TRANSFORMERLESS DOUBLE BOOST CONVERTER FOR NONCONVENTIONAL ENERGY APPLICATION

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Abstract
This paper presents a Transformer less Double Boost Converter (DBC) which delivers a feasible answer for non-conventional energy applications. The proposed DBC combines the conventional boost converter and the switched capacitor function. The tactic is to achieve double output voltage compared to conventional boost converter using appropriate duty cycle. The key benefits of this topology are: a continuous input current, a double conversion ratio without extreme duty cycle and without transformer, which permit high switching frequency. Simply single switch, single inductor, three diodes, three capacitors are desirable to design proposed DBC. The constituents present in the proposed converter are designed using performance equations. The proposed DBC converter is planned for rated power 100W, output voltage 100V with input supply voltage 20V. The proposed DBC is simulated in MATLAB and simulation result will authenticate the legitimacy of the theoretical design.

Keywords: *DC-DC; Double Boost converter (DBC); Single Switch. Non-Conventional energy.*

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1. INTRODUCTION

Various applications necessitate a dc-dc converter with high step-up voltage gain [1-10]. One of the most vital applications is the non-conventional energy generation, where the low voltage from a renewable energy source desires to be boosted for feeding a load or a grid connected inverter [2-6].To attain a very high voltage gain with customary topologies of DC-DC converters is difficult for the reasons such as: parasitic components, the condition of an extreme duty cycles or transformers limiting the switching frequency and systems scope [7-9]. Many topologies have been anticipated to overcome these challenges with high voltage gain without the usage of extreme duty cycles [10-27], with a relatively high complication compared with the traditional single-switch converters family; the current solutions for this challenge can be distributed into numerous categories.

In this paper a non-isolated Double Boost Converter (DBC) is recommended. This converter delivers a feasible solution for non-conventional energy applications. The proposed DBC combines the conventional boost converter and the switched capacitor function. The approach is to attain double output voltage compared to conventional boost converter using appropriate duty cycle. The foremost advantages of this topology are: a continuous input current, a double conversion ratio without extreme duty cycle and without transformer, permitting large switching frequency. Merely single switch, single inductor, three diodes, three capacitors are necessary to design proposed DBC. The essentials required in the proposed converter are designed by means of performance equations. The proposed DBC converter is designed for rated power 100W, output voltage 100V with input supply voltage 20V.

This paper is structured as follows: Brief outline of recent DC-DC converter is delivered in section I. Conventional boost converter and proposed DBC is discussed in section II and III respectively. Operation Modes and Conversion ratio of proposed DBC is discussed in section IV. The proposed DBC is simulated in MATLAB and simulation results are deliberated in V. Lastly, conclusion is provided in section VI.

2. CONVENTIONAL DC-DC BOOST CONVERTER

In DC-DC Boost Converter, the output voltage V_o is larger than the input voltage Vin. The power circuit illustration of DC-DC boost converter is depicted in Fig-1. Single inductor, single diode and single switch are used to design Boost converter. The operation modes of boost converter can be distributed into two modes, one when switch S is turn ON and another when switch is turned OFF. When switch S is turned ON, inductor is charged by input voltage Vin through switch S. Fig-2 clarify the operational mode when switch S is turned ON. In practical boost converter circuits, the switch and diodes has finite internal resistance. When Switch S is turned OFF, inductor is discharged through load, diode and input voltage. Fig-3 describes the mode of operation when switch S is turned OFF.

