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High Gain Step Up DC-DC Converter at Lower Duty Cycle

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Abstract: Micro-grid provides high efficiency, low cost and clean energy. Micro-grid comes on variety of design and sizes. Nowadays, DC micro-grid plays a vital role because of remarkable amplifying DC load. Photo voltaic source is the first source of energy. High voltage gain in Boost converter are limited by high duty cycle. This will leads to serious reverse recovery problem, high conduction loss etc. Isolated converter such as fly back, Bridge converter etc., since the above problem. But it uses transformer or coupled inductor which causes voltages spike at the main switch and power loss due to leakage inductance. The conventional Boost converter is compared with the high gain step-up DC-DC converter circuit. Thus results the, high gain with low duty cycle. The major important is we can supply power for two loads. Theoretical verification is done using MATLAB software. Where practical verification is done by Ardiuno connected with the isolated circuit and then connected with the main circuit.

Keywords: DC-DC boost converter; DC microgrid; Duty cycle

I. INTRODUCTION

In recent years High gain step up DC-DC converter used in many applications such as renewable conversion. Renewable energy source like solar photovoltaic, fuel cells etc., generate DC power [2] [3]. Due to small size and power density the DC-DC converter is gaining more attention is renewable energy system. Almost every electronics device run or DC. Dc is stable, so all the electronics device performing logic operation and need to have specific levels which defines them. Solar power is the to a clean energy future. Solar panels produce electricity by transforming the continuous flow of energy [1]. The photo voltaic process thus does not require any fuel has no variable cost. No greenhouse gas emissions are released into the atmosphere when your use solar panel to create electricity and because the sun provide more energy than use need. Transformer less DC-DC converter is used in this paper [4]. The converter which basically uses transformer to boost the voltage which cause voltage spike at the main switch and power loss [2]. In this paper we proposed the high gain DC-DC converter with switched capacitor. The continuous conduction mode and discontinuous conduction mode is briefly discussed in this paper. The main issues which caused by using a transformer in DC-DC converter such as cost, size, weight is drastically reduced in the paper [5]. The additional advantage is, it is compared within the conventional converter and the experimental verification is done with the help of theoretical value. We have used switched converter is used in this paper to achieve the high gain[5]. In this paper a high gain step-up DC-DC converter using switched capacitor for solar PV application is proposed. The converter used in this paper is compared with the conventional converter. The converter used in this paper is transformer less converter which will overcome the above stated problem. The converter used in this paper, the experimental verification is done with the help of theoretical value.

II. RELATED WORK

The output voltage has a direct relationship with the duty cycle. In the beginning the conventional Boost converter like SIC (Switched Inductor Converter), SCC (Switched Capacitor Conductor), CBC (Cascaded Boost converter) is used. But it is limited by extreme duty cycle which is the main drawback to attain high gain. In accordance with the extreme duty cycle it causes problems like serious reverse recovery time, high conduction losses, serious reverse recovery time leads to large voltage across the diode and consumption of large current while its recovering. High conduction loss leads to higher gate drive loss that emits an electromagnetic emission that causes a disturbance in another piece of electrical equipment. Due to this limitation the conventional Boost convertor are not used nowadays. To overcome this limitation Isolated Converter such as Fly-back Converter, Bridge Converter is used. Where is overcomes the limitations of Conventional Boost Converter, whereas the Isolated Converter uses transformer or Coupled Inductor, which cause voltage spike at the main switch and power loss due to Leakage inductance. Thus, the proposed high gain DC-DC Converter eliminates all the issues faced by the Conventional Converter and Isolated Converter.

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III. MOTIVATION

Since the usage DC-DC Converter is high nowadays. It plays a vital role. The DC-DC converter is used while connecting DC Source to DC micro-grid. Generally, DC-DC converter are electronic devices used whenever there is a need to bring up or down a DC voltage level to another. It is also used to match the loads to the power supply. Photovoltaic source is one of the prime sources of energy in Dc micro-grid. Thus, to overcome all these facts the high gain DC-DC Converter is proposed in this paper.

IV. PROPOSED CONVERTER

In this paper a high gain step-up DC-DC converter is proposed. It contains two DC voltage level. The one is very high voltage level for high power DC bus. Another one is relatively less high voltage level for low power DC bus.

