TECHNOCRATS ROBOTICS

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STEP-UP AND STEP-DOWN CONVERTERS AND SUBSTITUTES

SET-1

Figure 1. A Step-Down Converter

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Step-Up and Step-Down Converters

A buck converter is a switch mode DC-DC converter in which the output voltage can be transformed to a level less than the input voltage.

A boost converter is a switch mode DC-DC converter in which the output voltage can be transformed to a level greater than the input voltage.

The output voltage of the DC to DC converter is less than or greater than the input voltage. The output voltage of the magnitude depends on the duty cycle. These converters are also known as the step up and step down transformers and these names are coming from the analogous step up and step down transformer. The input voltages are step up/down to some level of more than or less than the input voltage. By using the low conversion energy, the input power is equal to the output power. The following expression shows the low of a conversion.

$$\text{Input power } (P_{in}) = \text{Output power } (P_{out})$$

For the step-up mode, the input voltage is less than the output voltage ($V_{in} < V_{out}$). It shows that the output current is less than the input current. Hence the buck booster is a step-up mode.

$$V_{in} < V_{out} \text{ and } I_{in} > I_{out}$$

In the step-down mode the input voltage is greater than the output voltage ($V_{in} > V_{out}$). It follows that the output current is greater the input current. Hence the buck boost converter is a step-down mode.

$$V_{in} > V_{out} \text{ and } I_{in} < I_{out}$$

Buck boost converter

It is a type of DC to DC converter and it has a magnitude of output voltage. It may be more or less than equal to the input voltage magnitude. The buck boost converter is equal to the fly back circuit and single inductor is used in the place of the transformer. There are two types of converters in the buck boost converter that are buck converter and the other one is boost converter. These converters can produce the range of output voltage than the input voltage. The following diagram shows the basic buck boost converter.

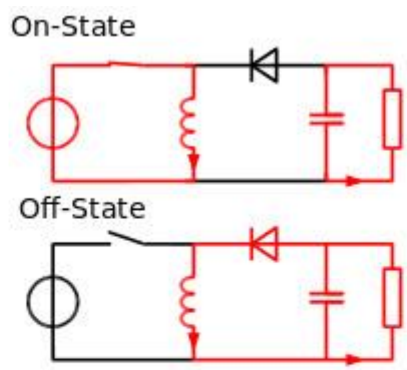


Figure 2. Buck-Boost Converter Circuit Diagram

Working principle of Buck Boost Converter

The working operation of the DC to DC converter is the inductor in the input resistance has the unexpected variation in the input current. If the switch is ON, then the inductor feed the energy from the input and it stores the energy of magnetic energy. If the switch is closed it discharges the energy. The output circuit of the capacitor is assumed as high sufficient than the time constant of an RC circuit is high on the output stage. The huge time constant is compared with the switching period and make sure that the steady state is a constant output voltage $V_o(t) = V_o(constant)$ and present at the load terminal.

There are two different types of working principles in the buck boost converter:

- Buck converter.
- Boost converter.

Buck Converter Working

As shown in Fig. 3.1.1 the buck Converter circuit consists of the switching transistor, together with the flywheel circuit (Dl, L1 and C1). While the transistor is on, current is flowing through the load via the inductor L1. The action of any inductor opposes changes in current flow and also acts as a store of energy. In this case the switching transistor output is prevented from increasing immediately to its peak value as the inductor stores energy taken from the increasing output; this stored energy is later released back into the circuit as a back e.m.f. as current from the switching transistor is rapidly switched off.

TRANSISTOR SWITCH 'ON' PERIOD

In Fig. 3, therefore, when the switching transistor is switched on, it is supplying the load with current. Initially current flow to the load is restricted as energy is also being stored in L1, therefore the current in the load and the charge on C1 builds up gradually during the 'on' period. Notice that throughout the on period, there will be a large positive voltage on D1 cathode and so the diode will be reverse biased and therefore play no part in the action.

