PULSE WIDTH MODULATION AND CONTROLLED DC-DC BOOST CONVERTER

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Abstract—

A boost converter is a type of DC-DC converter that steps up the input voltage to a higher output voltage level. Pulse width modulation (PWM) is a commonly used control technique in boost converters that allows the output voltage to be regulated by adjusting the duty cycle of a switching transistor. This paper presents an overview of the boost converter topology and describes the principles of operation of the PWM control method. The design considerations for selecting the components of the converter circuit are also discussed, including the choice of the inductor and capacitor values. Simulations are performed to evaluate the performance of the boost converter under different load conditions, and the results are presented and analyzed. The effectiveness of the PWM control technique in regulating the output voltage and minimizing ripple is demonstrated, and the advantages and limitations of this approach are discussed. Overall, this paper provides a comprehensive overview of the boost converter using pulse width modulation, and it can serve as a useful reference for engineers and researchers working in the field of power electronics.

Index Terms **PWM, Microcontroller, Boost, Converter**

INTRODUCTION

THE growing demand for energy, the limited availability of conventional energy sources, and the environmental impact of using them have led to the development of new and clean energy sources. With the increasing use of renewable energy sources such as solar and wind power, the need for efficient energy conversion has become essential. DC-DC converters have gained popularity as they are used to regulate the voltage of power sources such as solar panels. Among different types of DC-DC converters, the boost converter has become increasingly prevalent, especially in industries. A considerable amount of research has been carried out to identify the best switching method for boost converters. In recent years, numerical control has been widely used in power electronics, leading to an improvement in circuit performance while decreasing costs. The boost converter is also commonly used in auxiliary power sources of hybrid vehicles, fuel cell systems, and solar panels. Additionally, for electric vehicles powered by fuel cells, energy storage devices with under-voltage battery packs are needed, and DC-DC converters play a vital role in connecting the under-voltage battery packs and the high-voltage fuel cell systems.

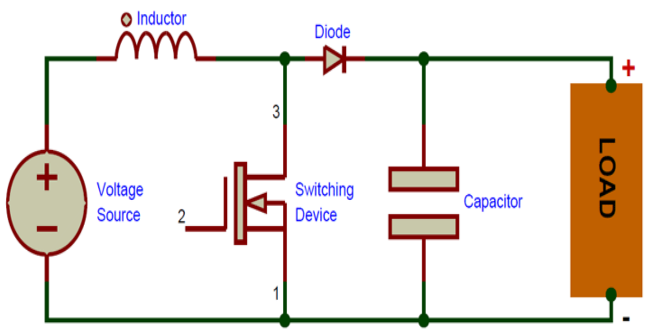


Fig. 1. **Conventional Boost converter**

A. Equations

The equations for the boost converter design are as follows: -

1. For calculating duty ratio-

$$D = 1 - \frac{V_{IN(min)} \times \eta}{V_{OUT}}$$

- Here 'D' is the duty ratio of the cycle
- Vin is the input voltage
- Vout is output voltage.

2. For calculation of inductor current-

$$\Delta I_L = \frac{V_{IN(min)} \times D}{f_S \times L}$$

- Vin(min) = minimum input voltage
- D = duty cycle
- S = minimum switching frequency of the converter
- L = selected inductor value

3. For calculation of Inductor Value-

$$L = \frac{V_{IN} \times (V_{OUT} - V_{IN})}{\Delta I_L \times f_S \times V_{OUT}}$$

- Vin = typical input voltage
- Vout = desired output voltage
- fs = minimum switching frequency of the converter
- ΔI_L = estimated inductor ripple current,

4. <u>Output Capacitance Selection-</u>

$$C_{OUT(min)} = \frac{I_{OUT(max)} \times D}{f_S \times \Delta V_{OUT}}$$

- Cout(min) = minimum output capacitance
- Iout(max) = maximum output current of the application
- D = duty cycle
- fs = minimum switching frequency of the converter
- ΔVOUT = desired output voltage ripple

B. Components used in boost converter

The components used for the boost converter, are as follows:

→ Power MOSFET
→ Diode
→ Caps/Resistors – values as shown on circuit diagram
→ The purpose of the control circuit is to provide the MOSFET with gating pulses. The main components of the control circuit are the microprocessor, the optocoupler and the Mosfet drivers.