The proposed converter contains,

Inductors → L_1, L_2

Capacitors → C_1, C_2

Diodes → D_1, D_2, D_3

Controlled Switches → S_1, S_2, S_3.

To control the voltages at two DC buses by using a duty cycle. By applying single Duty cycle voltage gain at two buses are, the voltage at one bus can be maintained within a permissible range, then other bus voltage as kept desired.

The parameters used for this proposed converter are:

Parameter	Values
Switching frequency(F_s)	10kHz
Inductor(L_1)	1MH
Inductor(L_2)	3MH
Capacitor(C_1)	1000μF
Capacitor(C_2)	1000μF
Load at low power DC bus($Load_1$)	1000Ω
Load at low power DC bus($Load_2$)	100 Ω
Source Voltage(V_i)	48V
Duty Cycle(D)	0.369

Table 1. Parameters considered for the converter

V. CIRCUIT DIAGRAM FOR PROPOSED CONVERTER

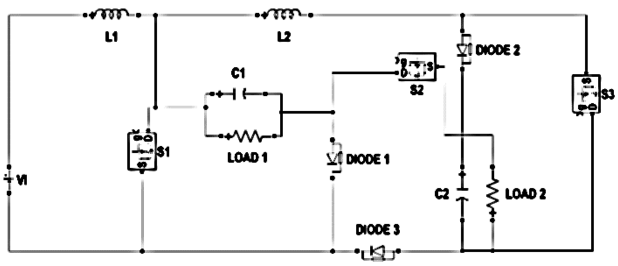


Fig 1. Equivalent circuit of high gain step up DC-DC converter when DC buses are replaced by loads

A. *Mode 1*

Circuit diagram:

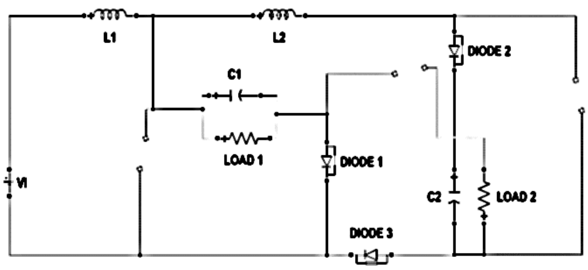


Fig 2. The equivalent circuit of high gain step up DC-DC converter when all the controlled switches are turned OFF

Let,

V_i → Low voltage PV source

V_{L1} → Voltage across inductor L_1

V_{L2} → Voltage across inductor L_2

V_{C1} → Voltage across capacitor C_1

V_{C2} → Voltage across capacitor C_2

D → Duty cycle of controlled switches

T_S → Switching time period of controlled switches

T_{ON} → Switch ON time period.

When controlled switches S_1, S_2, S_3 are OFF, the diodes D_1, D_2, D_3 are forward biased. So, the input voltage V_i and L_1, L_2 energize the capacitors C_1, C_2.

By applying Kirchhoff's voltage law, the voltage across inductors are, as below,

$$V_{L1}=V_i - V_{C1} \quad (1)$$

$$V_{L2}=V_{C1} - V_{C2} \quad (2)$$

B. *Mode II*

Circuit Diagram:

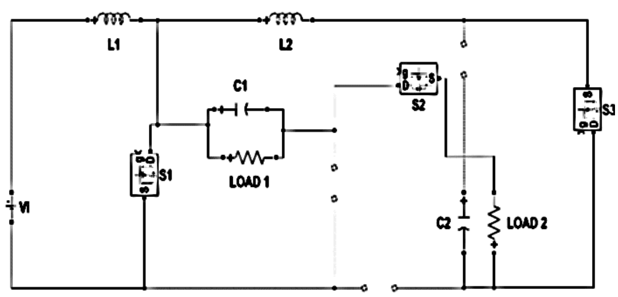


Fig 3. The equivalent circuit of high gain step up DC-DC converter when all the controlled switches are turned ON

When the controlled switches S_1, S_2, S_3 are in ON state, the diodes D_1, D_2, D_3 are in reverse biased. So that the input voltage V_i along with capacitors C_1, C_2 energize the inductors L_1, L_2.

