Design and Simulation of Boost Converter

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Abstract

This paper presents the Design and Simulation of a DC-DC Boost Converter by using a resistive load. A boost converter steps up voltage from its input to the output load. This study focuses on determining the suitable value of the inductor and capacitor for use in the circuit. Then, this design focuses on continuous conduction mode of operation. comparison of calculated and simulated output voltages with a switching frequency input is 25 kHz with MOSFET as a switching device. The evaluation of this circuit design is to input a 24VDC and obtain a 48V DC at the output. An inductor was used to store energy in the form of current at the input, and a capacitor is used as a filtering component to minimize the voltage ripple at the load. The circuit analysis was observed in Matlab Simulink Environment where the theoretical result was compared to the experimental simulation result. From the analysis, calculated values of component were used for the simulation and it was observed that, the simulated result has a negligible difference with the calculated result.

Keyword: *Boost Converter, Continuous Conduction, Matlab Simulink, MOSFET, Switching Frequency*

1. INTRODUCTION

Power Electronics is ushering in a new kind of industrial revolution due to its versatility in terms of fields of application like energy conservation, renewable energy system, bulk utility energy storage, electric and hybrid vehicles and industrial automation. When it comes to power conversion, a DC-DC converter plays a significant role resulting in widespread applications in cellular phones, laptop computers, LED drivers, maximizing energy harvest for photovoltaic systems and for wind turbines, electric vehicles, hydro power plants and many more applications in industry, it is required to convert a DC input voltage into variable DC output voltage (Binti Mahmor et al., 2020). The conversion voltage supply directly from DC voltage to a different DC voltage is called a DC converter. This converter is used to step the input voltage to desired voltage (Boujelben et al., 2017). DC converters are used in DC voltage regulators; and also are used, with an inductor in conjunction, to generate a DC current source, specifically for the current source inverter (Rai et al., 2017). DC converter widely used in industrial applications that include motor control for electric automobiles, trolleys cars, marine hoists, uninterruptible power supplies, and battery-operated equipment (Abdessamad, S., & Mohamed, 2013). Generally, to step up input DC supply from the power sources such as batteries, solar panels, the output of the rectifier, DC supply, or DC generator the boost converter is used. (Palanidoss & Vishnu, 2018). The main objective of a DC-DC converter is to maintain a constant output voltage despite variations in input/source voltage, components and load current. Designers aim to achieve better conversion efficiency, minimized harmonic distortion and improved power factor while keeping (Mirza Fuad Adnan et al., 2017). The converter can therefore operate in two different modes depending upon its energy storage capacity and the relative length of the switching period. These two modes are known as the discontinues conduction and continuous modes (Hasaneen & Mohammed, 2008)

2. Design Calculation of DC-DC Boost Converter

The Schematic Circuit of the DC-DC Boost Converter is shown in Fig 1. It consist of a single MOSFET, Inductor, Capacitor and a Diode with a resistive load at the Output.

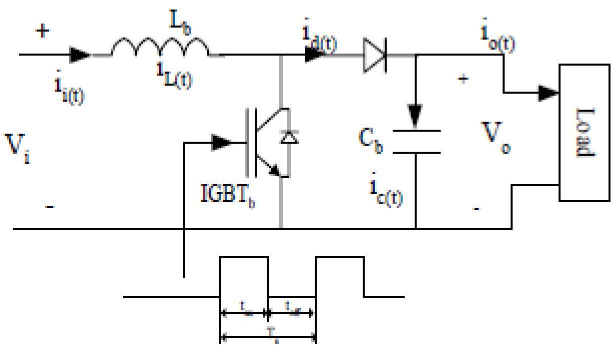

Figure 1. Circuit Schematic of DC-DC Boost Converter

The circuit operation can be divided into two modes. Mode 1 begins when the switch is closed also called continuous conduction mode and Mode 2 when the switch opens also calld discontinuous conduction mode as seen in Fig 2.

