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Maximum Power Point Tracking of an Off-grid Photovoltaic System Consisting of a Series Connected Supercapacitor with a Step-down Converter

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An off-grid photovoltaic (PV) system's PV array is connected with a charge controller as the first power conversion stage. The average efficiency of the power stage of charge controllers is around 90%. Supercapacitor (SC) - battery hybrid PV system is a novel PV system that utilizes some of the wasted energy of a typical system and enhances the system's efficiency up to 98%. However, the feasibility of maximum power point tracking (MPPT) for this system is yet to be validated. This paper presents a comparative study to adapt MPPT for the proposed system consisting of a series-connected SC bank with PV array and step-down DC-DC converter. The step-down converter is used as the impedance matching network. Different solar irradiance profiles were emulated to check the feasibility and efficiency of MPPT. Experimentally, it was shown that the typical MPPT could be adapted to the proposed PV system with very high MPPT efficiency.

Introduction

Renewable energy sources are essential for meeting the 21st century's energy demands. Solar photovoltaic (PV) technology is one of the most quickly increasing renewable energy-producing techniques. Despite the many benefits of solar PV technology, the maximum efficiency of commercially available solar panels could only reach around 25% (1), wasting approximately 75% of incident solar irradiation on solar panels. Therefore, finding an effective method to use the energy generated by solar panels is critical. Figure 1 shows the block diagram of a typical off-grid PV system, consisting of several essential components, including the PV array, charge controller, and battery bank. The charge controller is the most important component of an off-grid PV system because it must extract, transfer, and store maximum energy from the PV array into the battery bank to maximize system efficiency. Several types of off-grid PV systems have been introduced over the years, each having unique power management and control methodologies (2,3), despite most of them using the same hardware. Researchers worldwide are trying to increase the power stage efficiency of charge controllers while limited attention is given to finding alternative methods. The average conversion efficiency of a modern charge controller could only reach around 90% (4).