Working Principles for Selecting a Boost Converter

Introduction

Converter selection is the first step in power supply design that directly impacts stable system operation and performance. Typically, the designer must determine whether a power converter meets the actual load capacity based on the rated current value.

For example, selecting a 36V/3A buck converter for a 24V to 5V/2A power rail achieves excellent efficiency, temperature rise, and cost performance. However, if a 3A/5.5V boost converter is selected for a 3.6V to 5V/2A power rail, then the chip protection mechanism is triggered abruptly. This is because the boost converter's nominal current is not equivalent to the amount of current that the converter can output.

This article discusses the working principles of the boost converter to determine the switching current capability.

Boost Converter Working Principles

When the switch tube (M1) turns on within one switching cycle, the current path occurs in the following order: input voltage (V_{IN}), inductance (L), and M1. The inductor current (I_L) rises, resulting in energy storage in the inductor (see Figure 1).

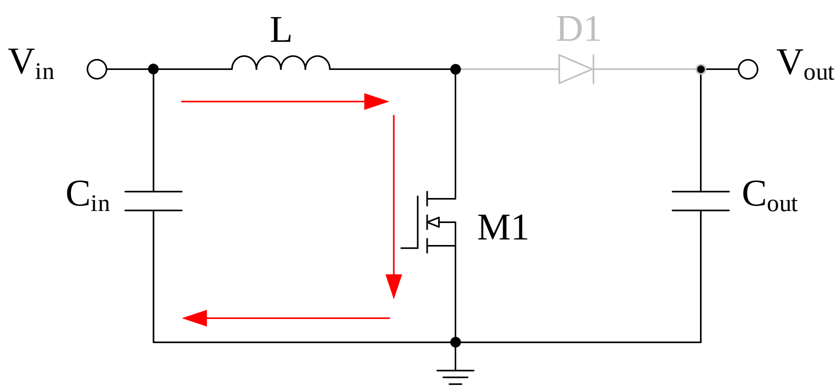

Figure 1: Current Path when M1 Turns On

When M1 turns off, the diode (D1) continues to flow and the inductor releases energy since I_L does not change abruptly. The current path occurs in the following order: V_{IN}, L, D1, and output voltage (V_{OUT}) (see Figure 2).

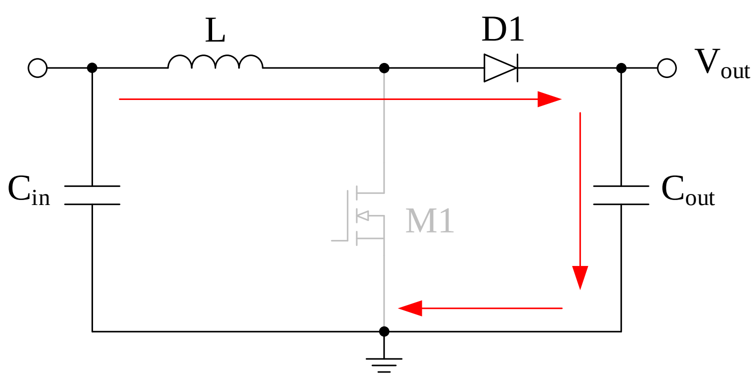

Figure 2: Current Path when M1 Turns Off

In the boost circuit during a switching cycle, the input continuously transfers energy to the output through the inductor's energy storage and release (see Figure 3).