By applying Kirchhoff's voltage law, voltage across L_1, L_2 are defined as follows,

$$V_{L1}=V_i \quad (3)$$

$$V_{L1}=V_{C1}+V_{C2} \quad (4)$$

By using equations (1) and (3),

$$(1)*(1-D)T_S \rightarrow (V_i-V_{C1})\,(1-D)T_S \quad (5)$$

$$(3)*DT_S \rightarrow V_i\,DT_S \quad (6)$$

By using equation (5) and (6),

$$(V_i-V_{C1})\,(1-D)T_S + V_i\,DT_S = 0 \quad (7)$$

From this equation (6),

$$V_{C1} = \frac{V_i}{1-2D} \quad (8)$$

Similarly, using equations (2) and (4),

$$(2)*(1-D)T_S \rightarrow (V_{C1}-V_{C2})\,(1-D)T_S \quad (9)$$

$$(4)*DT_S \rightarrow (V_{C1}+V_{C2})\,DT_S \quad (10)$$

By using equations (9) and (10),

$$(V_{C1}-V_{C2})\,(1-D)T_S + (V_{C1}+V_{C2})\,DT_s = 0 \quad (11)$$

From this equation (11),

$$V_{C2} = \frac{V_{c1}}{1-2D} \quad (12)$$

By using V_{C1} from equation (8),

$$V_{C2} = \frac{V_i}{(1-2D)(1-2D)} \quad (13)$$

By comparing equations (8) and (13), the voltage gain at capacitor C_2 is significantly high.

VI. COMPARISON

A comparison is made between the conventional Boost converter and proposed High gain DC-DC converter. The comparison is made with a. The comparison is specifically based on the duty cycle. The graph is plotted between voltage gain and duty cycle.

The difference table is given below,

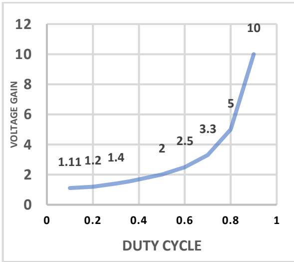
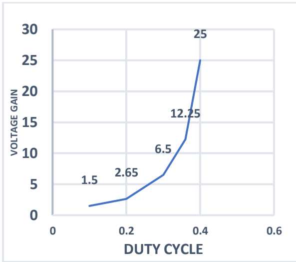
Boost Converter	**Proposed Converter**
	
Output Voltage: $V_o = \frac{V_S}{1-D}$	Output Voltage: $V_o = \frac{V_i}{(1-2D)(12D)}$
Voltage Gain (V_g) = $\frac{V_o}{V_i}$ For our duty cycle 03.6, V_g = 1.11V	Voltage Gain (V_g) = $\frac{V_o}{V_i}$ For our duty cycle 03.6, V_g =1.5V

Table 2. Comparison between Boost Converter Proposed Converter

VII. APPLICATION

The main objective of this converter is significantly increase in DC loads and demand of high quality. DC micro-grid are more efficient than the AC system because, DC electrical loads such as LE lighting of electronic gadgets which are 20% of total electricity consumers in residential and commercial buildings. Changing stations for electric vehicles, Heating, Ventilation and Air Conditioning (HVAC) systems and various household appliances are well suited to DC power. Data centred which operate at 10% higher efficiency, 20% less installation cost and 10% reduced equipment cost.

VIII. CHALLENGES FACED

Output voltage across capacitors are high sensitive to changes in duty cycle. Large inductor and capacitor is required to provide ripple free output. By getting output gain across capacitors are so difficult.

IX. RESULT AND DISCUSSION

The circuit has been designed and implemented using MATLAB Simulink. The circuit parameter has been taken for simulation is as given in TABLE I. Using equation (6) and equation (9), mathematically the high power and low power DC bus voltages for the given source voltage is found to be V_{C2} =80 Volts, V_{C1} = 40 Volts respectively. After simulation the voltage at low power DC bus (V_{C1}) has been found to be very near to 40 Volts. Similarly, after simulation the voltage at high power DC bus (V_{C2}) has been found to be nearly 80 Volts which was shown in Fig(4) and Fig(5).

