太陽光発電向けの高ゲイン電力変換器に関する研究

Form 3

Abstract

A study of high gain power converters for photovoltaic applications

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The increase in global energy demand and the impending depletion of conventional energy sources, i.e. fossil fuels, has led to increased renewable energy research. Additionally, emissions and by-products of conventional energy sources have led to increased pollution and detrimental effects on the environment. Renewable energy offers a clean, sustainable and viable alternative to fossil fuels. The most popular renewable energy types are wind energy and solar energy. In addition to being renewable, solar energy has no moving parts, is a growing popular energy source for electric vehicles, and is a viable solution for the electrification of rural and remote areas. Despite these advantages, there are some hurdles to overcome for solar energy to become a primary energy supply. In photovoltaic (PV) systems, the voltage obtained from the solar panels is far lower than the utility levels and needs significant power processing before transmission or utilization. This low voltage is also affected by a plethora of external factors such as temperature, angle of irradiation and partial shading. A DC-DC converter interface is essential for the extraction of power from solar panels.

The main function of the converter is to boost the panel's output voltage to meaningful levels. There are several topologies to achieve high converter gain. Some popular choices for high gain conversion are isolated or transformer-based converters, multi-level converters, cascaded converters and hybrid converters which employ one or more of these strategies. But some of the problems faced by these topologies are operation at high duty ratio to deliver the high gain, complicated design with many active elements which requires complex control circuitry, usage of several magnetic elements which increase the cost and weight of the converter and discontinuity of the input current which affects the overall performance of the solar panel. The objective is to design a suitable DC-DC converter topology that delivers high gain, at a moderate duty ratio which is simple to design.

This dissertation seeks to investigate the issues mentioned and to develop a viable topology that delivers high gain while minimizing the drawbacks of existing topologies. An in-depth study of the existing literature has led to the development of two unique hybrid topologies. The first topology uses a hybrid switched-capacitor network to achieve high gain and the second topology uses a voltage multiplier network to do the same. Also, an in-depth mathematical analysis of the operation of the proposed converters is presented. The proposed converters are simulated in PSIM and the obtained results prove the validity of the operation. Suitable hardware prototypes are built and tested and the results are presented to show the validity of the research. The proposed converters are compared against converters presented in the literature to show their effectiveness as a viable alternative to the existing topologies.

Finally, the future scope of this research work has also been detailed.

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