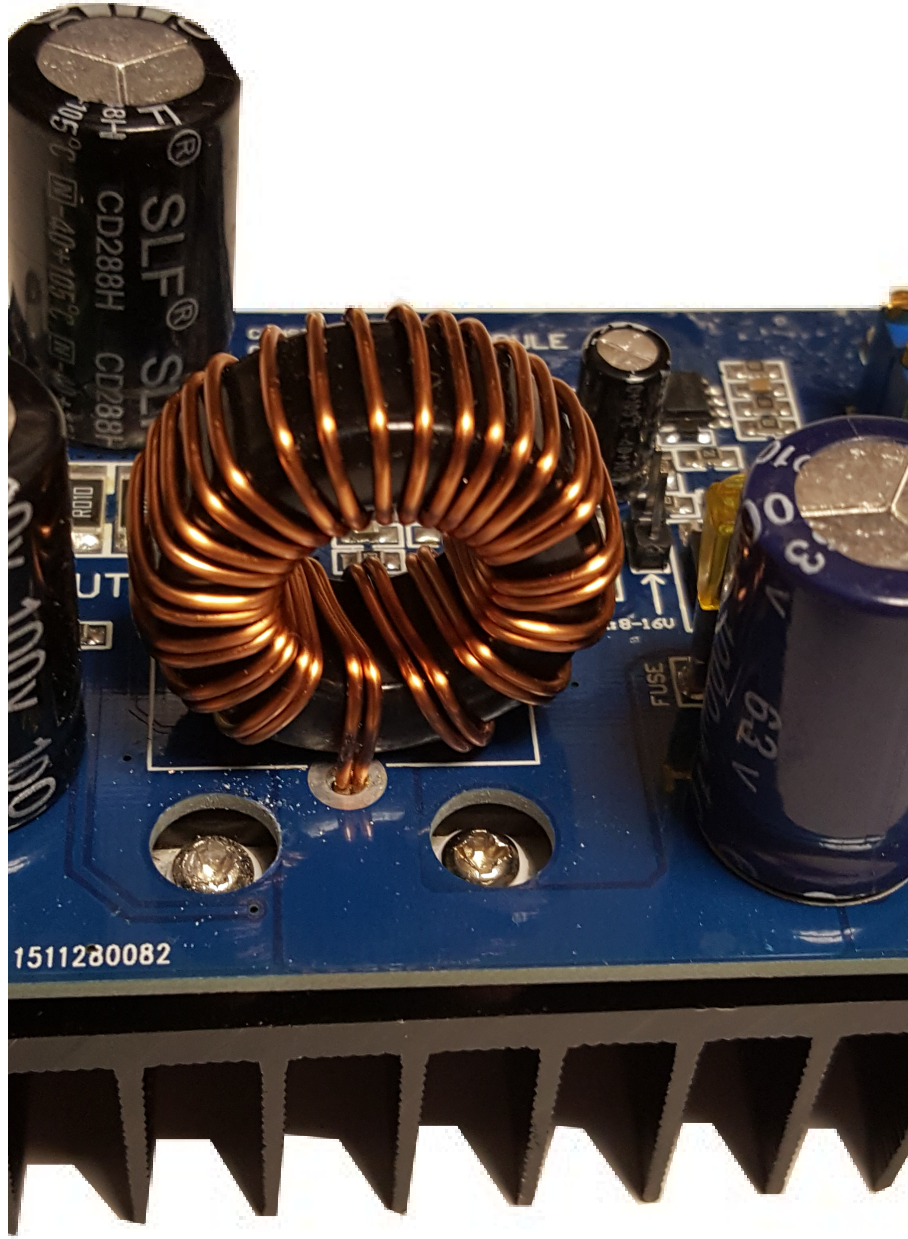
Boost Converter Design with PWM Feedback Using STM32 Microcontroller

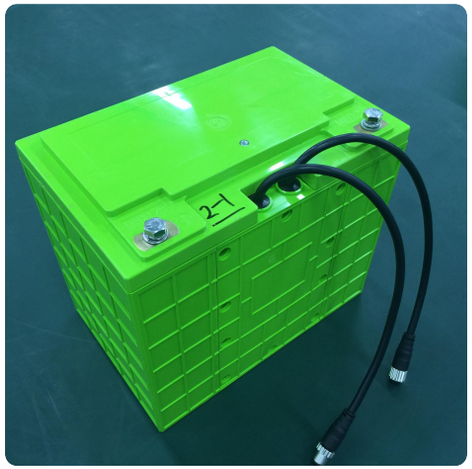
In this presentation, we will discuss the purpose of Boost Converter design, the formula for calculating duty cycle, circuit diagram of Boost Converter, working procedure of Boost Converter, applications of Boost Converter, introduction to PWM feedback, and how STM32 Microcontroller is used in Boost Converter design.



