STEP-UP CONVERTER WITH HIGH VOLTAGE GAIN USING QUASI SWITCHED INDUCTOR AND CAPACITOR

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Abstract - This paper presents the design and simulation of the modified step-up converter with high voltage gain using quasi switched inductor and capacitor. High Voltage gain are the major requirements for renewable energy applications. The operating modes of the converter is analyzed and the proposed converter is simulated using MATLAB/SIMULINK platform.

Key Words: High voltage gain, step-up converter, lower duty ratio.

1.INTRODUCTION

Step-up converters play a major role in power electronics. Although the conventional converters provide good performance, it requires higher duty ratio which is considered as an issue as it causes some disadvantages like reducing efficiency of the converter, increasing the stress and losses across the passive components. The proposed converter overcomes the above addressed issues by operating at lower duty cycle ratio.

Step-up converter with dual switch is proposed with minimum number of components by maintaining high gain ratio to maintain identical voltage between the cell stack and batteries in fuel-cell vehicles [1].

A switched inductor with two switches has been proposed to increase the gain of the converter, but there are more passive components, which increase the cost and size of the converter [2].

Efficiency of the system is increased by adopting coupled inductor technique. This converter can be used efficiently for photovoltaic source [3].

In order to overcome the drawback of the leakage inductor a step-up converter with coupled inductor and quasi-Z source network is implemented to reduce the voltage stress across the switch [4].

Active coupled-Inductor network [ACLN] is integrated with the boost converter. Lesser number of components increases the efficiency of power conversion [5].

Switched capacitor concept plays a major role for increasing the boosting capability of the system. Smaller size of passive components is required for maintaining higher efficiency [6].

Methods for increasing the voltage gain of the system have been analyzed by replacing the branches by various passive components from the same structure of the derived system [7].

A High voltage gain converter is proposed in this paper by integrating switched capacitor and quasi switched boost network modules. This converter provides voltage gain in the range of five to eight times of the input voltage [8] to meet the higher DC link voltage in fuel cell vehicles.

The hybrid DC Converter is proposed with lesser number of components which gives high voltage gain with lower duty cycles. This reduces voltage stress and conduction losses across the power semi-conductor switches [9].

A Novel step-up converter with active switched inductor (ASL) and a passive switched-capacitor (PSC-SU2C) networks is proposed. It reduces voltage stress across switches with reduced number of components while comparing with topologies that provides with same voltage gain [10].

In [11], a hybrid gain DC-DC converter is proposed. A single voltage source is integrated with a trio of voltage booster modules. An active switch, a linked inductor, diodes, and capacitors make up this three-boost module. Voltage spikes are lessened by clamping the voltage across the switch, and the converter's efficiency is raised by recycling leakage energy in the inductor. This converter is effective for solar and fuel cell power systems [11].

The simulation result of the proposed converter is shown in this paper. Section 2 elaborates the operating modes of the proposed converter. Section 3 reveals about the component parameters design, specifications of the converter. Section 4 displays the voltage across Switches and passive components and comparison of Output voltage between existing and the proposed converter.

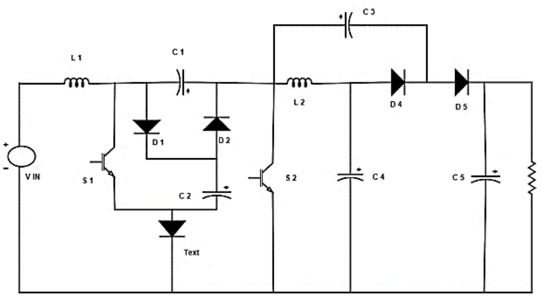

Figure 1: Proposed Converter

2.OPERATING MODES OF THE PROPOSED CONVERTER

This part provides the operating principle of the proposed converter in continuous conduction mode (CCM). This converter has two power semi-conductor switches S1 and S2. The inductor and capacitor at the output side of the converter increase the voltage gain of the converter. The proposed converter has two inductors, five capacitors and five diodes.

