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Large Scale Monolithic Solar Panel Simulation – A Study on Partial Shading Degradation

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ABSTRACT

Shadow-induced degradation is a major concern for both power output and long-term reliability in solar cells. Apart from the obvious fact that shading reduces the amount of solar irradiance available to solar panels, it may lead to formation of hot spots, where solar cells are forced to reverse breakdown with localized heating, and potentially, permanent damage. To get a better understanding of shadow-induced degradation, we develop an electro-thermal coupled simulator that can self-consistently solve the electrical and thermal distributions of solar panel under arbitrary shading conditions. The simulation framework consists of two part: a) compact models that can describe the cell-level IV characteristics; b) a circuit network of thousands of compact models connected in series and parallel to form a solar module. The framework is based on open-source software, namely, Verilog-A for industrial standard compact model development and a SPICE-based circuit simulator capable of parallel computation. It is found that power loss due to shadowing is dependent on both the percentage of area shaded and its orientation. The degradation is more prominent for cells that have lower reverse breakdown voltage. The ultimate outcome of the framework is to create the first open source, physics-based module simulation tool to accelerate the pace of PV research and development in academia and industry and to reduce the cost of development by revising qualification protocols (e.g. IEC612125) to better represent the actual operating condition.

KEYWORDS

Solar Cells, Partial Shading, Compact Models