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Development of Protection Measures for Microinverters against Lightning Transients

by

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ABSTRACT

The effects of lightning on electrical systems have been studied extensively in the past several years. Despite this establishment, lightning's induced, and indirect effects on microinverters used in photovoltaic installations (PVIs) have not been studied in detail. This includes induced overvoltages in the power cables of the solar cell arrays in the event of partial lightning currents. The lack of such information is a barrier to determining the voltage, current and energy characteristics when developing surge protection devices (SPDs) to protect photovoltaic (PV) systems with microinverter technology.

Overvoltages can destroy, degrade or cause malfunction of a PVI. Therefore, PVIs should be protected from this overvoltage risk. Furthermore, microinverters have lower voltage and current rating characteristics than central or string inverters, and therefore, on this basis, they become more sensitive to lightning stresses. Therefore, evaluation of the waveforms, representing the equivalent lightning surges, is essential in developing the necessary protection measures. This research explored this through experiment and simulation settings using COMSOL Multiphysics® and Power Systems Computer-Aided Design (PSCAD).

Induced overvoltage simulations, performed with COMSOL Multiphysics® software and validated experimentally, indicated the influence of electromagnetic coupling on PV systems caused by lightning transients. It was found that lightning currents flowing through lightning protection system (LPS) structures or the PV frame can cause transient overvoltages on the DC cabling of a PVI. The magnitudes and waveforms of these overvoltages varied as a function of several parameters, including the lightning current amplitude, protection scenario and mode of measurement. Furthermore, by injecting impulse currents at different positions using standard lightning current waveforms (8/20 μs and 10/350 μs), the induced electric field was caused by a time-varying magnetic field, which further induced an emf (electromotive force) on the DC cables of the PV panel. Based on these findings, the induced overvoltages on the DC cables of a solar panel, which can go up to several kilovolts in extreme impulse currents, can exceed the impulse withstand voltage of microinverters.

The protection of the microinverter against lightning transients was also investigated by simulation using PSCAD software, where surge protection in the form of Metal Oxide Varistor (MOV) was connected to the DC cables of the PV system with a microinverter. This

investigation measured the energy overload and the current flowing through the SPD caused by lightning-induced overvoltages. The results demonstrated that a class II internal SPD seems appropriate for PV installations with a microinverter with and without LPSs for impulse currents not exceeding 20 kA.

Keywords: microinverter, lightning protection system, PV system, lightning-induced overvoltage, impulse current, surge protection device (SPD)