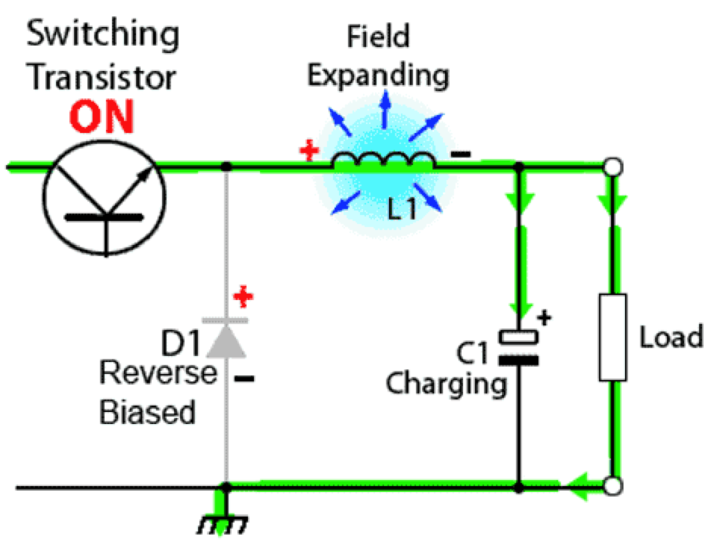


Figure 3. Switching Transistor 'on' Period

TRANSISTOR SWITCH 'OFF' PERIOD

When the transistor switches off as shown in Fig 3.1.3 the energy stored in the magnetic field around L1 is released back into the circuit. The voltage across the inductor (the back e.m.f.) is now in reverse polarity to the voltage across L1 during the 'on' period, and sufficient stored energy is available in the collapsing magnetic field to keep current flowing for at least part of the time the transistor switch is open.

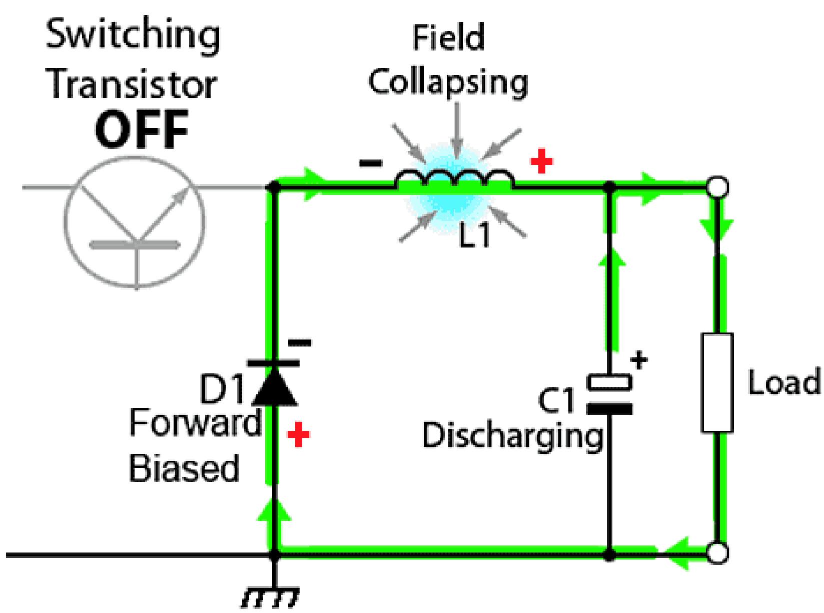


Figure 4. Switching Transistor 'off' Period

The back e.m.f. from L1 now causes current to flow around the circuit via the load and D1, which is now forward biased. Once the inductor has returned a large part of its stored energy to the circuit and the load voltage begins to fall, the charge stored in C1 becomes the main source of current, keeping current flowing through the load until the next 'on' period begins.

Boost Converter Working

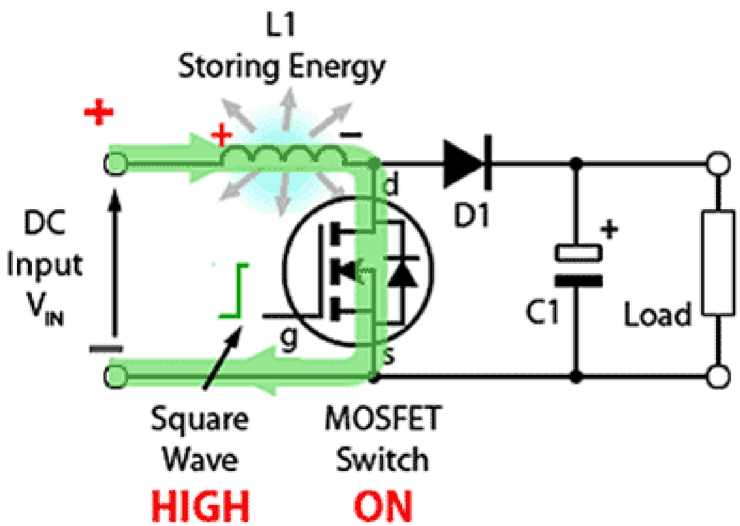


Figure 5. Boost Converter Operation at Switch On

Fig 5 illustrates the circuit action during the initial high period of the high frequency square wave applied to the MOSFET gate at start up. During this time MOSFET conducts, placing a short circuit from the right-hand side of L1 to the negative input supply terminal. Therefore a current flows between the positive and negative supply terminals through L1, which stores energy in its magnetic field. There is virtually no current flowing in the remainder of the circuit as the combination of D1, C1 and the load represent a much higher impedance than the path directly through the heavily conducting MOSFET.

