High Conversion Step Up Converters With Boost Inductors and Bootstrap Capacitors

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***Abstract*— In this paper, new high voltage step-up converters are presented. Different voltage conversion ratios can be obtained by changing the connection position of anode of the diode. With the help of boost inductors and bootstrap capacitors these converters are implemented. Even though with different boost inductor values the converters will function appropriately. The simulation is carried over by the MATLAB-SIMULINK software.**

***Keywords*— Step up converter, Boost inductor, Bootstrap capacitors**.

I. INTRODUCTION

Generally high step up converters have numerous applications in the industry, such as in uninterruptible power supply, solar cell system and high intensity discharge lamp[1]. A dc-dc converter converts the fixed dc voltage to variable dc voltage. If the output voltage is less than the input voltage the converter to be referred as boost (step-up) converter. In PV system the output voltage of a typical photovoltaic panel is 12V, in order to increase the voltage level step up converter is used.

The structure of boost converter is simple and the conversion ratio is not high, in case of fly-back converter even though the conversion ratio is high there will be high leakage inductance [2]. By increasing the number of inductors high voltage conversion ratio may obtain. With inductors connected in series, during the demagnetizing period the input voltage and the energy stored in the inductors will be added to the output voltage to have the high voltage conversion ratio. The current flowing through the inductor can be considered as a current source [3][6]. If inductors with different values are connected in series means current source with different values are connected in series there by Kirchhoff's current law (KCL) is violated and failing such a circuit.

From the above reasons, two high conversion ratio step up converters based on two boost inductors and two bootstrap capacitors are presented. Although, two different inductors are connected in series during demagnetizing period these converters will function appropriately. Depending upon the connection of the diode in the circuit two step-up converters with different voltage conversion ratios are presented with similar circuit structure [4].

II. CONVERTER TOPOLOGY

Figure1. shows the block diagram of the proposed converter topology here input supply is a dc source which is connected to the load with the help of bootstrap capacitors and boost inductors. The switching signals will control the power semiconductor switches in the circuit.

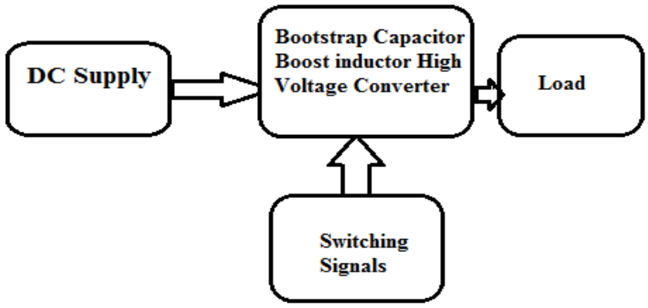

Figure1. Proposed converter block diagram

A. Proposed converter circuit

The two proposed converters have two different voltage conversion ratios. The Type-1 circuit is shown in figure 2 and type-2 circuit is shown in figure 3.

The difference in the type1 and type2 circuit is the position of the diode anode in the circuit. Both the circuits consist of three MOSFET's, two bootstrap capacitors , two boost inductors, three bootstrap diodes, one output capacitor, one output diode and the resistance load. Here v_i represents the input voltage and V_o represents the output voltage [5].

