Fuzzy Control based Quadruple Boost Converter

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Abstract— A voltage quadruple boost converter is presented. This converter is used to obtain higher voltage gain and reduces the voltage stress across the switches and diodes. These voltage multipliers are used in high voltage, low current applications such as for accelerating purpose in a cathode ray tube and also this converter topology is advanced than previous dc-dc converters. Voltage quadruple converter uses parallel-input series-output connection. Comparing with two phase interleaved boost converter one can see that two more capacitors and two more diodes are added so that during the energy transfer period partial inductor stored energy is stored in one capacitor and partial inductor stored energy together with the other capacitor store energy is transferred to the output to achieve much higher voltage gain. However, the proposed voltage gain is twice that of the interleaved two-phase boost converter. Simulation of the converter is carried out using MATLAB/SIMULINK software. The converter is simulated using fuzzy logic control and also the experimental setup was done.

Key words: DC–DC boost converter, quadruple converter, voltage gain, voltage stress

I. INTRODUCTION

The DC-DC converter with high step-up voltage gain is widely used for many applications, such as fuel-cell energy-conversion systems, solar-cell energy-conversion systems, and high-intensity-discharge lamp ballasts for automobile headlamps. The proposed converter in lecturer [1]employs a Zeta converter and a coupled inductor, without the extreme duty ratios and high turns ratios generally needed for the coupled inductor to achieve high step-up voltage conversion; the leakage-inductor energy of the coupled inductor is efficiently recycled to the load. These features improve the energy-conversion efficiency. The operating principles and steady-state analyses of continuous and boundary conduction modes, as well as the voltage and current stresses of the active components discussed.

The proposed converters in [2] are different from the conventional dc–dc step-up converters, and they posses higher voltage gain with small output voltage ripples. Other advantages of the proposed converters include lower voltage stress on the semiconductor devices, simple structure, and control. Moreover, the reduced voltage stress on the diodes allows using Schottky diodes for alleviating the reverse-recovery current problem, as well as decreasing the switching and conduction losses.

In paper [3] presents a new design method for dc–dc converter with switched-capacitor technology. The new method can reduce the high pulse current which usually causes serious problem in traditional converters. Therefore, the power level of this new designed converter can be extended to 1 kW or even higher. A 1-kW 42/14-V switched-capacitor converter was designed for 42-V automotive system.

The concept is composed in literature [4] of two capacitors, two diodes, and one coupled inductor. Two capacitors are charged in parallel, and are discharged in series by the coupled inductor. Thus, high step-up voltage gain can be achieved with an appropriate duty ratio. The voltage stresses on the main switch and output diode are reduced by a passive clamp circuit.

In paper [5] in this paper to implement dual operation of the well-known soft-switching full bridge dc/dc buck converter for bidirectional high power applications. It provides unique commutation logic to minimize a mismatch between current in the current-fed inductor and current in the leakage inductance of the transformer when commutation takes place, significantly reducing the power rating for a voltage clamping snubber and enabling use of a simple passive clamped snubber.

This paper proposes in[6] a novel zero-current-switching pulse width-modulation (ZCS-PWM) flyback dc/dc converter using a simple ZCS-PWM commutation cell. The main switch and auxiliary switch operate at ZCS turn-on and turn-off conditions, and all uncontrolled devices in the proposed converter operate at zero-voltage-switching (ZVS) turn-on and turn-off. In addition, given constant frequency and decreasing commutation losses, the proposed converter has no additional current stress and conduction loss in the main switch compared to the conventional hard switching flyback converter.

This paper presents[8]a simple and effective solution that involves shifting the original rectifier current to a new branch, which consists of a rectifier and a coupled winding of the boost inductor. When the active switch turns on, the current through the original boost rectifier is zero and the current decrease rate in the new branch is controlled by the leakage inductor.

The circuit operation modes are described in section 2. The section 3 includes the simulation analysis and section 4 presents the experimental results to verify the theory. Section 5 include the conclusion.

