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A DUAL SWITCH BOOST CONVERTER WITH HIGH VOLTAGE GAIN

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Abstract: **A traditional boost converter cannot provide high voltage gain because of the equivalent series resistance present in the circuit. Studies are going on to develop high gain boost converters without extremely high duty ratio. Coupled inductor or transformer link can be used in to get a high step up converter. Transformer links make the circuit bulkier. A dual switch step up converter is a compact solution to get high conversion ratio. High voltage gain can be obtained in a dual switch boost converter, with a low voltage and current stress on the switches. Here a method to further improve the voltage gain of a dual switch converter is presented. A dual switch step up DC/DC converter circuit with high voltage gain is explained. The converter achieves high voltage gain with a low duty cycle. For the same conversion ratio, voltage stress across the switches is also low compared to the traditional dual switch converter. Simulation results in MATLAB/Simulink are also presented.**

Keywords: **High voltage gain, Dual switch boost converter, Resonant voltage, DC/DC converter, Low voltage stress.**

I. INTRODUCTION

Boost converters having high voltage gain are invariably used in applications such as fuel cells, uninterruptible power supply and renewable energy. Due to the presence of series equivalent resistance present in the circuit, the boost ratio of a conventional boost converter is limited. It is possible to obtain a high conversion ratio in a traditional boost converter, but with a high duty cycle. A high duty cycle may introduce, large peak current, high conduction losses and it may damage the capacitors. Various configurations have been developed to get a high boost ratio, without a high duty ratio. One method is to use a transformer link. Such converters use DC/AC/DC link [1]. The high gain is achieved by changing the turn's ratio of the transformer used. But with multistage DC/AC conversion the cost as well as the bulkiness of the converter is increased. Also if the inductance of isolated converter is not handled properly, it may cause high voltage spike across the switches. The coupled inductors can also serve the same purpose of transformer link[2]. Similar to transformer link the gain can be increased by increasing the turns ratio. But here also leakage inductance is a problem and if not handled properly will cause high voltage spikes across the power switches.

A dual switch converter has a high voltage gain compared to a conventional boost converter[3], but the converter has a problem that if there is a slight change in parameters, high resonant voltage may occur across the power switches and they get destroyed easily. Additional clamping circuit is needed to suppress the resonant voltage [4]. In this paper a dual switch boost converter with high voltage gain is presented. The voltage gain of dual switch converter is improved with the addition of some passive elements. For the same conversion ratio the duty cycle requirement of converter is low compared to traditional dual switch converter. In addition to that the voltage stress across the power switches of the converter is also low.

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II. DUAL SWITCH CONVERTER WITH HIGH VOLTAGE GAIN

A. Configuration:

The circuit diagram of the converter is shown in fig. 1. In a conventional boost converter, one inductor is the only energy storage element. A dual switch converter uses two inductors as energy storage elements. The proposed converter uses two inductors and two capacitors as energy storage elements. Power switches are shown along with its associated parasitic capacitances. When the switches are on, two capacitors and two inductors get charged, and when the switches are off, the stored energy is serially discharged through the load. The converter can operate in two different modes continuous conduction mode (CCM) and discontinuous conduction mode (DCM) as explained below.

