International Journal for Modern Trends in Science and Technology, 7(03): 76-79, 2021

ISSN: 2455-3778 online
DOI: https://doi.org/10.46501/IJMTST0703013
Available online at: http://www.ijmtst.com/vol7issue03.html

A Quadratic Boost Converter with Voltage Multiplier Cell to Increase Voltage Gain

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To Cite this Article
P.Rangeela and Dr.A.RubyMeena, "A Quadratic Boost Converter with Voltage Multiplier Cell to Increase Voltage Gain", *International Journal for Modern Trends in Science and Technology*, Vol. 07, Issue 03, March 2021, pp.: 76-79.

Article Info
Received on 03-February-2021, Revised on 02-March-2021, Accepted on 05-March-2021, Published on 10-March-2021.

ABSTRACT

The high step up dc-dc converter with a quadratic boost converter with voltage multiplier cell (VM) to achieve a high voltage gain in the continuous conduction mode (CCM). To increase higher voltage gain, lower voltage stress on diodes and capacitors and requiring smaller inductors with reduced number of components. Quadratic Boost DC-DC converters are mainly used in applications like HEVs and EVs vehicles. The purpose of boost converter is to charge a low-voltage (12 V) battery during boost mode and to assist the high-voltage 200V battery. In this implementation, closed-loop control in high voltage side is implemented using PI (proportional integral) controller.

I. INTRODUCTION

Implementation of renewable energy resources like solar panels requires DC-DC converters for boosting their voltage [1-5]. The converters increase voltage gain and low voltage stress on the components. The used voltage multiplier cell consists of more number of components to the converter and the components cost also high to design the converter [1]. The Z-source converter, it gain higher voltage and lower stress on the switch, but the circuit needs the smaller inductors on the switch to operate the boost mode of the operation to increase the voltage gain and high efficiency [2]. Thequadratic-boost converter circuit to increase the voltage gain through the capacitors and diodes of the converter. Through slightly increasing the duty ratio to the converter switch [3]. The non-isolated high gain converters use to low input current ripple, isolated converters for PV applications and the converter can be used to the solar panel but the cost and design of the converter is very difficult [4]. Two or more basic DC-DC converters connected in cascade, the power loss, stress on the switch and lower efficiency of the converter can be obtained [5]. A novel high step-up non-isolated single switch DC-DC converter suitable for PV cells and the DC bus to increase the voltage. The Quadratic boost and switched-capacitor technique are used as primary and secondarycircuit[6].Touse largerrangeof voltage conversion and use of the multi stage boost converters, because its voltage gain is higher with quadratic characteristic as a function of duty cycle [7].

The combinations of a quadratic boost converter and a voltage multiplier cell are used to increase output voltage. A designed controller is to validate the converter dynamic and stability. The advancements and increasing towards in Electric Vehicles would soon see increased influx of EVs on the road. This sudden increase in load would be affecting the traditional grid system that is present

in India. So it is necessary to enable a smooth integration of the EVs to the grid. The EVs should act as act as an Auxiliary source to the grid rather than aload.

The proposed converter includes a quadratic boost converter and a voltage multiplier cell. The multiplier cell consists of two diodes, two inductorsand one capacitor has been used to the quadratic boost converter. The proposed converter operates in bidirectional way to voltage gain. The proposed converter achieves increase high voltage gain and large efficiency. The PI controller to control the boost converter operation in closed loop. The modified quadratic boost converter operates with a storage battery. The bidirectional quadratic boost converter is used for charging and discharging of the EV battery. The charging method can be very useful to the future applications and electric vehicles can be used to this method to charge the battery.