II. QUADRUPLE BOOST CONVERTER

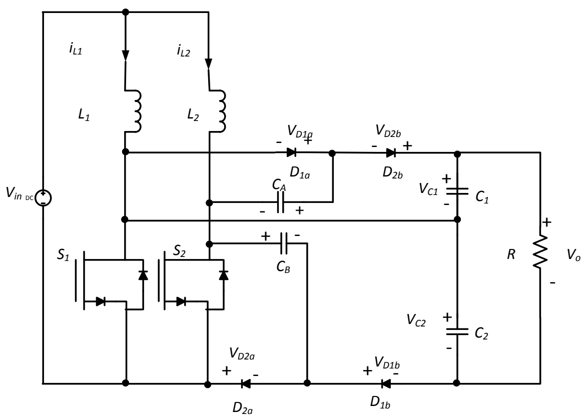


Fig. 1: quadruple boost converter

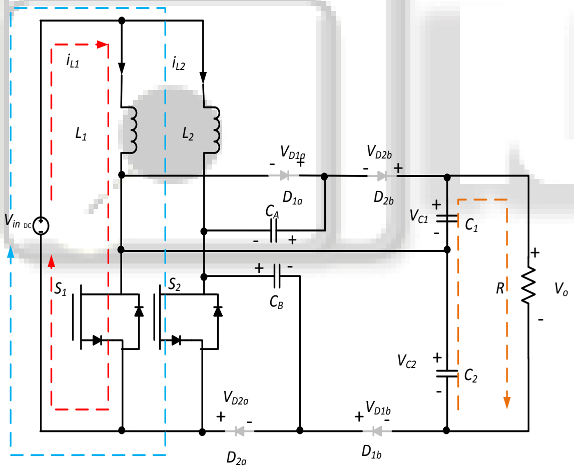
A quadruple boost converter is shown in fig. 1. The voltage quadruple converter produces an output voltage four times the peak value of its input voltage .The quadruple converter topology is basically derived from a two phase interleaved boost converter and the quadruple converter uses a parallel input series output connection Basically, the operating principle of the proposed converter can be classified into four operation modes.

As shown in fig. 2(a), for state 1 the switches S_1 and S_2 are turned ON, D_{1a}, D_{1b}, D_{2a},D_{2b} are all OFF. During this state, i_{L1} and i_{L2} are increasing to store energy in L_1 and L_2 respectively. In this state load power is supplied from capacitors C_1 and C_2.

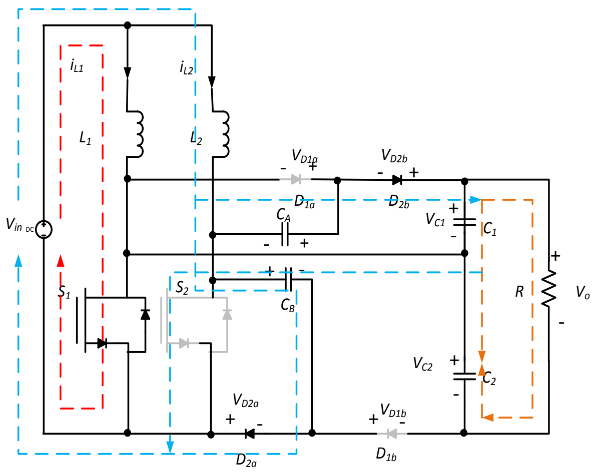
In the switching state2 in fig. 2(b), switch S_1 remains conducting and switch S_2 is turned OFF. Diodes D_{2a}andD_{2b} become conducting andi_{L1} still increases continuously and i_{L2} decreases linearly. A part of stored energy in inductor L_2 as well as the stored energy of C_A is now released to output capacitor C_1 and load. Meanwhile

The switching state3 is shown in fig. 2(c). For this state switches S_1 and S_2 are turned ON,D_{1a},$D_{1b}$$D_{2a}$$D_{2b}$ are all OFF. During this state i_{L1} and i_{L2} are increasing to store energy in L_1 and L_2 respectively. In this state load power is supplied from capacitors C_1 and C_2.The corresponding equivalent circuit turns out to be the same as that of Fig 2(a).

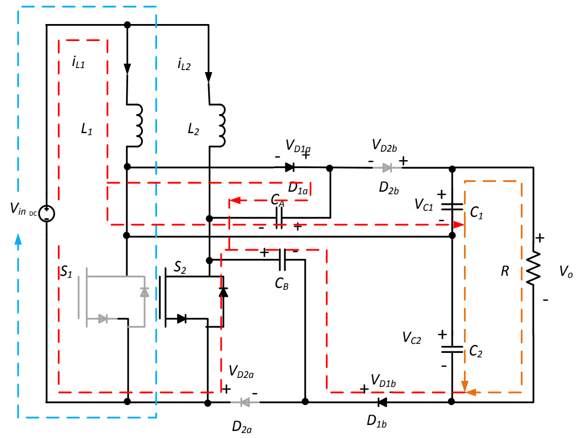
In the switching state4 in fig. 2(c), switch S_2 remains conducting and switch S_1 is turned OFF. Diodes D_{1a}andD_{1b} become conducting andi_{L2} still increases continuously and i_{L1} decreases linearly. A part of stored energy in inductor L_1as well as the stored energy of C_B is now released to output capacitor C_2 and load. Meanwhile part of stored energy in inductor L_1 is stored in C_A.



