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Buck converter design for Photovoltaic generators with supercapacitor energy storage

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Abstract. In Maximum Power Point (MPP) applications for photovoltaic generators, the DC-DC tracker converter is as important as the MPP tracking algorithm. The purpose of this work is to present the design methodology of a buck converter applied in maximum power point tracking. In this paper we also compare Hill-climbing and Fractional Voc MPPT efficiency. The MPPT algorithms were implemented with an autonomous DC/DC converter. It allows to determine their real advantages and disadvantages. Finally, our system will be used to charge supercapacitors. The most significant advantage supercapacitors have over batteries is their ability to be charged and discharged continuously without degradation and their low operating temperature (-40°C).

Key words

BUCK converter, maximum power point tracking, MPPT, photovoltaic, PV, supercapacitor

1. Introduction

The environmental problem is an enormous issue of today. Utilization of renewable energy is a good potential way to solve this problem. Therefore, clean-energy resources such as solar arrays, wind generators and others have attracted wide attention in both research and industry fields. However, solar energy attracts much attention because it can be used for powering many types of appliances. A photovoltaic (PV) energy conversion system may employ a DC to DC convertor including a Maximum Power Point Tracking (MPPT) function. It allows the PV array to transfer the maximum available energy to the load. As mentioned above, this paper proposes a design methodology of an autonomous buck converter with the maximum input power at 7 watts. We finally present in this paper the DC/DC converter efficiency implemented with MPPT algorithms (Hill-climbing and Fractional Voc). The approach presented in this paper is designed for charging supercapacitors.

2. Related work and Background

Several DC/DC converters for photovoltaic generators have been proposed in literatures. In [1], the energy efficiency between buck and boost converters is compared. It is shown that an MPPT based on the Boost converter configuration results in higher efficiency, thus better utilizing of the solar cells. In [2], the DC-DC Buck, Boost, Buck-Boost, Cúk, Sepic and Zeta converters are analyzed in order to determine which one is more proper to be applied as Maximum Power Point Tracker (MPPT). However, the simulation results demonstrated that, under low radiation, Boost converter has a poor tracking behavior. A development of a microcontroller-based boost converter for photovoltaic system is presented in [3]. The converter is designed to step up solar panel voltage to a stable output without storage elements such as battery. A Buck converter used to enhance the energy conversion efficiency in PV systems is analyzed and practically evaluated in [4-6]. The Buck converters presented in literatures are used to charge batteries. Nevertheless, by removing the battery altogether and storing energy solely in the supercapacitors, there is now a viable option for achieving long-life operation of any systems. In addition, charging a supercapacitor and drawing maximum solar power are both areas of active research. However, based on the authors' knowledge, only a publication is presented in [7]. The novelty of this system lies in the pulsed frequency modulated converter and open-circuit solar voltage method for maximum power point tracking, enabling the solar cell to efficiently charge the supercapacitors and power the load. However the system is very complicated to implement. Accordingly, we present in this paper a simple Buck converter that cans efficiency charge supercapacitors. However, in order to have high efficiency DC/DC converter, developers have to select appropriate components. Therefore we present in this paper how to select appropriate component with buck converter. Different MPPT algorithms are finally also compared.