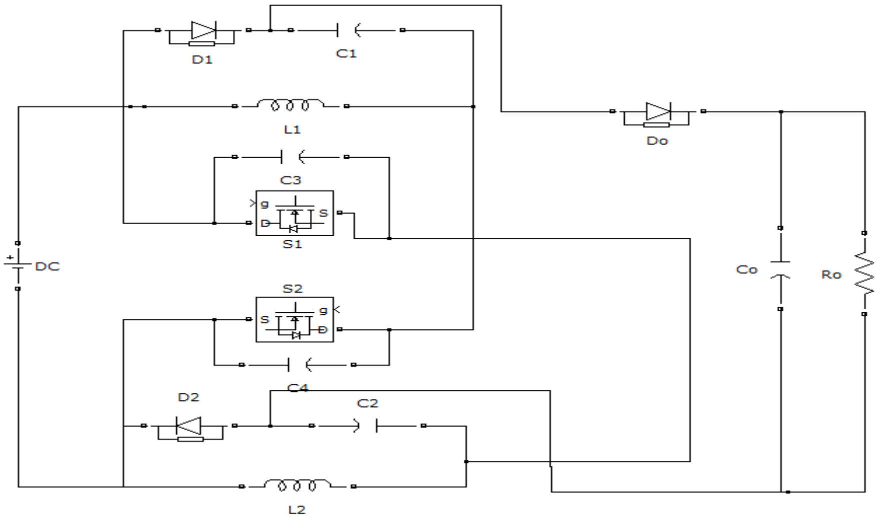

Fig.1. Dual Switch converter with high voltage gain

B. Operating modes:

The waveforms of CCM is shown in fig .3a and the wave forms of DCM is shown in fig .3b .There are two operating modes under CCM and three operating modes for DCM. Mode 1 and 2 are similar to both cases.

Continuous Conduction Mode

Mode1 ($0<t<DT_s$) : When the power switches are supplied with gate pulses, there are four parallel current paths as shown in fig .2a. Both the inductors and capacitors get charged because of the current flowing through them. D_0 is reverse biased and the output capacitor discharges through the load. The voltage across inductors can be obtained as.

$$V_{L1} = V_{L2} = V_i \qquad \text{……………….(1)}$$

Mode2 ($DT_s<t< T_s$) : When the switches are off L_1 ,L_2 ,C_1 ,C_2 discharges serially through D_0 and the load as shown in fig .2b. The output capacitor also gets charged. The voltage across inductors can be written as,

$$V_{L1} = V_{L2} = \frac{V_i+V_{C1}+V_{C2}-V_o}{2} = \frac{3V_i-V_o}{2} \qquad \text{………………….(2)}$$

The voltage stress across the off switches can be obtained as,

$$V_{S1} = V_{S2} = \frac{V_o - V_i}{2} \qquad \text{………………….(3)}$$

Applying the voltage balance equation across the inductors, the voltage gain can be obtained as,