The working of the converter operates in two modes. They are ON mode and OFF mode.

a. ON MODE

In this mode, both the switches S_1 and S_2 are turned on simultaneously. The diodes D_1 and D_3 gets reverse biased. The capacitor C_2 charges the capacitor C_1 through the forward biased diode D_2. The inductor L_2 is charged by the capacitor C_3. The capacitor C_4 and C_5 charges the load through the diode D_4 and D_5.

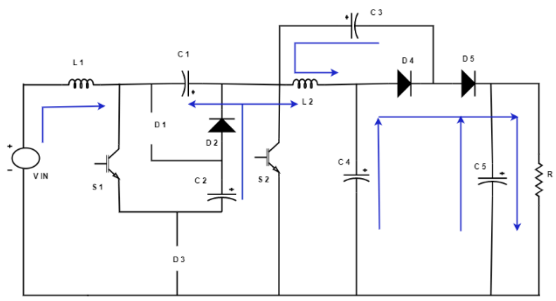

Figure 2: Mode 1 Operation

$$C_2 = C_1 \quad (1)$$

$$V_{in} = L_1 \quad (2)$$

$$C_4 + C_5 = V_o \quad (3)$$

b. OFF MODE

In this mode, Both the switches S_1 and S_2 are turned off at the same time. The inductor L_1 discharges through the diode D_2 and charges the capacitor C_2. The diode D_3 is forward biased. The diode D_2 gets reverse biased. The capacitor C_1 charges the capacitor C_3. The inductor discharges and charges the capacitors C_4, C_5 and the Load.

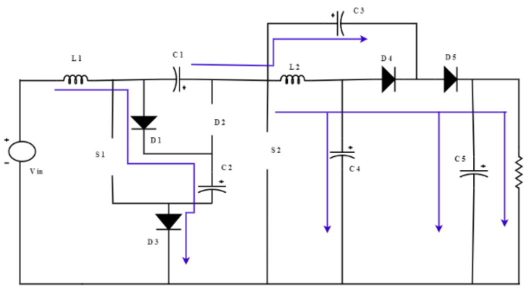

Figure 3: Mode 2 Operation

$$L_2 = C_4 + C_5 + V_o \quad (4)$$

By applying volt-second balance to the proposed topology, the voltage gain of the converter can be given as,

$$G_{CCM} = \frac{2V_{in}}{(1-D)D} \quad (5)$$

3.COMPONENT PARAMETERS DESIGN

By considering the amount of ripple in the inductor current, the inductances of the inductors can be calculated as follows,

$$L = \frac{V_{in}(1-D)D}{\%rofIL} \quad (6)$$

$$\Delta I_L = r\%ofIL \quad (7)$$

Where r is the amount of percent ripple.

Table 1: Specification of the converter.

Parameter	Value
InductorsL_1, L_2	500µH
Capacitors C_1, C_2	40µF
Capacitors C_3, C_4, C_5	100µF
Resistance	200Ω
Input Supply	28V
Frequency	40kHz

The proposed converter obtains 386 volts at 0.25 duty cycle. The simulation and output of the proposed converter is obtained as follows.

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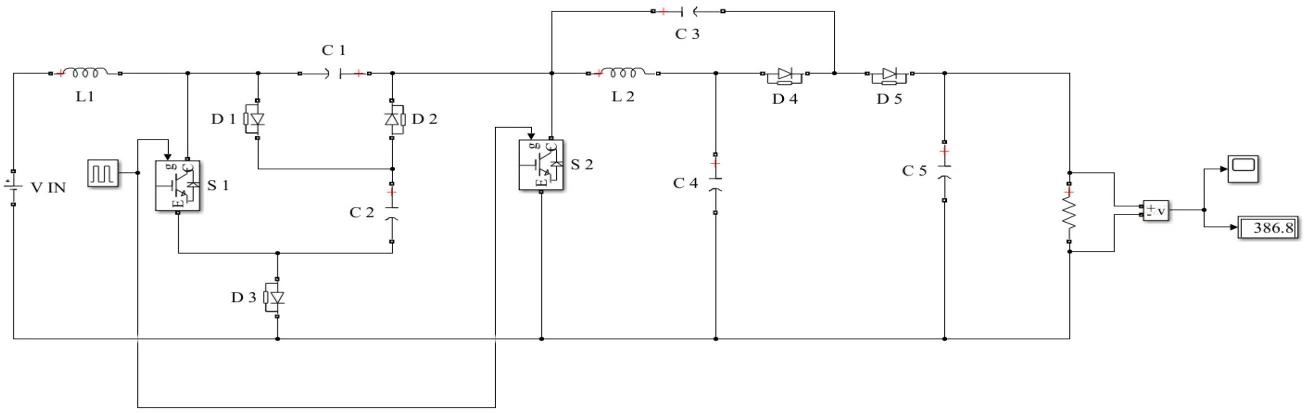