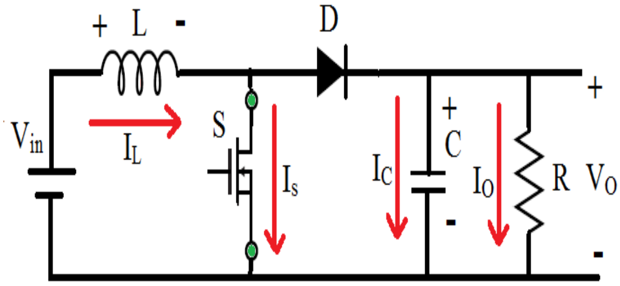

Fig-1: Power Circuit illustration of DC-DC Boost Converter

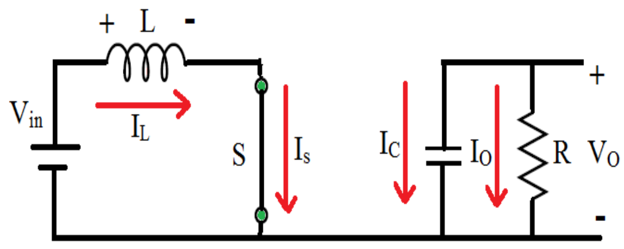

Fig-2: Equivalent Circuit of Boost Converter switch is ON

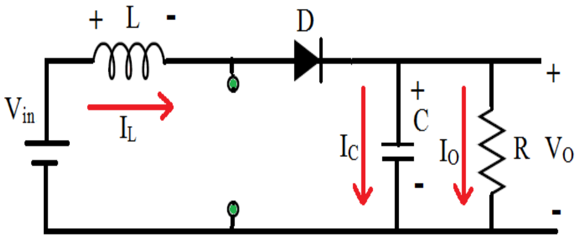

Fig-3: Equivalent Circuit of Boost Converter switch is OFF

If voltage across diode and switch is small then, $V_d = 0$

$$\frac{V_O}{V_{in}} = \frac{1}{(1-D)} \quad (1)$$

3. DOUBLE BOOST CONVERTER (DBC) CIRCUIT

Double Boost Converter (DBC) circuit is exemplified in Fig-1. In proposed DBC, single inductor L is connected in series with voltage source. Single controlled power switch S with three uncontrolled switch i.e. diodes D1, D2, D3 are necessary to design DBC. Also, three capacitors C1, C2, C3 are required to boost the voltage. The arrangement of three diodes and three capacitors form a voltage doubler circuit at the output side of the converter.

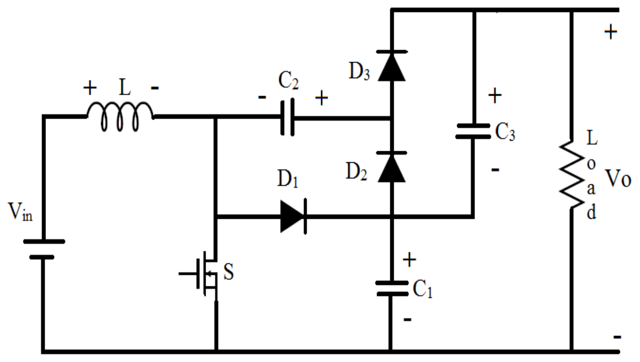

Fig-4: Circuit of Double boost converter (DBC)

4. OPERATIONAL MODES OF PROPOSED DOUBLE BOOST CONVERTER

The operation of proposed converter is distributed into two modes, when control switch S is ON and another when switch S is OFF.

When switch S is turned ON, inductor is charged by input voltage Vin through switch S. Capacitor C2 is charged by capacitor C1 through diode D2 and switch S. Finally, Capacitor C1 and C3 are discharged through load. The output voltage is equivalent to summation of voltage across capacitor C1 and capacitor C3. Fig-5 describes the mode of operation of DBC when switch S is turned ON.

When switch S is turned OFF, capacitor C1 is charged through series connection of inductor voltage and input voltage through diode D1. Capacitor C1 and C3 are charged by series connection of capacitor C2, inductor voltage and input voltage through diode D3. Finally, the output voltage is equivalent to addition of voltage across Capacitor C1 and capacitor C3.

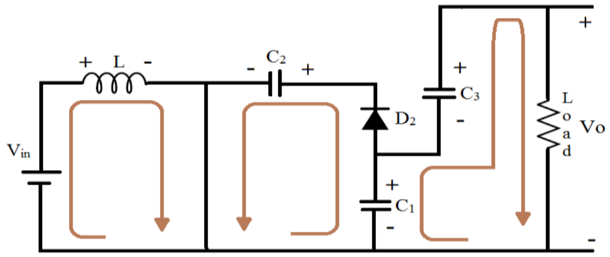

Fig-5: Equivalent Circuit and current direction of DBC when switch is ON

Fig-6 clarifies the mode of operation of DBC when switch S is turned OFF.