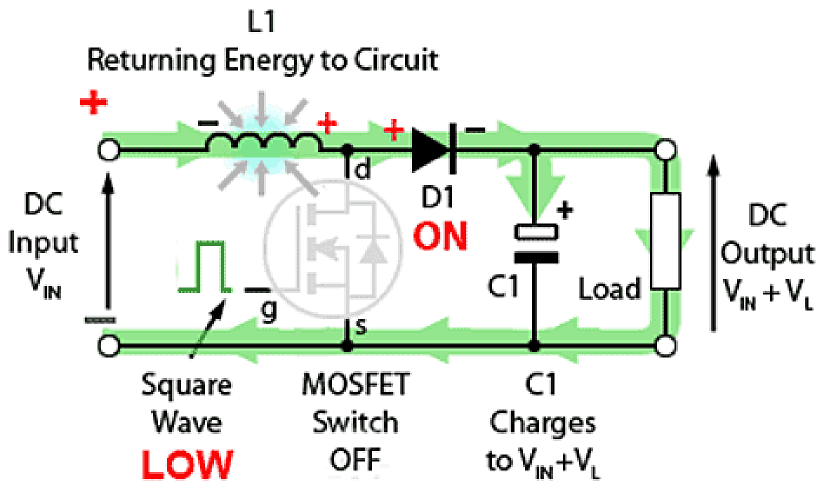


Figure 6. Current Path with MOSFET Off

Fig. 6 shows the current path during the low period of the switching square wave cycle. As the MOSFET is rapidly turned off the sudden drop in current causes L1 to produce a back e.m.f. in the opposite polarity to the voltage across L1 during the on period, to keep current flowing. This results in two voltages, the supply voltage V_{IN} and the back e.m.f.(V_L) across L1 in series with each other.

This higher voltage (V_{IN} +V_L), now that there is no current path through the MOSFET, forward biases D1. The resulting current through D1 charges up C1 to V_{IN} +V_L minus the small forward voltage drop across D1, and also supplies the load.

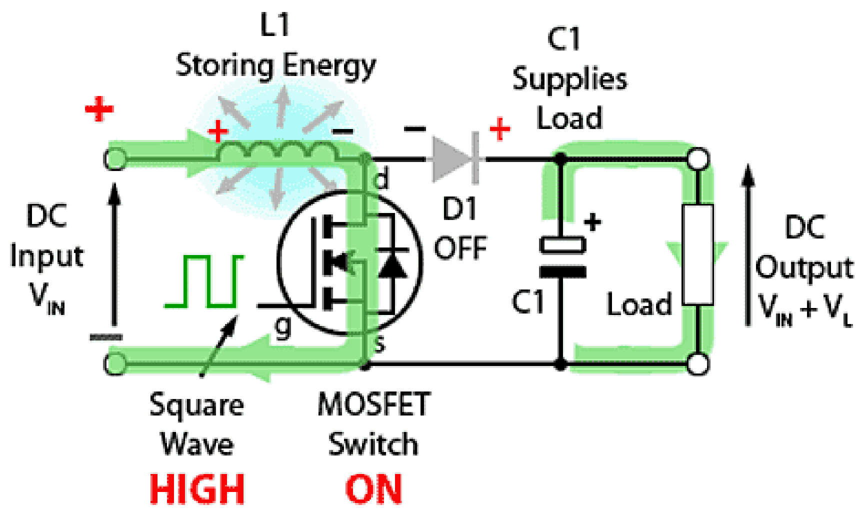


Figure 7. Current Path with MOSFET On

Fig. 7 shows the circuit action during MOSFET on periods after the initial start-up. Each time the MOSFET conducts, the cathode of D1 is more positive than its anode, due to the charge on C1. D1 is therefore turned off so the output of the circuit is isolated from the input, however the load continues to be supplied with V_{IN} +V_L from the charge on C1. Although the charge C1 drains away through the load during this period, C1 is recharged each time the MOSFET switches off, so maintaining an almost steady output voltage across the load.

Modes of Buck Boost Converters

There are two different types of modes in the buck boost converter. The following are the two different types of buck boost converters.

- Continuous conduction mode.
- Discontinuous conduction mode.

