

Common Power Supply Topologies

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The three basic topologies used in switching power supplies are buck, also known as forward, boost and buck-boost, also known as Flyback.

All three topologies use the same three elements, transistor, inductor and diode but they are arranged in different manners.

The essential difference between the three topologies is that the buck has an output voltage lower than its input, the boost has an output voltage higher than its input and the flyback can have an output voltage either higher or lower than its input but inversed in polarity.



Other topologies include push pull, half bridge, full bridge, CUK and self oscillating types.

The topologies detailed here are pulse width modulated. These can either be direct, where energy is transferred to the output during the on period of the switching element, or indirect where energy is transferred to the output during the off period of the switching element.

Buck

The buck topology, shown in figure 1, can operate in two states: continuous, where the inductor current never falls to zero and discontinuous where the inductor current falls to zero at the end of each cycle.

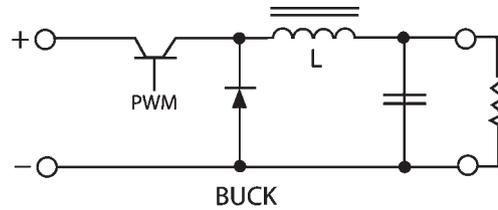


Figure 1.

In the discontinuous state, there are three stages.

1. The transistor is on and the inductor current rises from zero to the peak current. The inductor stores energy during this stage ($1/2 L I^2$).
2. As the transistor turns off, the inductor voltage reverses and the stored energy causes current to flow through the diode. During this time the inductor current is delivered to the output until the stored energy has been depleted.
3. When the inductor has no more energy, the current stops flowing in all elements until the start of the next cycle.

Adding a transformer to the basic circuit adds some important advantages. When the input is 120 or 230 VAC, the transformer provides isolation. It also allows the input voltage to the buck circuit to be matched to the required output voltage and multiple outputs can easily be achieved. The circuit shown is for a single ended forward converter. The series diode is required to provide a path for the current flowing due to the back emf generated as the transistor switch opens.

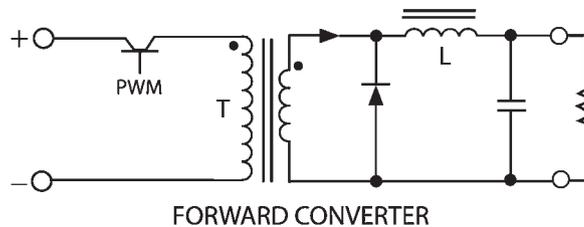


Figure 2.

The main advantage of the buck converter is its simplicity and flexibility. The buck converter is typically used in supplies from 10 to 250 W. A disadvantage is that the voltage stress across the primary switching element is 2 x the input voltage. This can be reduced by a variation on circuit whereby a 2nd switch on the other side of the transformer winding is employed.

Boost

The boost topology, shown in figure 3, is an indirect converter since the energy is only transferred to the load during the off time at the switching element. It can operate in two states : continuous, where the inductor current never falls to zero and discontinuous where the inductor current falls to zero at the end of each cycle.

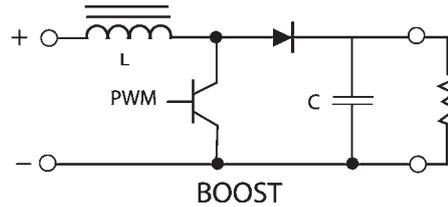


Figure 3.

In the discontinuous state, there are three stages.

1. The transistor is on and the inductor current rises from zero to the peak current. The inductor stores energy during this stage ($LI^2/2$) and the load is fed from the output capacitor. The diode isolates the load from the input.
2. As the transistor turns off, the inductor voltage reverses and the stored energy causes current to flow through the diode. During this time the inductor current is delivered to the output until the stored energy has been depleted.
3. When the inductor has no more energy, the current stops flowing in all elements until the start of the next cycle.

The important thing is that as the transistor turns off in stage 2, the reversed inductor voltage is then in series with the input voltage and therefore added to it creating the higher output voltage. The boost converter has the disadvantage of a relatively high output ripple current due to all the load current coming from the output capacitor during the off time. The advantage is simplicity, low component count and the ability to increase voltage without using a transformer. The voltage stress across the switching element is equal to the output voltage.

Flyback

The flyback topology, shown in figure 4 is an indirect converter since the energy is only transferred to the load during the off time of the switching element. It can operate in two states : continuous, where the inductor current never falls to zero and discontinuous where the inductor current falls to zero at the end of each cycle.

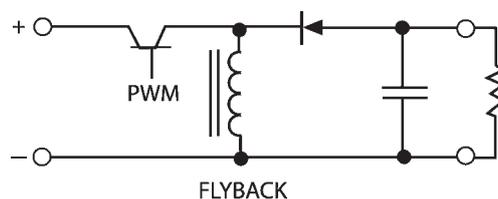


Figure 4.

In the discontinuous state, there are three stages.

1. The transistor is on and the inductor current rises from zero to the peak current. The inductor stores energy during this stage ($LI^2/2$).
2. As the transistor turns off, the inductor voltage reverses and the stored energy causes current to flow through the diode. During this time the inductor current is delivered to the output until the stored energy has been depleted. Because the load is connected to the anode of the diode, the voltage across the load is in the opposite direction to the input, i.e inverted.
3. When the inductor has no more energy, the current stops flowing in all elements until the start of the next cycle.

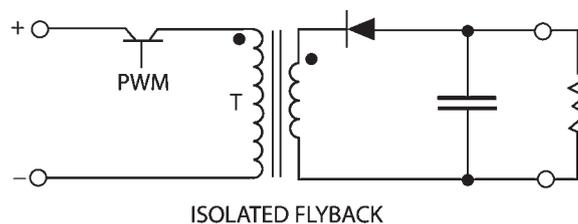


Figure 5.

Adding a transformer gives the advantage of providing isolation from mains voltages. The Flyback topology is one of the lowest cost means generating power output in the 5 to 150 W range. A disadvantage is the high output ripple current coming and the output capacitor during the off time.

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