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An Interleaved Buck-Boost Converter For High Efficient Power Conversion

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Abstract

In many applications, an efficient DC - DC converters are required as an interface between the available low voltage sources and the output loads, which are operated at much higher voltages. It is a major challenge to operate the conventional boost converters at high efficiency because it requires an extreme duty ratio to meet the high-voltage step-up requirements. Under such conditions, problems like high ON-state resistance, diode reverse recovery problem, increased conduction losses, degrade of efficiency, and voltage stresses will occur. In high current or high power applications, interleaving of buck and boost converters are well established.

Moreover, the active clamp circuit can successfully reduce the voltage stress of the switches and it collects the leakage energies from all the coupled-inductor boost converters and recycles the leakage energies to the output. In the viewpoint of improved performance and better choice of design, it can be proposed to interleave the coupled-inductor buck boost converter with common active clamp circuit to process high power, and to achieve high efficiency and high reliability. The proposed converter avoids the disadvantage of series conduction loss of the total power. Detailed analysis and design of the proposed converter are carried out. MATLAB software was used for simulation and verification of the proposed circuit. Simulation results of the proposed converter are presented.

Key Words: *Buck-Boost converter, interleaved, low switching loss, Active clamp circuit.*

1. Introduction

For the control of electric power or power conditioning the conversion of electric power from one form to another is necessary and the switching characteristics of the power devices permit these conversions. The static power converters perform these functions of power conversions. In applications where non isolation, step-down conversion In applications where non isolation, step-down conversion ratio, and high output current with low ripple are required, an interleaved buck-boost converter has received a lot of attention due to its simple structure and low control complexity the cost becomes high and the efficiency becomes poor as the converter operates under hard switching condition. This results in the high cost and the efficiency becomes poor. And, for higher power density and better dynamics, it is required that the converter operates at higher switching frequencies. To over come the drawbacks of conventional Interleaved buck converter[1] an interleaved buck-boost converter with active clamp circuit is introduced. It is a major challenge to operate the conventional boost converters at high efficiency because it requires an extreme duty ratio to meet the high-voltage step-up requirements. Under such conditions, problems like high ON-state resistance, diode reverse recovery problem, increased conduction losses, degrade of efficiency, and voltage stresses will occur. In high current or high power applications, interleaving of buck[4] and boost converters are well established. the active clamp circuit can successfully reduce the voltage stress of the switches and it collects the leakage energies from all the coupled-inductor boost converters and recycles the leakage energies to the output. In the viewpoint of improved performance and better choice of design, it can be proposed to interleave the coupled-inductor buck boost converter with common active clamp circuit[12] to process high power, and to achieve high efficiency and high reliability. The proposed converter avoids the disadvantage of series conduction loss of the total power.

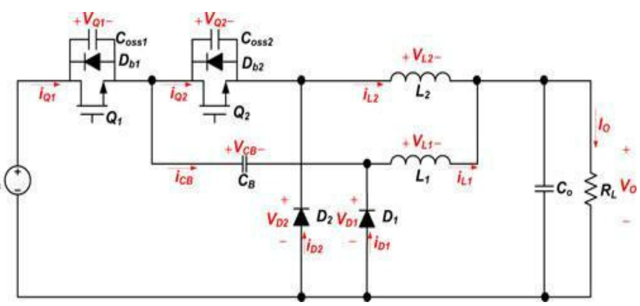

Fig. 1. Conventional Circuit

In this paper, The active clamp circuit[12] can successfully reduce the voltage stress of the switches and it collects the leakage energies from all the coupled-inductor[14] boost converters and recycles the leakage energies to the output. The buck-boost converter with closed loop controlled by Fuzzy logic helps in obtaining the needed output. In the viewpoint of improved performance and better choice of design, it can be proposed to interleave the coupled-inductor

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buck boost converter with common active clamp circuit[13] to process high power, and to achieve high efficiency and high reliability.

Here we can get constant value which we need as output voltage. This value is set at the Fuzzy logic reference value. The fuzzy logic controls the PWM controller thus adjusting the time delay for needed operation, whether buck converter operation or boost converter operation according to our needed output. When the input voltage is higher than the needed output voltage value the buck converter operation takes place and if the input voltage is lesser than the needed output voltage value the boost converter operation takes place.