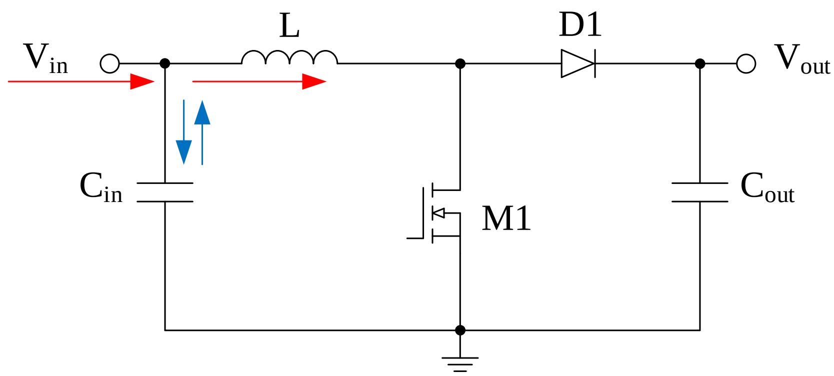

Figure 3: Continuous Energy Transfer to the Boost Circuit Output

Due to the charging and discharging balance of the input capacitor during a cycle, the average current is 0A. Therefore, the average I_L is equal to the average input current (I_{IN_AVG}), and the maximum I_L is equal to the maximum switch current (see Figure 4).

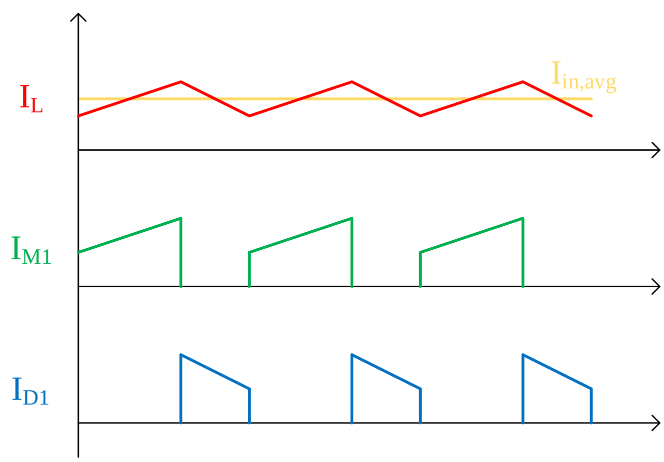

Figure 4: Inductor Current, Switch Tube Current, and Diode Current Waveforms

The nominal current of buck converters is I_{OUT}, while the nominal current of boost converters is the maximum switching current. The maximum switching current is equal to the peak inductor current (I_{L_PEAK}). Due to the ripple in I_L, I_{L_PEAK} must be calculated with Equation (1):

$$I_{L\_PEAK} = \left(\frac{V_{OUT} \, x \, I_{OUT}}{V_{IN\_MIN} \, x \, \eta}\right) x \, 1.15 \tag{1}$$

Calculate the maximum output power (P_{OUT_MAX}) using V_{OUT} and I_{OUT}. Divide V_{OUT} and I_{OUT} by efficiency η to obtain the maximum input power (P_{IN_MAX}), then divide P_{IN_MAX} by the minimum V_{IN} to determine the maximum input current (I_{IN_MAX}).

Where the current is the average value. Multiply the average current by the current ripple coefficient to obtain the peak-to-peak I_L value.

The ripple coefficient is typically 30%, meaning I_{L_PEAK} is equal to the average current multiplied by 1.15 times. According to this formula, I_{L_PEAK} must be below the maximum current flowing through the switch tube to make a preliminary selection of the chip (see Figure 5).

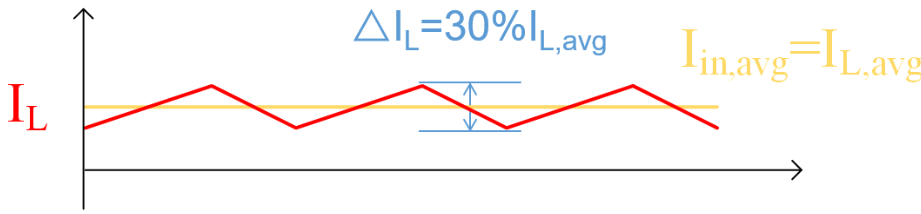

Figure 5: Peak Inductor Current for Preliminary Chip Selection

Conclusion

This article discusses the steps for determining the switching current capability for boost converters, which combined with V_{IN} and V_{OUT} requirements, are necessary for proper boost converter selection. For more details, explore MPS's wide selection of boost controllers and converters.