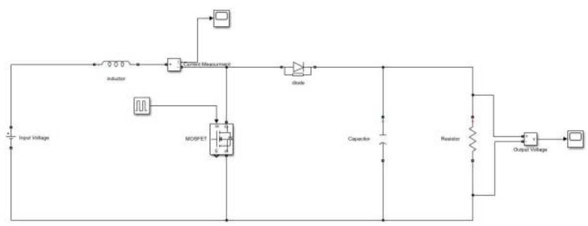
C. Working of boost converter

The working of a boost converter:

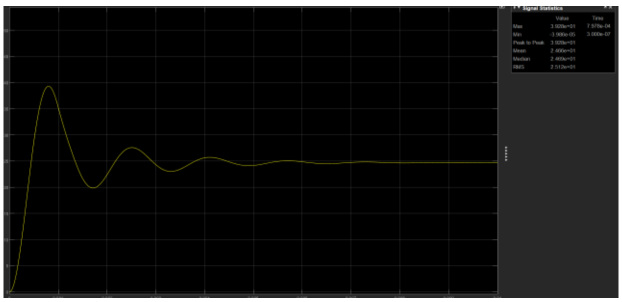
1. The power switch (usually a MOSFET) is turned on to allow current to flow through the inductor.
2. The current flowing through the inductor stores energy in its magnetic field.
3. When the power switch is turned off, the inductor releases its stored energy, which causes the voltage across the output capacitor to increase.
4. A feedback circuit monitors the output voltage and adjusts the duty cycle of the power switch to maintain the desired output voltage.
5. The output voltage is also monitored for overvoltage and undervoltage conditions, and the power switch is adjusted accordingly to prevent damage to the load or the converter.
6. The inductor current is monitored to avoid overcurrent conditions, and the power switch is turned off if the current exceeds a certain threshold.
7. The converter includes protection circuits to prevent damage from overtemperature and other faults.
8. The cycle is repeated at a high frequency to maintain a steady output voltage.
9. Overall, the boost converter algorithm is designed to step up the input voltage efficiently and reliably while ensuring safe and stable operation of the converter and the load.

D. MATLAB SIMULATION

Boost Converter Simulink Model

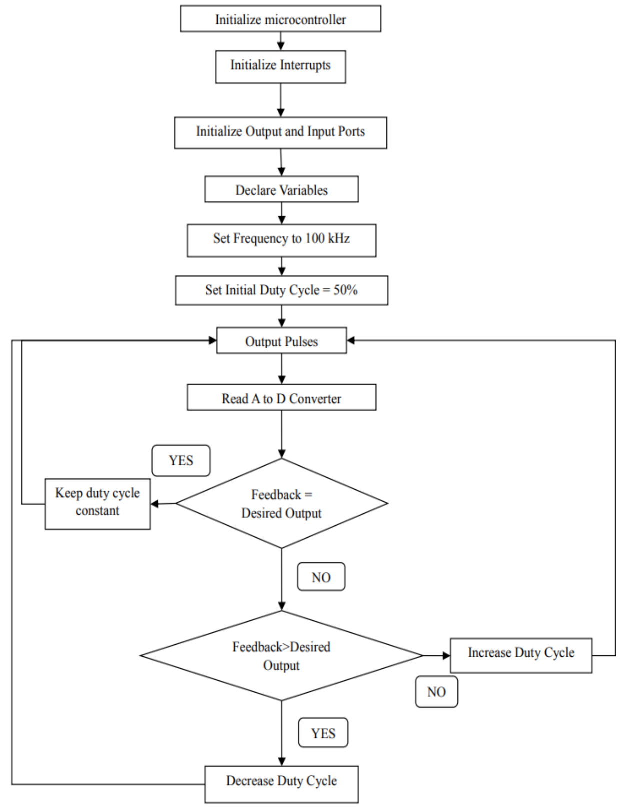


Output Voltage



A. Algorithms for Feedback

Algorithms for boost converter sing feedback loop analogy of boost converter by using stm32Microcontroler



PULSE WIDTH MODULATION

Pulse width modulation (PWM) is a technique used in electronic circuits to control the amount of power delivered to a load by adjusting the duty cycle of a pulse waveform. In PWM, a high frequency pulse waveform is generated and the width of the pulses is varied while the amplitude remains constant. By adjusting the duty cycle, the average power delivered to the load can be controlled without changing the amplitude of the waveform.

PWM is commonly used in applications such as motor control, lighting control, and power supply regulation, where precise control of power delivery is required. It offers several advantages over other methods of power control, including higher efficiency, lower heat dissipation, and more precise control over the output. PWM signals can be generated using microcontrollers, dedicated PWM controllers, or analog circuits.

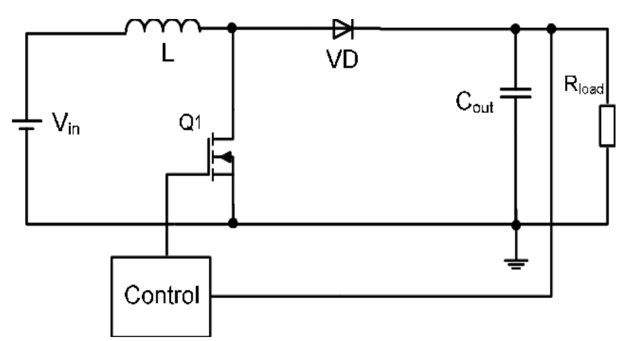


Fig 3. **PWM-feedback-controlled-DC-DC-boost-converter.**

. METHODOLOGY

1. .The Input voltage ranges from 9 to 30 volts, while the output voltage is set at 48 volts in a voltage boost type circuit.