Converting DC to DC can be a challenging task, depending on the application requirements. Some common problems that can arise during this process include:

1. Voltage Regulation: DC-DC converters must be designed to provide a regulated output voltage, regardless of input voltage variations and load changes.
2. Efficiency: The efficiency of a DC-DC converter determines how much of the input power is converted to the output power, and how much is lost as heat. High-efficiency converters are preferred as they reduce energy waste and heat dissipation.
3. Size and Cost: DC-DC converters must be designed to meet specific application requirements such as input voltage range, output voltage, and power rating. A well-designed converter should be compact, reliable, and cost-effective.

What is a Boost Converter and Why is it Used?

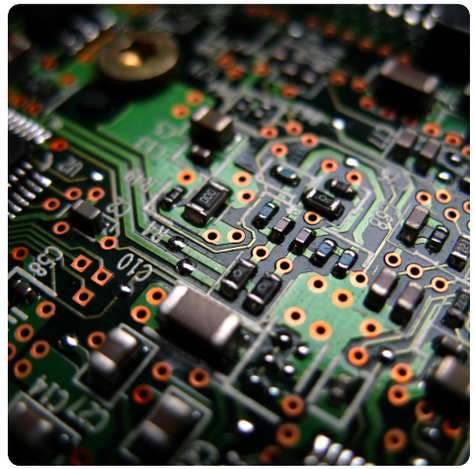


Raising Voltage

Boost Converter is used to raise the voltage level of a low voltage battery, typically used in portable devices, to a high voltage required for a particular application.

Increase Efficiency

It is widely used in portable devices because it increases the efficiency of the device by reducing the amount of power drawn from the battery.



Electronics

Boost Converter is used in various electronic devices such as LED lights, smartphones, laptops, and so on.

Duty Cycle Formula and PWM Feedback Introduction

1

Duty Cycle Formula

The Duty Cycle is the ratio of on-time of the Pulse Width Modulation waveform, and the period of the waveform. Duty Cycle = tON / T

2

Pulse Width Modulation (PWM)

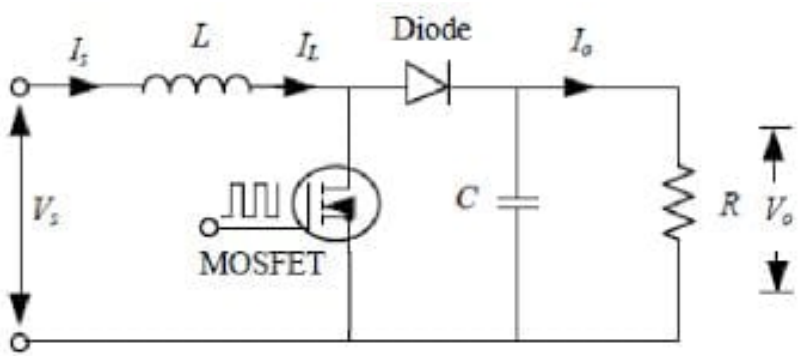
Pulse Width Modulation is a technique to encode a message into a pulsing signal by varying the width of the signal pulse. The PWM signal is fed back to the Boost Converter circuit using an analog-to-digital converter.

3

PWM Feedback and STM32 Microcontroller

The feedback allows the duty cycle to be dynamically adjusted, changing the output voltage of the Boost Converter. STM32 Microcontroller is used to generate the Pulse Width Modulation signal, read the feedback signal, and adjust the duty cycle accordingly.

Boost Converter Circuit Diagram and Working Procedure



Working Procedure

1. The input voltage is applied to the inductor, which stores energy in its magnetic field.
2. The control circuit signals the switch to open, and the inductor energy is delivered to the load.
3. When the switch is closed, the inductor stores energy again, and the cycle repeats.

The output voltage is higher than the input voltage because of the inductor's energy storage properties. The duty cycle is dynamically adjusted, changing the inductor's charge and discharge time, ultimately changing the output voltage.

