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Analysis, Synthesis and Simulation of Compact Two-channel Boost Converter for Portable Equipments Operating with a Battery or Solar Cell

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Abstract

This paper is intended to help engineers and designers of high power industrial application such as engineers of power systems as well as control engineers and designers of very low power industrial applications such as designers of computer motherboards and other microcomputer circuits supplied from alternative energy sources or battery via boost converters.

Alternative energy source systems such as solar-cells or photovoltaic systems (PV) are progressively becoming more popular. In these applications, it is often required to convert the generated low DC voltage to a higher variable voltage prior to converting it into an AC to be compatible with the electric grid and common appliances. Usually a boost converter is used to step up the d.c. voltage generated at the outputs of such systems [1]. The basic configuration of boost converters usually used for this purpose suffers from some drawbacks just like high ripple in their output

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currents and voltages which increases the losses of the system and makes their control complicated and their response to the variation in the input voltage and load parameters unstable.

To eliminate these drawbacks, this paper introduces a two-channel boost regulator with uncoupled smoothing reactors. Detailed analysis, design, control strategy and simulation have been proposed in this paper to investigate the advantages of using the two-channel connection with uncoupled smoothing reactors.

It has been proved throughout this paper that two-channel configuration of boost converter helps increasing the output power of the converter, filtering out the harmonic content from its output and input, making their control easier and more efficient, increasing the operating frequency of the converter and thus decreasing the size of the components and filters used in the circuit.

Moreover, the paper deals with voltage control strategy that usually used for such systems thus to regulate the boost converter to obtain a robust output current and voltage. Simulation results show that voltage mode control technique provides good current and voltage regulation of boost converters and is more feasible for the chopper up conversion technique of these converters.

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Keywords: Boost converter, uncoupled smoothing reactors, Two-channel and fundamental configuration, voltage mode control.

1. Introduction

The rapidly expanding application and demand for alternative energy resources has increased for last several years. With the development of different efficient technologies associated with the benefits of energy use, the demand for power electronic converters and switching regulators which nearly all of commercial and consumer energy products require has also dramatically increased [2].

One of the most common methods used to increase their efficiency and output power is to use two-channel series or parallel connection of these modules. However, due to the shading that may cover the area, the voltage of these modules falls down and the power is then insufficient. Furthermore, the size of solar cells, the area required for their implementation and the economical cost of such modules, all these parameters increase with the two-channel connection of these cells.

To overcome the drawbacks of PV systems, power electronic converters known as boost converters are often employed. Using DC-DC boost converter with smoothing inductors helps to store energy for longer periods of time and thus to increase the efficiency of the overall system as well as to remove the bad effect of the absence of sunlight and increases the area of usage of solar energy systems with a wide variety of load types [2].

However, the periodic switching of such systems generates harmonic contents in the input and output currents and voltages which increases the losses and makes their control more sophisticated and complex.

In this paper a boost converter with several channels connected in parallel is discussed. This solution may completely remove the ripple generated at the output, increases the power from the converter, improves efficiency and the overall dynamic behaviour as well as increasing the switching frequency and consequently lower the size of reactors. The outputs of the two-channel boost converter are combined through uncoupled smoothing reactors [3].

The equal division of the currents into the individual channels is achieved using voltage mode control which is developed in such a way just to yield a dynamic accuracy in the model and robustness in the load. Control algorithms of such converter are mainly used to determine the duty ratio and triggering PWM signals required to operate the converter switches adequately in its both regimes, uninterrupted and interrupted regimes.