Design Of Efficient Converter For Wind Energy Conversion

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ABSTRACT

An enhanced Droop controlled CUK-SEPIC combined DC-DC converter for wind power system is proposed in this project, based on the combination of the Cuk and SEPIC converters, which is well-suited for solar photovoltaic (PV) applications. The converter uses only one switch (which is ground-referenced, so simple gate drive circuitry may be used), yet provides dual outputs in the form of a bipolar DC bus. The bipolar output from the DC-DC converter is able to send power to the grid via any inverter with a unipolar or bipolar DC input, and leakage currents can be eliminated if the latter type is used without using lossy DC capacitors in the load current loop. The proposed converter uses integrated magnetics cores to couple the input and output inductors, which significantly reduces the input current ripple and hence droop control greatly improves the power extracted from the solar PV system. The design methodology along with simulation, experimental waveforms, and efficiency measurements of a DC-DC converter are presented to prove the concept of the proposed converter

INTRODUCTION

Power electronics started with the development of the mercury arc rectifier. Invented by Peter Cooper Hewitt in 1902, it was used to convert alternating current (AC) into direct current (DC). From the 1920s on, research continued on applying thyratrons and grid-controlled mercury arc valves to power transmission. Uno Lamm developed a valve with grading electrodes making mercury valves usable for high voltage direct current transmission. In 1933 selenium rectifiers were invented.

In 1947 the bipolar point-contact transistor was invented by Walter H. Brattain and John Bardeen under the direction of William Shockley at Bell Labs. In 1948 Shockley's invention of the bipolar junction transistor improved the stability and performance of transistors, and reduced costs. By the 1950s, semiconductor power diodes became available and started replacing vacuum tubes. In 1956 the Silicon Controlled Rectifier (SCR) was introduced by General Electric, greatly increasing the range of power electronics applications.

In the 1960s the switching speed of bipolar junction transistors allowed for high frequency DC/DC converters. In 1976 power MOSFET became commercially available. In 1982 the Insulated Gate Bipolar Transistor (IGBT) was introduced.

DC-DC converters are widely used to efficiently produce a regulated voltage from a source that may or may not be well controlled to a load that may or may not be constant. This paper briefly introduces DC-DC converters, notes common examples, and discusses important datasheet parameters and applications of DC-DC converters.

DC-DC converters are high-frequency power conversion circuits that use high-frequency switching and inductors, transformers, and capacitors to smooth out switching noise into regulated DC voltages. Closed feedback loops maintain constant voltage output even when changing input voltages and output currents. At 90% efficiency, they are generally much more efficient and smaller than linear regulators. Their disadvantages are noise and complexity.

Significance of DC to DC conversion

But why DC to DC converters are needed? What is the need to convert DC voltage to DC voltage? It can be explained as follows for example consider electronic switch mode converters used in cell phones and laptop computers. These devices are powered using rechargeable batteries. This battery has to power all the components in the cellular phone or laptop such as display, USB devices e.t.c. Each of these components may be operating at different voltages and current levels. DC to DC converters step up or step down DC voltage level so that it will be suited to the requirement of interest.

Also as the stored power drains with time, the battery voltage declines. By providing feedback from the output stage, DC to DC converters can be made to compensate this lowered battery voltage.

Important performance characteristics

DC-DC converter datasheets have key parameters that describe their important characteristics. The following are some important characteristics to consider in designs.

RELATED WORK

David Meneses et al presented a comprehensive review of step-up single-phase non-isolated inverters suitable for ac-module applications.

M. Forouzeshproposes et al power converter topologies that use the above voltage-boosting techniques, as well as some active and passive components, are continuously being proposed.

Mojtaba Forouzesh introduces et al a non-isolated high step-up dc-dc converter with dual coupled inductors suitable for distributed generation applications.

Samuel Vasconcelos Araujo et al follows this direction and propose a single-phase transformerless inverter circuit being composed of the association of two step-down converters.

Jia-Min Shen et al proposed grid-connected power converter to avoid the transparent conducting oxide corrosion that occurs in some types of thin-film solar cell array.