Figure 4: Simulation of the proposed system

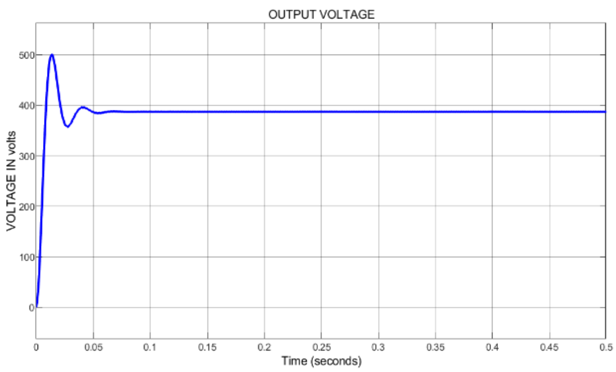
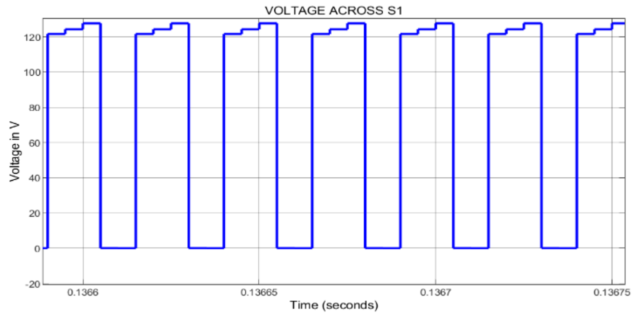


Figure 5. Output Waveform of the proposed Converter.

4.VOLTAGE ACROSS SWITCHES AND PASSIVE COMPONENTS



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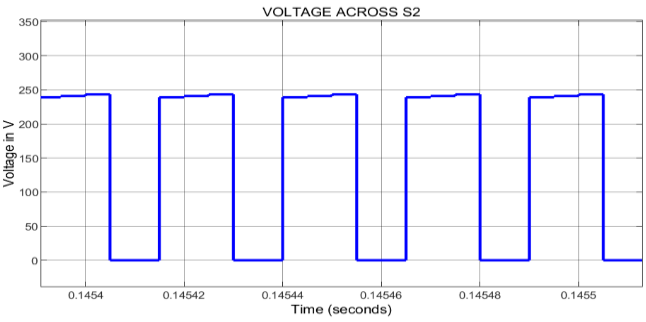
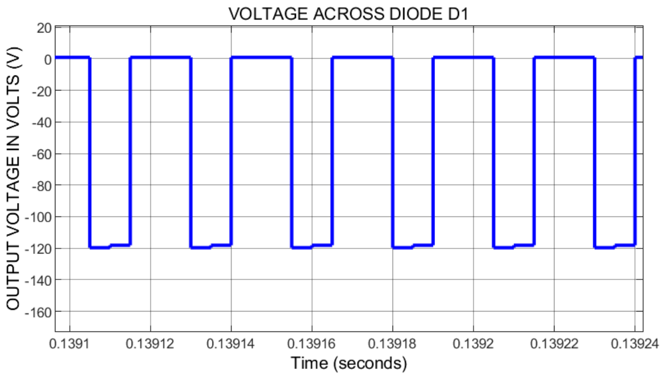


(b)