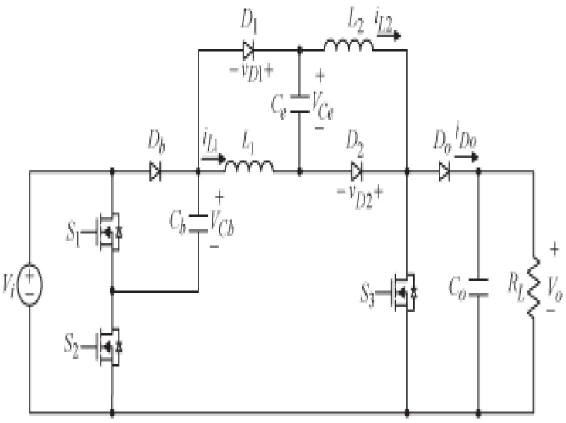

Figure 2. Type-1 converter circuit

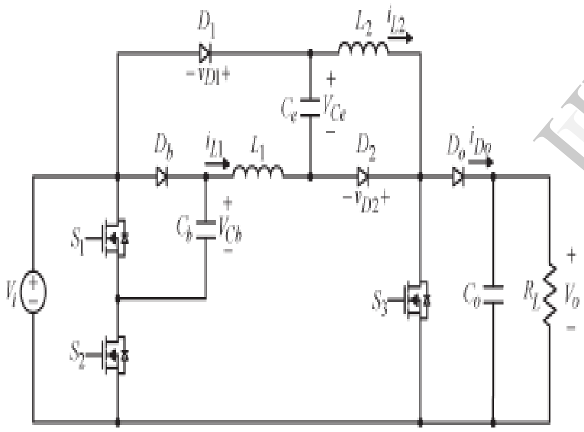

Figure 3.Type 2 converter circuit

The input voltage is 24V dc and the output voltage will be approximately 230V dc and the switching frequency is 50KHz. For type 1 circuit the voltage conversion ratio will be $\frac{3+D}{1-D}$ and the voltage conversion ratio of the type 2 circuit will be $\frac{3-D}{1-D}$ in the continuous conduction mode of operation.

III. OPERATING MODES OF THE CONVERTER

Both the converters are operated in continuous conduction mode are analyzed for unique and different values of inductors.

A. Type 1 with similar values of boost inductor:

Mode 1: In this mode switches S1 and S3 are turned on the capacitor C_e is immediately charged and the inductors are magnetized as the diode D_o is reverse biased due to turning on the S3 switch, during this period the output capacitor will supply the power to the load.

Mode 2: In this mode switch S2 is turned on the capacitor C_b is immediately charged to input voltage the capacitor C_e is going to be discharged and the inductors are demagnetized. The total voltage will be appeared across the load.

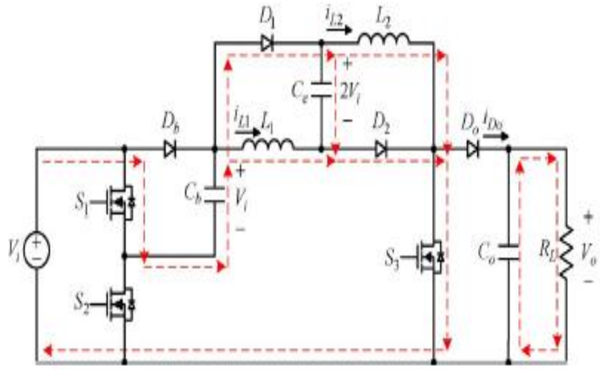

Figure 4. Type 1 converter during mode 1.

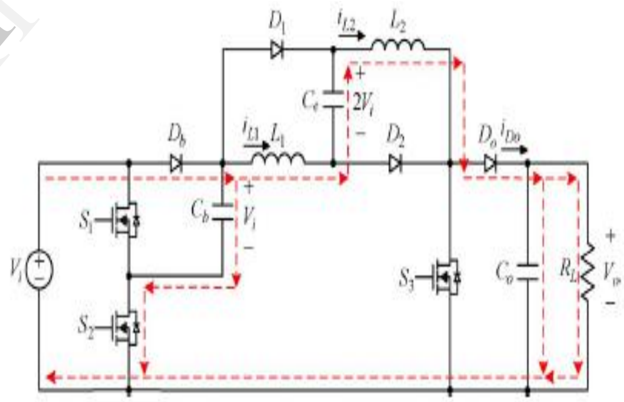

Figure 5. Type 1 during mode 2.

The voltage conversion ratio in the continuous conduction mode is given by

$$\frac{V_o}{V_i} = \frac{3+D}{1-D}$$

B. Type 1 with different values of boost inductor:

With different values of inductor three modes of operation will be there mode 1 and mode 3 are similar to that of mode 1 and mode 2 operation of similar values of inductor. Here, in mode2 the inductor with larger value will carry less current and gets magnetized whereas lower value will carry more current and becomes demagnetized. When ever both the currents are becoming equal it enters into the third mode of operation (Mode 3).