$$G_{CCM} = \frac{V_o}{V_i} = \frac{3-D}{1-D} \qquad \text{………………….(4)}$$

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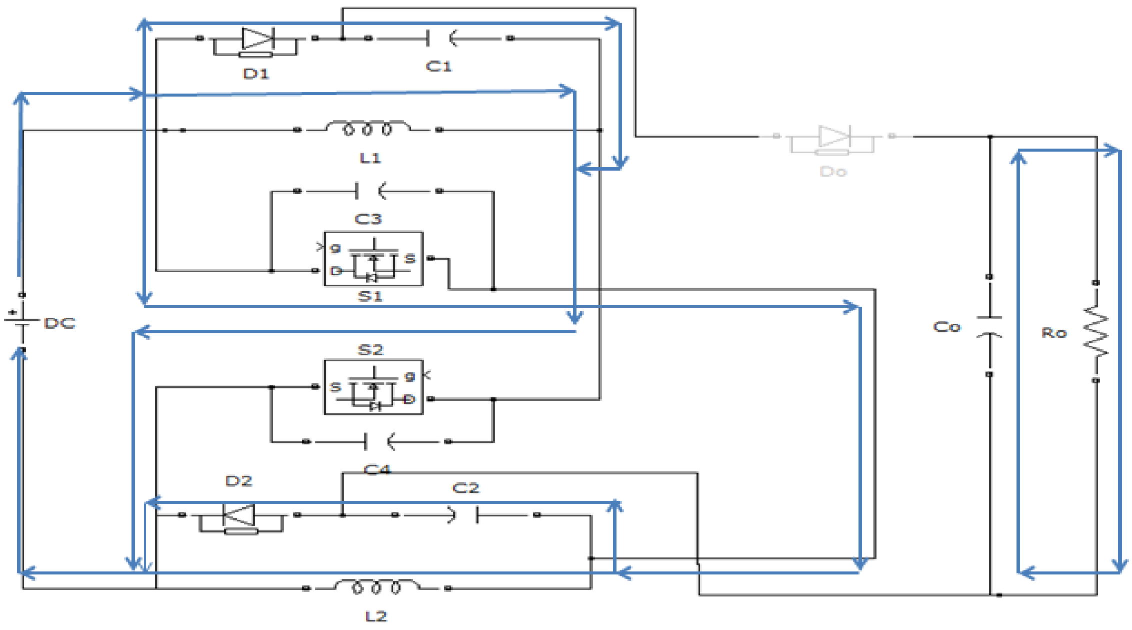
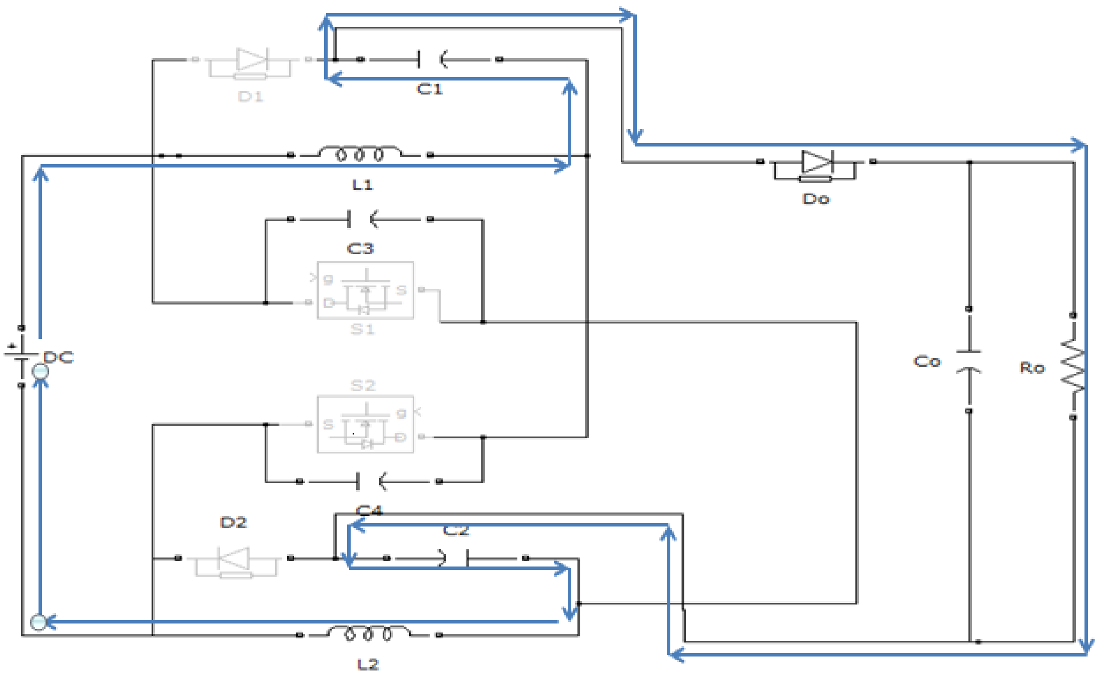
Discontinuous Conduction Mode:

DCM operation is also similar to CCM, Mode 1 and Mode 2 are the same. In the DCM mode, before the occurrence of next gate pulse , both inductor and capacitor currents get decayed to zero. Hence the stored energy in the output capacitor C_0 discharges to the load. And the voltage gain can be obtained as,

$$G_{DCM} = \frac{V_o}{V_i} = \frac{3}{2} + \sqrt{\frac{9}{4} + \frac{RD^2T_S}{L}} \qquad \text{…………………(4)}$$



(a)



(b)

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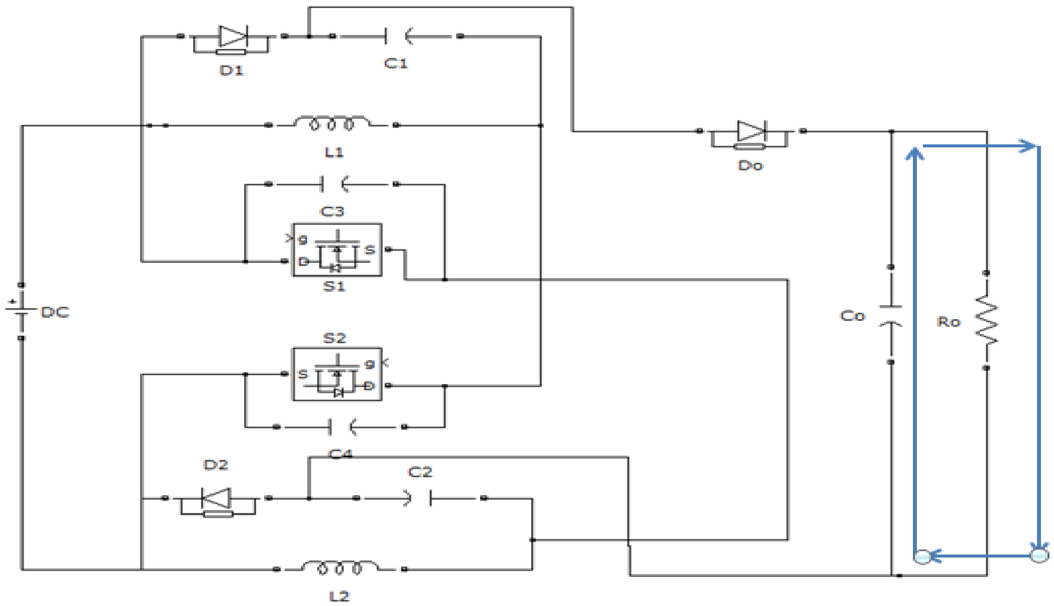