2. Circuit Operation

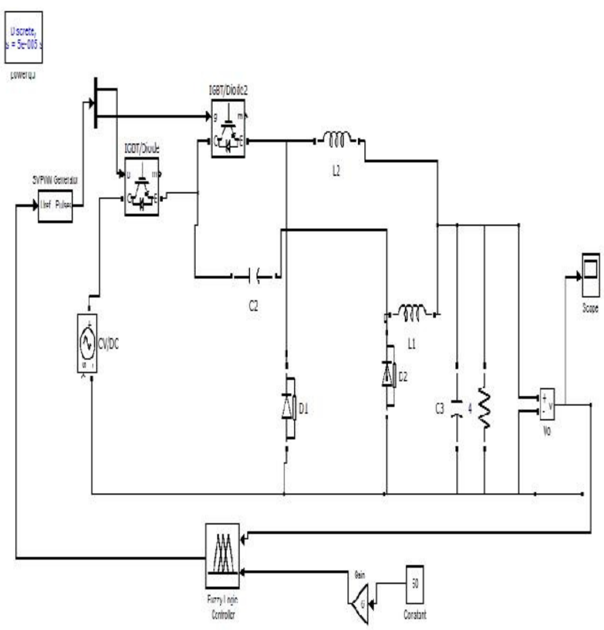


Fig. 2. Proposed circuit

The Fig.2 shows the circuit configuration of the proposed circuit. In the circuit IGBT/Diode 1 and IGBT/Diode 2 act as the interleaved Buck-Boost converter.

Here the switches are kept in series connection. The capacitor C2 and inductor L1 act as the active clamp circuit[12]. C3 is the ripple capacitor C4 is the load. Fuzzy Logic Controller controls the PWM controller time delay settings for choosing the operation which has to be done whether buck or boost converter. Diodes D1 and D2 are placed to block the reverse current flow direction.

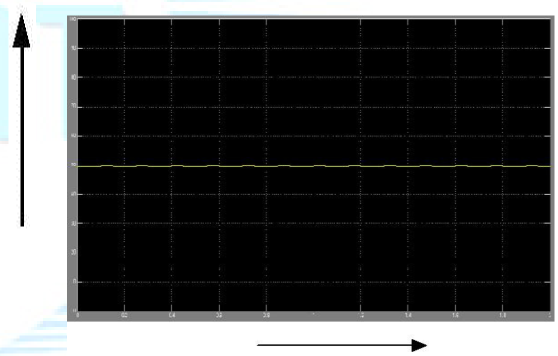
3. Modes Of Operation

Buck operation: When the reference voltage given to the fuzzy logic is lesser than the input voltage the circuit has to produce the voltage which is lesser than the input and thus the circuit act as Buck converter.

Boost operation: When the reference voltage given to the fuzzy logic is higher than the input voltage the circuit has to produce the voltage which is higher than the input and thus the circuit act as Boost converter.

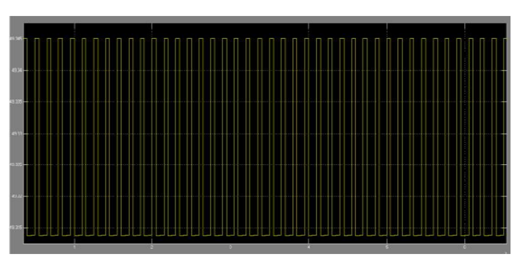
The waveform given here is for the output voltage of 50 volts, in the case of Buck converter operation the input given is 100 volts and for the Boost converter operation the input given is 25 volts.

Simulation Result



Time in ms

Simulation result



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4.Relevant Analysis Results

The proposed circuit is designed for a maximum wattage of 250 watts. The analysis of circuit with the operation of active parts is mentioned below.

4.1 Output Voltage Obtained

The output voltage obtained after the corresponding operation have the some losses present in it. The actual output obtained is 49.345 volts. It represents almost 0.655 volts is lost as losses in the circuit. These losses occur in each Buck and Boost operation. During this process losses will occur at the inductors and as the circulating currents in the active clamp area also.

4.2 Active Clamp Circuit.

The active clamp circuit present in the circuit reduces the voltage stress and also the ripple contents in the output voltage. The introduction of active clamp circuit reduces the ripple content in the proposed circuit to 0.03 volts comparing with the high value in the conventional circuit.

4.3 Interleaved Switches.

The interleaved switches[5] may be connected either in parallel or series. If connected parallel the current will be adjusted and controlled. Here series connection of switches is selected so that the voltage is adjusted according to the needed operation. The discharging voltage value of inductor is selected and added, for the Buck operation, and for the

Boost operation the peak voltage value of inductor is selected and added.

5. Details Of Buck And Boost Operation.

5.1 Buck Operation

Buck converter is commonly known as step down DC-DC converter[14]. It consists of dc input voltage source V_S, controlled switch S, diode D, filter inductor, filter capacitor C, and load resistance R. The circuit diagram for buck converter is shown in Fig. 5.

The state of converter in which the inductor current is never zero for any period of time is called the continuous conduction mode. It can be seen from the circuit that when the switch S is commanded to the ON state, the diode D is reverse biased. When the switch S is OFF the diode conducts to support an uninterrupted current in the inductor. When the average value of output current is low or the switching frequency f is low, the converter may enter the discontinuous mode. In DCM the inductor current is zero during a portion of switching period.