MOSFET for Boost Converter with PWM Modulation

A MOSFET is a type of transistor that is commonly used in boost converter circuits with PWM (Pulse Width Modulation) feedback. In this type of circuit, the MOSFET acts as a switch that controls the flow of current from the input voltage source to the output load.

The MOSFET is driven by a PWM signal that controls the duty cycle of the switch. The duty cycle is the ratio of the on-time of the MOSFET to the total switching period. The duty cycle is usually controlled by a microcontroller or other PWM controller.

The MOSFET must be chosen to have a low on-resistance and a high voltage rating to handle the high current and voltage in the circuit. The MOSFET's gate capacitance also affects the switching speed and efficiency of the circuit.

Here's the formula to calculate the duty cycle:

> $D = Ton / (Ton + Toff)$

Where:

- D is the duty cycle
- Ton is the on-time of the MOSFET
- $Toff$ is the off-time of the MOSFET

This formula is important for calculating the appropriate values for the PWM signal to achieve the desired output voltage and current.

PWM Technique in Boost Converters

Pulse Width Modulation (PWM) is a technique used in boost converters to control the amount of power delivered to the load. It works by rapidly switching the power on and off, with the ratio of on-time to off-time determined by the duty cycle. The duty cycle is the percentage of time that the power is on during one cycle of the PWM signal. By adjusting the duty cycle, the output voltage can be regulated.

The PWM signal is generated by the controller circuit, which uses feedback to adjust the duty cycle based on the output voltage. This feedback loop ensures that the output voltage remains constant, even if the input voltage or load changes. The feedback mechanism monitors the output voltage and adjusts the duty cycle to maintain a constant output voltage.

Flyback Output Diode in Boost Converters

The Flyback Output Diode (FOD) is an important component in boost converters that is used to improve the stability of the circuit. It is connected in parallel with the load, and is used to allow the inductor to discharge when the MOSFET is switched off. This helps to reduce the voltage spike that can occur when the MOSFET is switched off, which can cause damage to the circuit.

The FOD also helps to improve the efficiency of the boost converter by allowing the energy stored in the inductor to be transferred to the load. When the MOSFET is switched off, the energy stored in the inductor is transferred to the output through the FOD. This helps to reduce the amount of energy that is lost in the circuit, and improves the overall efficiency of the boost converter.

Overall, the FOD is an important component in boost converters that is used to improve the stability and efficiency of the circuit. By allowing the inductor to discharge when the MOSFET is switched off, it helps to reduce voltage spikes and prevent damage to the circuit. It also helps to improve the efficiency of the circuit by allowing the energy stored in the inductor to be transferred to the load.

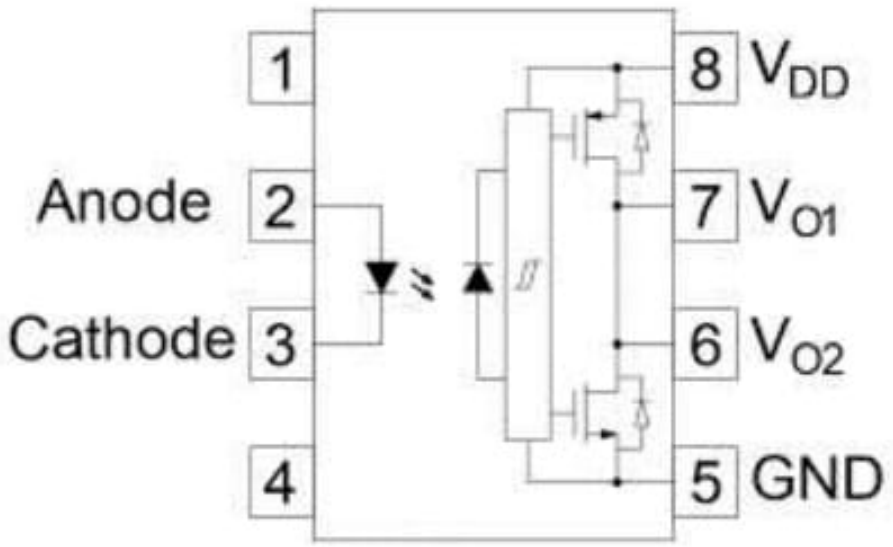


Fig. PIN Diagram of FOD

Critical Inductance Value

The critical inductance value for a boost converter is the minimum inductance required for the circuit to operate properly. It is affected by the switching frequency of the circuit.