Figure 6 : Voltage across Switches a) S_1 & b) S_2



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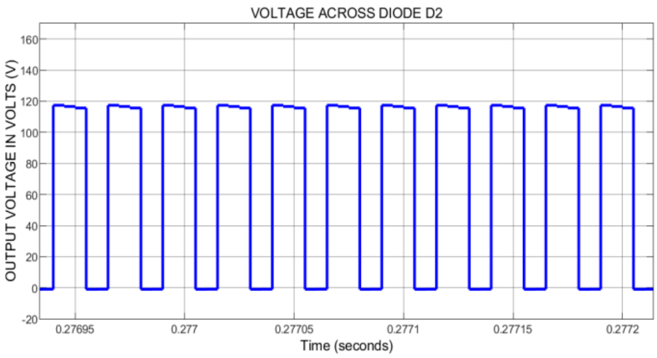

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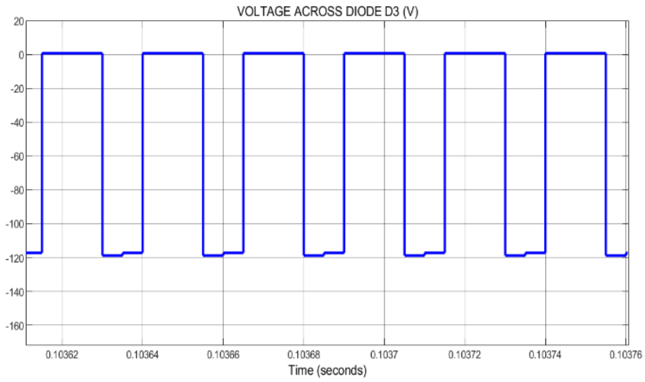

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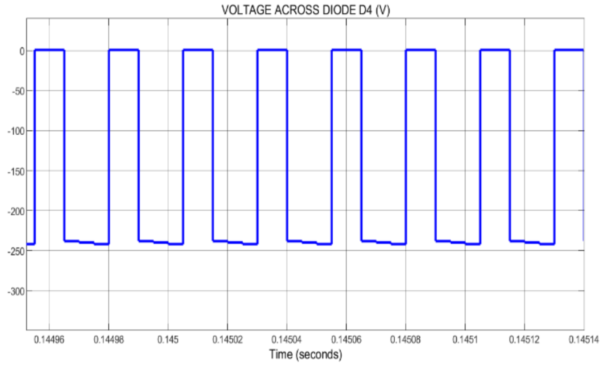

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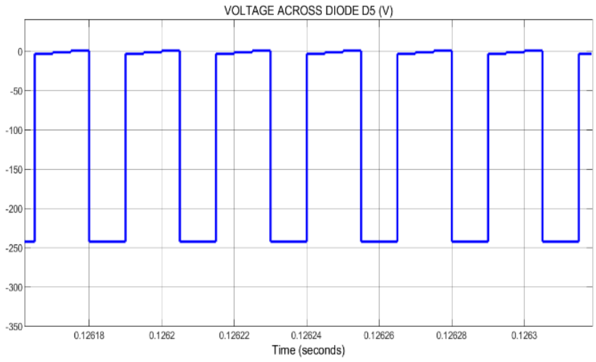
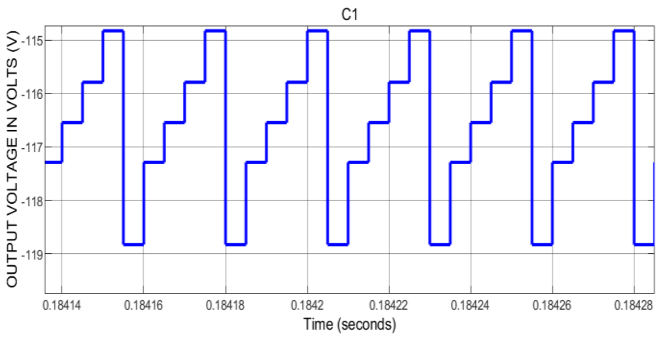


(e)

