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Design of Triple Switch Double Inductor Based High Voltage Gain DC-DC Boost Converter

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ABSTRACT

DC microgrids are well known due to the combination of sustainable power sources, for example, sun based photovoltaic and power device. Inferable from the low yield voltage of these DC power generators, high proficient high addition DC-DC converters are deprived to associate the DC microgrid. In this paper, a non-confined high addition dc–dc converter is proposed without utilizing voltage multiplier cell (VMC). The proposed topology uses two non-confined inductors that are associated in series/parallel during liberating/charging mode. The activity of switches with two distinctive duty ratio is the principle key factor of the converter to accomplish high voltage gain without using outrageous duty ratio. Likewise, a 100W, 20/200V model circuit of the high voltage gain DC-DC converter is simulated using MATLAB/SIMULINK software.

KEYWORDS: *Triple Switch Double Inductor, DC-DC converter, Voltage gain*

I. INTRODUCTION

DC microgrid innovation is advancing because of the infiltration of conveyed generating sources. DC power generators produce low yield voltage and thus require high effective high increase DC-DC converters to meet the DC load prerequisites. These days, high addition DC-DC converters are utilized in numerous applications other than the sustainable power source transformation, for example, battery reinforcement frameworks for continuous force supplies, high power release light weights for car headlamps, electric pulling forces and some therapeutic equipment [1-2].

In the ongoing past, traditional DC-DC help converter is utilized to step up the voltage. Be that as it may, the voltage weight on the switch is equivalent to the yield voltage. Subsequently, high appraised switch is chosen to meet the voltage weight on the switch that outcomes in high conduction loss [3-4].

Different segregated dc–dc converter topologies are proposed in the writing to accomplish desired high voltage gain [5].Some of the non-confined high addition converters are cascaded boost [6] and voltage lift [7-8].Hybrid high gain high power topologies are likewise created [9-10].

In the writing, various non-confined high-gain DC–DC converter topologies with voltage boosting strategies have been talked about, few of them are cascaded boost [11], quadratic lift [12], and switched inductor (SI)/capacitor (SC) [13]. In cascaded boost converter, the high-voltage gain has been accomplished with more segments, thereby expanding the system complexity and results in poor proficiency [14]. In this converter [15], the level of the voltage stress on the diodes and switches concerning the yield voltage are less.

The proposed converter has high voltage gain by choosing appropriate duty cycle for the three switches and by planning legitimate inductor and capacitor esteems. It has the accompanying points of interest: (I) the three switches in the proposed converter works with two diverse duty ratios to accomplish high voltage gain; (ii) the stored inductor energy is provided to the load without extra clamping circuit; (iii) the voltage gain accomplished by the proposed converter is more prominent than the traditional boost converter (iv) diminished voltage stress on the diodes and switches dependent on the rate yield voltage; and (v) the proposed converter is fit for accomplishing high voltage gain without VMC as well as hybrid switched capacitor techniques.

II. PROPOSED HIGH GAIN CONVERTER TOPOLOGY

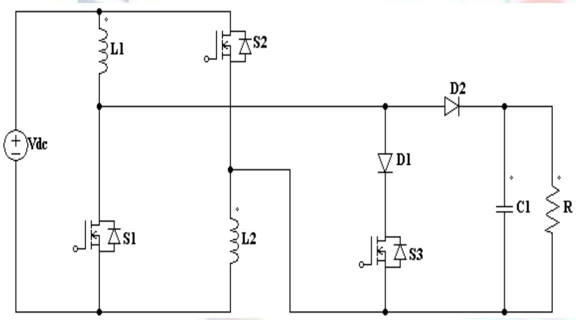

Fig. 1 Proposed circuit diagram

The proposed triple switch double inductor based high voltage gain DC-DC converter appeared in Fig-1 comprises of three dynamic switches S1, S2 and S3, two inductors L1 and L2, two diodes D1 and D2 and one yield capacitor Co. The switches S1, S2 and S3 work at an switching frequency of fs. The duty ratio of the switches S1 and S2 is D1 and the third switch S3 is D2.The output capacitance Co is adequately large to maintain constant output voltage. Let the number of turns in the two inductors is equal, so that

$$L1 = L2 = L \quad (1)$$

2.1. MODES OF OPERATION:

MODE 1:

During the time interval [t0, t1], switches S1 and S2 are turned ON and switch S3 is turned off. The flow of current in the circuit is shown in Fig. 2. The source energy is moved to the inductors L1, L2 and the energy stored in the capacitor Co is released to the load.

In this mode, diode D1 and D2 are in reverse bias condition. But, the inside diode of the switch S3 is in forward bias condition. In this mode, inductors are parallel to the source. The voltage across the inductor is given in equation 2.

$$Vl1 = Vl2 = Vi \quad (2)$$

MODE 2:

During the time interval [t1, t2], Switch S1 and S2 are turned OFF and switch S3 is turned ON. The current path during this period is shown in Fig. 3. The source energy is moved to the inductors and the current flows through L1, D1 and L2. In this mode, the voltage over the switch S1 and S2 is half of the source voltage.