CONTINUOUS CONDUCTION MODE

In the continuous conduction mode, the current from end to end of inductor never goes to zero. Hence the inductor partially discharges earlier than the switching cycle.

DISCONTINUOUS CONDUCTION MODE

In this mode the current through the inductor goes to zero. Hence the inductor will totally discharge at the end of switching cycles.

Applications of Buck boost converter

- It is used in the self-regulating power supplies.
- It has consumer electronics.
- It is used in the Battery power systems.
- Adaptive control applications.
- Power amplifier applications.

Advantages of Buck Boost Converter

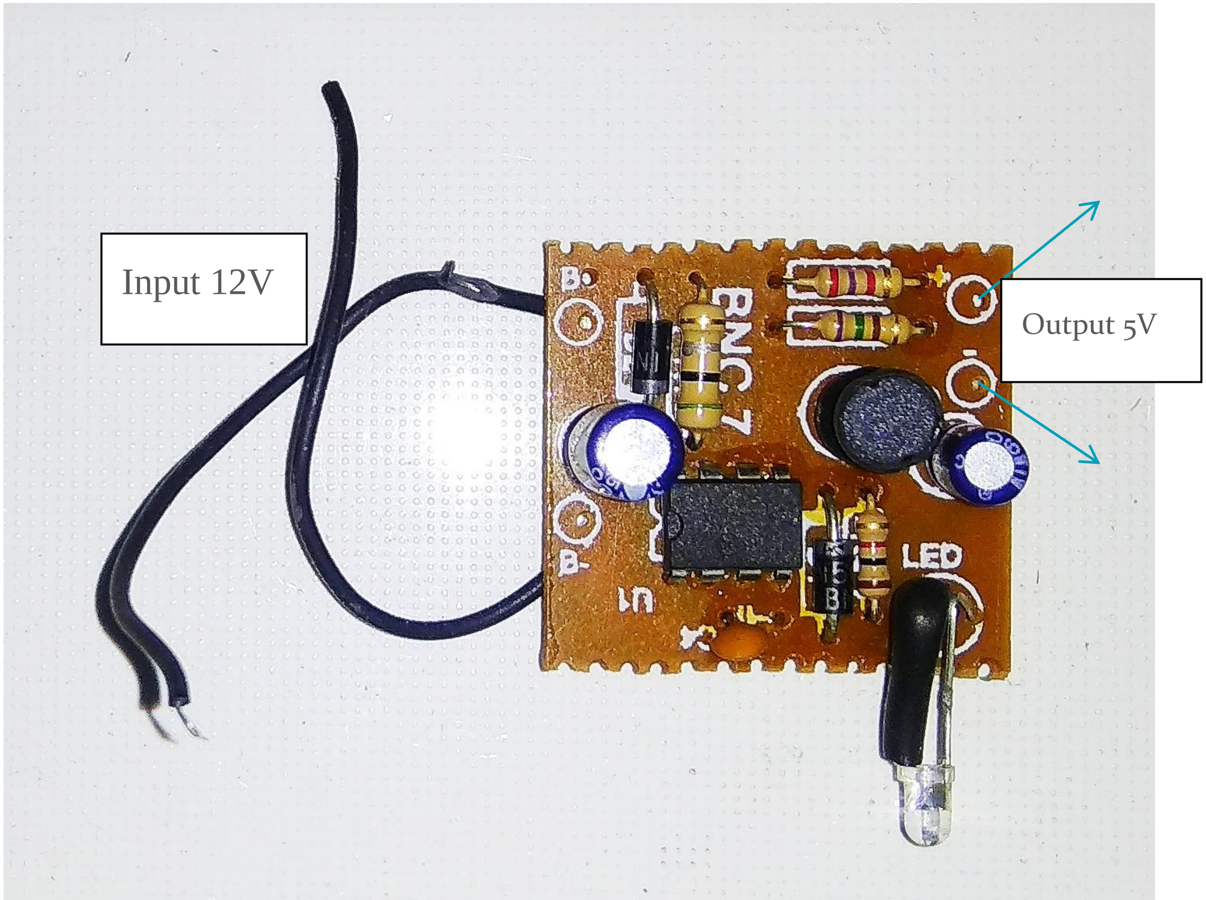
- It gives higher output voltage.
- Low operating duct cycle.
- Low voltage on MOSFETs

Substitute

The car mobile charger which converts 12V DC to 5V DC can be used as a substitute for converting higher DC voltages into lower DC voltage.

Figure 8. Car Mobile Charger

The PCB of the inside of the charger is shown below:



So, this can be used as a substitute for Step-Down converter.