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Single Switch High Boost Non Isolated DC-DC Converter

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***Abstract*— The major classification of the DC-DC converter is isolated and non-isolated converters depending on high voltage conversion ratio. The high voltage gain is attained by changing the turns of the transformer. One of the main features of this converter is which can provide a high step up voltage conversion ratio within a moderate duty cycle and also improved voltage gain. To minimise the voltage stress across the semiconductor devices this converter utilizes the properties of SEPIC and boost converter with diode capacitor circuit. This converter uses MOSFET switch with reduced switching and conduction loss. The single switch high boost non-isolated DC-DC converter can produce low switching voltage so it can improve its efficiency. The converter simulation is done in MATLAB/SIMULINK R2017a environment. Arduino microcontroller is utilized for the switching pulses of this control circuit. To verify the performance and operating principle output voltage of 390V and input voltage of 30V with output power of 390W prototype is constructed and the results are validated.**

Keywords*— *Boost converter, MOSFET switch, SEPIC converter, High voltage gain, non isolated dc–dc converter.

I. INTRODUCTION

Renewable energy is increasing enormously and plays a very crucial role in the production and distribution systems. In environment, the photo voltaic sources are capable of producing low voltage dc and hence it is not appropriate for direct connection to microgrid. Hence to increase the voltage level, PV modules are connected in series way. The usage of DC-DC converters are not only overcome this draw-back; it is also very helpful in boosting the low voltage level to high voltage with good efficiency. It's helpful in utilizing renewable energy in a better and efficient way. The main and important features of high step-up converters are their large conversion ratio, small size and high efficiency.

The main classification of the DC-DC converter is isolated converters and non-isolated converters based on high voltage conversion ratio. The Isolated converter type model has a transformer model in it. The high voltage gain is obtained by means of adjusting the number of turns of transformer. Under this type of classification of non-isolated converters conventional boost converter delivers high voltage gain ratio with large duty cycle resulting in large switching voltage stress which in turn lower the efficiency and produces very large inductor current ripples. In order to improve conversion efficiency and to obtain high step-up voltage gain, many DC-DC converter topologies are developed and implemented.

A property of switched capacitor and voltage lift techniques has used to obtain high step-up voltage gain ratio. But, in these structures, high charging currents will circulate through the main switch and thus it leads to the increase in conduction losses. By adjusting the turns ratio, Coupled-inductor based converters also can obtain high step-up voltage gain. Switched capacitor is aligned at the switching condition of the DC converter to get improved voltage ratio with required duty cycle. But one major drawback of this technique is, a pulsating input current is produced which causes to load problems and poor line in the system.

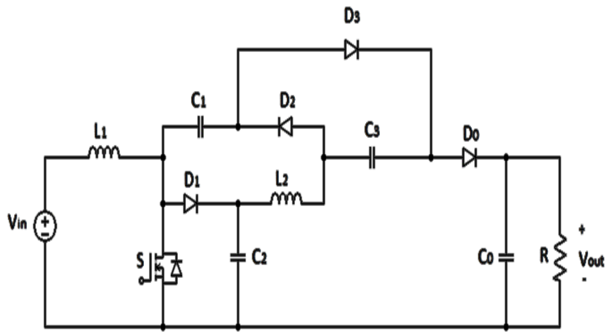

Fig. 1 Single switch DC-DC converter

S Saravanan, and N Ramesh Babu proposes a DC-DC converter which has high voltage gain even using a single switch. There are 4 modes of operation. In mode 1, the switch S is turned ON, Diode D_3 will be in conducting state and diodes D_0, D_1, and D_2 are in blocked state. inductors $L_1$and L_2 and Capacitor C_1 get charged. This mode terminates when current in diode D_3 becomes zero. The switch S is continue to be in ON state at mode 2 and diodes D_0, D_1, D_2, and D_3 are in blocked state. Inductor L_1 get charged from the input side. As D_O is in blocked state capacitor C_0 supplies current to output resistor. When the diode D_2 starts conducting, then this mode ends. In mode 3, the switch S is in ON state and diode D_2 is in conduction mode and diodes D_1, D_3, and D_O are in blocked state. $L_1$and L_2 get charged. The capacitor C_1 gets charged though diodes. This mode of operation ends, when current in diode D_2 become zero and switch S is turned OFF. The switch S is turned off at mode 4 and diode D_2 will be in blocked state and diodes D_0, D_1, and D_2 are in conduction mode. Inductors $L_1$and L_2 get discharged. The capacitor C_2 is getting charged. When the main switch S is turned ON then this mode of operation gets completed.

