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Implementation of Interleaved Boost Converter for PV Power Generation System

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Abstract

Solar energy is a non-conventional type of energy. Solar energy has been harnessed by humans since ancient times using a variety of technologies. Only a small fraction of the available solar energy is used in practice. Solar powered electrical generation relies on photovoltaic system and heat engines. Solar energy uses are limited only by human creativity. To harvest the solar energy, the most common way is to use photovoltaic panels which will receive photon energy from sun and convert to electrical energy.

The efficiency of PV module is very low and power output depends on solar insulation level and ambient temperature, so maximization of power output with greater efficiency is of special interest. In this paper, an interleaved soft switching boost converter (ISSBC) for a photovoltaic (PV) power-generation system is proposed. The topology used raises the efficiency for the dc/dc converter of the PV power conditioning system (PVPCS), and it minimizes switching losses by adopting a resonant soft-switching method.

This project proposes a novel soft-switching interleaved boost converter composed of two shunted elementary boost conversion units and an auxiliary inductor. The proposed controller scheme utilizes PWM techniques to regulate the output power of interleaved boost converter at its maximum possible value and simultaneously controls the charging process of battery. This converter is able to turn on both the active power switches at zero voltage to reduce their switching losses and evidently raise the conversion efficiency. Since the two parallel-operated elementary boost units are identical, operation analysis and design for the converter module becomes quite simple. The resulting system has high-efficiency, lower-cost, very fast tracking speed. The circuit will be simulated using MATLAB Simulink.

Keywords: *Boost converter, interleaved, maximum power point Tracking (MPPT), photovoltaic (PV) power-generation systems, resonant converter, and soft-switching.*

I.INTRODUCTION

RECENTLY, photovoltaic (PV) energy has attracted interest as a next generation energy source capable of solving the problems of global warming and energy exhaustion caused by increasing energy consumption. PV energy avoids unnecessary fuel expenses and there is no air pollution or waste. Also, there are no mechanical vibrations or noises because the components of power generation based on PV energy use semiconductors. The life cycle of the solar cell is more than 20 years, and it can minimize maintenance and management expenses. The output power of the solar cell is easily changed by the surrounding conditions such as irradiation and temperature, and also its efficiency is low. Thus high efficiency is required for the power conditioning system (PCS), which transmits power from the PV array to the load. In general, a single-phase PV PCS consists of two conversion stages (i.e., dc/dc conversion stage and dc/ac conversion stage). The dc/dc converter is the first stage and it performs maximum power-point tracking (MPPT) and Guarantees the dc-link voltage under low irradiance conditions.

This paper proposes a high efficiency dc/dc boost converter to increase the overall efficiency of PV power conditioning system (PVPCS).We studied a 2-phase interleaved boost converter integrated with a single-switch type soft-switching boost converter. The proposed single-switch type soft-switching boost converter can minimize switching loss by adopting a resonant soft-switching method. And, no additional switches are needed for soft switching. However, the drawback of this converter is that the voltage across the switch is very high during the resonance mode. The voltage across the switch depends on the parameters of the resonant components (i.e., resonant inductance and resonant capacitance) and the resonant inductor current. In this paper, the optimal design of the resonant components and the interleaved method is applied for resonant current reduction. Since the interleaved method distributes the input current according to each phase, it can decrease the current rating of the switching device. Also, it can reduce the input current ripple, output voltage ripple, and size of the passive components .The proposed soft-switching interleaved boost converter can not only exploit the interleaved converter but also reduce switching losses through the soft-switching technique. Therefore, the output power of the PV array can be boosted with high efficiency. This paper presents the operational principle of the converter, a theoretical analysis and design guidelines. A1.2-kW prototype of the converter has been built, and simulation and experimental results are provided to verify the theoretical analysis.

II.CONVENTIONAL BOOST CONVERTER

A. Circuit operation

The figure 1 below shows a step up or PWM boost converter. It consists of a dc input voltage source Vg; boost inductor L controlled switch S, diode D, filter capacitor C, and the load resistance R. When the switch S is in the on state, the current in the boost inductor increases linearly and the diode D is off at that time. When the switch S is turned off, the energy stored in the inductor is released through the diode to the output RC circuit.

