Basic Boost Converter — Step-Up DC–DC Conversion

This paper is part of the Power Electronics Learning Portfolio, a self-study documentation series.

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Abstract

This paper investigates the fundamental operating principles of the Boost Converter, a type of DC–DC converter used to step up voltage efficiently.

Using PSIM simulations, a 25 V input was boosted under open-loop PWM control, and voltage gain and transient characteristics were evaluated.

Simulations were performed at duty ratios 0.3, 0.5, and 0.7 to analyze how the duty ratio affects output voltage, waveform response, and stability.

The results confirmed that inductance, capacitance, and switching frequency are the key parameters determining the dynamic response, ripple, and overall performance of the converter.

Introduction

The Boost Converter is one of the basic DC–DC power conversion topologies that raises a lower DC voltage to a higher level.

It operates by storing energy in an inductor during the switch ON period and releasing that energy to the output through a diode during the OFF period.

This study simulates a Boost Converter in PSIM to analyze how duty ratio, inductance, and capacitance influence output voltage, rise characteristics, and waveform smoothness.

Basic Principle

Operating Modes

When the switch is ON:
The inductor stores energy from the source, and the diode is reverse-biased, isolating the load.

$$V_L = V_{in}$$

When the switch is OFF:
The inductor's stored energy is released through the diode to the load, adding to the

input voltage.

$$V_L = V_{in} - V_{out}$$

The average output voltage is given by:

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

Example: For $V_{in} = 25V$and $D = 0.5,\ V_{out} \approx 50V.$

Circuit Parameters

PARAMETER	SYMBOL	VALUE	DESCRIPTION
INPUT VOLTAGE	(Vin)	25 V	Supply voltage
LOAD RESISTANCE	(R)	5Ω	Represents load
INDUCTOR	(L)	1mH	Controls current ripple
CAPACITOR	(C)	100µF	Smooths output voltage
SWITCHING FREQUENCY	(fs)	5 kHz	Determines ripple and loss
DUTY CYCLE	(D)	0.5	Target ratio for 2× boost

The parameters were selected to balance visible transient response with stable operation and moderate ripple for waveform observation.

Simulation Results

The PSIM simulation schematic is shown in Figure 1.
Output-voltage and inductor-current waveforms for duty ratios 0.3, 0.5, and 0.7 are shown in Figures 2 and 3.

- **D = 0.3:** Output stabilizes around 36 V
- **D = 0.5:** Output reaches approximately 50 V
- **D = 0.7:** Output rises to about 82 V

Inductor current increased with duty ratio, and peak current became larger at higher duty cycles.

Voltage ripple was moderate, and rise time became slightly longer at high duty.