In order to improve the voltage gain of the circuit pointed above modified the circuit by adding a capacitor in the input

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side. By adding this, it is observed that the gain can improved to 13. There is no any difference in designing aspects.

II. PROPOSED CONVERTER

Proposed non isolated single switch high step up DC-DC converter is shown in figure 2. It consists of two inductors (L_1 and L_2), four power diodes (D_0–D_3), five capacitors (C_0 –C_3 and C_M), one power switches (S), and a resistive load (R).

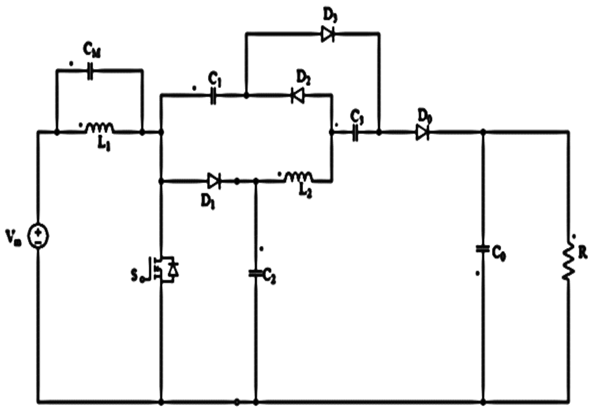

Fig.2: Proposed converter

the following assumptions are taken consideration while designing the converter:

1) All components are taken as ideal and lossless.
2) Frequency of the switches are kept constant.
3) Capacitors are designed in such a way that ripple voltage across the capacitor are low.

III. OPERATING PRINCIPLES

The working of the circuit can be explained by the given 4 modes. The given figure (3), (4), (5), (6) shows the operating modes of the converter in the CCM.

Mode 1

In this mode of operation, the switch S is in ON state. And diode D_3 is in conduction mode and diodes D_1, D_2, and D_O are in blocked state. The energy will store in both inductors during this operation. The input voltage makes the capacitor C_1 to charge the capacitor C_3. The input capacitor Cm will get charged. Output capacitor C_O gets discharged at this stage so that output load gets energy. This operation completes, when diode D_3 current becomes zero.

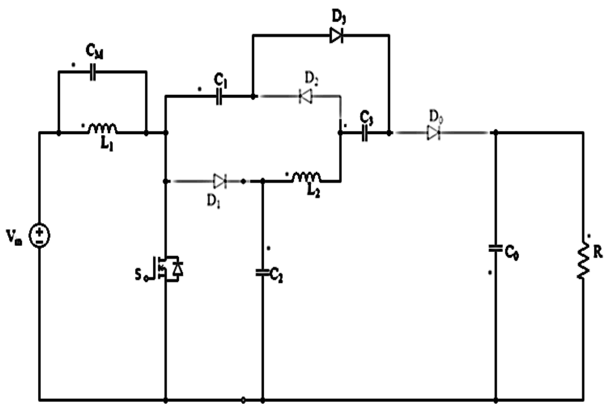

Fig.3: Mode 1

Mode 2

The switch is continued to be in ON state. Diodes D_1, D_2, D_3, and D_0 will restrict the flow of current ie; blocked state. Inductor L_1 and input capacitor Cm get charged at this stage. When the diode D_2 starts conducting then this mode of operation finishes.

