A New Protection Method for MTDC Solar Microgrids Using on-line Phaselet, Mathematical Morphology, and Signal Energy Analysis

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Extended Abstract

Introduction: In this paper, a new method for the detection, location, and classification of faults in MTDC solar microgrid has been presented. Some issues such as the expansion of renewable energy sources and DC loads as well as the efforts to increase power quality and to reduce the environmental impact of electricity generation have led to the expansion of solar networks. Identifying the types and locations of faults is important to ensure that the service continues and further breakdowns are prevented and the protection's selectivity characteristic is increased. In this method, an orbital kit is connected to the network. At time of fault occurrence in the network, the fault is detected by passing a current through the connected kits, measuring the traveling waves derived from the fault current, and applying it to a mathematical morphological filter. The location of the fault is determined using orbital equations and flow calculations. Mathematical morphology filter output and signal energy analysis have been used to determine the type of faults. This method was tested with many faults. The results have indicated the accuracy of the proposed method. This method is resistant to changes in arcs resistance (up to 100 ohms) and has a very good performance in high impedance fault conditions (up to 1000 ohms).

Materials and Methods: The presented mathematical morphology filter detects pole-to-ground arcs and pole-to-pole faults in every DC grid such as DC solar microgrid, DC distribution systems, or DC solar nanogrids. The presented current injection kit was optimized considering switching losses and current injection kit's reactive losses, and the cost of kit elements. The injection current passed through the current injection kit and the faulty part of line (the faulty part of the network) only in fault conditions,; in other conditions, the injection current and switching losses and kit's reactive losses are equal to zero.
The presented fault detection and location method works very fast due to online phaselet transforms used.
The presented mathematical morphology filter output is none zero only on the fault conditions
The signal energy analysis, used to classify faults in this method, was in tune with online phaselet transform outputs and worked accurately.
The location of the fault is determined using circuit equations, attention factor (β), and current calculations.

Results: In the presented method, the detection, classification, and location of faults are done very fast and accurately. This method has been tested by various types of positive-pole-to-ground faults, negative-pole-to-ground faults, and positive-pole-to-negative-pole faults in a DC solar micro grid.
The resistance of the faults has a wide range between 0 to 100 ohms. This method is resistant to changes in fault resistance and has a very good performance in high impedance fault conditions with resistance of 500 and 1000 ohms. The error of presented fault location method is limited to only 7% using by an optimized current injection kit (in the worst case).

Discussion and Conclusion: The presented fault classification method works very fast due to mathematical morphology filter and online phaselet transform.
This method works fast and accurately in solar DC distribution networks neglected by a number of buses, branches, resources, loads, and levels of voltage and power.
This method robustly works with changes of sampling frequency in a wide range, including 500 Hz, 1 kHz, 2 kHz, 5 kHz, 12 kHz, 20 kHz, 32 kHz, 50 kHz.

Keywords: DC solar microgrid protection, signal energy analysis, fault classification, fault detection and location, current injection kit, online phaselet and mathematical morphology filter

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