(a)



(b)



(c)

Fig. 2: Switching states of a quadruple boost converter (a) state1circuit (b) state2 circuit (c) State3 circuit

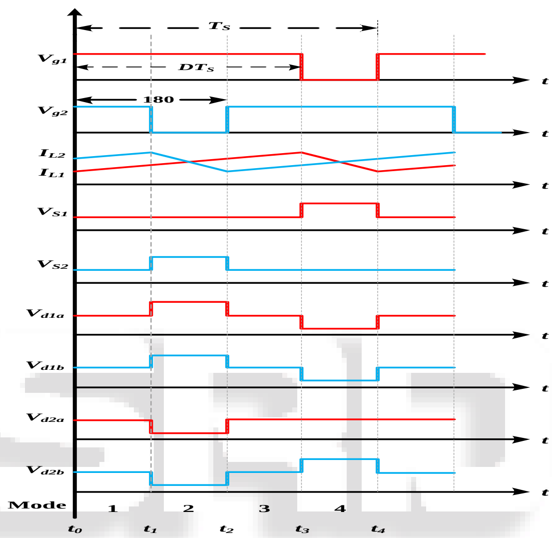


Fig. 3: Operating waveform of the quadruple boost converter.

III. SIMULATION AND RESULTS

The simulation of the proposed method is done in MATLAB2014. The focus was on the output voltage gain and reduce the voltage stress across the switches and diodes. The switching frequency is taken as 40 kHz. The dc input voltage applied to the converter is 25V.The values of two capacitors C_A and C_B are 10µF and C_1 and C_2 are 550µF and that of inductor is 0.253mH. The value of load resistance is taken as400Ω.

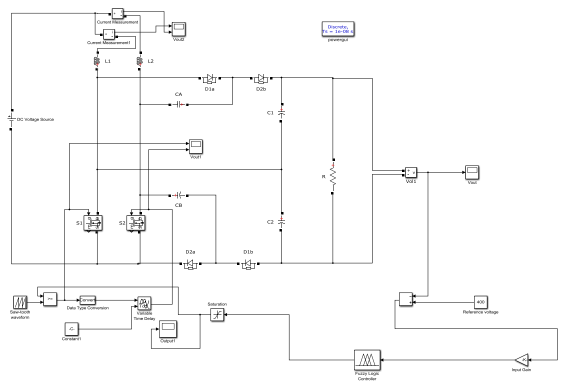
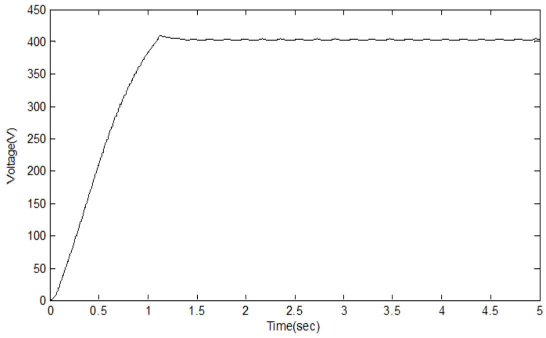
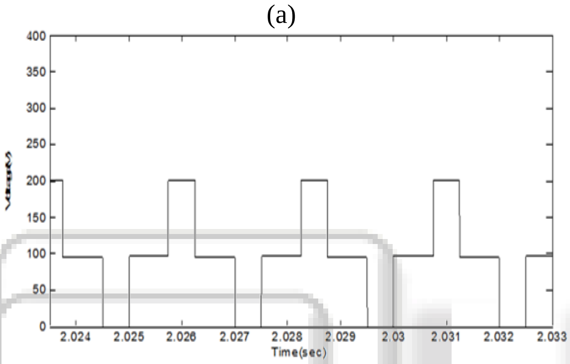


Fig. 4: Simulation model using fuzzy control

The controlling is done by using fuzzy. The simulink model of the circuit using fuzzy controller is shown in fig. 5. The dc output voltage is obtained as 400V .Also the voltage stress across the diodes and switches are reduced The simulated waveforms of output voltage and voltage across switches and diodes are shown in fig. 4(a),fig. 4(b) and fig. 4(c) respectively.