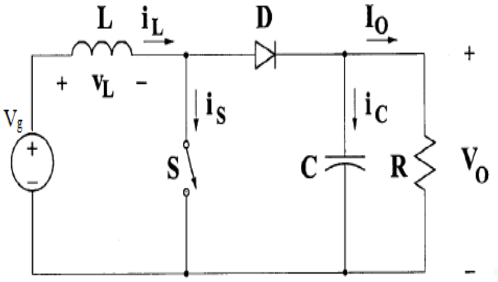

Figure 1. Circuit diagram of boost converter

Steady state analysis of the Boost converter

(a) OFF STATE:

In the OFF state, the circuit becomes as shown in the Figure 2. below

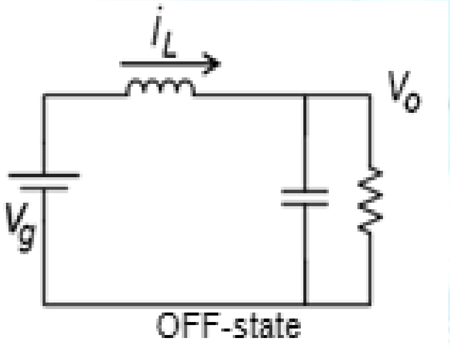

Figure 2. The OFF state diagram of the boost converter

When the switch is off, the sum total of inductor voltage and input voltage appear as the load voltage.
(b) ON STATE:

In the ON state, the circuit diagram is as shown below in Figure 3:

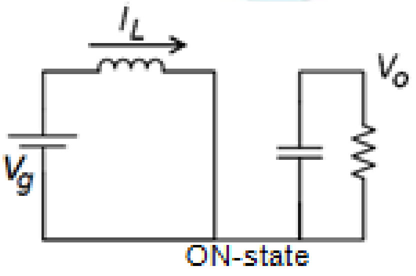

Figure 3. The ON state diagram of the boost converter

When the switch is ON, the inductor is charged from the input voltage source Vg and the capacitor discharges across the load. The duty cycle, D=Ton/T, where T=1/f

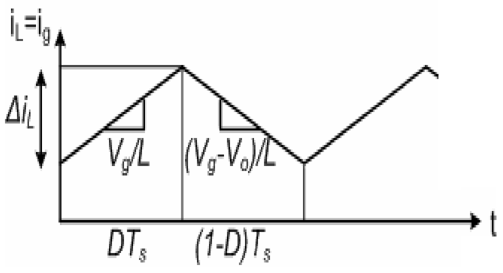

Figure 4.Inductor current waveform

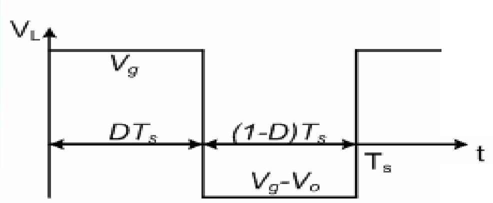

Figure 5.Inductor voltage waveform

The current supplied to the output RC circuit is discontinuous. Thus a large filter capacitor is used to limit the output voltage ripple. The filter capacitor must provide the output dc current to the load when the diode D is off.

Boost converters are popularly employed in equipments for different applications. For high-power-factor requirements, boost converters are the most popular candidates, especially for applications with dc bus voltage much higher than line input. Boost converters are usually applied as pre regulators or even integrated with the latter-stage circuits or rectifiers into single-stage circuits. Most renewable power sources, such as photovoltaic power systems and fuel cells, have quite low-voltage output and require series connection or a voltage booster to provide enough voltage output. Several soft-switching techniques, gaining the features of zero-voltage switching (ZVS) or zero-current switching (ZCS) for dc/dc converters, have been proposed to substantially reduce switching losses, and hence, attain high efficiency at increased frequencies.

There are many resonant or quasi-resonant converters with the advantages of ZVS or ZCS presented earlier. The main problem with these kinds of converters is that the voltage stresses on the power switches are too high in the resonant converters, especially for the high-input dc-voltage applications. Passive snubbers achieve the ZVS, which are attractive, since no extra active switches are needed.