(c)

Fig.2. Equivalent circuits of dual switch converter with high voltage gain (a) Mode 1. (b) Mode 2. (c) Mode3

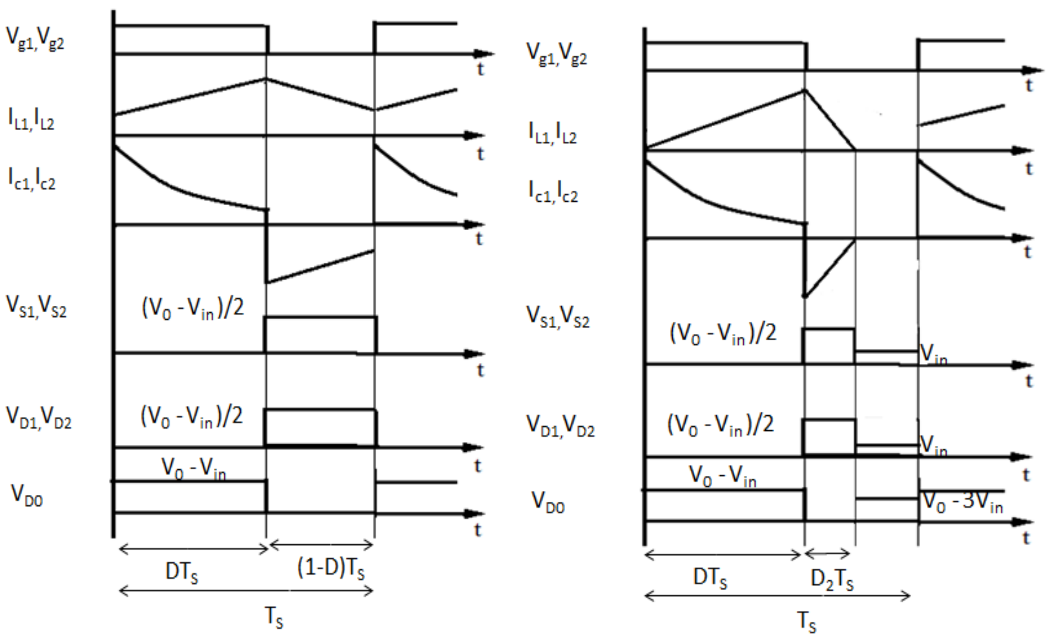

Fig.3. Key Waveforms (a) CCM (b) DCM

III. SIMULATION RESULTS

A converter with voltage gain 8 is designed for 4 volt input. The duty ratio of power switches is 2/3. To check if resonant voltage is present across the power switches, slight variation in parameters is considered. Inductors L_1 and L_2 are taken as 490µH and 510 µH respectively. Capacitors C_1 and C_2 are taken as 470 µH. Parasitic capacitance across the switches are taken as 900pF and 800pF respectively. Output resistance of 100 Ω and filter capacitance of 5.6 µF is selected. The circuit is simulated in MATLAB/Simulink and simulation results are given below.