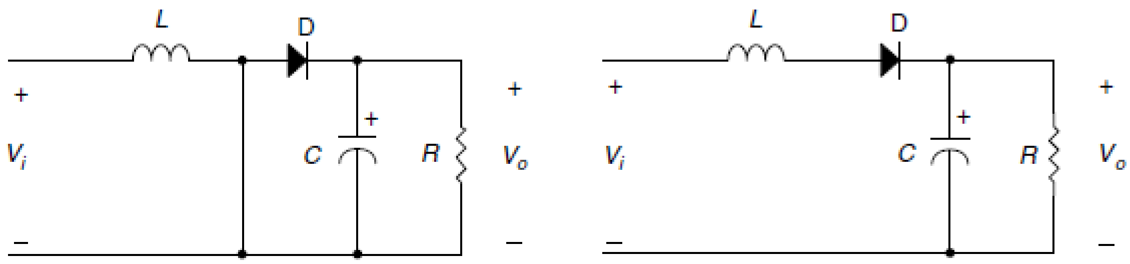

Figure 2. Basic Boost Converter Switch States: (a) switch closed; (b) switch open

The Boost Converter was designed using MOSFET with switching frequency of 25kHZ, with input voltage of 24VDC and an output voltage of 48V.

Design Calculation of Boost converter is shown be;low, where the inductance and capacitance to be used in obtaining the expected output was calculated and compared with the simulated result.

Te equation of the output voltage is

$$V_o = \frac{V_s}{1-D}$$

Average inductor current and making various substitutions, I_L expressed as

$$I_L = \frac{V_S}{(1-D)^2 R}$$

To determined the value of maximum and minimum inductor currents by using the average value and the change in current I_L.

$$I_{Max} = I_L + \frac{\Delta i_L}{2} \text{ and } I_{Min} = I_L - \frac{\Delta i_L}{2}$$

By design perspective, it is important to express L in terms of a desired, iL , and also an equation to express required capacitance C, in term of specified voltage ripple can be calculated by the equation below.

$$\boldsymbol{L} = \frac{V_S DT}{\Delta i_L} = \frac{V_S D}{\Delta i_L f} \text{ and } \boldsymbol{C} = \frac{D}{R(\Delta V_O/V_O)f}$$

$$\boldsymbol{V_{LON} = V_S = 24V}$$

$$\boldsymbol{V_{LOFF} = V_S - V_O = 24 - 48 = -24V}$$

$$\boldsymbol{D = 1 - \frac{24}{48} = 0.5}$$

$$\boldsymbol{I_L = \frac{24}{(1-0.5)^2 \times 100} = 0.96A}$$

$$\boldsymbol{I_L = \frac{25}{100} \times 0.96 = 0.384A}$$

$$\boldsymbol{I_{MAX} = 0.96 + \frac{0.384}{2} = 1.152A}$$

$$\boldsymbol{I_{MIN} = 0.96 - \frac{0.384}{2} = 0.768A}$$

$$\boldsymbol{L = \frac{24 \times 0.5}{0.384 \times 25000} = 0.00125H = 1.25mH \ or \ 1250\mu H}$$

$$\boldsymbol{C = \frac{0.5}{100 \times 0.01 \times 25000} = 20\mu F}$$

3. Simulation of DC-DC Boost Converter

From the calculation, a 24V input with 0.5 duty cycle gives a 48V output.. The calculated value of the inductance is $1250\mu H$ and the capaciance is $20\mu F$. These values werw used in the boost converter circuit and simulation was done in MATLAB-Simulink environment. The parameters used for this simulation are given in Table I:

Table I Simulation Parameters

Parameter	**Value**
Input Voltage	24V

Output Voltage	48V
Boost Inductor	1250µH
Filter Capacitor	20µF
Duty Cycle	0.5
Resistive Load	1mΩ
Diode	
MOSFET	

The proposed DC-DC Boost converter is shown in Fig. 3, was simulated at duty cycle 0.5 and the output wave shapes observed for an input voltage is 24V which gives an output of 48V.

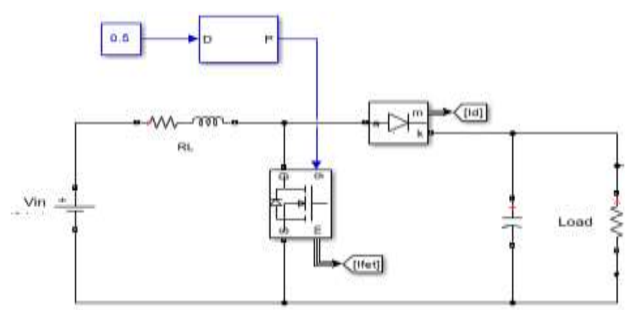

Figure 3. Matlab Simulink Model for the Proposed Boost Converter with Pulse Width Modulation (PWM)

4. RESULT

The simulation was run and waveforms observed on Scope. It was verified that the mean value of the output voltage is very close to the theoretical value of: Vout = 24 / (1 - 0.5) = 48 V.
The gating pulse of the Boost Converter is Shown in Fig 4. With an amplitude of 1V and a duty cycle of 0.5 (50%).
The waveform is observed to have minimal overshoot with a risetime 314µs.

