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*Article*

# Supercapacitor Assisted Hybrid PV System for Efficient Solar Energy Harnessing

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**Abstract:** In photovoltaic (PV) systems, maximum power point (MPP) is tracked by matching the load impedance to the internal impedance of the PV array by adjusting the duty cycle of the associated DC-DC converter. Scientists are trying to improve the efficiency of these converters by improving the performance of the power stage, while limited attention is given to finding alternative methods. This article describes a novel supercapacitor (SC) assisted technique to enhance the efficiency of a PV system without modifying the power stage of the charge controller. The proposed system is an SC—battery hybrid PV system where an SC bank is coupled in series with a PV array to enhance the overall system efficiency. Developed prototype of the proposed system with SC assisted loss circumvention embedded with a DC microgrid application detailed in the article showed that the average efficiency of the PV system is increased by 8%. This article further describes the theoretical and experimental investigation of the impedance matching technique for the proposed PV system, explaining how to adapt typical impedance matching for maximum power transfer.

**Keywords:** hybrid photovoltaic system; impedance matching; maximum power point tracking; solar energy; supercapacitor



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## 1. Introduction

Renewable energy sources are the key to meet the energy demands of the 21st century. Solar Photovoltaic (PV) technology is one of the most rapidly growing renewable energy generation methods used to harness the sun's energy. During the last decade, there has been a massive decrease in the energy generation costs through PV technologies compared to other energy generation methods [1]. Even though solar PV technologies have many advantages, the efficiency of conventional solar panels is still at a lower value compared to other energy harnessing methods. At present, conventional monocrystalline silicon solar panels have the highest efficiency of around 25% [2], wasting the 75% of incident solar irradiation on solar panels. Due to this reason, it is essential to find an efficient way to utilize the energy generated by solar panels.

Standalone (off-grid) PV systems are used in rural areas where the national electricity grid is not accessible. These systems mainly consist of a PV array, charge controller and battery bank, as shown in Figure 1. Over the years, several types of standalone PV systems were introduced with novel power management and controlling strategies [3–5], although most of them have the same hardware. The charge controller is the most crucial part of a standalone PV system because it must extract, deliver and store maximum energy from the PV array into the battery bank to optimize the system efficiency. Modern commercial maximum power point tracking (MPPT) charge controllers employ switch-mode DC-DC converters to extract maximum available power from the PV array while stepping up or down the PV array voltage into the required voltage. The maximum power point (MPP) of the PV array is achieved by matching the instantaneous internal impedance of the