C. Type 2 with similar values of boost inductor:

Mode 1: In this mode switches S2 and S3 are turned on the capacitors C_e and C_b will be charged to input voltage and the

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inductors L1 and L2 will be magnetized as the switch S3 is turned on the diode D_o is reverse biased, during this period the output capacitor will deliver the power to the load.

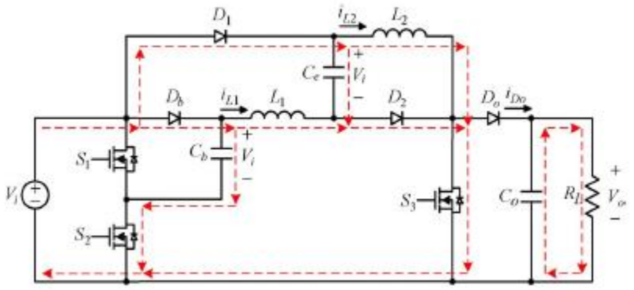

Figure 6. Type 2 converter during mode 1.

Mode 2: In this mode, the switch S1 is turned on and remaining switches will be in off condition. Here, both the capacitors will be discharged and the inductors L1 and L2 will be demagnetized and the output capacitor will be charged. Hence, the output voltage will be boosted and is higher than the input voltage.

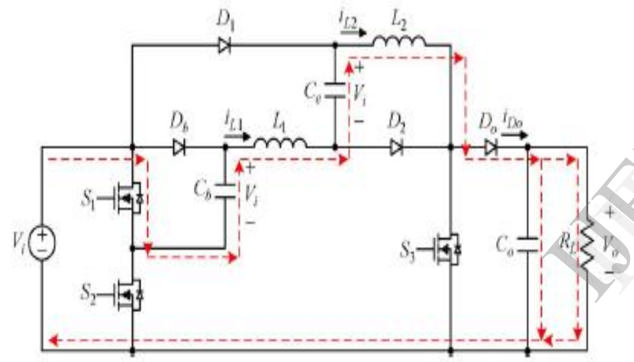

Figure 7. Type 2 converter during mode 2

D. Type 2 with different boost inductors:

With different values of inductor three modes of operation will be there mode 1 and mode 3 are similar to that of mode 1 and mode 2 operation of similar values of inductor. Here, in mode2 the inductor with larger value will carry less current and gets magnetized whereas lower value will carry more current and becomes demagnetized. When ever both the currents are becoming equal it enters into the third mode of operation (Mode 3).

IV. Simulation Results

MATLAB/SIMULINK is used for the simulation results. Figure 8 shows the simulation diagram of Type 1 converter circuit.

By observing the figure11 the capacitor voltage C_b and C_e are approximately equal to V_i and $2V_i$ respectively for type 1 circuit. In figure15 the capacitor voltage C_b and C_e are equal to V_i for type2 circuit. Figure12 shows the output voltage for type1 circuit and figure16 shows the output voltage for type2 circuit.

