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NAME OF SCHOLAR: PUSHPENDER

NAME OF SUPERVISOR: Prof. Shahida Khatoon

NAME OF CO-SUPERVISOR: Dr. Mohd Faisal Jalil

NAME OF DEPARTMENT: ELECTRICAL ENGINEERING

Title of Thesis: Modeling and Performance Analysis of Solar Photovoltaic Array Reconfiguration under Partial Shading Conditions

Findings

Through this thesis, the systematic and application-based research on how a photovoltaic (PV) system can be enhanced to work in non-uniform irradiance and partial shading conditions have been introduced. The four key dimensions that are used in the study are correct PV array models, smart maximum power point tracking (MPPT), maze (puzzle)-based physical reconfiguration and a new Improved Odd Even (IOE) reconfiguration. The combination of these contributions results in the solution of the key issues of power degradation in PV arrays nonlinear nature, current mismatch, multi-local maxima and shading-induced losses, and are easy to understand, scale and cost-effective. The first input to this work is the invention of the entire PV modelling scheme, which is based on single-diode equivalent circuit. The model considers the effect of the irradiance and the temperatures on the current generated by the photos, diode saturation current and resistive losses, which enable the model to sufficiently simulate the behaviour of the PV cells, modules and arrays. The modelling environment was written in MATLAB/Simulink and checked against datasheets of manufacturers, ensuring that it recreates correctly current voltage (I-V) and power voltage (P-V) curves under standard test conditions, as well as variable environmental inputs.. The second contribution was on smart control using MPPT strategy based on fuzzy logic to a hybrid PV system. The traditional MPPT techniques are usually characterized by constraints of the fast varying irradiance, e.g., oscillation about the operating point and the exposure to local maxima in the partial shading. The fuzzy MPPT developed in the study utilized a rule-based inference method in error and change-in-error to dynamically adjust the on time and off time of boost converter. This strategy made tracking more stable and made it easier to respond to changes in the environment. While this conclusion emphasizes qualitative performance over numerical metrics for assessing MPPT, the results distinctly indicate that intelligent fuzzy control promotes effective maximum point, reduces operational instability relative to structural reconfiguration, and improves the overall reliability in dynamic environments. The third significant one is the Maze (Puzzle)-based approaches to reconfiguring the static without changing the electrical interconnections in PV modules, which provides the solution to the mismatch losses by re-distributing the PV modules in the array geometrical. This method divides shaded modules in varying rows and columns, minimizing present bottlenecks and lessening the PV characteristics. They have made a detailed comparison of the Maze configuration and the Total Cross-Tied (TCT) topology which is widely used across 8 prototypical shading scenarios(SW,SN,LW,LN,DU,DD,CS,CO)

The quantitative findings reveal that the Maze set up performs well in all shading conditions where TCT set up is doing poorly. With the shading of Short-Wide the output power rose by 25.28 per cent. to 5669 W (TCT) as compared to 4525 W. In the case of Long-Wide shading power increased 3354 W to 4713 W, which was increased 40.51%. With Short-Narrow shading, there was an increase in power of 4931 W to 5421 W which is 9.93 percent and with Long-Narrow shading; there was an improvement of 4752 W to 4902 W which is 4.0 percent. In Diagonal upward shading, the output increased by 3060 W to 3460 W (13%), and in Diagonal downward shading, it increased by 3060 W to 4057 W (32.58%) which is a significant increase. Centre Shading now generated 5542 W, which was an improvement of 9.65% of 5054 W, and Corner Shading 5589 W, which was an improvement of 10.80% of 5044 W. Those findings validate that the Maze configuration offers a great power advantage especially at wide and diagonal shading conditions at no extra hardware, sensors or switching elements are necessary. The method is thus a very practical and inexpensive way of enhancing performance of arrays in the field. The most important and last part of this thesis is the development of the Improved Odd Even (IOE) reconfiguration technique. The idea behind this method is that after moving the modules around physically, the electrical interconnection remain unchanged and the shade modules are dispersed more evenly across the building.