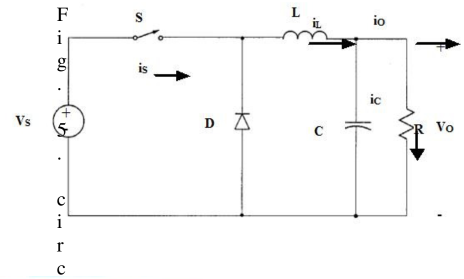

Fig.5 Circuit diagram of Buck converter

The waveform showing the operation of buck converter is shown in Fig. 6.
According to Faraday's law, the inductor volt-second product over a period of steady-state operation is zero. For the buck converter

$(V_S-V_O)DT=V_O(1-D)T$ 3.1

Hence, the dc voltage transfer function, defined as the ratio of the output voltage to the input voltage, is

$M_V=V_O/V_S=D$ 3.2

It can be seen from Eq. (3.2) that the output voltage is always smaller that the input voltage.

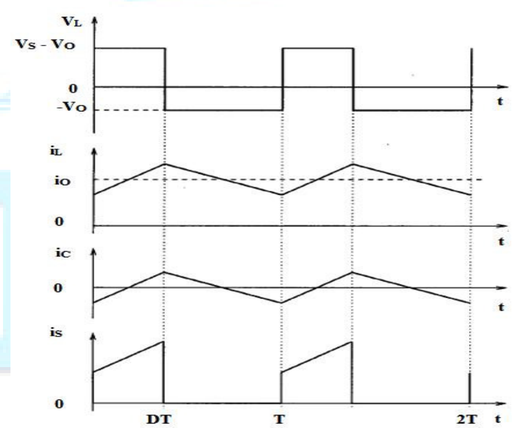

Fig. 6. Waveform for buck converter

5.2 Boost Converter

A boost converter is also known as step-up or PWM boost converter. A boost converter (step-up converter) is a power converter with an output DC voltage greater than its input DC voltage. The circuit diagram for buck converter is shown in Fig. 7. It consists of dc input voltage source V_S, boost

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inductor L, controlled switch S, diode D, filter capacitor C, and load resistance R. When the switch is the ON state, the current in the boost inductor increases linearly and the diode D is OFF at that time.

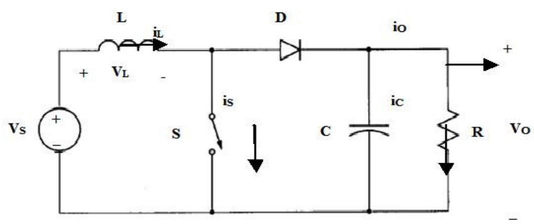

Fig. 7. Circuit diagram of Boost converter

When the switch S is turned OFF, the energy stored in the inductor is released through the diode to the output RC circuit. Filters made of capacitors (sometimes in combination with inductors) are normally added to the output of the converter to reduce output voltage ripple.
Using the Faraday's law for the boost inductor

$V_S DT=(V_O-V_S)(1-D)T$ 3.3

The DC voltage transfer function turns out to be

$M_V=V_O / V_S= 1/ (1-D)$ 3.4

As the name of the converter suggests, the output voltage is always greater than the input voltage. The boost converter operates in the CCM for $L > L_B$ where

$L_B=(1-D)^2DR/2F$ 3.5

The waveform representing operation of boost converter is represented in Fig. 8.

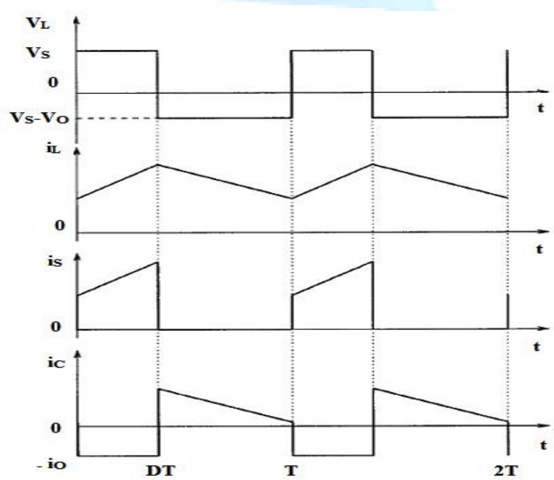

Fig. 6. Waveform for boost converter

6. Conclusion

In general operation of buck converter problems like high ON-state resistance, diode reverse recovery problem, increased conduction losses, degrade of efficiency, and voltage stresses will occur. Losses occur in relation with the diodes. In interleaved buck converter[2] the variation of voltage can be done only with step-down region. This results in use of circuit only for step-down operation. The absence of active clamp circuit can results in the voltage stress of the switches and the leakage energies from all the coupled-inductors. In the proposed system introduction of buck-boost converters with closed loop controlled by Fuzzy logic is introduced. Also active clamp circuit[13] is added to the circuit.
The active clamp circuit can successfully reduce the voltage stress of the switches and it collects the leakage energies from all the coupled-inductor boost converters and recycles the leakage energies to the output. The buck-boost converter with closed loop controlled by Fuzzy logic helps in obtaining the needed output. In the viewpoint of improved performance and better choice of design, it can be proposed to interleave the coupled-inductor buck boost converter with common active clamp circuit to process high power, and to achieve high efficiency and high reliability.