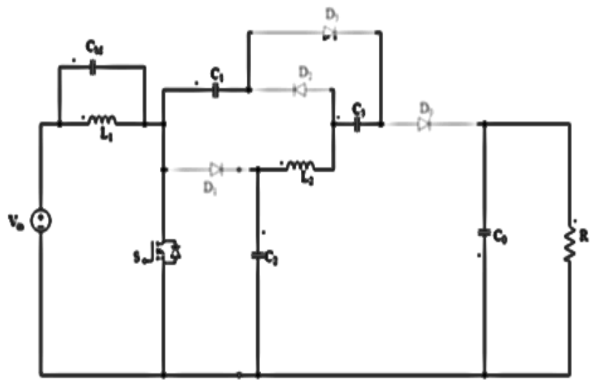

Fig.4: Mode 2

Mode 3

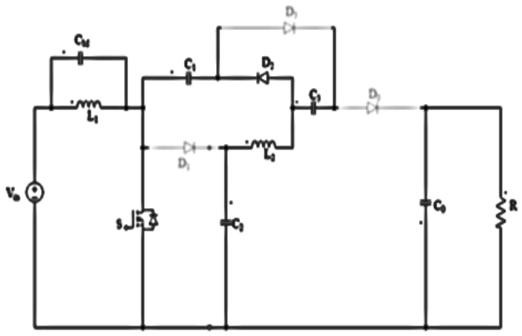

Fig.5: Mode 3

The switch S is ON at this mode and is shown in figure 5. Diode D_2 is in conducting mode. The diodes D_1, D_3, and D_O are in blocked condition. The capacitor Cm will get charged. Inductors $L_1$and L_2 and the C_1 capacitor are charged through the path diode D_2. When current through diode D_2 become zero and the main switch S is turned OFF, then this mode of operation completes.

Mode 4

In this mode of the operation, the switch S is in OFF state. The diode D_2 is also in OFF condition and the current flows through diodes D_1, D_3, and D_O as shown in figure 6.

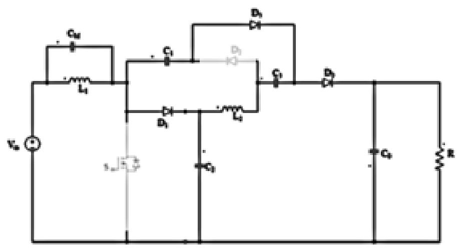

Fig 6: Mode 4

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The inductor L_1 and inductor L_2 will discharged and capacitor C_2 is charged at this stage. Also the input capacitor C_m will discharge the energy. When the main switch is turned ON, one period of cycle ends.

IV. DESIGN CONSIDERATIONS

A. Inductors

The value of the inductor L_1 and L_2 are calculated as per the given equations.

$$L_1 \leq \frac{V_{in} * D}{\Delta I_L * f_s} \qquad (1)$$

$$L_2 \leq \frac{V_{C2} * (1-D)}{\Delta I_{L2} * f_s} \qquad (2)$$

B. Capacitors

$$C = C_1 = C_2 = C_3 = \frac{I_{out} * D}{\Delta V_c * f_s} \qquad (3)$$

C. Output Capacitor C_0

$$C_0 = \frac{I_{out} * D}{\Delta V_0 * f_s} \qquad (4)$$

V. SIMULATION RESULTS

The simulation parameters of single switch high boost up non isolated dc-dc converter is given in the below table.

An input voltage V_{in} of 30V gives an output voltage V_O of 390V for an output power P_O of 390W.

TABLE 1. SIMULATION PARAMETERS

Parameter	Values
Output voltage	390 V
Input voltage	30 V
Output power	390 W
Capacitor C_1, C_2, C_3, C_0	2.08 µF 140 µF
Inductor L_1, L_2	205 µH,180 µH
Switching frequency	24 kHz

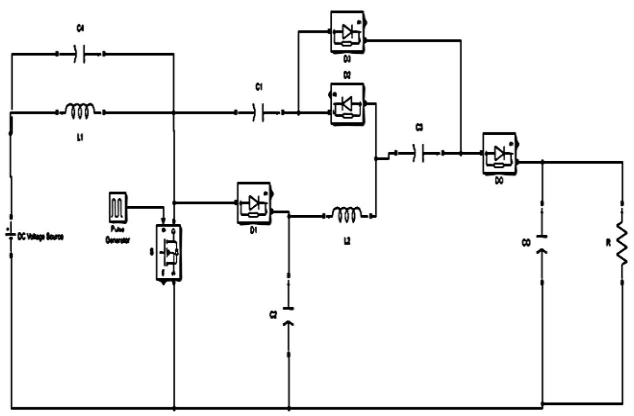
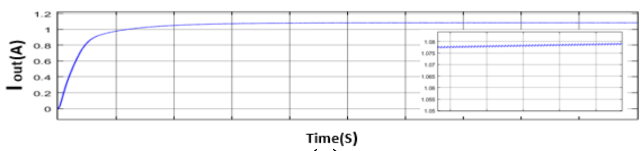
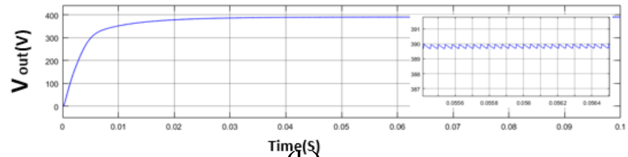


