Considerations in overvoltage protection design for photovoltaic panels and systems

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Abstract **— This paper describer objectives that have to be taken into account with overvoltage protection strategy and design for photovoltaic systems. These serve as renewable energy source and are nowadays widely used.**

Keywords: Overvoltage; photovoltaic panel

I. INTRODUCTION

With this energy demand increase most of the energy sources used so far appears to be insufficient and exploitable in relatively short time horizons. One of the alternative solutions is to increase the contribution of renewable energy sources. Nowadays widely used alternative among these sources like e.g. wind power plants is the exploitation of solar energy. Solar light energy exploitation uses photovoltaic effect. This requires an installation of more and more photovoltaic and solar systems. This situation requires this energy source to be more and more reliable. One of the risks in exploiting and relying on such energy source is overvoltage and damages caused by overvoltage. Lightning protection systems are intended to prevent or to minimize the physical damage due to lightning flashes to the protected photovoltaic system. It consists of both external and internal lightning protection system.

II. EXTERNAL LIGHTNING PROTECTION SYSTEM

External lightning protection system has to be established in order to prevent photovoltaic system parts such as air-termination system, vertical air-termination rods and masts, horizontal wires and mesh air-termination system. It conducts the lightning current safely into earth by conductor system and disperses the lightning current into the earth by an earth-termination system.

According to IEC 63305-3 physical design and construction, maintenance and inspection of an external lightning protection system can be executed. We have to take into account the class of lightning protection system, isolation of external lightning protection system from protected structure, potential use of natural components, positioning, used materials and sizing of components [5].

Area protected by the external lightning protection system can be calculated using of the following methods:

- protection angle or
- rolling sphere or mesh method.

In photovoltaic systems external lightning protection system has to be designed so that all components of the system must be inside of the protected area.

III. INTERNAL LIGHTNING PROTECTION SYSTEM

Internal lightning protection system is designed to prevent dangerous overvoltages intruding into protected photovoltaic system or it's components. There are various measures to fulfill this task, e.g. equipotential bonding, equipotentialization by interconnecting the external lightning protection system with structural metal parts, external conductive parts, internal metal installations and systems and incoming services.

IV. MEASURES FOR LEMP PROTECTION

Main aim of lightning protection system is to avoid failure of electrical and electronic equipment of photovoltaic systems due to LEMP. This can be caused by conducted and induced surges via connecting wiring according to surge coupling type. All measures lead to avoid the formation of surges and equalizing all different potentials to a common potential at the instant of surge. Lightning protection system divides the protected space into successive zones according to IEC 63305.

Basic measures are mentioned below:

Grounding

DC photovoltaic device grounding needs bonding to earth including any metal parts. The grounding of devices must not be executed if the prevention against electric shock is achieved by use of class II insulation. That means safety class II or extra-LV safety class III. But DC photovoltaic component grounding is compulsory if there is protection by automatic disconnection of supply applied, i.e. we have safety class I.

If a separate grounding electrode is provided for DC photovoltaic component grounding, it shall be connected to the installation earth.

Equipotential Bonding

A bonding network minimizes differences between potentials. Network can be arranged by integrating magnetic shields of lightning protection zone at the periphery or conductive parts of the systems inside of the LPZ, and by bonding metal parts or conductive services at the boundary of each lightning protection zone directly or by using reliable .

Network connected to the earth terminal system consists of complete grounding system. It consists of structural metal parts, external conductive parts, magnetic shields, internal metal installations parts, metal components of internal systems.

It is necessary that incoming ports should enter the lightning protection zone at the same location and be connected to the same bonding bar.

Magnetic Shielding

Magnetic shielding is used for magnetic field minimization inside lightning protection zone. This magnetic field can be induced by lightning flash near photovoltaic system.

To protect volumes spatial shields are used to create single protected areas. This should include inverter control building in lightning protection zone 1, space containing sensitive photovoltaic equipment and devices in lightning protection zone 1 or 2, area intended for sensitive equipment e.g. monitoring equipment in lightning protection zones 2 or 3.

To protect buildings steel reinforcement in concrete and metal walls are used to shield buildings or rooms. The mesh width below should be 5 m.

The line and cable screening is used for power and telecommunication lines. This is designed to use metallic shield of cables.

Cable Routing

Suitable cable routing minimizes induction loop area helping to reducing induced internal overvoltages. Loop area must be minimized by routing the cables. Electrical and signal lines should be routed together. + and – cables must be bundled together. Layout of the wiring is also important, so that enclosed wiring areas should be as small as possible.

Line routing and shielding are important for outer lightning protection zone design and for LPZ 1.

Isolating interfaces

Isolating interfaces is used to avoid induced overvoltages through the sensitive photovoltaic equipment and its connected signal lines due to large loops or bad bonding network.

Usage of surge protection devices

Surge protection devices are devices used to achieve lightning and surge equipotential bonding for live conductors of incoming lines in a lightning protection zones and its connected internal live circuits. The basic idea is to create temporary short-circuit between line and grounding in the case of overvoltage, so that the overvoltage can be led to the earth, avoiding the overvoltage to intrude into protected circuits.

V. OVERVOLTAGE PROTECTION OF PHOTOVOLTAIC SYSTEMS

These are e.g. compact I + II (according to IEC 61643-1 and STN EN 61643-11) protection devices. They are made especially for the protection of positive and negative buses of photovoltaic panels against overvoltage. It is advisable to connect these devices on the interface of LPZ $0_{A(B)}$ zones – 1 and above.

From the construction point of view they consist of varistors or varistor sections connected between L+, L- and PE wires. Varistor sections have internal disconnecters that are activated during faults or in the case of varistor overheating. Disconnecters indicate their state usually mechanically. Additionally, overvoltage protection devices can be equipped with remote signalization of faulty devices.

Protection devices usually have various levels of maximal continuous DC voltage UC (e.g. 200, 400, 600, 800 and 1000V) and various values of voltage protection level (at I_{imp}) U_P (e.g. smaller than 250, 1100, 2000, 2400 and 3400V). Maximal leakage current is also an important parameter - I_{max} (8/20 shaped wave) can be e.g. 120kA.

VI. CONCLUSION

There are various measures that have to be taken into account when designing photovoltaic system and lightning protection system for it's components. These measures can be divided into internal and external lightning protection system. These measures help us to improve the reliability of source operation. The strategy against energy supply drop-outs caused by lightning hit into unprotected solar power plants is very important nowadays and requires also the knowledge in the area of overvoltage protection system design.

ACKNOWLEDGEMENT

This publication is the result of the Project implementation: Výskum charakteristík fotovoltaických komponentov pre efektívne projektovanie solárnych systémov, ITMS: 26220220080 supported by the Research & Development Operational Programme funded by the ERDF.

Európska únia
Európsky fond regionálneho rozvoja

Agentúra Ministerstva školstva, vedy, výskumu a športu SR pre štrukturálne fondy EÚ

We support research activities in Slovakia / Project is cofinanced from EU funds.

Operačný program VÝSKUM a VÝVOJ

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