The stored energy in the capacitor Co is delivered to the load since diode D2 is in the reverse bias condition. In this mode, the inductors are in series to the source. During this mode, the voltage across the inductor is shown in equation 3.

$$Vl1 + Vl2 = Vi \quad (3)$$

MODE 3:

During the interval [t2, t3], S1, S2 and S3 are turned OFF. the current path within the circuit is shown in Fig. 4. During this mode, each supply and also the inductors offer the load. Diode D1 is in reverse bias condition.

The voltage across the switches S1 and S2 is that the average of the input and output voltages, whereas, the voltage across switch S3 is that the addition of input and output voltages.

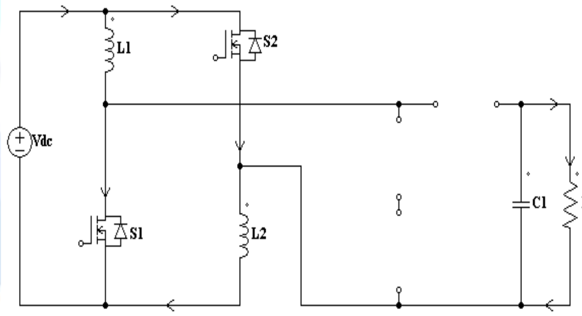

Fig. 2 MODE 1 S1 & S2-turned ON, S3-turned OFF

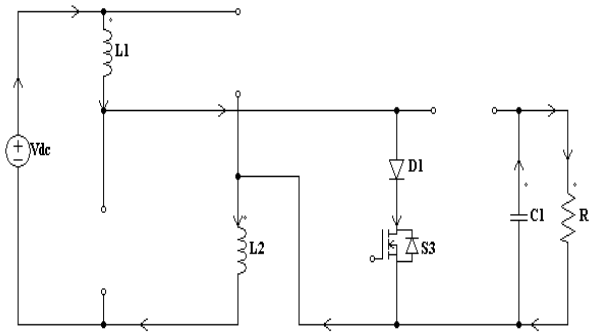

Fig. 3 MODE 2 S1 & S2-turned OFF S3-turned ON

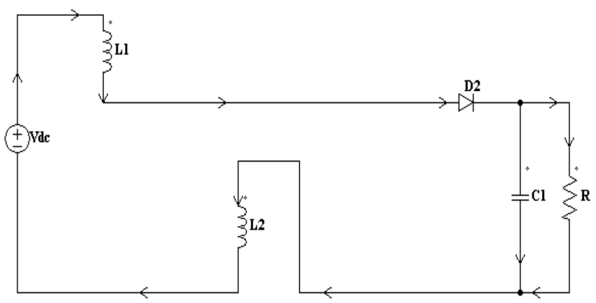

Fig. 4 MODE 3 S1, S2 & S3-turned OFF

During this mode, the inductors are series to the supply. Therefore,

$$Vl1 + Vl2 = ViVo \qquad (4)$$

Where V_o is the Output Voltage.

From equations 2, 3, & 4, the voltage gain equations of the proposed high voltage gain DC-DC converter is

$$\frac{vo}{vin} = \frac{1+D1}{1-D1-D2} \qquad (5)$$

Where D is the Duty Ratio.

III. SIMULATION RESULTS AND DISCUSSION

The proposed high voltage gain converter topology is simulated in MATLAB / Simulink environment as shown in Fig. 5

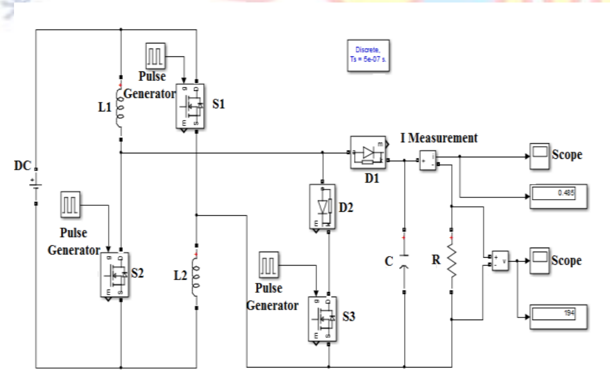

Fig. 5 Simulation Diagram

The value of inductance of the series inductor L1 and L2 are 360 µH. The output capacitor C0 have 100 µF capacitance value. The load resistance RL is 400 Ω.

The switching frequency is 50 kHz. The duty cycle ratio of the switches S1 and S2 are taken as 50% (d=0.5) and the switch S3 is taken as 35% (d=0.35). When the duty cycle is in the range between 0.5 and 0.8, the output voltage level may get boosted up to 10 to 30 times the input voltage. The output current is of the order of 0.5A.

The Simulation Parameters are shown in Table 1. The waveform of fig 6 and 7 shows the gate pulse for the switch S1, S2 and S3.

