Design and Simulation of Quadratic Boost Converter

A PROJECT REPORT

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ABSTRACT

The project is a simulation and hardware of a Quadratic Boost Converter. In PWM (square-wave) DC-to-DC converter topologies, DC conversion ratio M is a function of duty ratio D of the active (transistor) switch. Both minimum and maximum attainable conversion ratios are limited in practical converters. Mmax is limited by the degradation in efficiency as duty ratio D approaches 1. On the lower end, minimum ON-time of the transistor switch results in a minimum attainable duty ratio and, consequently, in a minimum conversion ratio Mmin. Conversion range can be extended significantly if conversion ratio M has a quadratic dependence on duty-cycle. Quadratic boost converter (QBC) is a modified step up converter with single switch and better conversion ratio.

Our aim was to construct a hardware model of a Quadratic Boost Converter and also simulate it on Matlab Simulink. We completed the simulation part on Matlab Simulink and the results have been attached below. We completed everything in the hardware part except the control circuit. We could not

complete the control circuit because of the ongoing pandemic.

INTRODUCTION

DC-DC converters are considered to be of great economical importance in today and are widely used at home solar systems to produce the desired output power. The quadratic boost converter with a single switch is shown below where E is the input voltage, VC2 the output voltage and S independent switch. This model usually requires active and passive switches are to be appearing in pairs and to form a three-terminal network. However, this methodology can be extended for the analysis of the quadratic boost converter with a single switch, which contains an active switch and three passive switches. Thus, diode D2 and transistor switch S are replaced by the corresponding current source, and diodes D1 and D3 by voltage sources.

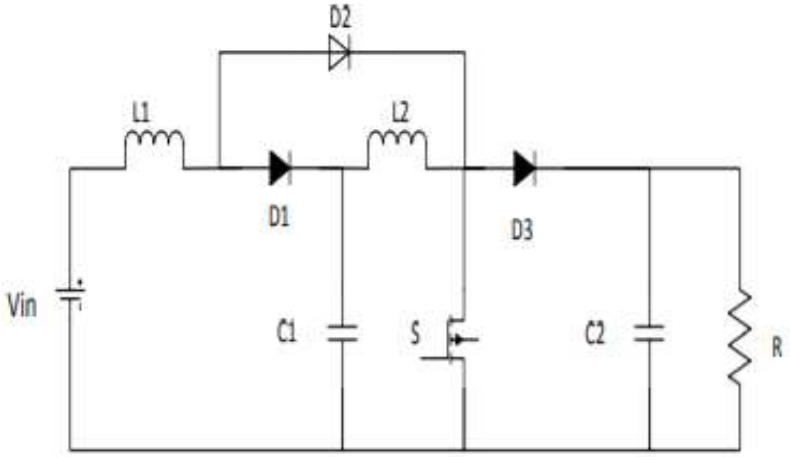


Fig.7 Circuit Diagram for Quadratic Boost Converter

Mode 1: The circuit operation is based on the assumption that the switch S is ideal in operation and capacitors C1 and C2 is taken as large value so that the voltage across the capacitors VC1 and VC2 are nearly constant over a switching period. When switch S is turned on D2 is forward biased, whereas D1 and D3 reverse biased. Currents are supplied to L1 and L2 by Vin and C1 respectively. The mode 1 circuit of quadratic boost converter is given below.

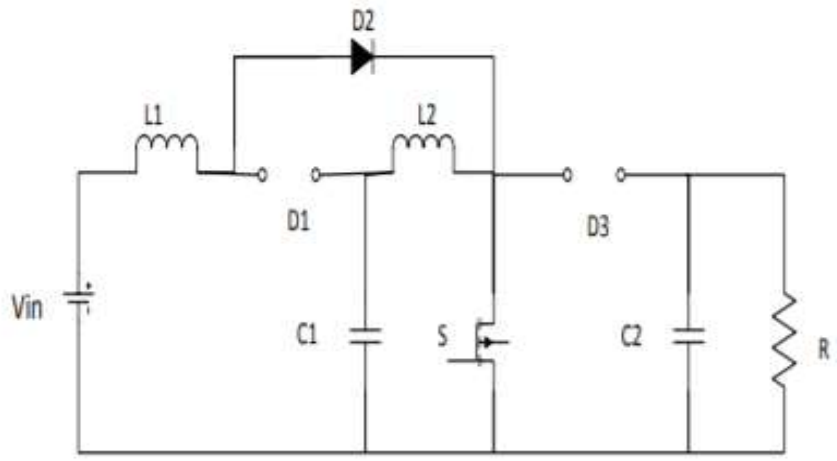


Fig.8 Circuit Diagram for Mode 1 Operation of Quadratic Boost Converter

Mode 2: In this condition D1 and D3 are forward biased, whereas D2 reverse biased. L1 and L2 are charging C1 and C2 respectively. During this state, iL1 and iL2 is decreased. The mode 2 circuit of quadratic boost converter is given below.