III.PROPOSED INTERLEAVED BOOST CONVERTER

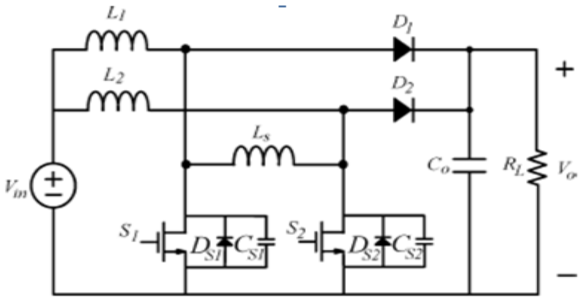

Figure 6.Interleaved boost converter

Interleaved boost converters are applied as power-factor-correction front ends. An interleaved converter with a coupled winding is proposed to provide a lossless clamp. Additional active switches are also appended to provide soft-switching characteristics. These converters are able to provide higher output power and lower output ripple. This paper proposes a soft-switching interleaved boost converter composed of two shunted elementary boost conversion units and an auxiliary inductor. This converter is able to turn on both the active power switches at zero voltage to reduce their switching losses and evidently raise the conversion efficiency. Since the two parallel-operated boost units are identical, operation analysis and design for the converter module becomes quite simple.

Therefore feature a simpler control scheme and lower cost. However, the circuit topology is complicated and not easy to analyze. Auxiliary active snubbers are also developed to reduce switching losses. These snubbers have additional circuits to gate the auxiliary switch and synchronize with the main switch. Besides, they have an important role in restraining the switching loss in the auxiliary switch. Converters with interleaved operation are fascinating techniques now-a-days.

A. Circuit configuration

Fig.6 (a) shows the proposed soft-switching converter module. Inductor L1, MOSFET active switch S1 and diode D1 comprise one step-up conversion unit, while the components with subscript “2” form the other Dsx.and Csx are the intrinsic anti parallel diode and output capacitance of MOSFET Sx respectively. The voltage source Vin, via the two paralleled converters, replenishes output capacitor Co and the load. Inductor Ls Is shunted with the two active MOSFET switches to release the electric charge stored within the output capacitor Csx Prior to the turn-ON of Sx to fulfill zero-voltage turn- ON (ZVS), and therefore, raises the converter efficiency.

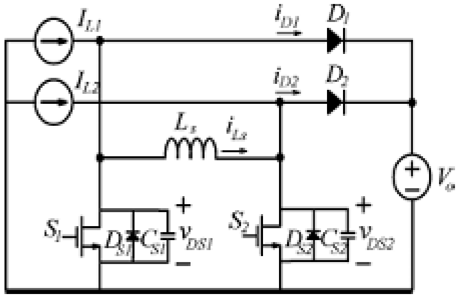

Figure 6. (a). Simplified Circuit diagram

IV.SIMULATION RESULTS

A. Conventional Boost Converter Simulation

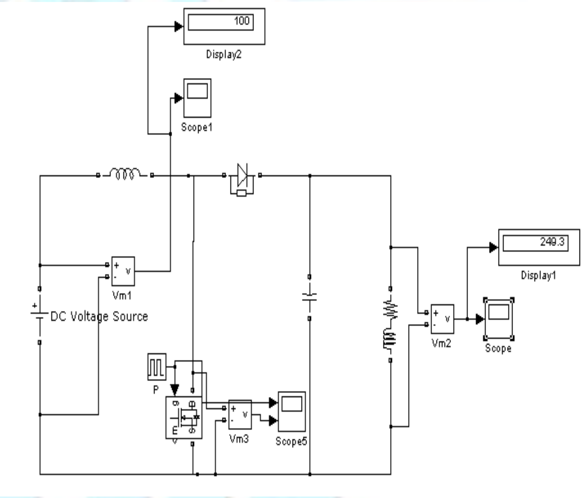

Figure 7.Simulation circuit for boost converter

B. Output voltage of conventional boost converter

The output voltage of boost converter is 249.3V for a given sinusoidal input voltage of 100V. The figure 8. Clearly shows that the peak overshoot is more for boost converter and the settling time is 0.1 seconds. The output is observed as stable after a peak overshoot and a long oscillatory response.

