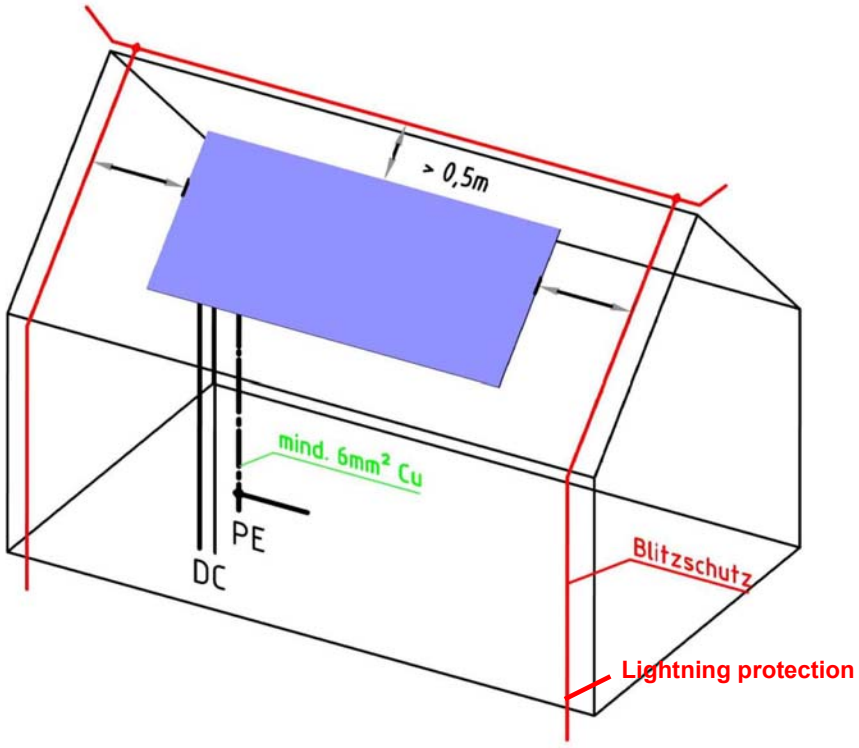

*Direct lightning strikes are always a danger to the system. The possible damages can be reduced by a corresponding protective circuit of the DC conductors.*

*General hint:*
*Some insurance companies demand that wires generally have to run on the outside of a building from the roof to the connection to the power grid. In this case not only the PE but also the DC wires have to be on the outside.*

## 5.2 Plants on buildings in the protected zone of the lightning protection (optimal protection of the plant)

*Especially for smaller photovoltaic plants on buildings with lightning protection, an entire protection of the plant by the existing lightning protection system is possible. For that all parts of the photovoltaic generator have to be located within the meshes of the lightning protection system. Additionally a safety distance between the photovoltaic plant and all parts of the lightning protection system has to be kept. The calculation of the distance is made according to DIN V VDE V 0185-2. In practice a distance of app. 0.5m has proven of value..*

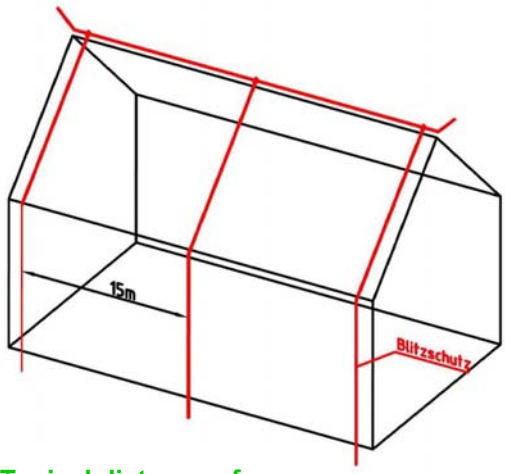
*Example: On buildings up to a length of 15 meters, the lightning protection usually consists of a ridge wire and two wires on each side. In this case the plant can be positioned within this mesh (see picture).*