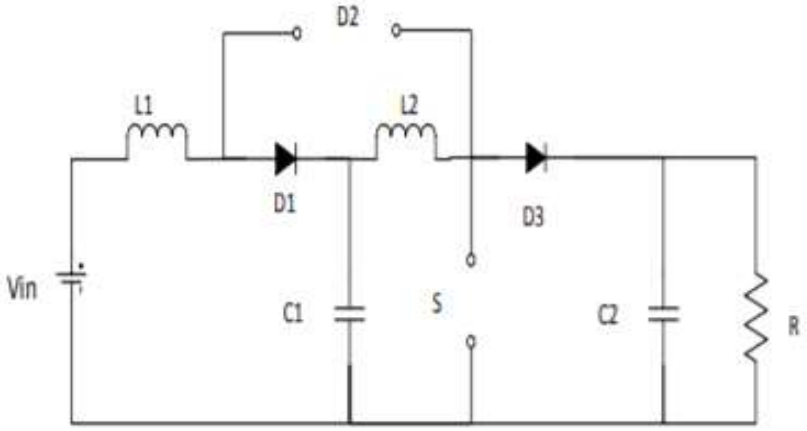


Fig.9 Circuit operation for Mode 2 of Quadratic Boost converter

PROJECT DESCRIPTION

This project consists of hardware and the software part. Let's see both of the parts in detail.

Hardware:

1) First we designed our printed circuit board (pcb) using ExpressPCB.

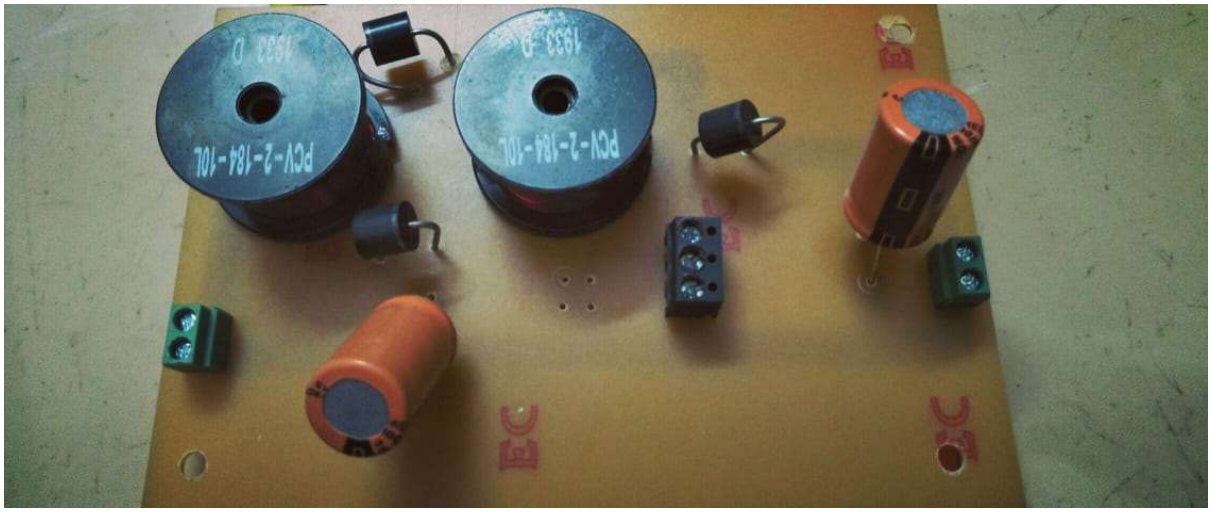
2) Then using Ferric Chloride we removed unwanted Copper.

3) Once our PCB was ready we made holes as per requirement using drill machine.

4) Then the components were placed as per circuit diagram.

5) Signal is given to our switch (MOSFET) using TLP250 and Arduino.

6) Output can be seen using oscilloscope.