2. .The circuit is intended to have a maximum power of 240Watts. The two basic components of a circuit system are the power and control circuits. The design of the power circuit will begin once the control circuit has been created.
3. PWM signal is required since the circuit being constructed is a voltage converter that is controlled by PWM.
4. A microcontroller (STM32f103c8T6) creates the PWM signal. Due to the characteristics of the microcontroller that will be utilized, metal pins can be used to get PWM signals with a range of frequency values and duty cycle rates. Additionally, the output voltage of the circuit will be applied to the analogue entrance of the STM32 microcontroller because the output voltage of voltage boost type circuits must be at a constant 24V.
5. 3.Feedback may be sent in this method, and the output voltage will be set in software to 24V. By varying the duty cycle rate of the PWM signal in software and adjusting it with the value obtained from the circuit output, the output voltage may be set. Software will be written in the language C. Power card design and material selection are started after developing the control card and obtaining the proper PWM signal. It will essentially be a voltage boost kind of circuit layout. This circuit topology will determine which components are required. MOSFET transistor will be used as switching element.
6. The microprocessor was programmed to output two gating pulses. The circuit was tested effectively with a switching frequency of 100 kHz. A pulse is sent at a frequency of 100 kHz with an initial duty cycle of the Mosfet set to 50%.

To maintain a stable 24V output from a 12 VDC input, a feedback loop is employed. The microprocessor controls the duty cycle by comparing a 4.2V reference voltage with the feedback signal obtained from a voltage divider at the output, using the stm32Microcontroller the voltage divider is designed to produce a feedback signal of 4.2V when the output voltage is at the desired 24V level, which corresponds to no duty cycle adjustment being needed. If the output voltage goes above 24V, the duty cycle is reduced to bring it back to the desired level. Conversely, if the output voltage drops below 24V, the duty cycle is increased. This process is continuously repeated to adjust the output voltage in response to changes in the input voltage, with the reference voltage being checked periodically to ensure stability. Figure 1 shows a diagram of the voltage divider.

1. STM32 Microcontroller.

The STM32 microcontroller is a powerful and versatile platform that can be used for a wide range of applications, including pulse width modulation (PWM). PWM is a common technique used for controlling the amount of power delivered to a load, such as a motor or LED.

→ - The STM32 microcontroller is a popular 32-bit ARM Cortex-M based microcontroller.
→ - It offers a wide range of features and peripherals, including Pulse Width Modulation (PWM).
→ - PWM is a technique used to control the amount of power delivered to a load by varying the duty cycle of a signal.
→ - The STM32 microcontroller offers several hardware PWM channels that can be used for a variety of applications such as motor control, LED dimming, and audio processing.
→ - The STM32 microcontroller also offers software-based PWM solutions that can be customized to specific applications.
→ - The PWM output can be configured to generate different waveforms, such as square wave, sine wave, and triangle wave.
→ - The duty cycle and frequency of the PWM output can be adjusted dynamically in real-time using the STM32's on-chip timers and interrupts.
→ - The STM32 microcontroller also offers advanced features such as Dead-Time Generation, complementary PWM output, and fault protection for high-reliability applications.

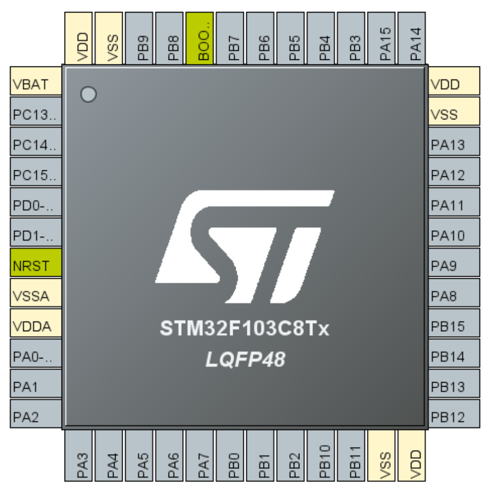


Fig. STM BOARD

2.Diode

→ A diode is an electronic component that allows current to flow in one direction while blocking it in the opposite direction.

- → Diodes are typically made from semiconductor materials such as silicon or germanium.
- → The most common type of diode is the p-n junction diode, which is formed by joining a p-type semiconductor with an n-type semiconductor.
- → When a voltage is applied to the p-n junction diode in the forward direction, it conducts current easily.
- → When a voltage is applied in the reverse direction, the diode blocks current flow almost completely, except for a small amount of leakage current.

CONCLUSION

In conclusion, a boost converter is a type of DC-DC converter that can efficiently step up the input voltage to a higher output voltage. The boost converter operates by storing energy in an inductor during the on time of a power switch and then releasing that energy to the output during the off time of the switch. This creates a higher output voltage than the input voltage. The output voltage is monitored and adjusted using a feedback circuit to maintain a steady voltage, while also protecting against overvoltage and undervoltage conditions. With its efficient and reliable operation, the boost converter is widely used in various electronic applications such as power supplies, LED drivers, and battery chargers.