# Boost converter

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## 1 Introduction

Voltage is electrical potential, and is integral in circuits.

In practice, it is easy to reduce a given voltage; that is, create a voltage level between 0 and the source. A simple way to do this is a resistor voltage divider, made up of two resistors in series.

In loose terms, it is more complicated to increase the voltage practically. This is because, of the three basic components — resistor, capacitor, and inductor —, the inductor is the only one that can create a voltage larger than the source, and it does so transiently.

The boost converter is a circuit that increases voltage, and it does so by using this property of the inductor, in a controlled manner.

## 2 Theory

Figure 1 shows the boost converter circuit. During proper operation, the circuit generates a high output voltage across the capacitor.

Two inputs are required for this. First, a power supply is connected to VDC. Second, the transistor gate is driven with a square wave, periodically turning completely on and off.

### 2.1 Analysis

When the MOSFET is on, current flows through the inductor and transistor, eventually reaching a steady state determined by the resistance.

The inductor is governed by the equation $V = L\frac{dI}{dt}$. When the transistor is suddenly switched off, the current drops in a short period of time, and $\frac{dI}{dt}$ becomes very large in magnitude. Therefore, the voltage across the inductor rises significantly.

When the voltage across the inductor becomes higher than that of the capacitor, current flows through the diode, adding charge to the capacitor. The diode prevents the capacitor from discharging in the reverse direction.

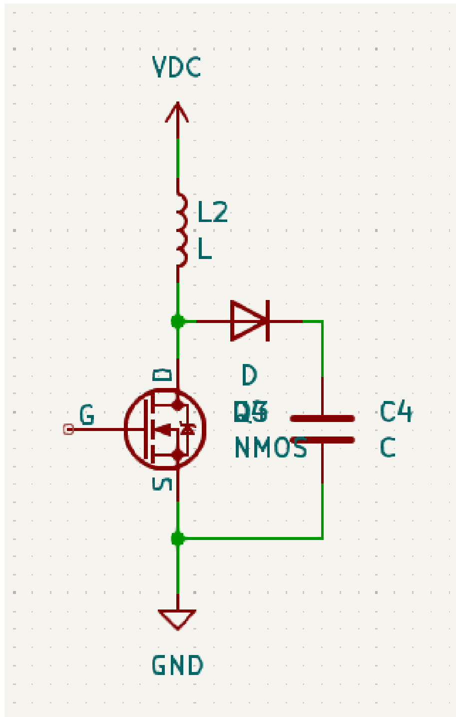


Figure 1: Base boost converter circuit.

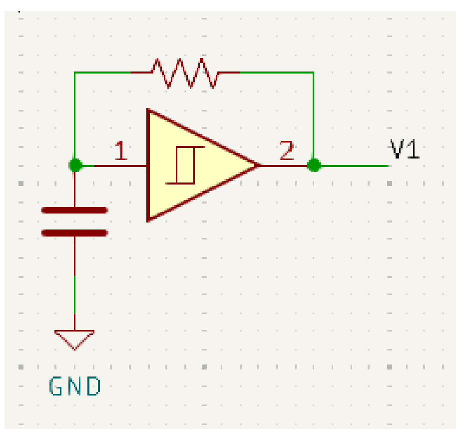


Figure 2: Square wave oscillator via Inverting Schmitt Trigger.

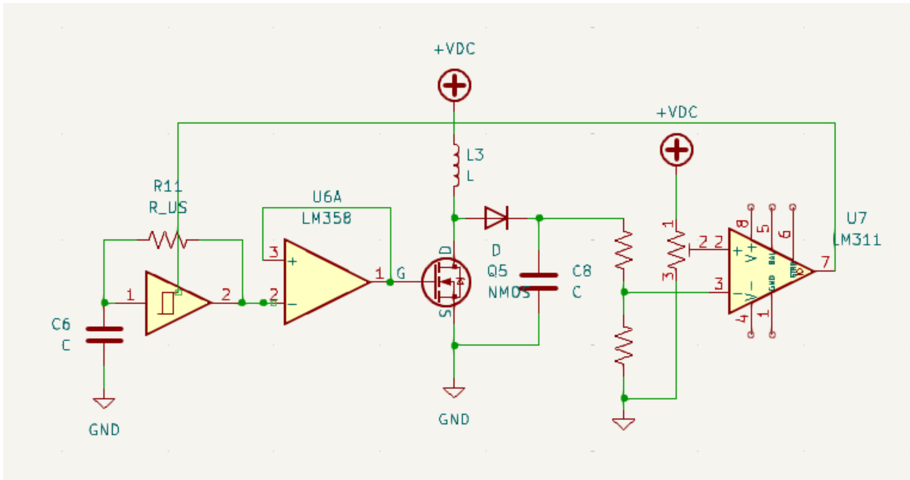


Figure 3: V1 circuit schematic.