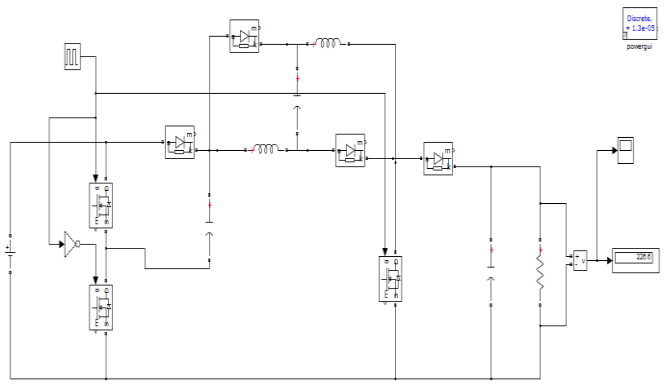

Figure 8 Simulation diagram for type 1 converter

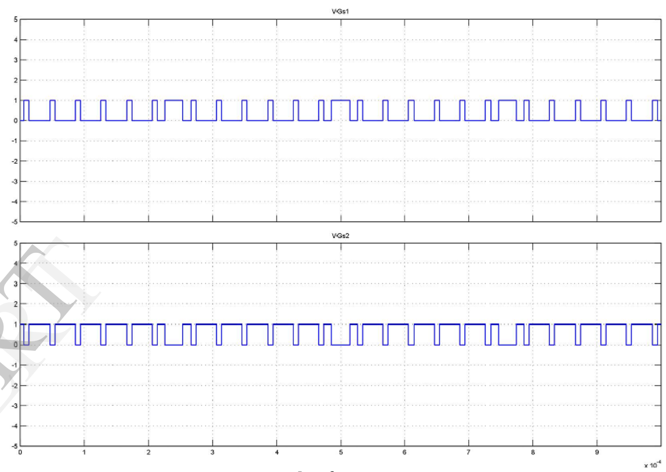

Figure 9 Gate Pulse for Type 1 converter

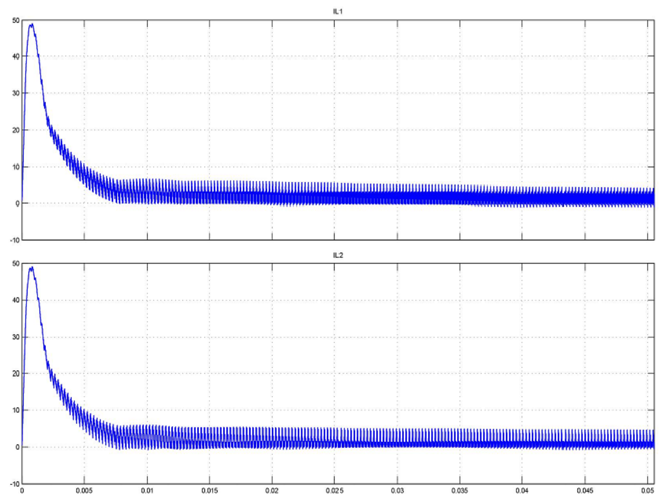

Figure 10 Simulation waveforms of Inductor current

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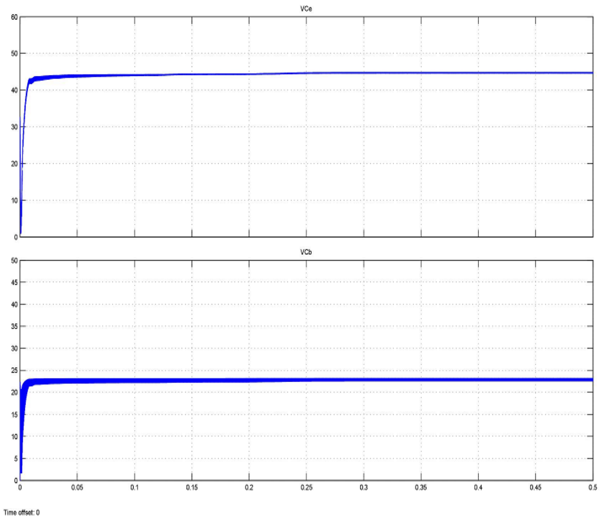

Figure 11. Simulation waveform for capacitor voltages.