YanfengShen et al proposed a new series resonant dc-dc converter for PV microinverter applications. Compared with the conventional series resonant converter, a dual-mode rectifier is configured on the secondary side, which enables a twofold voltage gain range for the proposed converter with a fixed-frequency phase-shift modulation scheme.

Yushan Liu et al proposed a Front-End Isolated Quasi-Z-Source DC–DC Converter Modules in Series for High-Power Photovoltaic Systems.

Jaime W. Zapata et al presented analysis of Partial Power DC–DC Converters for Two-Stage Photovoltaic Systems.

Hanyun Shen et al presented a new family of hybrid Z-source boost dc-dc converters intended for photovoltaic applications, where the high step-up dc-dc converters are demanded to boost the low-source voltages to a predefined grid voltage.

Andrii Chub et al proposed a dc voltage blocking capacitor in series with the isolation transformer results in resonance that could be utilized for soft-switching.

Yushan Liu et al proposed the continuation of Part I in which a quasi-Z-source modular cascaded converter (qZS-MCC), comprising front-end isolated qZS half-bridge dc-dc converter submodules (SMs), for dc integration of high-power photovoltaic (PV) systems is proposed.

Moumita Das et al proposed a novel high voltage gain, high-efficiency dc-dc converter based on coupled inductor, intermediate capacitor, and leakage energy recovery scheme.

YuanweiGu et al introduced an active switched capacitor (ASC) network, where only one capacitor and one diode are added, while the voltage gain is efficiently increased by a compound of ASL and ASC networks.

Rachid Errouissi et al presented a design and practically implement a robust continuous-time model predictive control (CTMPC) for a dc-dc boost converter, feeding a three-phase inverter of a grid-connected PV system to regulate the PV output voltage.

Namwon Kim et al presented system architecture and control scheme of a photovoltaic (PV) string inverter allowing seamless battery integration with the dc-series integration method.

Faezeh Kardan et al proposed a new three-port dc/dc converter is presented for hybrid photovoltaic (PV)/fuel cell (FC)/battery applications.

EXISTING SYSTEM

In this paper, based on the combination of the Cuk and SEPIC converters, which is well-suited for solar photovoltaic (PV) applications. The converter uses only one switch (which is ground-referenced, so simple gate drive circuitry may be used), yet provides dual outputs in the form of a bipolar DC bus. The bipolar output from the DC-DC converter is able to send power to the grid via any inverter with a unipolar or bipolar DC input, and leakage currents can be eliminated if the latter type is used without using lossy DC capacitors in the load current loop. The proposed converter uses integrated magnetics cores to couple the input and output inductors, which significantly reduces the input currentripple and hence greatly improves the power extracted from the solar PV system.

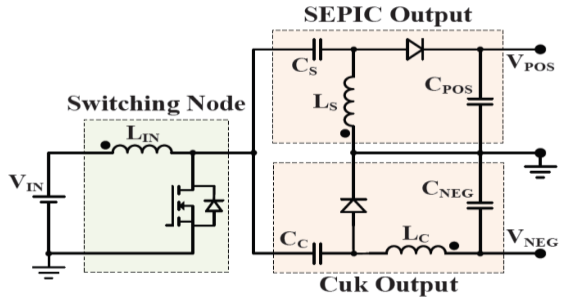

Fig1 Combined Cuk-SEPIC (CCS) converter

The Combined Cuk-SEPIC (CCS) converter, shown in Fig, is an emerging DC-DC converter topology that is well-suited for this application and has hence been investigated recently. It uses a single switching node, whichis common to both Cuk and SEPIC energy transfer stages, to provide matching ground-referenced positive and negative outputs. During the switch 'on' state, all inductors are charging and the capacitors are discharging. When the switch turns off, the inductor currents redirect into the two diodes and the capacitors charge while the inductors discharge. In continuous conduction mode (CCM) operation considered, the switch turns on again prior to the complete discharge of any inductor.