### 2.2 Implementation

A simple way to generate a square wave is an Inverting Schmitt Trigger oscillator (Figure 2). The system is in an astable state from the negative feedback, hence the oscillation. The trigger also rectifies the output voltage to 0 or VDC, creating the square wave shape. The frequency of oscillation can be tuned by changing the values of resistance and capacitance, and will be on the order of $RC$ (the time constant).

The oscillator output can be attached to the boost converter transistor gate, which creates a minimalist, working circuit. However, in practice it can be inefficient, and several practical additions can be added.

## 3 V1

The V1 circuit uses the implementations described above, and adds a voltage controller that turns the circuit off once a desired threshold is reached.

We add a voltage follower, the LM358 Op Amp, to the output of the square wave. This increases the maximum *current* output of the square wave signal (i.e. decreases output impedance). As a result, the MOSFET gate charges and discharges faster, reducing power waste on the transistor.

The voltage controller is a comparator. One input is the boost converter's output, through a 20x voltage divider (i.e. $\frac{V}{20}$). The other is a voltage between 0 and 5V, chosen by the user with a potentiometer. Therefore, the circuit has a maximum voltage setting of $100V$. The comparator outputs logical 1 (5V) when the output voltage is less than the set threshold.

The comparator output goes to the Schmitt Trigger's power input. When the desired voltage is reached, the power to the square wave generator is cut

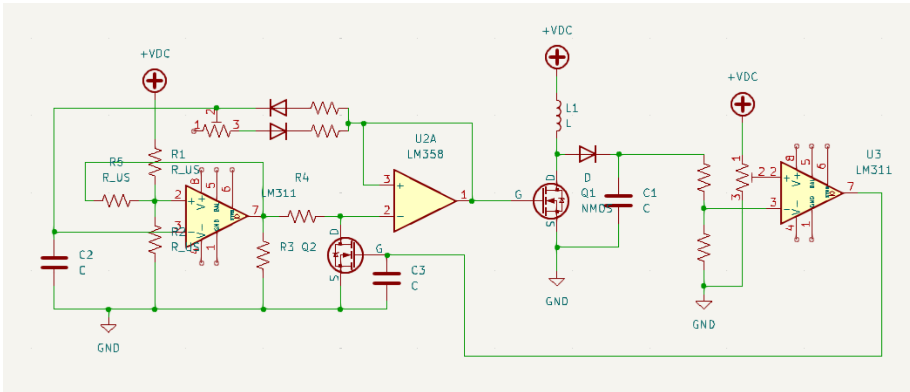


Figure 4: V2 circuit schematic.

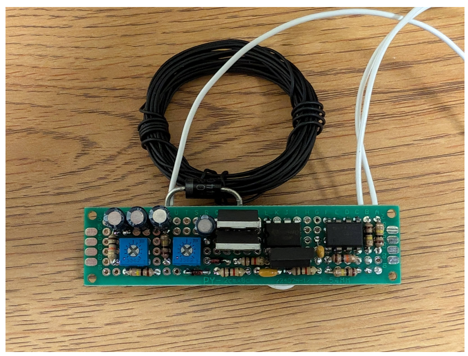

Figure 5: V2 circuit protoboard.

off, turning the transistor off. This pauses the boost converter.

The bottleneck for the voltage level is the MOSFET drain-source breakdown voltage. The transistor we used, 30N06L, has a 60V limit. If we attempt to output a higher voltage, the inductor discharges across the MOSFET breakdown instead of into the capacitor.

This circuit could achieve 64V. This is likely larger than the breakdown voltage due to inaccuracies in manufacturing.

## 4 V2

The V2 circuit improves on V1 with a reimplemented Schmitt trigger, controllable power, and a different transistor.

As mentioned above, the drain-source breakdown voltage of the MOSFET is a bottleneck. We use a different transistor, IRL540N, which has a 100V limit.

We implement the Schmitt trigger with different resistances for charging and discharging, changing the duty cycle of the square wave. This effectively changes the output power of the boost converter.

The circuit was soldered with two MOSFETs in parallel, reducing the resistance and power waste.

This circuit can achieve around 120V faster than V1, and maintains at least 10V across a 100Ohm resistor, which is 1 Watt of power.