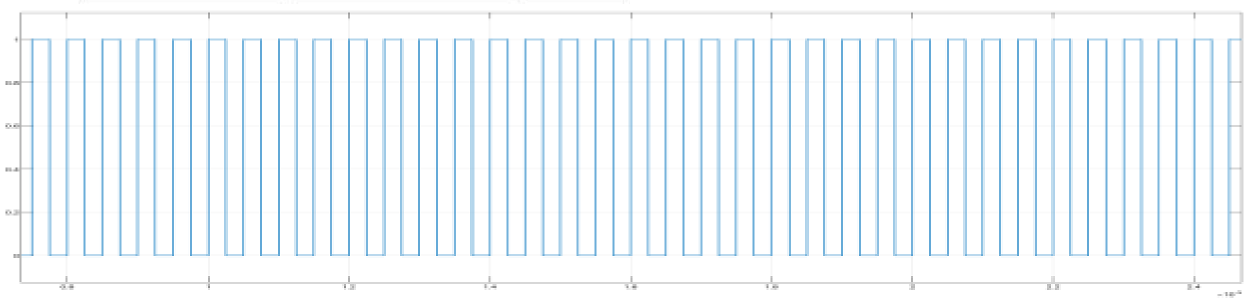

Figure 4. Gate Pulse of the MOSFET

Fig 5. is the waveforms as observed from the simulation of the Boost Converter. output voltage, the FET current and the Inductor current.. From the result obtained at different point of the plots are 48.11, 48.09 and 48.06 volts which is very close to the theoritical result.

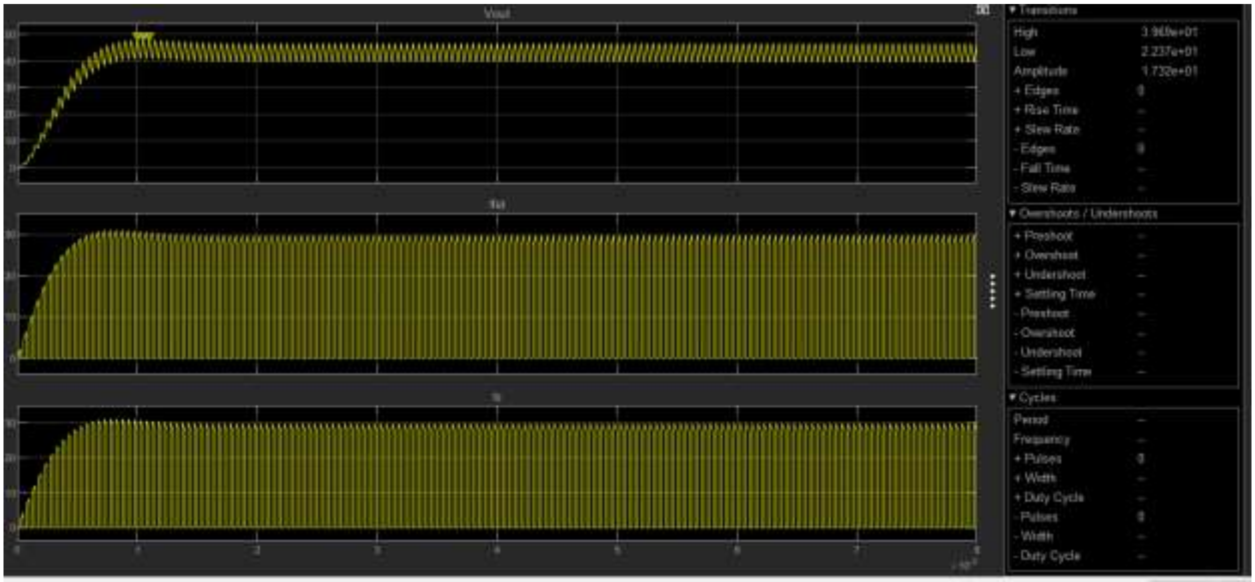

Figure 5. Output Voltage of DC-DC Boost Converter, MOSFET Current and Diode Curreent

5. CONCLUSION

The aim and objective of the paper has been achieved. The proposed Boost converters with Pulse Width Modulation (PWM) provides a voltage that is very close to the calculated value. The calculated value gave the input voltage as 24V and an output of 48V. The simulated circuit gave an output od 48.06V with a percntage errror of 0.01%. This paper successfully provides a method to satisfy the objective of calculated and simulated DC-DC Boost converter with negligible error.

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