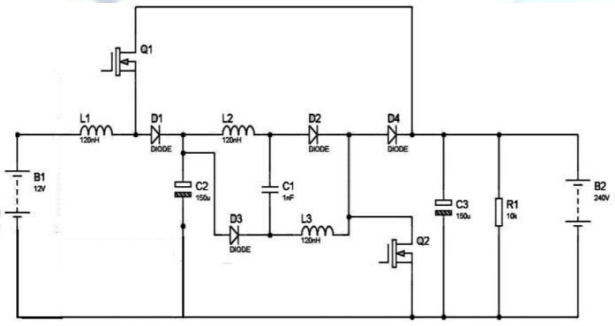

Fig.1 Configuration of the proposed converter

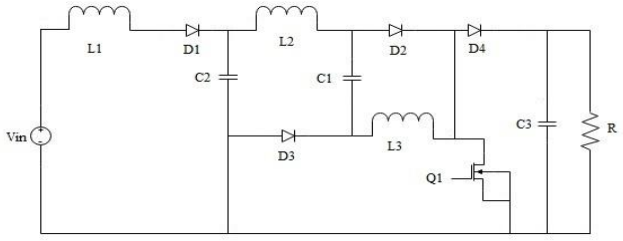

Fig.2a

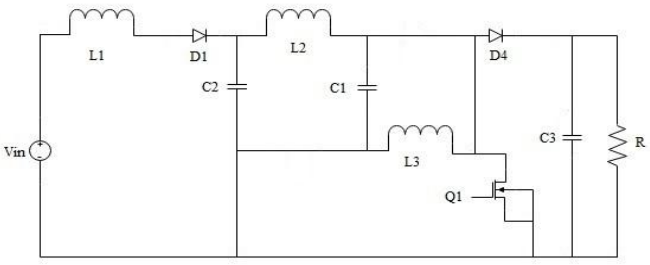

Fig.2b

Fig.2 Switch on and off states of the proposed converter (a) First state, switch ison,(b) Second state, switch is off

II. Configuration of Proposed Converter

The converter is a two switch DC–DC converter. Operation principle of the converter is continuous conduction mode (CCM). To give low voltage input to the converter and multiplier cell to gain the output voltage. The closed-loop control in high voltage side is implemented using PI (proportional integral controller). Switch one operates bidirectional way to restore the output voltage through switch 2 and L1 inductor. Switch two have two switching states turn on and turn off states. A PI Controller is calculate the error signal of the proposed converter, then given to the switching pulse of the switch to operate the boost converter. In this converter we use PI controller giving switching pulse switch to operate the boost converter.

III. Operation States of the Converter

The Bidirectional Quadratic Boost converter with voltage multiplier cell to increase voltage is shown in Fig.1. It comprises oneactivepower switch (Q1), four power diodes (D1-D4), three inductors (L1, L2 and L3) and three capacitors (C1-C3).
First Switching State: In this state, the switch 2 is turned on shown in fig.2a, the converter operates, the inductor L1 and diode D1 conducting, the energy given to the voltage multiplier cell. In addition, the capacitor C2 charges the inductors L2 and L3 and the capacitor C1 in the loops which contain D2 and D3. Through diode D4 and capacitor C3, the convertervoltage given totheload resistor R.

Then the high output voltage stored the battery. The defined loops on the equivalent circuit following equations is,

$$VL1 = Vin \qquad (1)$$

Second Switching State: In this state, the switch2 is turned off shown in fig.2b, the diodes D1 and D4 are conducting. The otherdiodes D2, D3 are blocking. The diodes D1 and D4 prepare the paths for the loops in the inductors L1, L2 and L3 and the capacitor C1 are discharged. The capacitor C2 is charged by Vin and L1 through D1.The discharge energy, stored the capacitor C3 through diode D4. Then voltage given to the R load and store the high voltage battery. The below equation isobtained,

$$VL1 = Vin - Vc2 \quad (2)$$

The voltage gain of the converter equation is,

$$M = \frac{Vo2}{V\,in} = \frac{}{(1-D)^2} \qquad (3)$$

IV. Simulation Experimental Parameters

The simulation parameters used in the proposed system with its specifications, input range, output ranges are represented in the following table1.

Table 1

PARAMETERS	VALUES
Input voltage	40V
Switching frequency	4kHz
Inductance L1	200Mh
Inductance L2,L3	360µH
Capacitance C1, C2	47µF
Capacitance C3	470Mf

V. Simulated Bidirectional Quadratic Boost Converter

The Simulink model for A Quadratic Boost converter with voltage multiplier cell is shown in the figure 3. The control of the converter is simple. The pulse generates with PI controller to give switching pulse.

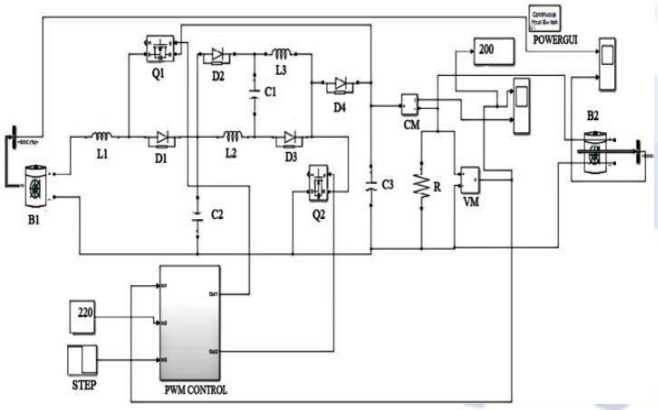

Fig.3 Simulation of AQuadratic Boost converter with voltage multiplier cell to increases voltage gain

VI. EXPERIMENTAL RESULTS

A Quadratic Boost Converter with voltage multiplier cell to increase voltage gain. The simulated output voltage and current of the proposed system is shown in the below figures.