The CCS converter can provide large step-up, as well asstep-down voltage conversion ratios. The converter has an output/input ratio of D=(1 □ D) for each of the positive and negative DC output terminals, providing step-up conversion for duty ratios greater than 1/2, and operating in step-down mode for duty ratios below 1/2. The converter's overall gain(i.e. considering the output voltage as the positive-to-negative voltage) is 2D=(1 □ D). This distinct output/input voltage ratio allows regulation of larger input voltage variations with the same duty cycle range, or alternatively allows the converter to handle the same input voltage variation with a narrower duty cycle range, allowing for smaller inductors to be used.

Inductor Magnetic Coupling

The benefits of inductor coupling in Cuk converters and SEPIC converters has been described in the literature. Despite recent interest in the CCS converter however, research is yet to be conducted into the effects of coupling its input and output inductors and the benefits this has for PV systems. This paper examines the impact of coupling between LIN, LS, and LC. This converter is henceforth referred to as the Coupled Inductors Combined Cuk-SEPIC (CI-CCS) converter. A multi-variable optimization has been conducted to determine the optimum coupling levels, which also includes simulation and experimental results. The results demonstrate that this coupling can significantly reduce the input current ripple, which allows the overall inductance – and hence volume and weight – to be reduced.

PROPOSED SYSTEM

An enhanced Droop controlled DC-DC converter is proposed in this project, based on the combination of the Cuk and SEPIC converters, which is well-suited for solar photovoltaic (PV) applications. The converter uses only one switch (which is ground-referenced, so simple gate drive circuitry may be used), yet provides dual
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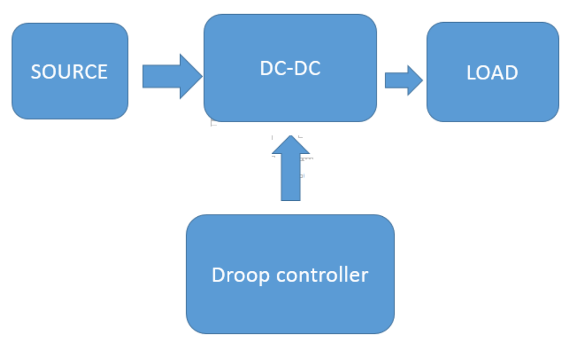

Fig2 Proposed system

One of most popular control technique for proper sharing is droop control method. This project mainly focus on the voltage control and power sharing of the converters using droop index and also maximum power point tracking for better performance. The droop control method is a decentralized control technique in which each converter is controlled based on the output current. This project explains the importance of cable resistance in load sharing. In existing methods the droop used for voltage control is fixed which a major drawback. An instantaneous droop is calculated to overcome this drawback which can improve the voltage control to larger extend.

The droop control method is local control technique that relies on externally or internally added resistance of the parallel connected modules for maintaining relatively equal current sharing. Generally, the droop method is easy to implement, and it does not require any communication system. However, fixed droop method also achieves the equivalent current sharing accuracy but major drawback is its poor voltage regulation whereas in case of instantaneously produced droop, it can adaptively controls the reference voltage of each module. This will improve the voltage regulation and the current sharing of the traditional method.

The frequency of a synchronous generator is given by

$$F = PN / 120$$

where

- F, frequency (in Hz),
- P, number of poles,
- N, speed of generator (in RPM)

The frequency (F) of a synchronous generator is directly proportional to its speed (N). When multiple synchronous generators are connected in parallel to electrical grid, the frequency is fixed by the grid, since individual power output of each generator will be small compared to the load on a large grid. Synchronous generators connected to the grid run at various speeds but they all run at the same frequency because they differ in the number of poles (P).

A speed reference as percentage of actual speed is set in this mode. As the generator is loaded from no load to full load, the actual speed of the prime mover tends to decrease. In order to increase the power output in this mode, the prime mover speed reference is increased. Because the actual prime mover speed is fixed by the grid, this difference in speed reference and actual speed of the prime mover is used to increase the flow of working fluid (fuel, steam, etc.) to the prime mover, and hence power output is increased. The reverse will be true for decreasing power output. The prime mover speed reference is always greater than actual speed of the prime mover. The actual speed of the prime mover is allowed to "droop" or decrease with respect to the reference, and so the name.