Figure 7: Voltage across Diodes a) D_1 b) D2, c) D_3, d) D_4, e) D_5



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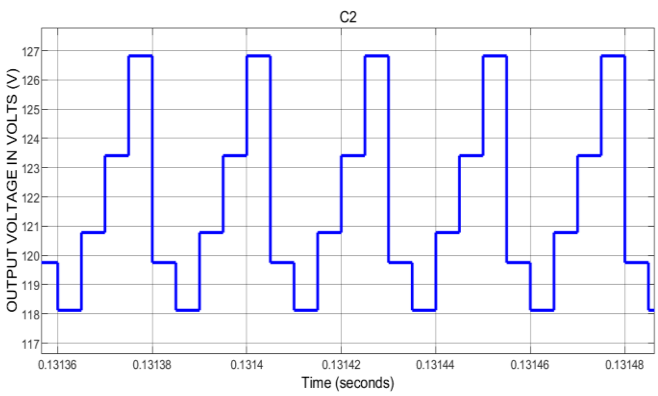

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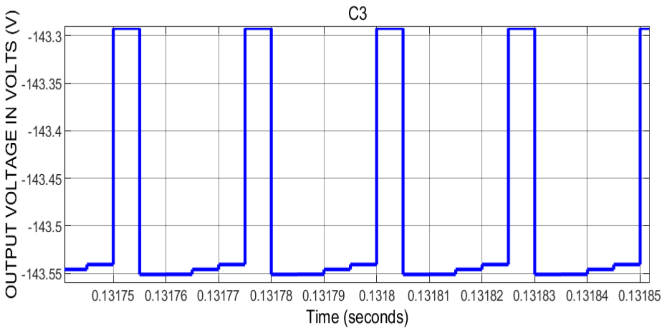

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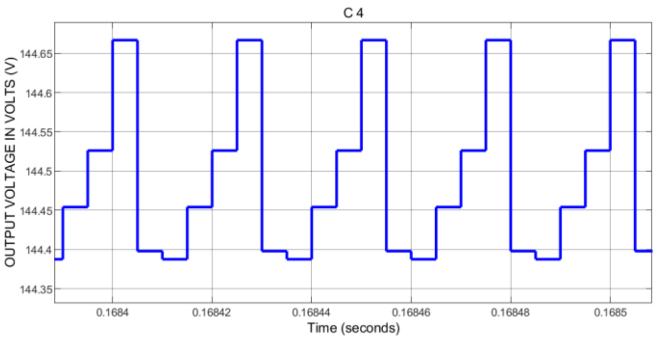

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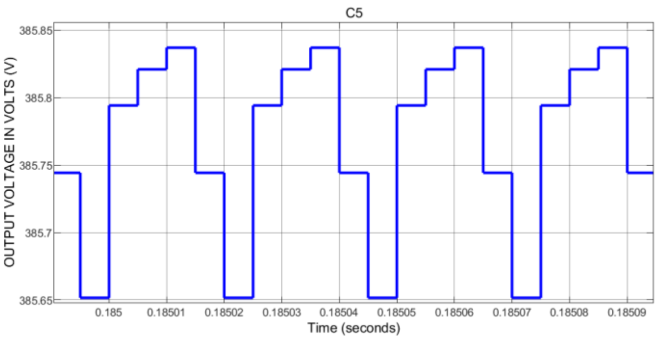

(e)

Figure 8: Voltage across Capacitors (a) C_1, (b) C_2 , (c) C_3 ,(d) C_4 ,(e) C_5.

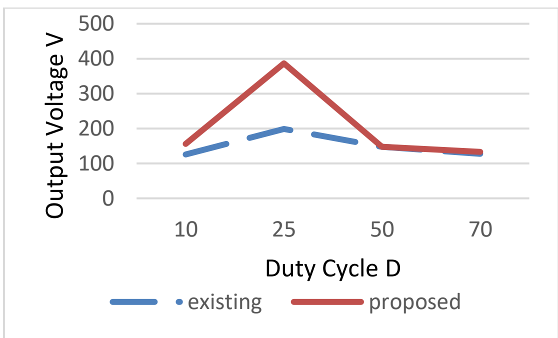

Figure 9: comparison of Output voltage of the converter in [8] and the proposed converter

5.CONCLUSION

In this paper, a step-up DC-DC converter with high voltage gain is proposed. The proposed converter has higher voltage gain than the existing converter. This converter has minimum stress across the passive components. This can be used for renewable energy applications, fuel cell vehicles. The proposed converter can be operated efficiently at lower duty cycles. Proposed Converter is simulated using MATLAB/SIMULINK platform successfully.

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