(a)



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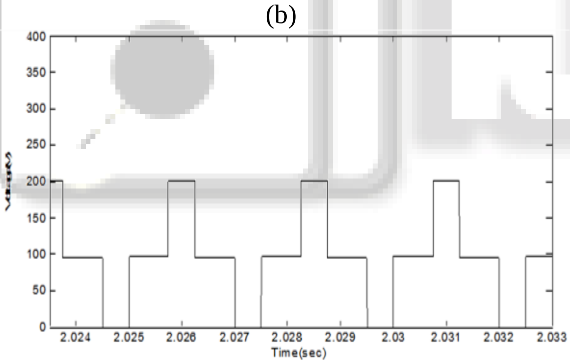


(c)

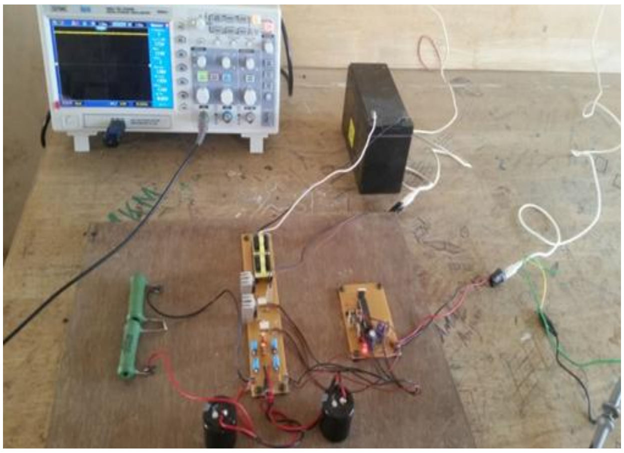
Fig. 4: (a) Output voltage (b) Voltage across switch (c) Voltage across diodes

IV. EXPERIMENTAL RESULTS

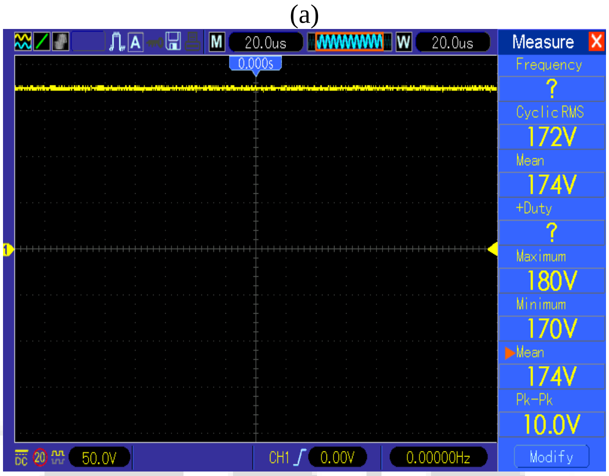
The system is implemented by using dsPIC30f2010 controller. The nominal parameters are shown in table I. two ADC channels are used to sense the output voltage, and another one to provide the desired reference voltage. In the input section 12V is applied. The output voltage is regulated at 174V. The experimental setup and output voltage waveform are shown in fig. 5(a) and fig. 5(b) respectively.

Input voltage	**12V, 50Hz**
Output voltage	174V
Carrier frequency	20kHz
Inductor	.4mH
Capacitor	1µF and 1500µF

Table 1: Hardware parameters of a quadruple boost converter



(a)



(b)

Fig. 5: (a) Experimental setup of the proposed system (b) Output voltage

V. CONCLUSION

A Quadruple converter is used for high voltage applications. The proposed topology utilizes input-parallel output-series configuration and integrates two phase interleaved boost converter. They are used in high voltage, low current applications. The voltage gain of this converter is twice that of the interleaved two-phase boost converter. This converter has the ability to obtain higher voltage gain and reduces the voltage stress across the switches and diodes.. Comparing with two phase interleaved boost converter one can see that two more capacitors and two more diodes are added so that during the energy transfer period partial inductor stored energy is stored in one capacitor and partial inductor stored energy together with the other capacitor store energy is transferred to the output to achieve much higher voltage gain. Simulation of the converter is carried out using MATLAB/SIMULINK 2014 software. The converter is simulated using fuzzy logic control and and also the experimental setup was done.

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