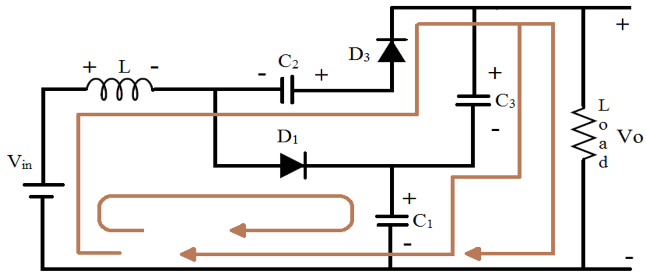

Fig-6: Equivalent Circuit and current direction of DBC when switch is OFF

If voltage across diode and switch is small then, Vd = 0

$$\frac{V_o}{V_{in}} = \frac{2}{(1-D)} \quad (2)$$

Thus, the gain of DBC is double as compared to the conventional boost converter.

5. SIMULATION RESULTS

The proposed Double Boost converter with the designed parameter is simulated in MATLAB/SIMULINK. The parameters value is listed in Table-I.

Table-1: Designed parameters value

No	Parameter	Value
1	Input voltage	20 V
2	Output voltage	100V
3	Output power	100W
4	Inductor, Capacitors	700uH, 220uF
5	Switching frequency	50 KHz

Switch S is triggered by using pulse generator. The output voltage, output current and Input voltage waveform are displayed in Fig-7. The voltage and current ripple in output voltage is revealed in Fig-8. It is witnessed that the voltage ripple is 0.15V. Output power waveform is shown in Fig-9.