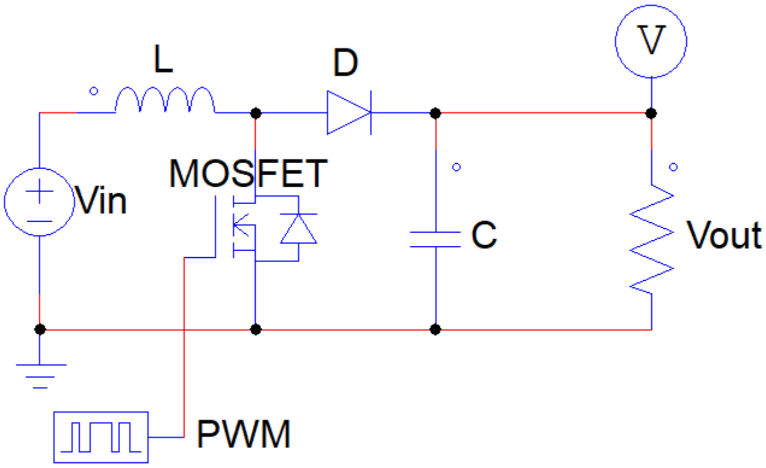

Figure 1

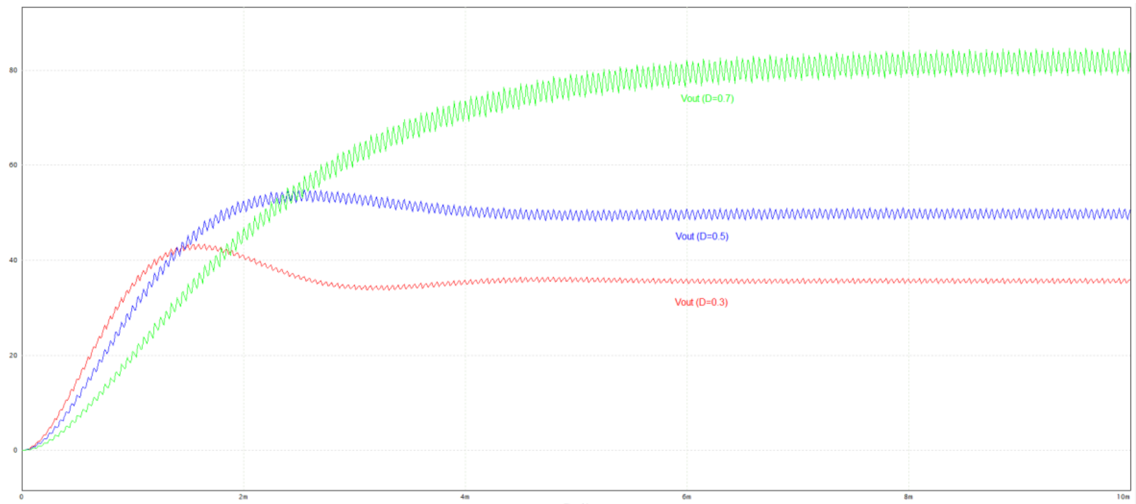

Figure 2

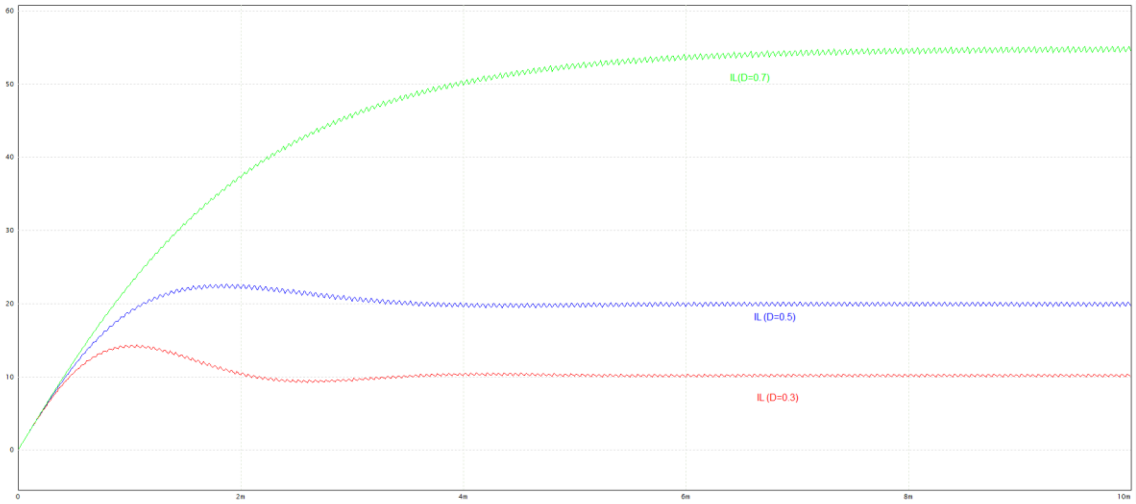

Figure 3

Discussion

The relationship between duty ratio and output voltage was clearly observed.

Higher duty ratios increased the energy stored during ON time and released during OFF time, resulting in higher output voltage.

When duty exceeded approximately 0.6, energy transfer increased significantly, causing higher transient overshoot and more inductor-current stress.

Changing L and C showed the following tendencies:

- Larger inductor (5 mH) reduces ripple and overshoot but slows response
- Larger capacitor (200 µF) reduces voltage ripple but slightly delays settling
- Higher switching frequency improves damping and smooths startup behavior

These waveform evaluations clarified energy-transfer characteristics at duty ratios 0.3, 0.5, and 0.7 and highlighted the dependence on PWM ratio.

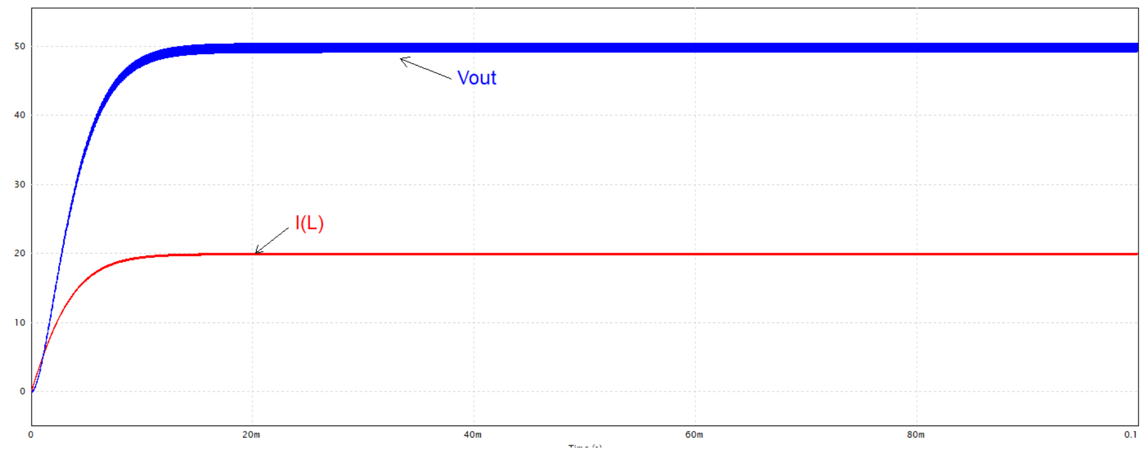

Figure 4

Conclusion

This study confirmed the basic boost operation of the Boost Converter and demonstrated how duty ratio affects output voltage and transient characteristics.

With a 25 V input, duty ratios 0.3, 0.5, and 0.7 produced output voltages of approximately 36 V, 50 V, and 82 V, respectively.

Higher duty increases voltage gain but also increases inductor stress and overshoot.

Optimizing the inductor, capacitor, and switching frequency can significantly improve startup response and output-voltage stability.

Future work will involve implementing closed-loop control and soft-start to achieve stable startup under various load and input-voltage conditions.