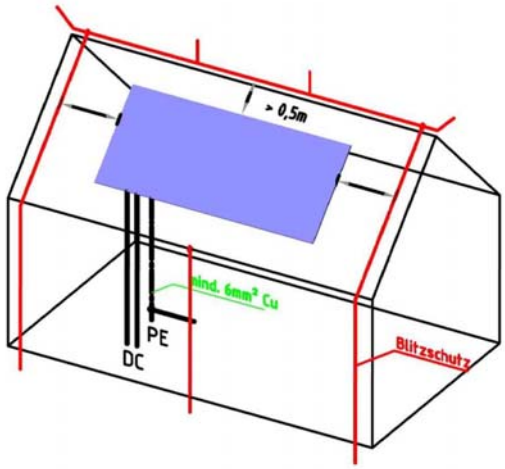

- *The potential equalisation at the frame can not be left out!*
- *Photovoltaic plant and lightning protection are not connected (minimum distance 0.5m)*
- *The photovoltaic generator is protected by the lightning protection system*

## 5.3 Photovoltaic plants with additional lightning protection measures (optimal protection of the plant)

*Especially for big photovoltaic generators the minimum distances between plant and lightning protection often cannot be kept. The plant may not cover existing lightning protection conductors because then surge currents could get into the building over the generator in case of a lightning strike and cause damages there.*
*In this case normally a complete revision of the lightning protection concept is necessary:*

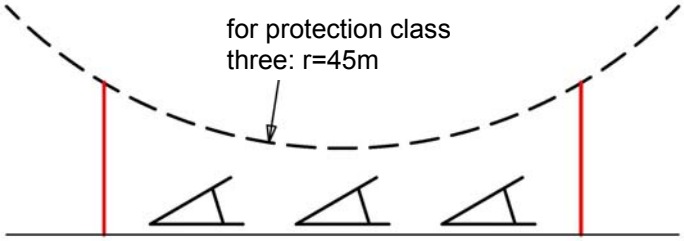



**Typical distance of conductors (protection class three): 15m**




- *Lightning protection connections are possibly left out respectively replaced by HVI conductors to allow the required minimum distances.*
- *Additional connections and arresting devices protect building and plant.*

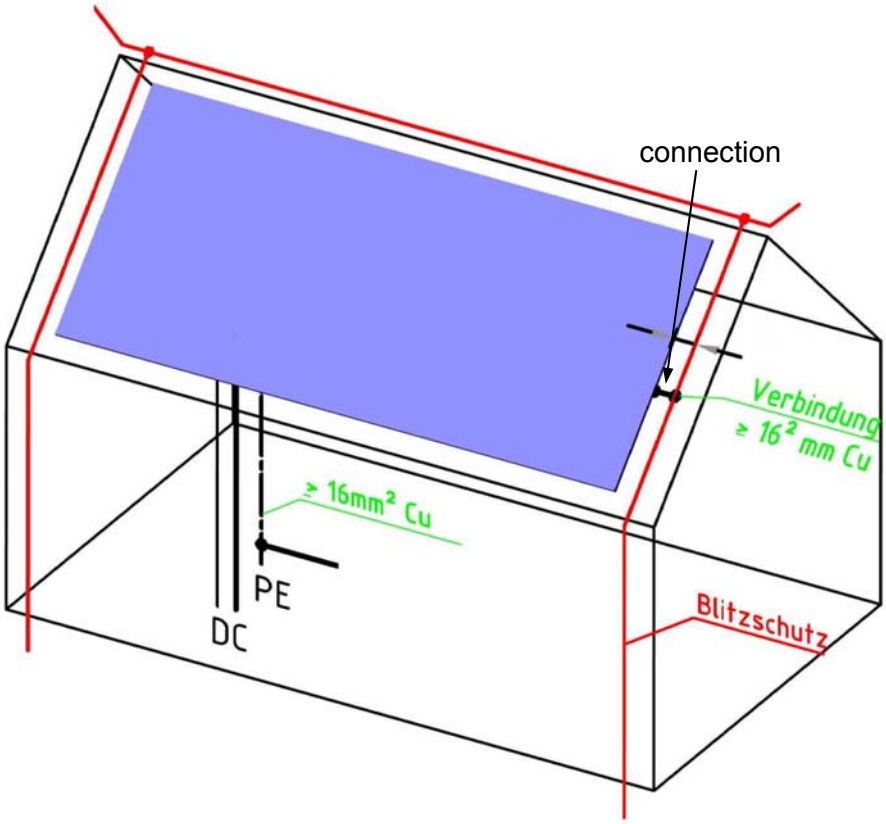
*Additional arresting devices can for example be dimensioned according to the following method: For example for protection class three an imaginary ball with a radius of 45 meters may only touch the arresting devices and not at the same time parts of the building or the photovoltaic plant (see picture).*