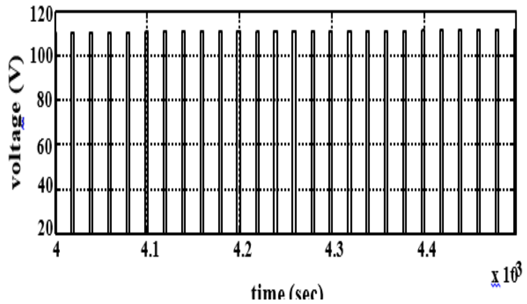

Fig. 6 Gate pulse to the switches of the proposed converter

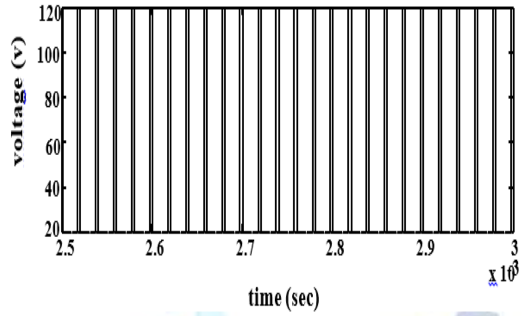

Fig. 7 Gate pulse to the switches of the proposed converter

This figure 8 and 9 shows the output voltage and current waveform of the high gain boost converter. The simulated output voltage and values are 194V and 0.48A. The theoretical output voltage from equation 5 is 200V.

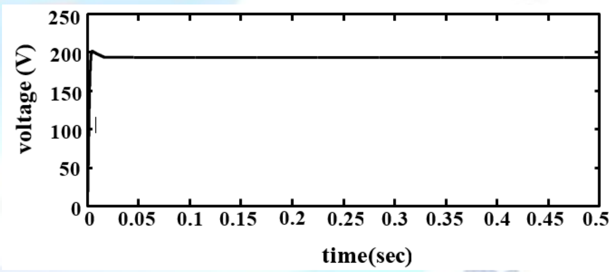

Fig. 8 Output Voltage waveform

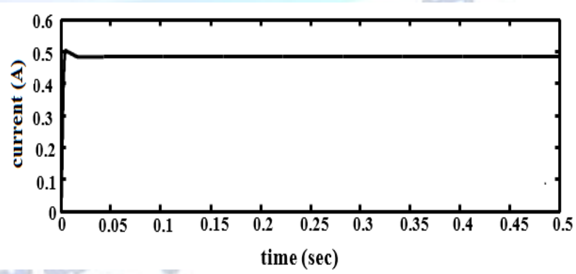

Fig. 9 Output Current waveform

The figure 10 and 11 show the inductor current L1 and L2 waveform of the proposed high voltage gain dc to dc converter. The current varies from positive to negative which show the current flow in both directions.

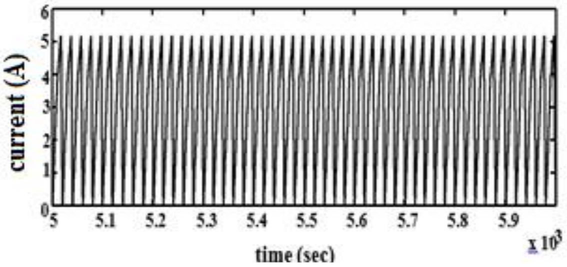

Fig. 10 Inductor Current waveform

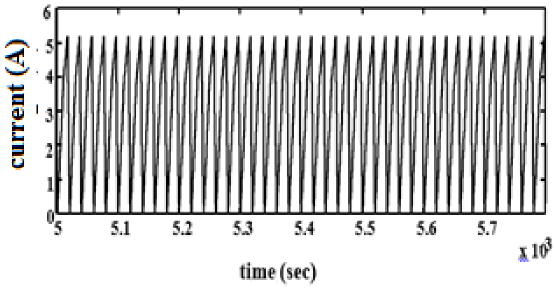

Fig. 11 Inductor Current waveform

Table -1: Simulation Parameters

PARAMETER	VALUE
Power Rating	100 W
Input voltage	20V
Output voltage	194V
Inductor	300µH
Capacitors	100µF
Switching frequency	50000 Hz
Duty cycle	D1=50%, D2=35%

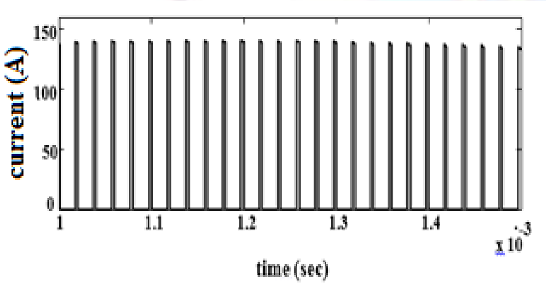

Fig. 12 Capacitor Current waveform

The figure 12 shows the waveform of current through the capacitor across load resistor.

IV. CONCLUSION

In this paper, a triple switch double inductor based high voltage gain DC-DC converter is simulated to accomplish high voltage gain using MATLAB/Simulink Software. For any converter that operations using single duty ratio D, the extreme duty ratio isn't reliable. In the proposed converter, the consideration of switch S3 and the activity of three switches with two distinctive duty ratio are the primary points of interest. The simulation results approve that high voltage gain of 10 times is gotten without utilizing voltage multiplier cell (VMC) as well as hybrid switched capacitor system with output voltage of 194V and output current of 0.48A for an input voltage of 20V.

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