As the switching frequency increases, the critical inductance value decreases. This is because a higher switching frequency allows the inductor to store and release energy more quickly, so less inductance is required to maintain a smooth output voltage.

However, there are limits to how high the switching frequency can go. A higher switching frequency leads to increased switching losses and higher electromagnetic interference (EMI). Therefore, the switching frequency must be chosen to balance the tradeoff between critical inductance value and switching losses/EMI.

This formula is used to calculate the critical inductance value:

> $$L = \frac{D(1-D)^2 R}{2f}$$

The formula can be used to calculate the minimum inductance required for a given set of input and output parameters, and can be used to select an appropriate value for the inductor.

Capacitor Value

$$C = \frac{(< V_o > D)}{Rf \triangle V}$$

Formula used

Output Voltage

$$\frac{V_{out}}{V_{in}} = \frac{1}{1-D}$$

Power

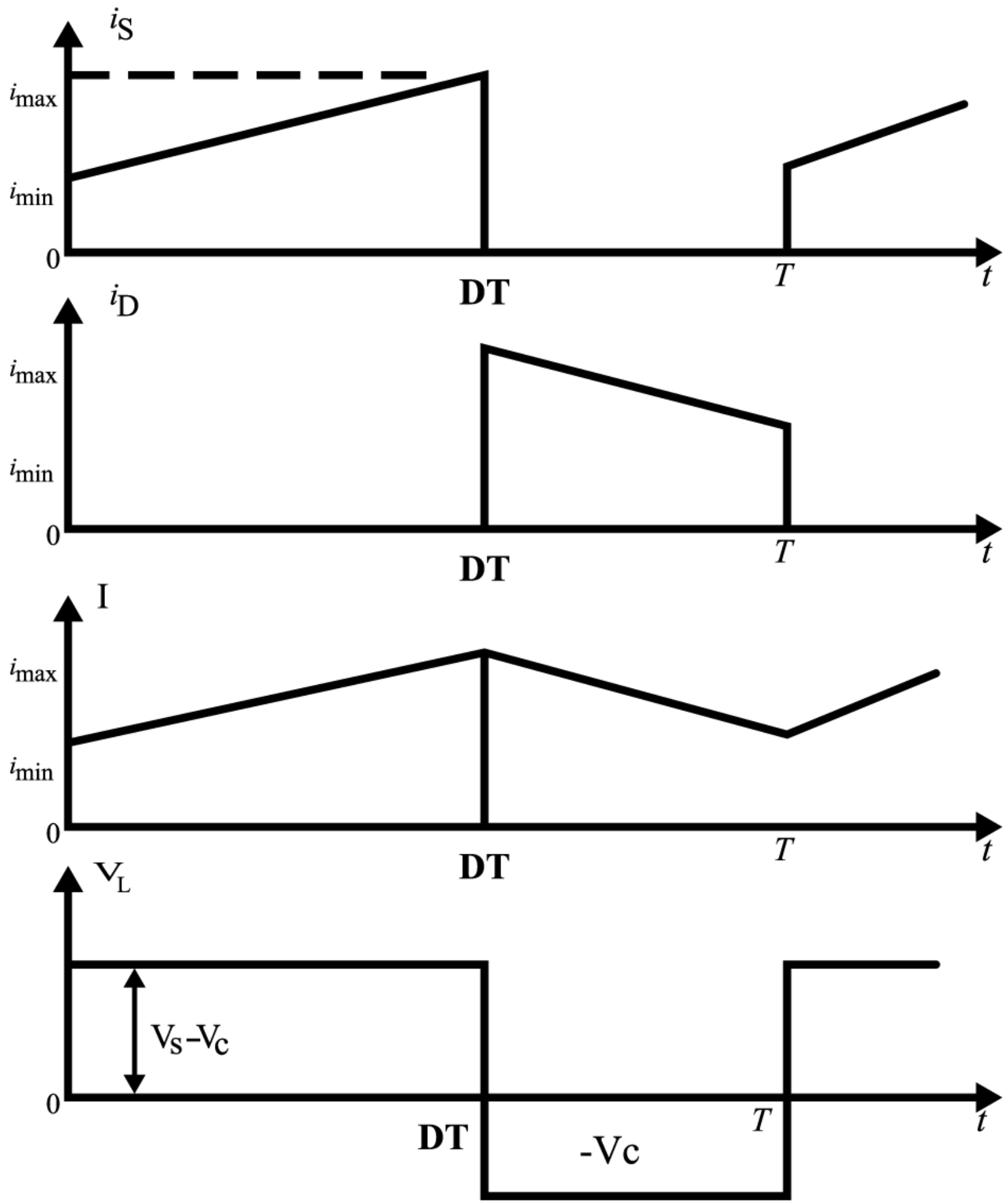
$$P = \frac{V_{in}^2}{R}$$

Inductor current ripple $\triangle I_L$

$$\triangle I_{L_{Ton}} = \frac{V_{in} DT}{L}$$

$$\triangle I_{L_{Toff}} = \frac{-(V_{in} - V_o) DT}{L}$$

Graphs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Applications of Boost Converter

