The Design and Testing of a Maximum Power Point Controller for a Large PV Generator under Nonuniform Testing

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A Photovoltaic array (PV) has a current-voltage characteristic curve with a maximum power point (MPP) that varies with changing atmospheric conditions, i.e. solar radiation and temperature. An important consideration in the design of an efficient PV system is its ability to correctly track the MPP as the atmospheric conditions vary. The thesis presents a new method for maximum power point tracking, which combines Ripple Correlation and Incremental Conductance, in a system consisting of a photovoltaic generator, a boost converter, and their associated control. The method relies on the natural disturbance created by the switching operation of the converter, and on estimating the incremental and average conductance values of the PV generator output. It is based on a characteristic property which stipulates that the incremental and average inductances have the same absolute values at the MPP. Thus when operating at a voltage point higher than that of the MPP, the absolute incremental conductance is higher than the absolute average conductance and so the duty cycle of the converter needs to be increased. The required change in the duty cycle is obtained using a digital proportional-integral-derivative (PID) controller that aims to equalize the average and incremental inductances. A system simulation model from first concepts was developed in MATLAB taking into consideration implementation details of voltage and current measurements and the presence of a junction capacitance. The characteristics get more complicated if the array does not receive uniform irradiance, which results in multiple peaks. The non-uniform irradiance in large PV arrays is attributed to partially shaded PV modules and may significantly increase the complexity of the MPP tracking problem to track the global peak without getting stuck at a local one. The thesis introduces a novel two-stage approach for tracking the maximum power point of a large photovoltaic generator under non-uniform irradiance. In Stage 1, the method makes use of real-time irradiance measurements in certain regions of the generator’s panels to estimate the total power versus voltage (P-V) curve and to deduce an estimate of the global peak region. This is followed in Stage 2 by the single peak tracking approach to accurately locate the exact global power point. The system consists of a PV generator, with pyranometers distributed across it, a DC-DC converter feeding a battery, and a controller implementing the tracking algorithm. The system simulation model was developed in MATLAB, taking into consideration the implementation of bypass and blocked diodes together with the pyranometer irradiance inputs.