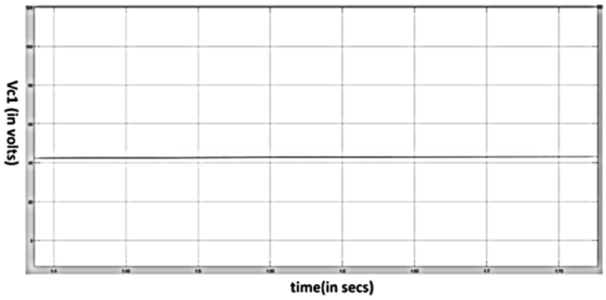


Fig 4. Voltage across Capacitor (C_1)

Fig. 4. Implies the low gain. The graph is lies in 40 which is at low duty cycle. The graph is plotted between time and voltage at capacitor 1.

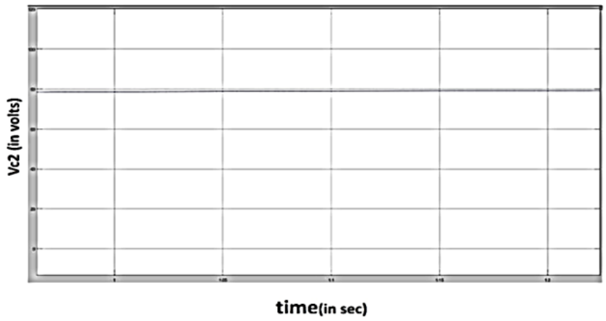


Fig 5. Voltage across Capacitor (C_2)

Fig. 5. Implies the high gain. The graph is lies in 80 which is at high duty cycle. The graph is plotted between time and voltage at capacitor 2.

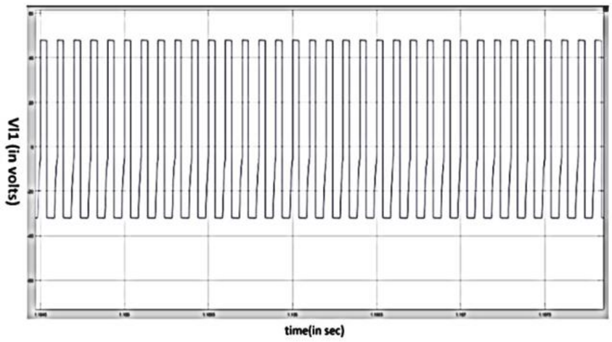


Fig 6. Voltage across Inductor (L_1)

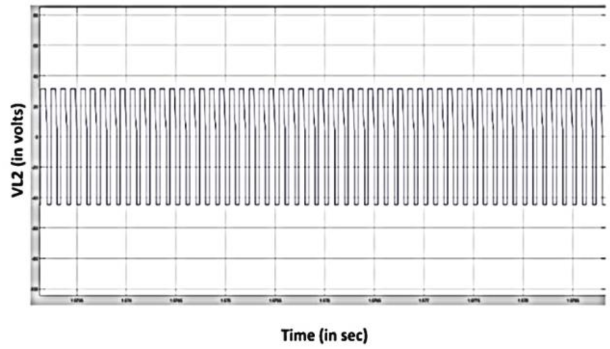


Fig 7. Voltage across Inductor(L_2)

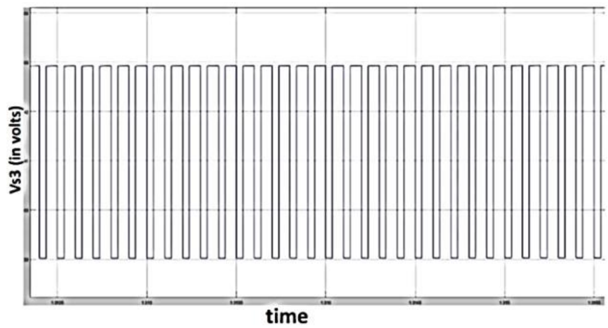


Fig 8. Voltage across Switch (S_3)

X. CONCLUSION

This paper presents the high gain step up DC-DC converter. This converter which is capable to attain higher voltage with low duty cycle. It overcome all the limitation faced by conventional converter has isolated. This converter can provide load to both low and high voltage. It is also capable of eliminating the problem faced when operated by extreme duty cycle and power loss due to leakage inductance. This converter operation is analyzed and verified by simulation using MATLAB Simulink.

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