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Single Sensor Charging System with MPPT Capability for Standalone Streetlight Applications

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Abstract

Maximum power point tracking (MPPT) and battery charging control are two important functions for a solar battery charger. The former improves utilization of the available solar energy, while the latter ensures a prolonged battery life. Nevertheless, complete implementation of both functions can be complex and costly, especially for low voltage application such as standalone street lamps. In this paper, the operation of a solar battery charger for standalone street light systems is investigated. Using only one voltage sensor, the solar charger is able to operate in both MPPT and constant voltage (CV) charging mode, hence providing high performance at a low cost. Using a lab prototype and a solar simulator, the operation of the charger system is demonstrated and its performance under varying irradiance is validated.

Key words: Battery charger, Low cost, Maximum power point tracking (MPPT), Photovoltaic (PV)

I. Introduction

Solar energy has received much attention due the fact that it is abundant, free and clean. Solar energy systems can generally be categorized into i) standalone PV systems which consist of a PV panel, battery and load; and ii) grid connected PV systems which feed additional power to the grid. Standalone PV systems are essential as they provide a power solution for remote and isolated areas which are unreachable by grid. A lot of applications involving solar energy as the sole power source have been developed to reduce the dependency on conventional energy sources. For example, street light systems consume up to 40 billion kWh of electricity annually [1]. Therefore, there is a huge potential for the use solar energy in powering these systems. By incorporating batteries and power electronics converters into solar street light systems, solar energy can be stored in the batteries during the day and used for powering the lamps during the night. Despite the attractiveness of solar street lamps, there are several major drawbacks, i.e. high installation cost and intermittency of solar irradiance. In terms of cost, solar street lights cost almost 2-4 times more than conventional systems [1]. The intermittency of solar irradiance, on the other hand, reduces the reliability of the system and has to be mitigated via oversizing the batteries and solar panels [2]. This also contributes to the high cost. Nevertheless, studies indicate that solar street lights can be a better solution in the long run in term of cost and environmental impact [1], [3], [4]. As a matter of fact, solar street lamps have been quite a successful solar product and a good selection of products is commercially available as shown in Table I.

Fig. 1 shows the typical components of a solar street light system. For a sustainable operation, the battery needs to be large enough to sustain operation over bad-sun-days, such as during rainy season. This leads to the need for increasing the size of both the solar panel and the battery. As a matter of fact, based on Table I, it has been found that the solar panels of commercial solar street lights have a rated power that is 4-7 times the lamp's power consumption, and that a high capacity battery to allow autonomous operation for up to 2-4 days.

In the past, various studies related to the technical

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