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Performance Enhancement of Solar Photovoltaic Fuzzy Logic Control of Maximum Power Point Tracking

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ABSTRACT

The growth of demand on energy together with the lack of conventional resources has made avenues for renewables an imperative and urgent necessity. The photovoltaic (PV) systems are a remarkable renewable source in recent times as they have spread widely. It is considered an effective and promising strategy to deliver electrical energy.

There are various methods used for enhancing and increasing the efficiency and the accuracy of the PV systems such as; mechanical sun trackers, concentrators, maximum power point tracking (MPPT), and thermal reflectors. The MPPT techniques that track the maximum power point (MPP) are characterized by their high precision and performance, easy implementation, usage, and maintenance. The MPPT techniques are numerous, among them the conventional methods such as Perturb and Observe (P&O) and Incremental Conductance (INC) methods. As well, there are the non-conventional methods, such as Fuzzy Logic Control (FLC), Artificial Neural Networks (ANN), and Adaptive Network-based Fuzzy Inference System (ANFIS). These techniques differ in their MPP tracking performance, computational complexity, and cost.

Due to its rapid response to the variability of the ecological conditions without being affected by PV array parameters changes, the FLC-based MPPT method, as smart control, is the preferred one for the proposed approach in this thesis to track the output voltage of the PV array and the MPP under the specified environmental conditions variations. Additional benefits of FLC include its simplicity and its flexibility.

The MATLAB/Simulink was the environment used for the mathematical modeling and the simulation presented in this thesis. Firstly, a model for the PV module is introduced by the aid of the manufacturer's specifications of two different PV modules which are; KC200GT and ASEC325G6M, to provide their electrical characteristics curves under various environmental conditions; the solar irradiance level and the ambient temperature. Then, a simulation for the PV array is presented to validate the mathematical modeling results verified with the PV modules datasheets. Moreover, a PV system with an FLC-based MPPT controller and boost DC-to-DC converter model is implemented by Simulink under varying ambient temperature and irradiance. The FLC will manage this by varying and adjusting the duty cycle ratio (D) fed to the pulse width modulator (PWM) that controls the MOSFET switching of the boost DC-to-DC converter adopted to further step-up the output voltage. The effect of the PV modules connections such as series and parallel configurations under standard test conditions (STC) on the PV system performance is also investigated by the suggested approach. The simulation results are interpreted in this thesis on the two selected PV modules, which are different in their specifications and targeted applications.

The analysis of the proposed algorithm results in the various scenarios performed shows very fast, accurate, and stable tracking response of the MPP under the effect of the parameters taken into consideration and their variations. Thus, the performance of the PV system could be enhanced.