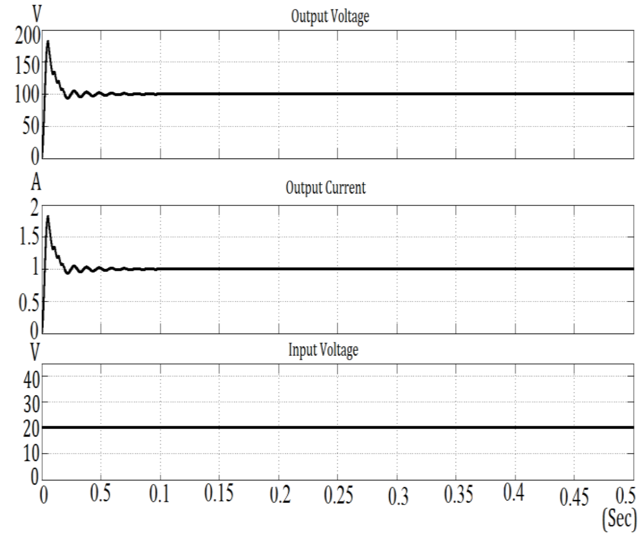

Fig-7: Output voltage, output current and Input voltage waveform

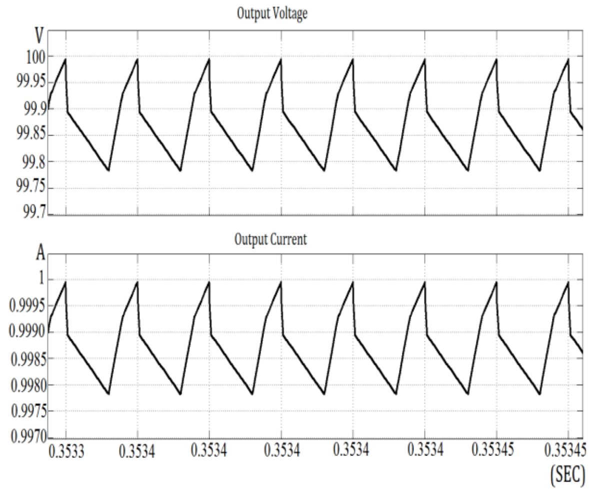

Fig-8: Voltage and current ripple in output voltage

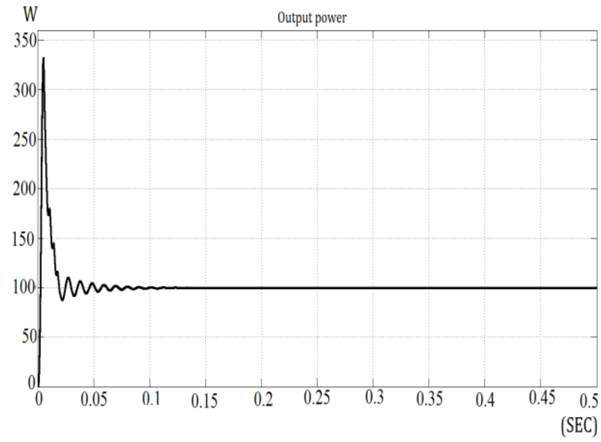

Fig-9: Output power of Converter

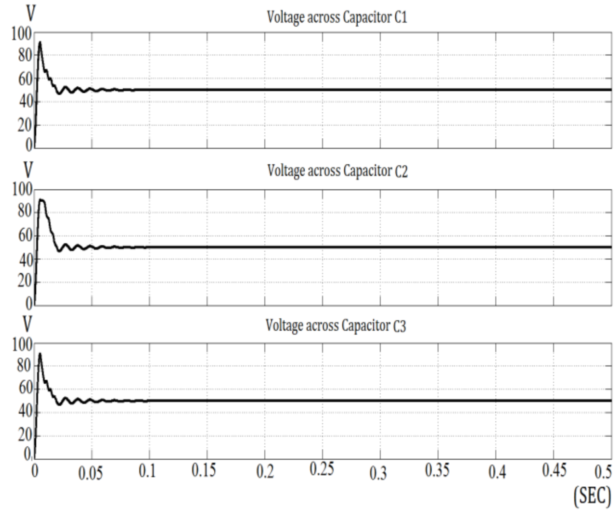

Fig-10: Voltage across capacitor C1, C2 and C3

Voltage across capacitor C1, C2 and C3 is shown in Fig-10. It is noticed that voltage across all capacitor is half of the output voltage i.e 50V. Voltage ripple across capacitor is displayed in Fig-11.

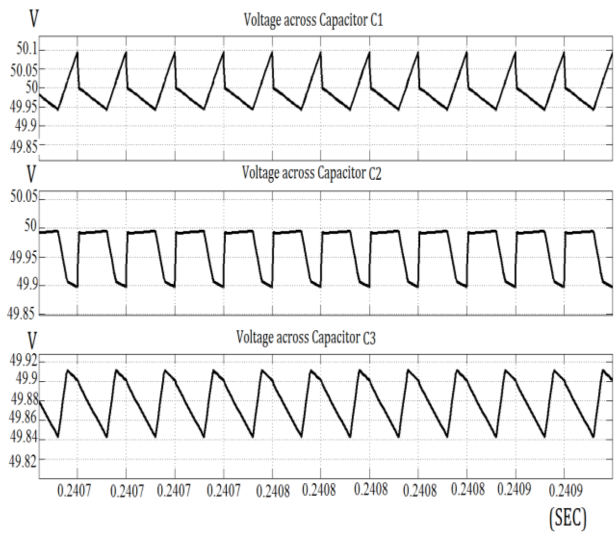

Fig-11: Voltage ripple across capacitor C1, C2 and C3

6. CONCLUSION

A non-isolated Double Boost Converter (DBC) is proposed for non-conventional energy applications to attain double output voltage compared to conventional boost converter by means of appropriate duty cycle. The proposed DBC conglomerates the conventional boost converter and the switched capacitor function. The main advantages of this topology are: a continuous input current, a double conversion ratio without extreme duty cycle and without transformer, which tolerate high switching frequency. Only single switch, single inductor, three diodes, three capacitors are obligatory to design proposed DBC. The proposed DBC is simulated in MATLAB and simulation results will confirm the legitimacy of the theoretical design.

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