An Analysis of Maximum Power Point Tracking Efficiency of a DC-DC Converter-Based Solar Charge Controller

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In Sri Lanka, hydropower and burning fossil fuels are the primary methods of generating electricity. Burning fossil fuels threatens all living beings' lives and is also a reason for global warming. Solar photovoltaic (PV) is the most popular option among renewable energy harnessing techniques. In standalone PV systems, the charge controller is used to manage the charging and discharging of the battery. Not using a charge controller will cause a reduction in the battery's lifetime and sometimes a reason for the hazardous effects of the systems. The percentage ratio between actual and expected power from the PV array is defined as the MPPT efficiency. MPPT efficiency is defined in two subcategories: static MPPT efficiency and dynamic MPPT efficiency. This paper analyses the performance in terms of the MPPT efficiency of a typical DC-DC converter-based MPPT charge controller. An experimental setup containing essential components was constructed, and a synchronous buck converter was used as the DC-DC converter. A simple constant voltage MPPT algorithm was used as the MPPT algorithm. This analysis on MPPT was done for four irradiance profiles. A constant irradiance profile was used for observing static MPPT efficiency, and fast ramp, slow ramp, and ramp and drop irradiance profiles were emulated using the PV array emulator to observe the dynamic MPPT efficiency. The results showed that the actual output power is very close to the available power for each emulated irradiance profile. For each profile, more than 96% MPPT efficiencies were observed. Therefore, it can be concluded that using a synchronous buck converter as the power stage of the charge controller, very high static and dynamic MPPT efficiencies can be obtained with the help of a proper MPPT algorithm.

Keywords: Buck Converter, Charge Controller, MPPT Efficiency, PV Systems