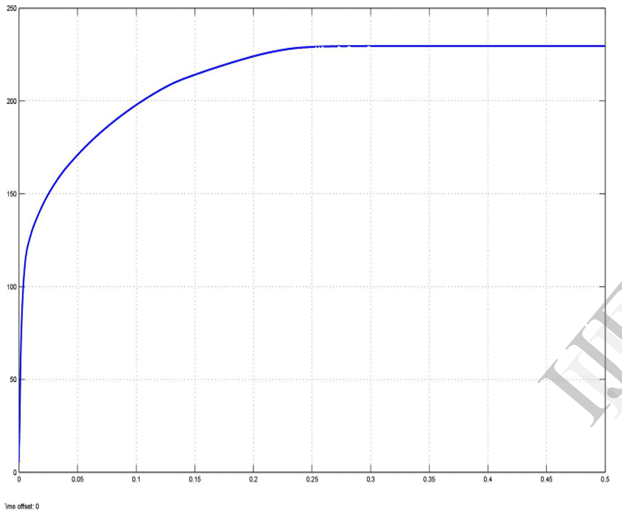

Figure 12. Simulation waveform for the output voltage

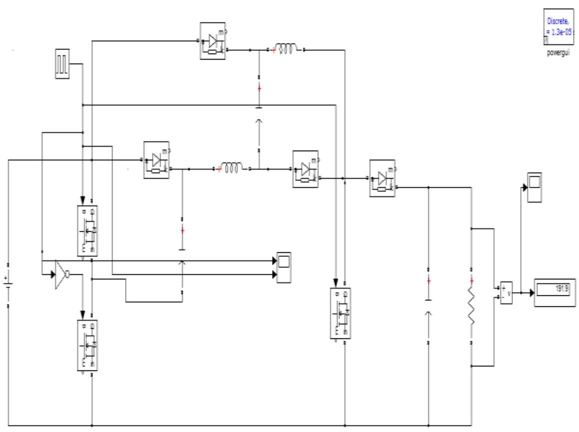

Figure 13. Simulation circuit diagram for type 2 converter

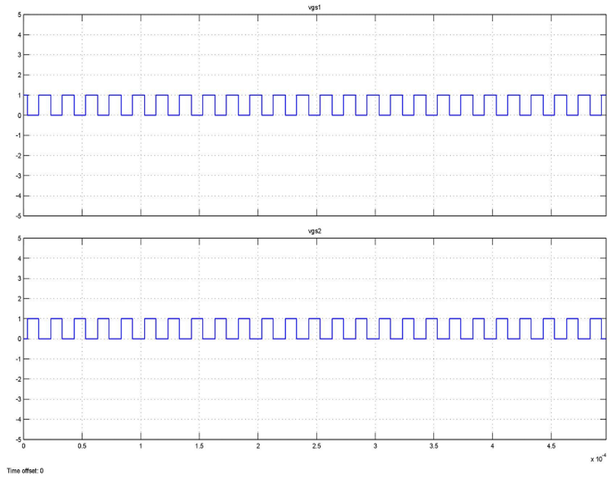

Figure 14.Gate Pulse for type 2 converter

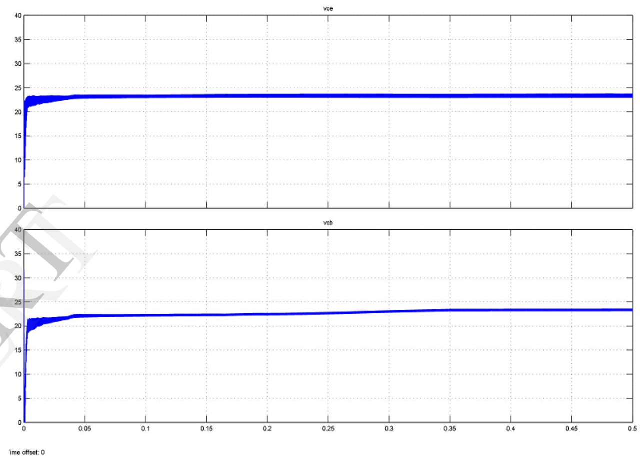

Figure 15. Simulation waveform for capacitor voltage

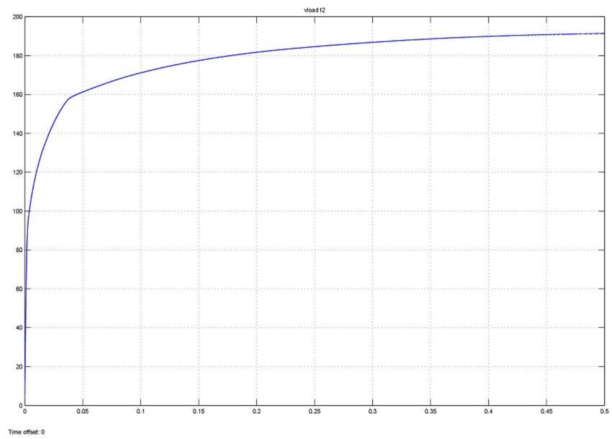

Figure 16. Simulation waveform for the output voltage

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V. CONCLUSION

In this paper, a novel boost converters are presented with the boost inductors and bootstrap capacitors with high conversion ratio is obtained. From the simulation results, both converters exhibit good performance with different inductor values and suitable for industrial applications.

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