A Study on Arc Fault Protection in Photovoltaic Systems Based on High-Frequency Noise Generated by Arcs

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Introduction

The rapid advancement of photovoltaic (PV) systems has unfortunately led to more fire incidents, creating a significant safety concern. These fires are primarily caused by DC arc faults. While Arc Fault Circuit Interrupters (AFCIs) are effective at prevention, they cannot identify the fault's precise location.

Our previous studies have explored fault localization techniques based on high-frequency noise (arc noise) generated during arc events [1]. In those studies, arcs were experimentally induced using copper electrodes, and the subsequent analysis confirmed that arc noise attenuates within specific frequency bands. The present study investigates whether these established findings can be applied to faults involving aluminum conductors, whose use has been increasing in modern PV installations.

Experimental Procedures

Figure 1 illustrates the configuration of the experimental circuit, which comprises a DC power supply, an arc generation device, and a resistor. To minimize line impedance, the power supply and arc generation device were positioned in close proximity. The distances from both the arc generation device to the resistor and the power supply to the resistor were set to 20 meters.

Since the output of PVS can fluctuate significantly due to changing weather conditions, a DC power supply was used as a substitute for the PVS in this experiment.

The arc generation device employed aluminum rods with a diameter of 3 mm as electrodes. An arc fault was simulated by separating the electrodes while current was flowing, thereby generating an arc.

To investigate the influence of distance on sensor output, the separation between the arc generation points and the sensor was varied (0 m, 10 m, and 20 m). The sensor signals were measured using a spectrum analyzer. A self-made sensor was used for all measurements.

Results and Discussion

Figure 2 shows the differential arc noise spectra at distances of 10 m and 20 m from 0 m, the reference position. From these results, it was observed that the output in the low-frequency range exhibited minimal difference compared to that at the 0 m position. However, an attenuation trend was observed in the frequency range from 1 MHz to 100 MHz.

These findings are consistent with previous results obtained using copper electrodes, confirming that arc noise generated with aluminum electrodes exhibits similar characteristics.

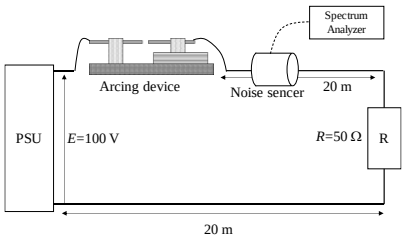

Figure 1 experimental circuit

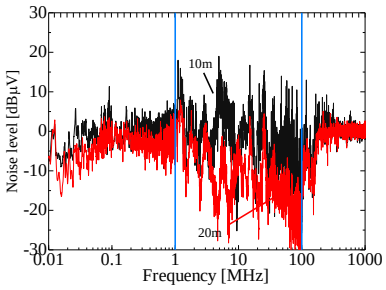

Figure 2 Difference in signal strength relative to 0m

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References

[1] A. Tsusaka, S. Hasegawa, T. Nanahara, Y. Goto, and A. Kato, “A Study on Location Method of Series Arc Fault Point in Photovoltaic Generation System”, ICRERA, IEEE, 2024, doi:10.1109/ICRERA62673.2024.10815203.