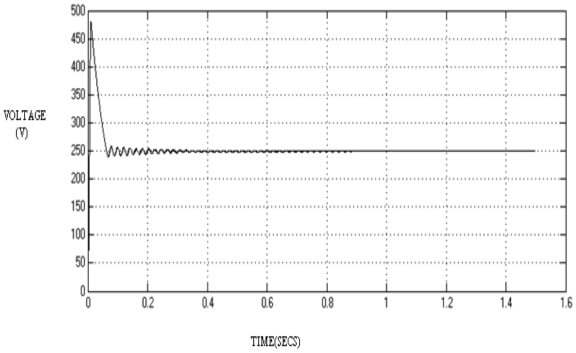

Figure 8.Output voltage of conventional boost converter

C.Proposed Interleaved Boost converter Simulation

Figure 9. Shows the simulation circuit of soft-switching interleaved boost converter composed of two shunted elementary boost conversion units and an auxiliary inductor .This converter is able to turn on both the active power switches at zero voltage to reduce their switching losses and evidently raise the conversion efficiency.

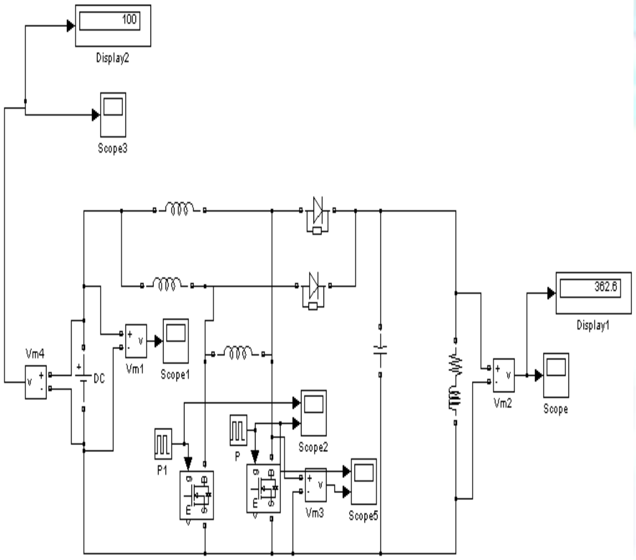

Figure 9.Simulation circuit for interleaved boost converter

D. Output voltage of interleaved boost converter

The output voltage of interleaved boost converter is 362.6V for a given sinusoidal input voltage of 100V.The figure 10. Clearly shows that the peak overshoot is less for interleaved boost converter and the settling time is 0.06 seconds.

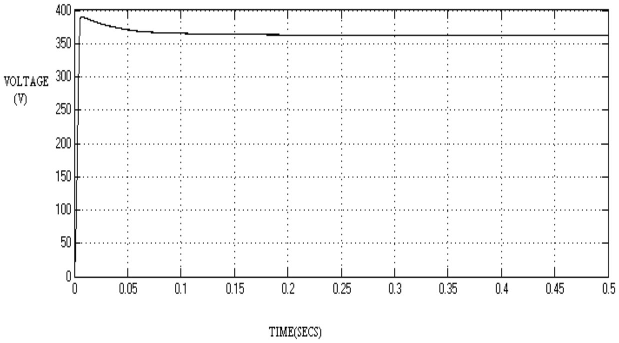

Figure 10.Output voltage of interleaved boost converter

E.Open loop simulation circuit of Capacitor start-run Induction Motor

Figure 11.Shows the open loop simulation circuit of single phase capacitor start run induction motor

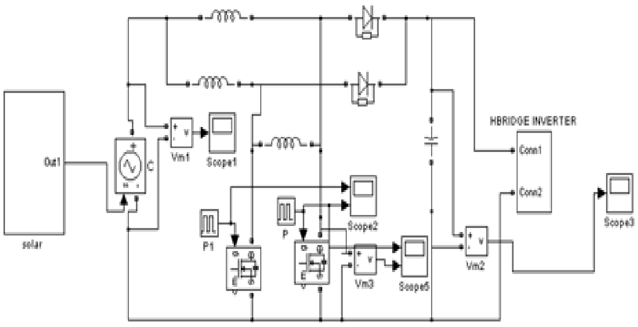

Figure 11.Open loop simulation circuit of single phase capacitor start run Induction motor