Output Voltage

The simulated output voltage is represented in the fig.4, when the DC source input voltage is fed, after simulating it will provide the output value which will be boosted while comparing with the input value of voltage. Here wehave set input voltage value as 40V, the resulted output voltage value is obtained as 200V.

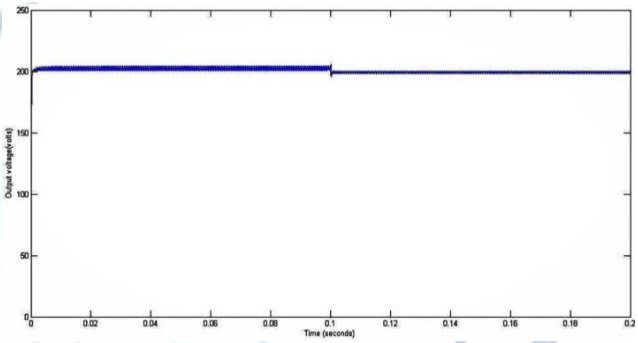

Fig.4 Output voltage waveform

Output Current

The simulated output current is represented in the fig.5, when the DC source input voltage is fed, after simulating it will provide the output value which will be boosted while comparing with the input value of voltage.

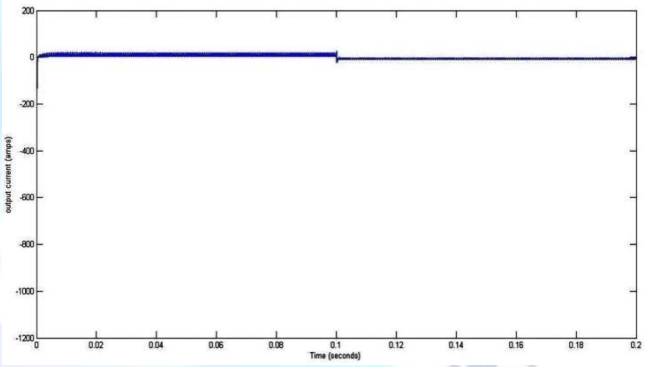

Fig.5 Output Current Waveform

Battery charging and discharging waveforms

The quadratic boost converter operates charging and discharging batteries. The input battery gives low voltage to quadratic boost converter with voltage multiplier cell. The converter output voltage gain stored battery, the battery voltage charge to input battery through the switchone.

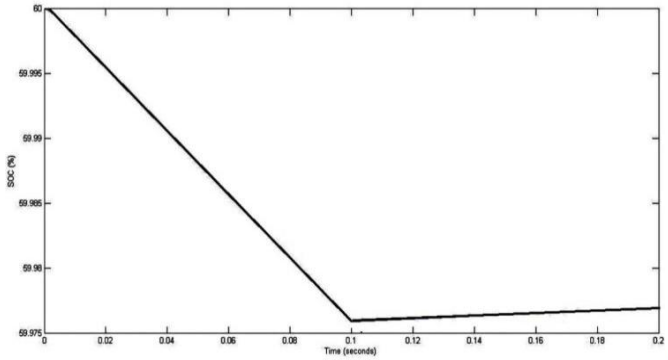

Fig.6a LV Battery Discharging and Charging Waveform

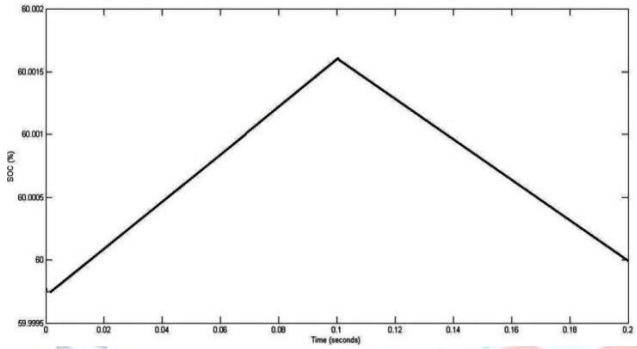

Fig.6b HV Battery Charging and Discharging waveform

VII. Conclusion

The proposed converter is composed of aquadratic boost converter and a voltage multiplier cell. The converter has higher voltage gain in comparison to the quadratic boost converter. The proposed converter requires smaller inductors in comparison to the converter in which can be introduced as an important advantage. In similar voltage gains, power losses of the proposed converter are lower in comparison to the converter in which has less number of the usedcomponents.

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