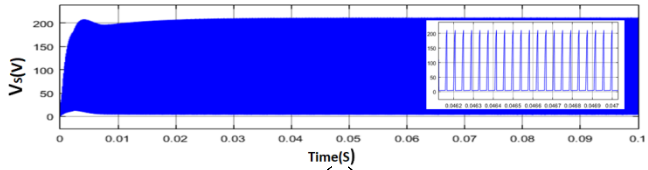
Fig. 7. Simulink model of proposed converter



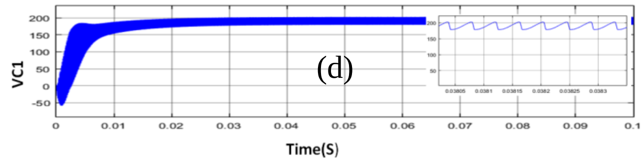
(a)



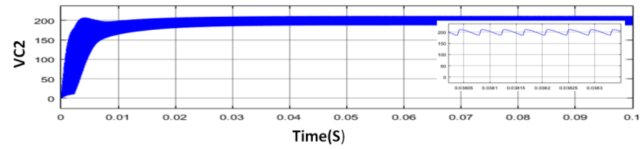
(b)



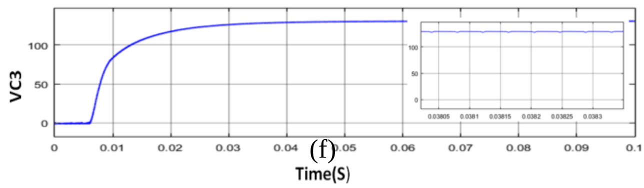
(c)



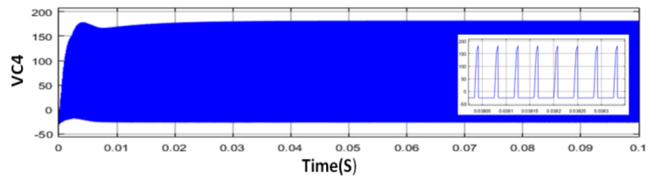
(d)



(e)



(f)



(G)

Fig.8:(a) Output Current (b) Output Voltage (c) Voltage Stress S (d) Voltage across C_1 (e) Voltage across C_2(f) Voltage across C_3 (g) Voltage across C_4

The simulation results of proposed converter is shown in the figures.

The switching frequency is 24kHz. The gate pulse of main power device has fixed duty cycle of 81%.

It can be seen from the Figure 8(a) and Figure 8(b) and 8 (c) that the output current is 1A, the output voltage V_0 is about 390 V and output power is 390W.As shown in Figs. 8(d) and 8(e), the voltage of the capacitor C_1 and $C_2$is boosted to 200V.

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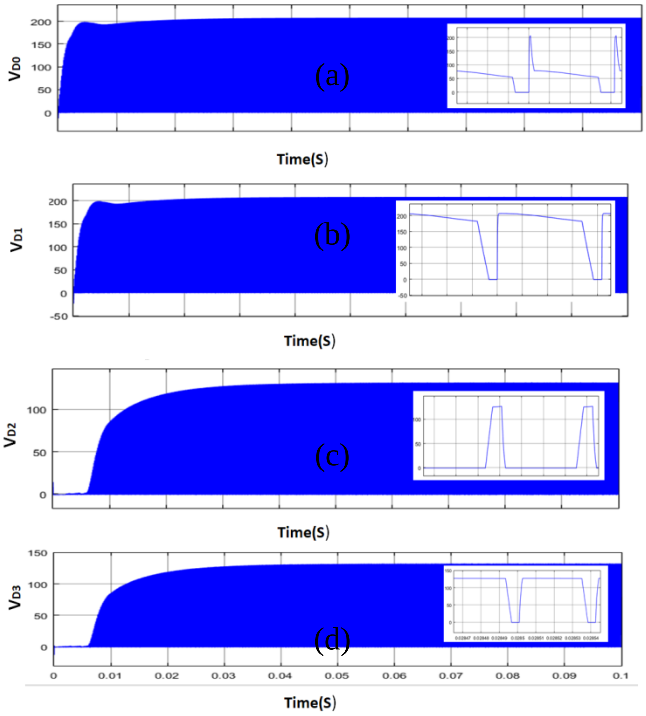


