Heaven's Light is Our Guide

Rajshahi University of Engineering and Technology

Course Code

ECE 3206

Course Title

Industrial Electronics Sessional

Project Report

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Contents

Study of Buck Converter Using Simulink

Working Principle of Boost Converter

A DC-DC Boost Converter (Step-Up Chopper) is a type of SMPS that increases input DC voltage to a higher output DC voltage using high-speed switching devices.

Circuit Diagrams

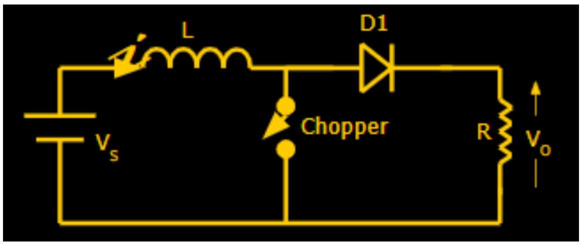

Figure 1: Basic Circuit Diagram of a DC-DC step up Circuit

Key Components

The key components of a boost converter include:

- An inductor (L)
- A switch (typically a MOSFET or IGBT)
- A diode (D)
- A filter capacitor (C)
- A load resistance (R)

Operation Modes

The operation of a boost converter consists of two intervals in each switching cycle:

ON-State (Switch Closed, t_1):

- The switch is ON, and current flows from the source (V_s) through the inductor, storing energy as a magnetic field.
- The diode is reverse-biased, blocking current to the load.
- Inductor voltage: $V_L = V_s$, and current increases linearly: $\frac{di}{dt} = \frac{V_s}{L}$.

OFF-State (Switch Open, t_2):

- The switch is OFF, and the inductor releases stored energy.
- Current flows through the diode, charging the capacitor and powering the load.
- Output voltage: $V_O = V_S + V_L$, higher than the input.

This cyclical switching process results in a higher average output voltage.

Output Voltage Expression

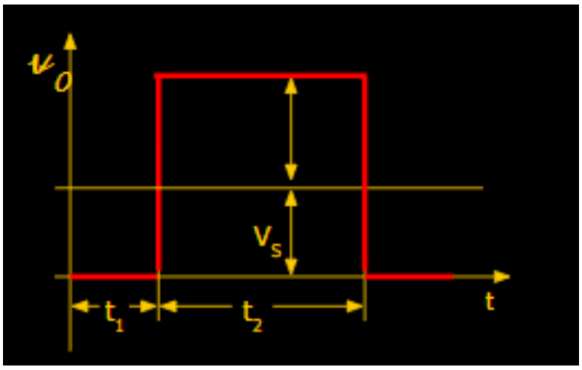

Figure 2: Output Voltage of the Booster Circuit

The output voltage of a boost converter is related to the input voltage and the duty cycle K by the following equation:

$$V_O = \frac{V_S}{1 - K}$$

Where:

- V_O = Output Voltage
- V_S = Input Voltage
- $K = \frac{t_1}{T}$ = Duty cycle (ratio of ON time to total period)

As K approaches 1 (i.e., longer ON-time), the output voltage increases significantly. However, it can never be infinite due to practical limitations such as switch losses and component ratings.[1]

Current Behavior

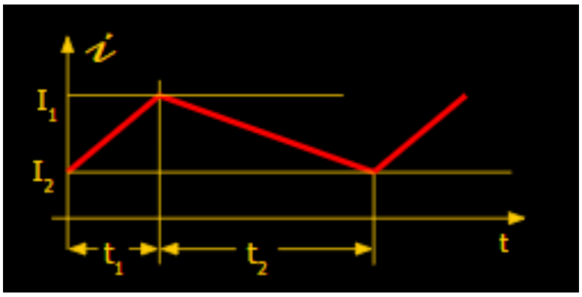

Figure 3: Output Current of the Booster Circuit

The inductor current forms a triangular waveform, ramping up during the ON state and down during the OFF state. Proper inductance and switching frequency minimize ripple.[1]

Designing a DC-DC Boost Converter:

Necessary Components

- LM2577T – Adjustable IC (1 piece)
- 100 µH Inductor (1 piece)
- IN5819 Schottky Diode (1 piece)
- 2kΩ Resistor (2 pieces)
- 220Ω Resistor (1 piece)
- Red LED (1 piece)
- 10µF Capacitor (1 piece)
- 470µF Capacitor (1 piece)
- 330nF Capacitor (1 piece)
- Trimmer/Variable Potentiometer 100k (1 piece)
- Screw Terminal (2 pieces)
- Slide Switch (1 piece)

- 5x1 Female Header Pin (1 piece)
- 5x1 Male Header Pin (1 piece)
- Digital Voltmeter + Ammeter (1 piece)
- Soldering Iron
- Solder
- Multimeter

Necessary Software:

- EasyEDA for Circuit Diagram and PCB Designing

Components choosing Justification:

LM2577-ADJ: A versatile boost converter IC with integrated switch, oscillator, and feedback control, allowing adjustable output voltage via external resistors.

IN5819 (Schottky Diode): Chosen for its low forward voltage drop and fast recovery, ensuring efficient high-frequency switching with minimal losses.

100 µH Inductor: Stores and releases energy during switching, enabling voltage boost while minimizing current ripple.

330 pF Capacitor: Stabilizes the LM2577's feedback loop for smooth output regulation.

470 µF Capacitor: Filters and smooths the boosted DC output, reducing ripple and transients.

100kΩ Potentiometer: Adjusts output voltage by forming a feedback voltage divider with R1.

2kΩ Resistor: Works with the potentiometer to set the feedback ratio and stabilize the output voltage.

Circuit Diagram

The circuit diagram illustrates a DC-DC boost converter using the LM2577-ADJ IC to step up a 5V input. Key components include a 100 µH inductor, 1N5819 Schottky diode, and adjustable potentiometer for output voltage control. Screw terminals and header pins ensure secure connections, while capacitors provide filtering and stability.

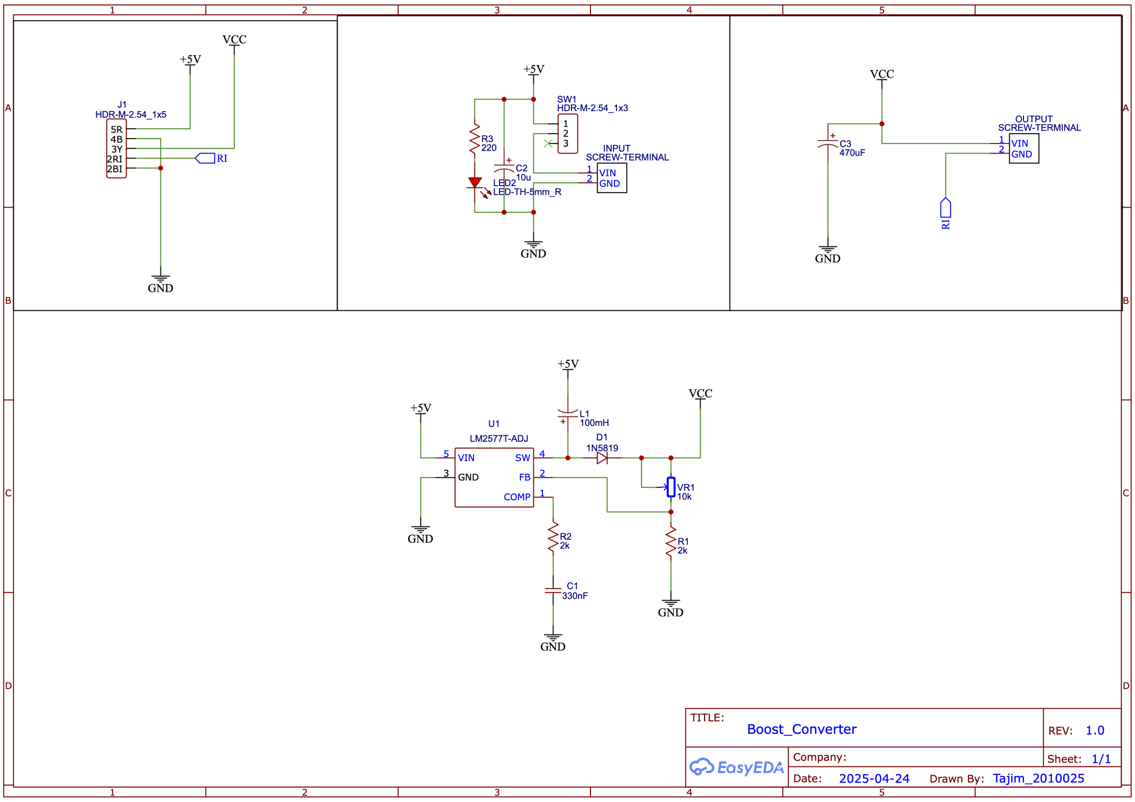

Figure 4: Precise Circuit Diagram of DC-DC booster Circuit

Printed Circuit Board (PCB) and 3D rendered View:

- PCB layout was designed with proper placement of components like LM2577 IC, inductor, and Schottky diode.
- Tracks were optimized for short, efficient high-current paths and ground planes added for noise reduction.
- Mounting holes and labels were included for easy assembly, and a DRC ensured error-free design.

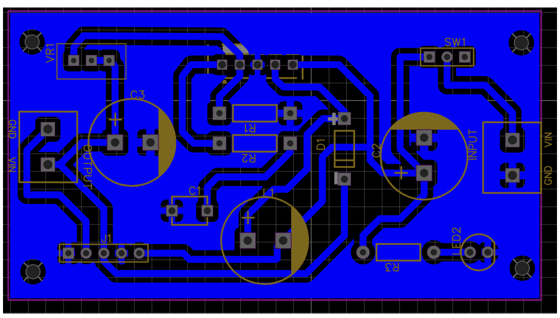

Figure 5: PCB Design

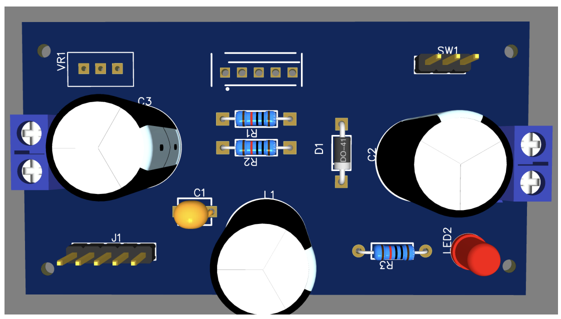

Figure 6: 3D Rendered View of PCB

Input-Output of the DC-DC Step Up Circuit:

According to the data sheet of the LM 2577, Voltage Output, $V_out = 1.23\left(1 \times \frac{R_1}{VR_1}\right)$
Where, V_out = Output Voltage of the Step Up circuit
$R_1 = 2\,k\Omega$
VR_1 = Variable Resistor of $100\,k\Omega$

Figure 7: 4V input and 18V output

Result Discussion

The aim of this project was to design and build a DC-DC step-up (boost) converter using the LM2577-ADJ IC. The circuit was designed and simulated in EasyEDA, and the PCB layout was created following best practices for switching power supplies, including optimized trace routing, decoupling, and component placement. After assembling the PCB and soldering the components, the circuit was tested and verified to operate as expected.

When powered by a 3.7V lithium-polymer (LiPo) battery, the converter successfully delivered a stable adjustable output voltage ranging from approximately 8V to 72V. This wide range highlights the efficiency of the feedback control loop and the switching process. The onboard potentiometer allowed precise adjustment of the output voltage, while real-time voltage readings were monitored using an external voltmeter/ammeter module connected via header pins.

During testing, the circuit exhibited stable performance without any thermal or functional issues. The use of a 1N5819 Schottky diode reduced switching losses, and the careful component layout minimized electromagnetic interference (EMI). Additionally, the power indicator LED and output filtering capacitors improved usability and ensured a smooth output voltage.

Applications of DC-DC Boost Converter

- DC motor drive systems
- Electric vehicles
- Battery voltage regulators
- Solar photovoltaic systems
- Regenerative braking in traction systems

Conclusion

The boost converter is an efficient solution for stepping up DC voltage through a switching mechanism. By controlling the switch's duty cycle, the output voltage can be effectively regulated. Mastering its operation is crucial in power electronics, especially for developing efficient power conversion applications.

References

[1] alldatasheet.com, "LM2577T-ADJ Datasheet (PDF)," https://www.alldatasheet.com/datasheet-pdf/pdf/527551/TI1/LM2577T-ADJ.html, n.d., texas Instruments.