MATHEMATICAL CALCULATION:

Mathematical Calculation :

$P_o = 100W$, $V_{in} = 18V$, $d = 0.5$, $f_{sw} = 50kHz$

$V_o = \frac{V_{in}}{(1-d)^2} = \frac{18}{0.25} = 72V$, $R_o = 50\Omega$

$I_{in} = \frac{100}{18} = 5.56A$; $I_o = \frac{100}{72} = 1.389$

$\Delta I_{L1} = \frac{V_s d T}{L_1} = 0.25 \times I_{in} = 1.39A$

11'y $\Delta I_{L2} = 0.25 \times I_{out} = 0.34725A$

① $L_1 = \frac{d V_s}{2 \times f_{sw} \times \Delta I_{L1}} = \frac{0.5 \times 18}{2 \times 50 \times 10^3 \times 1.39} = 64.7\mu H$

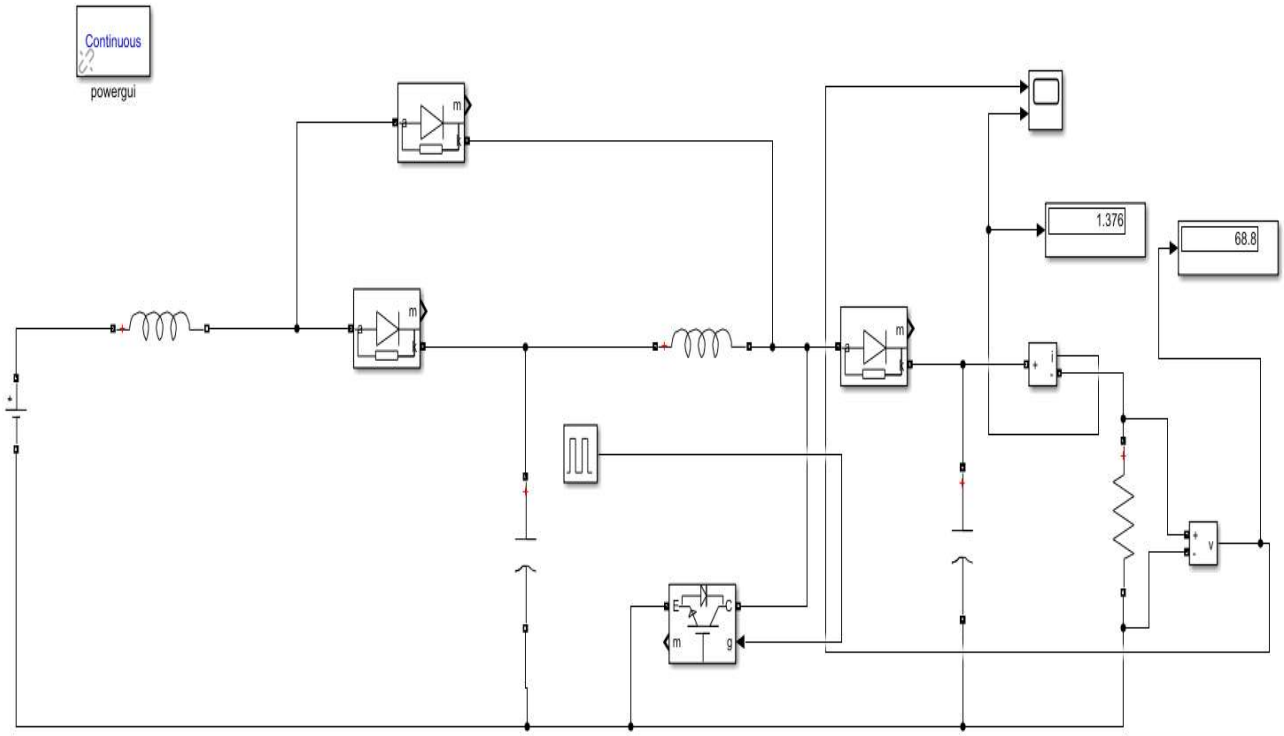
② $L_2 = \frac{d V_s}{2 \times f_{sw} \times \Delta I_{L2}} = \frac{0.5 \times 18}{2 \times 50 \times 10^3 \times 0.34725} = 259\mu H$

③ $C_1 = \frac{I_o d}{(1-d) \times \Delta V_{c1} \times f_{sw}} = \frac{1.389 \times 0.5}{0.5 \times 2 \times 50 \times 10^3} = 13.89\mu F$

④ $C_2 = \frac{I_o d}{(1-d) \times \Delta V_{c2} \times f_{sw}} = \frac{1.389 \times 0.5}{0.5 \times 3.6 \times 50 \times 10^3} = 7.71\mu F$

