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Supercapacitor based novel approach for efficient solar energy harnessing

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Finding greener solutions through renewable energy sources to provide energy demand in 21st century is an important task due to the shortage of world energy sources. From many types of renewable energy sources, photovoltaic cell is the most popular device that can be used to harvest solar energy and produce electricity. Currently, efficiency of conventional solar panels lies between 20-25%. In addition, part of energy is lost during the power conversion process in solar power converters. Standalone photovoltaic systems used in houses and other buildings in remote areas employ solar charge controllers to charge their battery banks in order to store energy. Efficiency of these systems relies mostly on the efficiency of in built DC-DC converter of the charge controller. With the advancement of modern semiconductor technologies and electronics, maximum of 90% efficiency can be achieved by a brand new solar charge controller. Usually this value will be decreased with the years of usage. Hence, the purpose of this work is to minimize the energy wasted during charging process of the battery bank of a standalone photovoltaic system. The initial approach was to connect DC-DC converter and battery bank in series with a capacitor charging loop. When an empty capacitor is charged by delivering Q charge using an external source, it can theoretically be shown that 50% of energy will be lost in the charging loop regardless of the resistance of the loop. If a useful resistive load is attached to the capacitor charging loop in series, this wasted energy can be effectively utilized by doing a treasured work while charging the capacitor too. In this work, this basic concept was used by replacing the conventional capacitor from a supercapacitor and attaching the DC-DC converter and the battery bank as the useful resistive load. Thereby, charging both supercapacitor and battery bank has been done. Theoretical analysis of this novel method shows promising outcomes on achieving high charging efficiency. Experimental results show this technique increases the overall charging efficiency of a standalone photovoltaic system by 9% when 80% efficient DC-DC converter is used to charge the battery bank. Therefore, it can be concluded that the overall charging efficiency of a typical standalone photovoltaic system can be enhanced by adding supercapacitor in series. The energy stored in both devices could be used to drive DC or AC loads using necessary electronics.

Keywords: Charging efficiency, DC-DC converter, standalone photovoltaic system, supercapacitor