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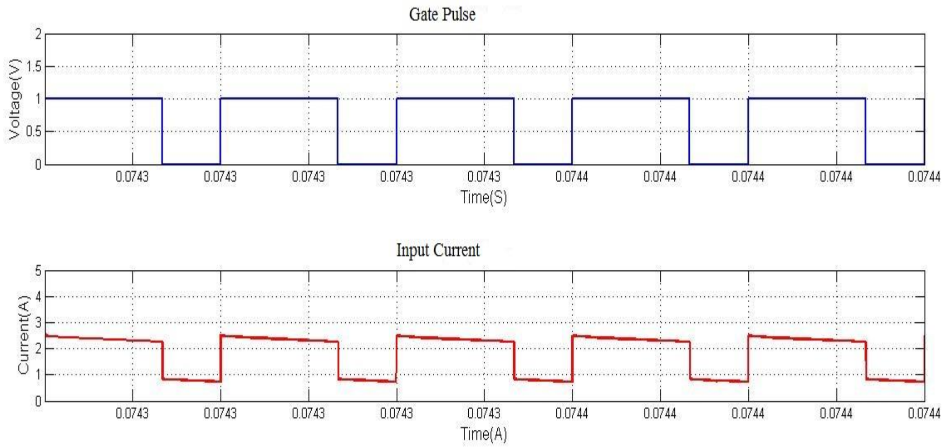

Fig.4. Gate pulse and input current

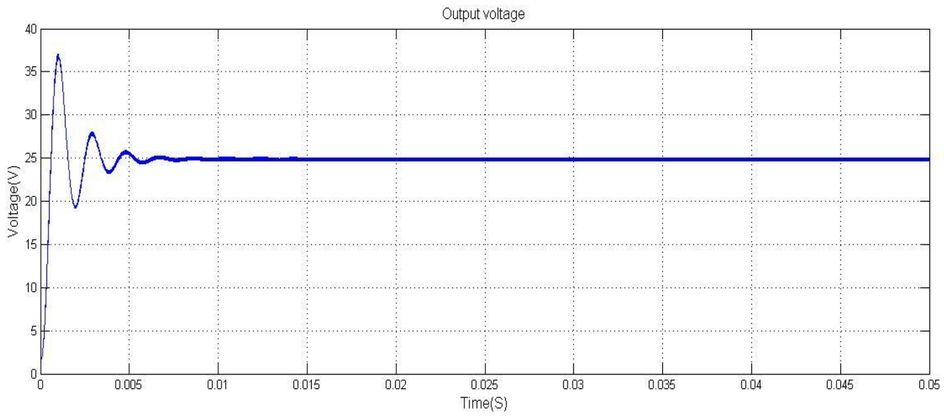

Fig.5. Output voltage

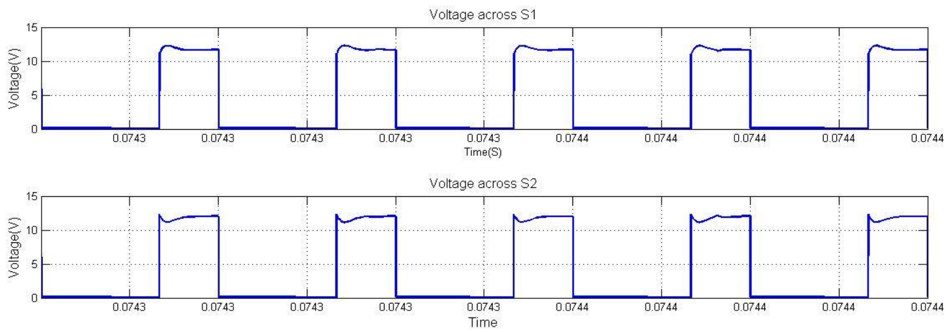

Fig.6. Voltage across S_1 and S_2

IV. CONCLUSIONS

A dual switch boost converter with high voltage gain is explained in this paper. For a 2/3 duty ratio analysed above, the voltage gain of a conventional boost converter and dual switch boost converters are 3 and 5 respectively. The above converter is expected to produce a gain of 7 for the same duty ratio. The simulation results reach nearer to the expected voltage gain. For a 4 volt input, an output voltage of 26 Volt with a voltage ripple of 3.5% is obtained. For the same conversion ratio, the voltage stress across the power switches are also low compared to a dual switch converter. For the parameter inconsistency considered, there is no resonant voltage across power switches as in a dual switch converter. Hence no clamping circuit is needed and power switches of low rating can be used.

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