

Boost converter

The **boost converter** converts an input voltage to a higher output voltage. The boost converter is also called a step-up converter.

Boost converters are used in battery powered devices, where the electronic circuit requires a higher operating voltage than the battery can supply, e.g. notebooks, mobile phones and camera-flashes.

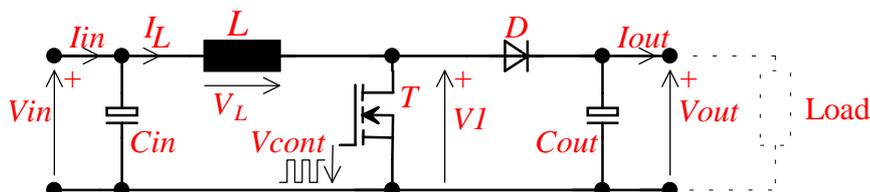


Figure 1.2.1: Boost converter

Figure 1.2.1 shows the basic circuit diagram of the boost converter. The transistor T operates as a switch, which is turned on and off by a pulse-width-modulated control voltage V_{cont} .

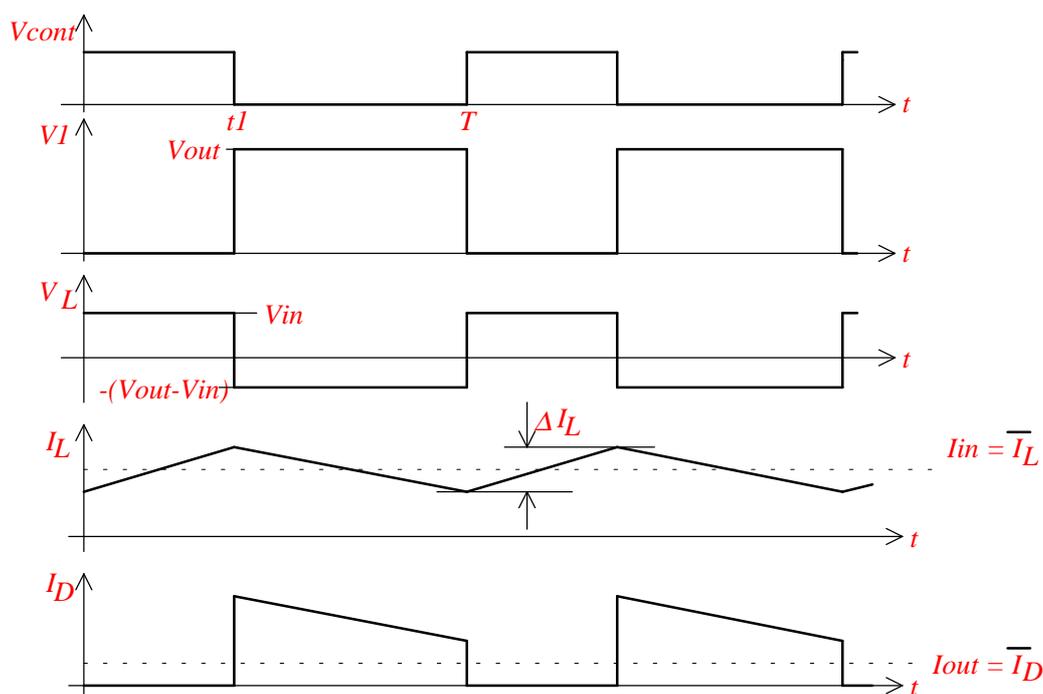


Figure 1.2.2: voltages and currents of the boost converter

In the following analysis it will be assumed that the conducting voltage drop of the transistor and the diode is zero.

During the on-time of the transistor, the voltage across L is equal to V_{in} and the current I_L increases linearly. When the transistor is turned off, the current I_L flows through the diode and charges the output capacitor.

The function of the boost converter can also be described in terms of energy balance. During the on-time of the transistor the inductance is charged with energy and during the off-time of

the transistor this energy is transferred from the inductor through the diode to the output capacitor.

If the transistor switch is not turned on and off by the clock the output capacitor charges via L and D to the level $V_{out} = V_{in}$. When the transistor is switched the output voltage will increase to higher levels than the input voltage.

As with the buck converter (see chapter 1.1: "buck converter") discontinuous and continuous mode is dependent on whether the inductor current I_L reduces to zero during the off-time of the transistor.

With the help of Faraday's Law the continuous mode and steady state conditions (see also figure 1.2.2) can be established:

$$\Delta I_L = \frac{1}{L} V_{in} \cdot t_1 = \frac{1}{L} (V_{out} - V_{in}) \cdot (T - t_1).$$

From which:

$$V_{out} = V_{in} \frac{T}{T - t_1}$$

- ♦ For the continuous mode the output voltage is a function of the duty cycle and the input voltage, it is independent of the load.
- ♦ The boost converter is not short circuit proof, because there is inherently no switch-off device in the short-circuit path.

NOTE:

If the boost converter is not regulated in a closed loop but is controlled by a fixed duty cycle of a pulse generator (this could be the case for a laboratory set up), the boost converter is not no-load proof. This is because each switching cycle results in energy in the choking coil being transferred to the output capacitor. This will result in the output voltage continuously increasing until the devices are eventually destroyed.

Calculation of L and C_{out} :

As with the buck converter the starting point of calculating L is to select a current ripple ΔI_L of about 20% of the input current: $\Delta I_L \approx 0.2 I_{in}$. The input current I_{in} can be calculated by assuming zero losses (input power = output power), therefore:

$$V_{in} \cdot I_{in} = V_{out} \cdot I_{out} \rightarrow I_{in} = I_{out} \frac{V_{out}}{V_{in}}$$

L can be calculated as follows:

$$L = \frac{1}{\Delta I_L} (V_{out} - V_{in}) \frac{V_{in}}{V_{out}} \cdot \frac{1}{f}$$

The peak value of the inductor current is (Ref: Fig. 1.2.2):

$$\hat{I}_L = I_{in} + \frac{1}{2}\Delta I_L.$$

Assuming that the inductor ripple current is small compared to its dc current the RMS value of the current flowing through the inductor is given by:

$$I_{L(RMS)} \approx I_{in}$$

The output capacitor is charged by pulses (Ref Fig. 1.2.2). The ripple ΔV_{out} of the output voltage results from the pulsating charge current I_D and is mainly determined by the impedance Z_{max} at the switching frequency of capacitor C_{out} . Z_{max} can be verified from the the capacitor data sheet.

The output voltage ripple is given by Ohm's law:

$$\Delta V_{out} \approx I_D \cdot Z_{max}$$