7. Experimental Results

Results from the proposed interleaved buck boost converter

Buck operation: When the reference voltage given to the fuzzy logic is lesser than the input voltage the circuit has to produce the voltage which is lesser than the input and thus the circuit act as Buck converter.

Input Voltage: 100V
Reference Voltage: 50V
Output Voltage: 49.345V
Output Voltage Ripple Content: .03V

Boost operation: When the reference voltage given to the fuzzy logic is higher than the input voltage the circuit has to produce the voltage which is higher than the input and thus the circuit act as Boost converter.

Input Voltage: 25V
Reference Voltage: 50V
Output Voltage: 49.345V
Output Voltage Ripple Content: .03V

Reference

[1]. Chen. Y. M, Teseng. S .Y, Tsai. C. T and Wu. T. F. (2004) "Interleaved buck converters with a single-capacitor turn-off snubber," IEEE Trans. Aerosp. Electronic Syst., vol. 40, no. 3, pp. 954–967.
[2]. Chuang. Y. C. (2010) "High-efficiency ZCS buck converter for rechargeable batteries," IEEE Trans. Ind. Electron., vol. 57, no. 7, pp. 2463–2472.
[3]. Du. X and Tai. H. M. (2009) "Double-frequency buck converter," IEEE Trans. Ind. Electron., vol. 56, no. 54, pp. 1690–1698.
[4]. Garcia. C, Zumel. P, Castro. A. D, and Cobos.J. A. (2006) "Automotive DC–DC bidirectional converter made with many interleaved buck stages," IEEE Trans. Power Electron., vol. 21, no. 21, pp. 578–586.

.
[5]. Ilic. M and Maksimovic. D. (2007) “Interleaved zero-current-transition buck converter,” IEEE Trans. Ind. App., vol. 43, no. 6, pp. 1619–1627.

[6]. Jin. K and Ruan. X. (2007) “Zero-voltage-switching multi resonant three-level converters,” IEEE Trans. Ind. Electron., vol. 54, no. 3, pp. 1705–1715.

[7]. Lee. J. Y, Jeong. Y. S, and Han. B. M. (2011) “An isolated DC/DC converter using high-frequency unregulated LLC resonant converter for fuel cell applications,” IEEE Trans. Ind. Electron., vol. 58, no. 7, pp. 2926–2934.

[8]. Lee. J. H, Bae. H. S, and Cho. B. H. (2008), “Resistive control for a photovoltaic battery charging system using a microcontroller,” IEEE Trans. Ind. Electron., vol. 55, no. 7, pp. 2767–2775.

[9]. Lin. R. L, Hsu. C. C, and Changchien. S. K. (2009) “Interleaved four-phase buck-based current source with isolated energy-recovery scheme for electrical discharge machine,” IEEE Trans. Power Electron., vol. 24, no. 7, pp. 2249–2258.

[10]. Moo. C. S, Chen. Y. J, Cheng. H. L, and Hsieh. Y. C. (2011) “Twin-buck converter with zero-voltage-transition,” IEEE Trans. Ind. Electron., vol. 58, no. 6, pp. 2366–2371.

[11]. Ruan. X, Li. B, Chen. Q, Tan. S. C, and Tse. C. K. (2008) “Fundamental considerations of three-level DC–DC converters: Topologies, analysis, and control,” IEEE Trans. Circuit Syst., vol. 55, no. 11, pp. 3733–3743.

[12]. Rodrigues. J. P., S. A. Mussa, M. L. Heldwein, and A. J. Perin, (2009)“Threelevel ZVS active clamping PWM for the DC–DC buck converter,” IEEE Trans. Power Electron., vol. 24, no. 10, pp. 2249–2258.

[13]Tsai.C. T. and C. L. Shen,(2009) “Interleaved soft-switching coupled-buck converter with active-clamp circuits,” in Proc. IEEE Int. Conf. Power Electron.
and Drive Systems., pp. 1113–1118.

[14]Wong. P. L, Xu. P, Yang. B, and Lee. F. C. (2001) “Performance improvements of interleaving VRMs with coupling inductors,” IEEE Trans. Power Electron., vol. 168, no. 4, pp. 499–507.