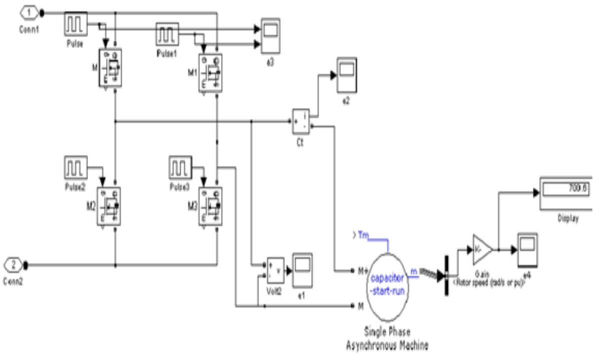

Figure 12.Internal circuit of H-Bridge inverter

Open loop response of Capacitor start-run Induction Motor at 700 rpm without load disturbance

Figure 13. shows the open loop response of a capacitor start –run induction motor at 700 rpm without any load disturbance. The figure clearly shows that the peak overshoot is very less and settling time is 0.15 seconds.

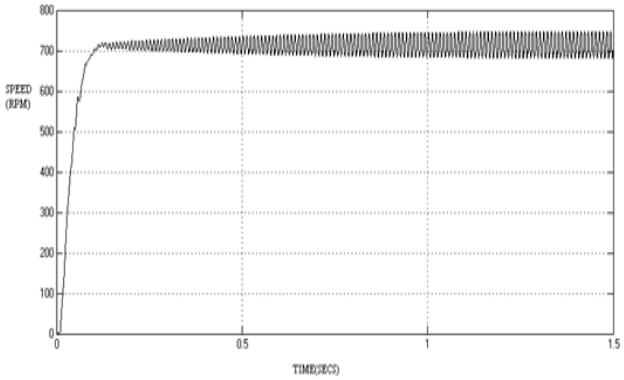

Figure 13.Open loop response of a capacitor start-run induction n
at 700 rpm without load disturbance

Open loop response of Capacitor start-run Induction Motor at 700 rpm with load disturbance

Figure 14. Shows the open loop response of a capacitor start –run induction motor at 700 rpm with load disturbance. The figure clearly shows that the peak overshoot is very less and settling time is 0.3 seconds.

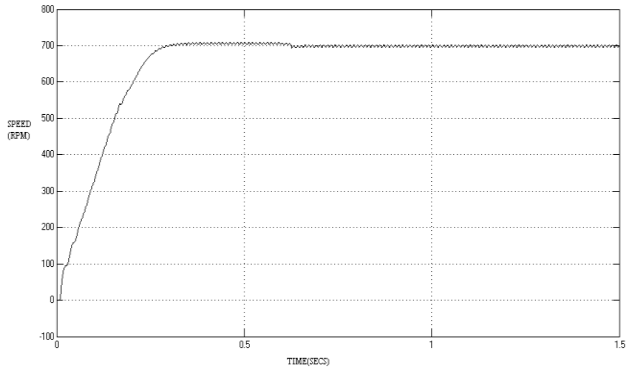

Figure 14.Open loop response of Capacitor start-run Induction Motor at 700 rpm with load disturbance

F. Closed loop response of a Single phase Capacitor start-run Induction motor

Figure 15.hows the closed loop simulation circuit of a single phase Capacitor start-run Induction Motor

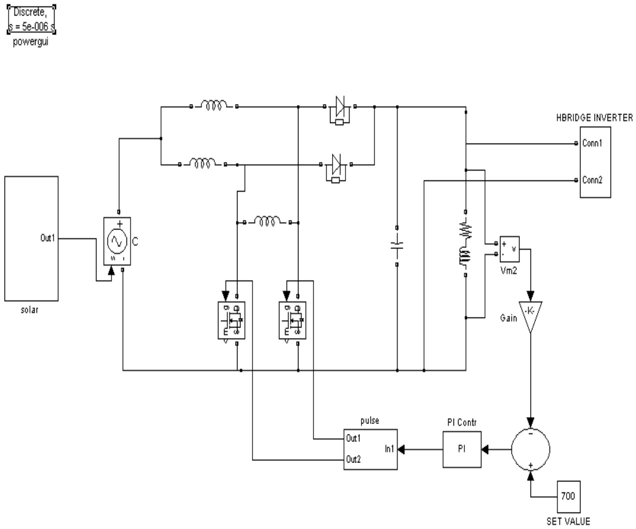

Figure 15.Closed loop simulation circuit of a single phase Capacitor start-run Induction motor

Closed loop response of Capacitor start-run Induction Motor at 700 rpm without load disturbance