RESULT

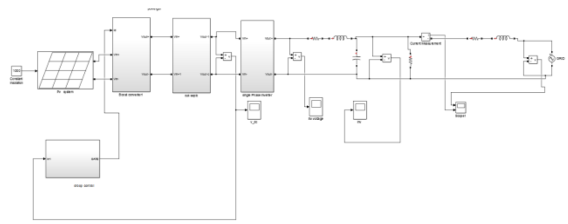

Fig3 overall Simulink

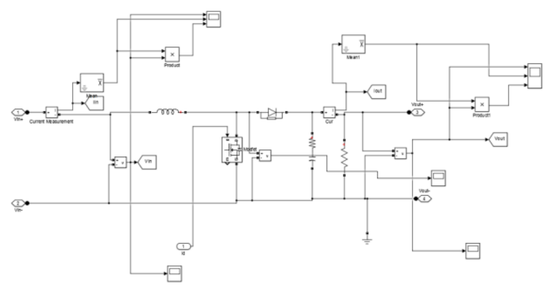

Fig4 converter section

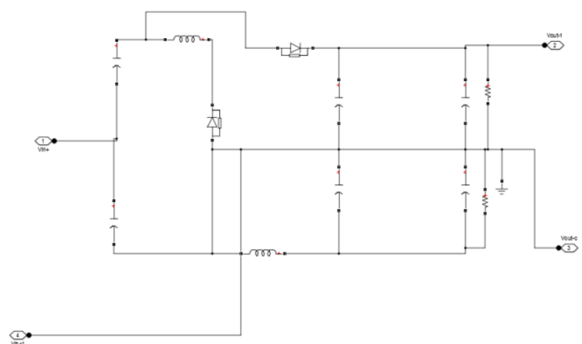

Fig5 combined CUK-SEPIC section

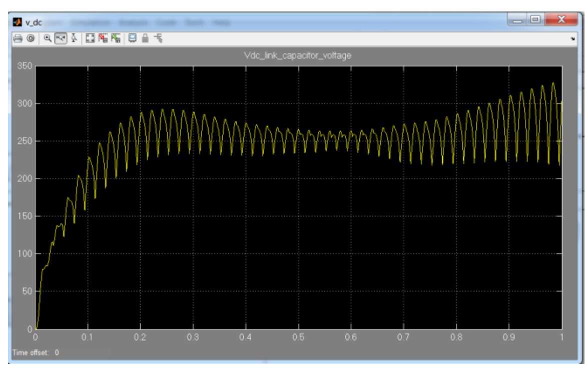

Fig6 boosted voltage

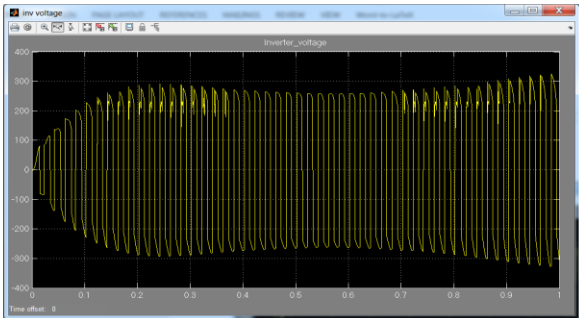

Fig7 output voltage

CONCLUSION

Combining the input stages of the Cuk and SEPIC converters allows a bipolar DC output to be generated from a unipolar input, using only a single switch. This emerging converter topology shows many advantages for PV applications as its bipolar output structure allows the both the PV system and grid to be grounded without an isolation transformer. In this project, the benefits that can be derived by magnetically coupling the converter's input and output inductors are investigated. Results have been obtained, in MATLAB simulations which show that input current ripple reductions of 80-93% are possible, in addition to demonstrating the converter's step-up and step-down capabilities. The current controller's performance demonstrates its ability to track rapid changes in the MPPT current reference.

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