1 Solar Panels

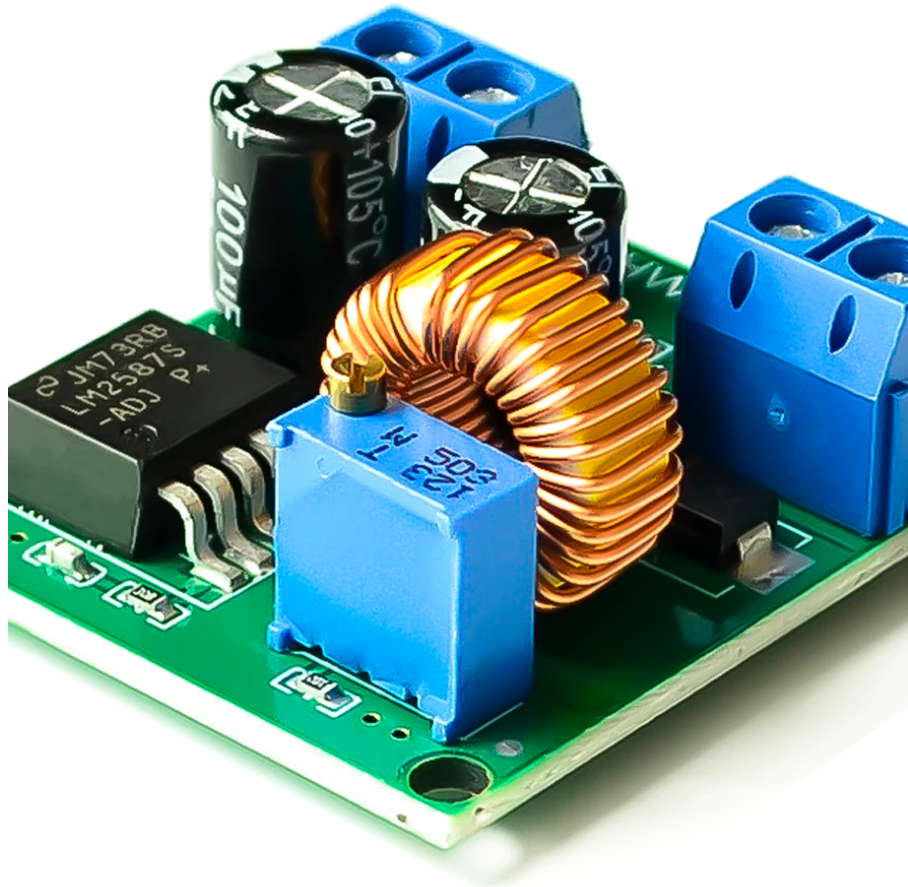
Boost Converter is used in solar panels to convert the low voltage output of the solar panel to a higher voltage required for battery charging.

2 Cars

It is used in vehicles to convert the battery voltage to a higher voltage required for the car audio system.

3 Medical Equipment

The Boost Converter is used in various medical devices, such as pacemakers, to convert a low voltage battery supply to a higher voltage required for the device's operation.



Advantages of Boost Converter

Efficiency

The Boost Converter is highly efficient and can convert the input voltage to the desired output voltage with minimal power loss.

Compact Size

It is relatively small in size and can be easily integrated into portable devices.

Cost Effective

The Boost Converter is inexpensive, making it an excellent choice for most electronic applications.

Regulation

It provides excellent voltage regulation, ensuring that the output voltage remains constant even when the input voltage fluctuates.

Boost Converter Design Summary

Purpose	Raising voltage level of low voltage battery for specific applications
Working Procedure	Inductor stores energy from input voltage and discharges it to the load through the switch
Advantages	• High efficiency with minimal power loss • Compact size and cost-effective • Excellent voltage regulation

Thank You