## *5.4 Connection of photovoltaic generators to lightning protection measures (if the necessary distances cannot be kept)*

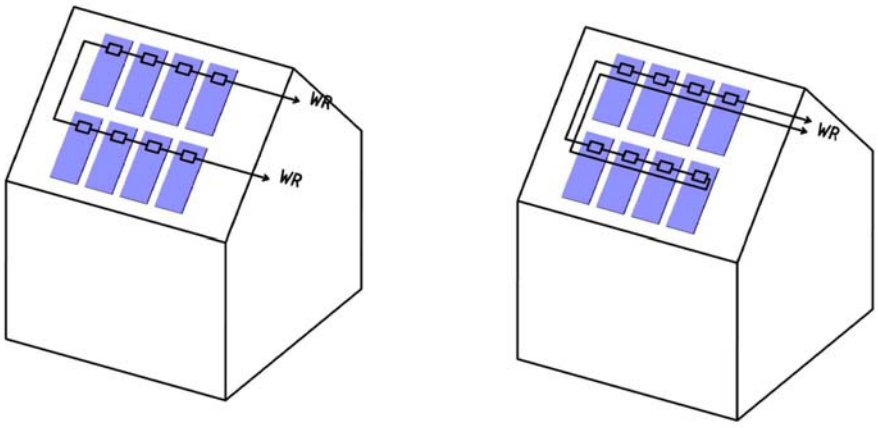
*Basically the prevention of lightning strikes into the photovoltaic generator respectively the supporting structure is the best protection. Because a lightning protection system has the purpose to discharge the occurring currents in case of a lightning strike there has to be a minimum distance between the photovoltaic generator and the lightning protection conductors.*

*Only in cases in which this minimum distance cannot be kept because of the size of the plant, the photovoltaic generator and the lightning protection system are connected. Like this the consequences of sparkovers are limited. The copper connection should at least have a cross-section of 16mm$^2$. Clamps have to be correspondingly conductive.*
*In this case there should also be a connection between the mounting frame and the potential equalisation of the house (not mandatory, but better). If such a connection is made, it should also have a cross-section of a least 16mm$^2$ Cu. To reduce couplings with the DC conductors, you should use shielded wires or put a closed metal cable duct around the connections. The conductors and ducts have to be grounded on both sides. Like this the lightning strike currents are as far as possible prevented from flowing into the power supply or data grids.*



## 5.5 Hints for the wiring of photovoltaic plants

*The wiring is very important for the protection against nearby strikes. Damages to the plant (for example destruction of the transverter by overvoltage) are often caused when induction voltages are induced in the module wiring. A lightning strike is accompanied by a very large current flow. This current flow (respectively it's derivative di/dt) causes a induction voltage in the conducting loop of the module wiring.*
*For that reason you should pay attention that as far as possible no loops are created in the module wiring. The best solution is shown on the right picture below: After passing all modules which are connected in series, the wire should run back in the same module row. For the return wire you can use the cable duct of the cross beam.*
*Furthermore adequate protection circuits in the connection boxes of the generator and the transverters have to be planned (accessories of lightning protection system vendors).*




**bad** **better**

# 6 Summary

***The installer of a photovoltaic plant bears a big responsibility for the correct construction of the plant and also for a professional lightning protection concept. He not only has to decide whether the plant needs its own lightning protection and how this could be realised, but also if the new photovoltaic plant disables the existing lightning protection or if the protection of status quo of existing old lightning protections expires with the new plant. To really cover all this concerns, a wide knowledge in many points and some planning and counselling efforts are necessary. But to avoid damages to the plant, a reasonable concept is fundamental.***
***It will be one important task for our sector to explain the importance of this minimum expenses to the end customer. Like this the advantages of a real professional in comparison with competitors can be pointed out.***

***We hope that we could give you some planning aids with our hints and we are happy that you continue to rely on our products and our competent consulting!***