Fig.9: (a) Voltage across D_0 (b) Voltage across D_1 (c) Voltage across D_2 (d) Voltage across D_3

VI. ANALYSIS

A. *Efficiency Vs Output Power*

Efficiency is an expression of the effectiveness exhibited by a machine to deliver as per its design. It is simply defined as the ratio of the power output to the power input. From this analysis we can understand that how much input power is delivered to the load. Figure 10 shows Efficiency Vs Output Power graph

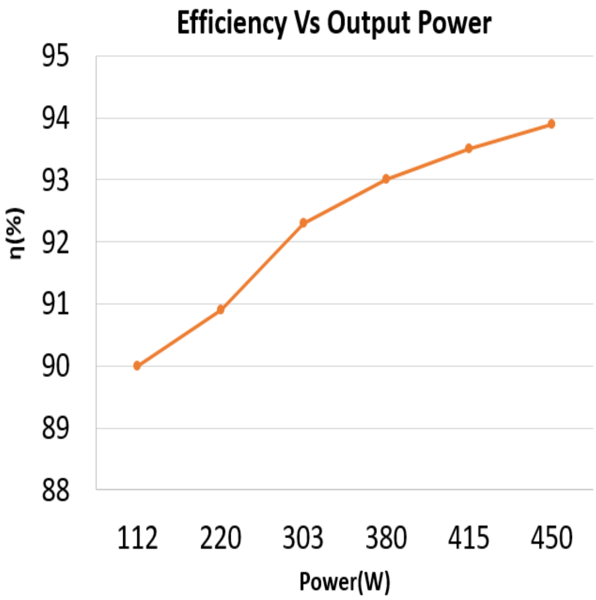


Fig.10: Efficiency Vs Output Power

B. *Gain Vs Duty Cycle*

A typical curve represented below shows the voltage gain as a function of duty cycle. From the figure 11, we realize the fact that the voltage gain is 13 when the duty cycle is equal to 0.81.

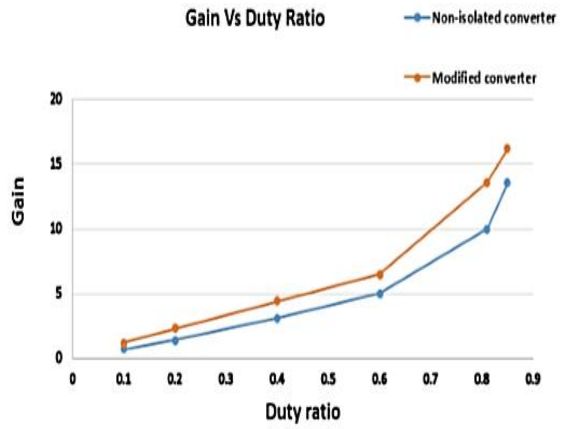
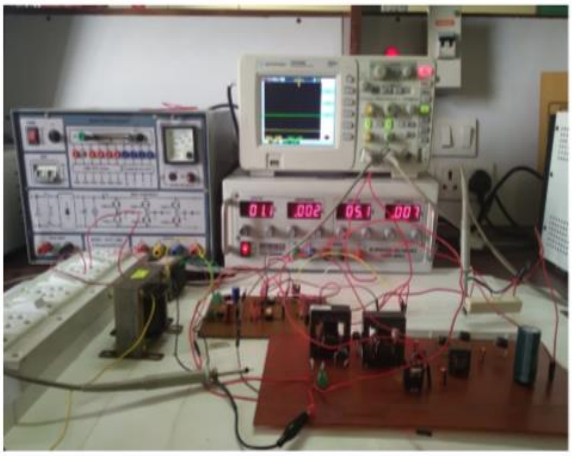


Figure 11: Gain Vs Duty Cycle

Fig.12.Experimental Setup



VII. CONCLUSION

The single switch high boost non isolated dc-dc converter offers a high conversion ratio, low switch voltage stress. The result of the design shows that the switch and diodes have relatively low voltage stresses and hence the switching and conduction losses are reduced. And as a result of this it achieves an improved overall efficiency. In this the input voltage is 30 V and the output voltage is 390 V, this shows the high step up voltage gain. The proposed converter has an efficiency of 94 % and voltage gain of 13. To limit the voltage stress across the switches and diodes, we must maintain a duty ratio of 0.81. The overall analysis and results shows that the converter can be used for applications with low input voltage and high output voltage, such as battery chargers, distributed power systems etc.

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