Figure 16. shows the open loop response of a capacitor start –run induction motor at 700 rpm without load disturbance. The figure clearly shows that the peak overshoot is very less and settling time is 0.2 seconds

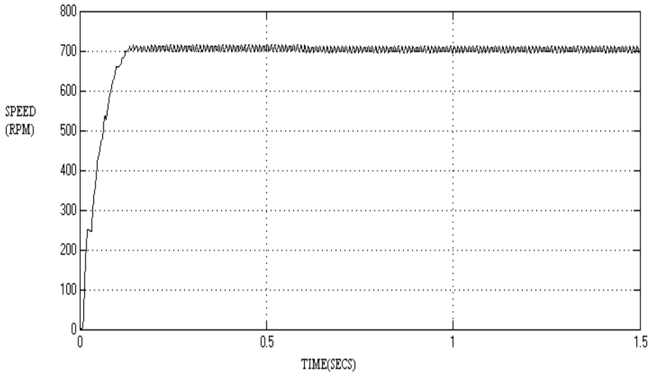

Figure 16.Closed loop response of Capacitor start-run Induction Motor at 700 rpm without load disturbance

Closed loop response of Capacitor start-run Induction Motor at 700 rpm with load disturbance

Figure 17.Shows the open loop response of a capacitor start –run induction motor at 700 rpm with load disturbance. The figure clearly shows that the peak overshoot is very less and settling time is 0.22 seconds.

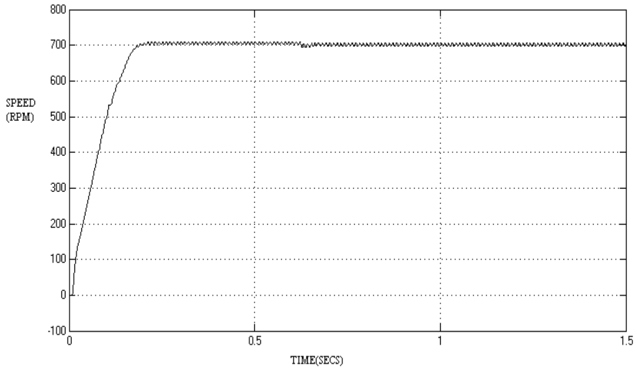

Figure 17.Closed loop response of Capacitor start-run Induction Motor at 700 rpm with load disturbance

V.COMPARISON OF OUTPUT RESULTS OBTAINED FROM INTERLEAVED AND CONVENTIONAL BOOST CONVERTER

The table 1. Output results obtained from interleaved boost converter and conventional boost converter

INTERLEAVED BOOST CONVERTER			BOOST CONVERTER		
INPUT VOLTAGE (VOLTS)	OUTPUT VOLTAGE (VOLTS)	OUTPUT POWER (WATTS)	INPUT VOLTAGE (VOLTS)	OUTPUT VOLTAGE (VOLTS)	OUTPUT POWER (WATTS)
100	362.8	145.12	100	249.3	99.72
110	398.9	239.34	110	299.4	179.64
130	471.5	377.2	130	324.4	259.52

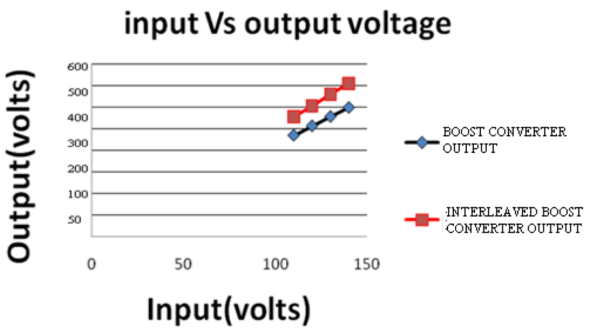

Figure 18.Shows the graphical representation of the results obtained from the conventional boost converter and interleaved boost converter

VI.CONCLUSION

Thus a novel soft-switching interleaved boost converter composed of two shunted elementary boost conversion units and an auxiliary inductor is proposed .This converter is able to turn on both the active power switches at zero voltage to reduce their switching losses and evidently raise the conversion efficiency. Since the two parallel-operated elementary boost units are identical, operation analysis and design for the converter module becomes quite simple. The resulting system has high-efficiency, lower-cost, low ripple current and reduced switching losses.

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