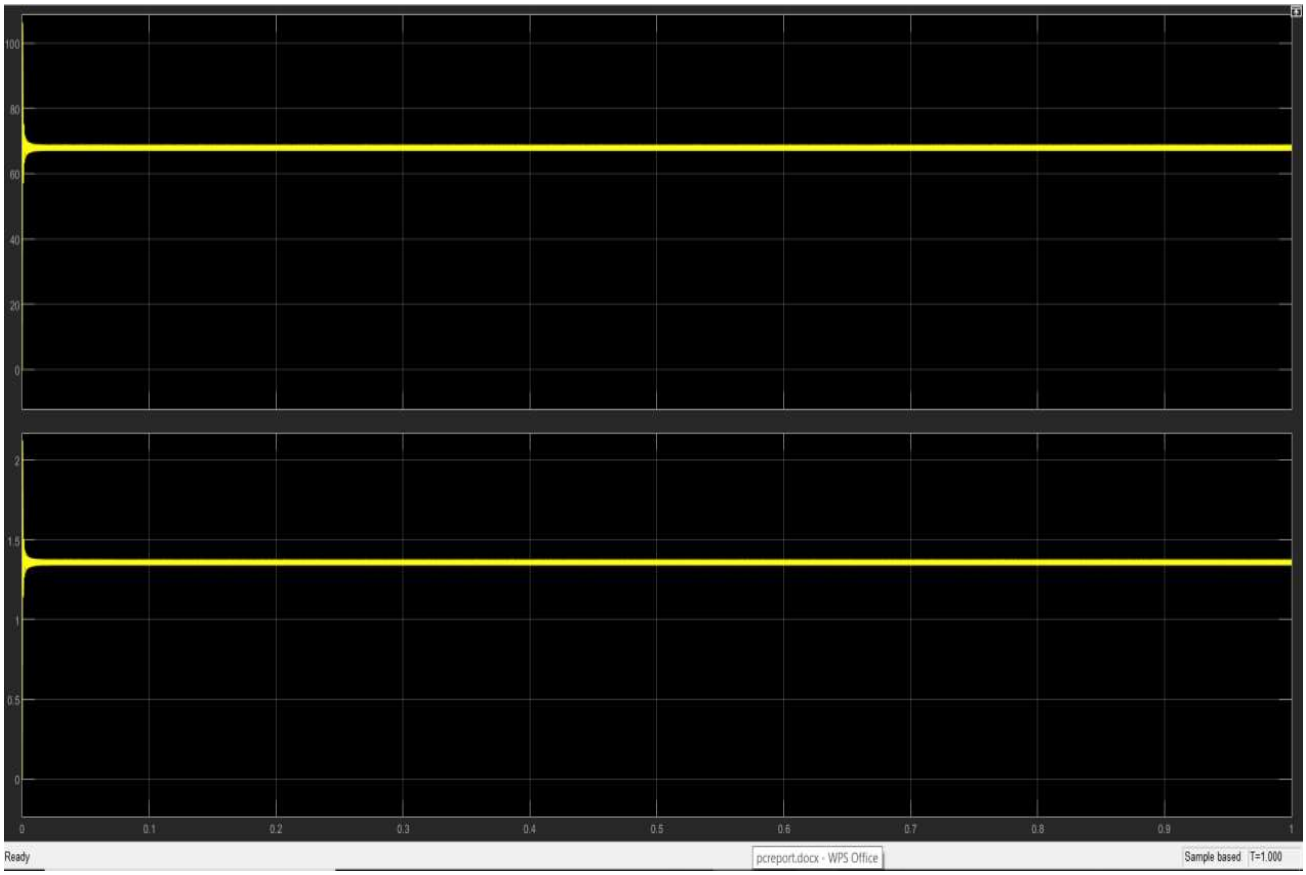
Software:

The Quadratic Boost Converter was Simulated on Matlab Simulink and the output load voltage and current were obtained.



RESULTS AND DISCUSSION

The Output Voltage and Current were obtained as follows:



As we can see the Output Voltage is 68.8V, which is 4 times of the Input Voltage (which is 18V). And therefore the calculated Theoretical Voltage (72V) is almost equal to the Obtained Output Voltage(68.8V).

And the Output Current obtained is 1.376V, which is almost equal to the calculated Theoretical Current(1.389A).

CONCLUSION

The Quadratic Boost Converter is preferred over the normal Boost Converter because of its High Efficiency and low losses. Some of its applications include High Gain DC Voltages and so on. The hardware and software model of a Quadratic Boost Converter was made and the output results were verified with the theoretical calculations.

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