The basic arrangement of a SMPS is shown in Fig. 1.

![Fig. 1. Block diagram of a SMPS](image)

In this configuration, the power input is rectified and a switch at a high frequency transmits the resulting DC voltage. The transmitted waveform is applied to the primary of a transformer and the secondary output is rectified and filtered to give the required DC output. A control circuit that supplies a correction signal to the drive circuit to vary the ON/OFF time of the switched waveform and compensate for any change at the output senses the output voltage.

Numerous circuit designs can be used to convert DC input voltage to the required DC output voltage. The requirements for the transformer or inductor depend largely on the choice of this circuit technology. If the circuits are analyzed in this way, three basic converter designs can be distinguished, based upon the magnetic converting device; Flyback converters, Forward converters and Push-pull converters.

**Flyback Converters**

Fig. 2 shows the basic circuit of a flyback converter.

![Fig. 2. Basic circuit of a flyback converter](image)
When the switch is closed (transistor conducts), the supply voltage is connected across the inductor and the output diode is non-conducting. The current rises linearly, storing energy, until the switch is opened. When this happens, the voltage across the inductor reverses and the stored energy is transferred into the output capacitor and load. By varying the conduction time of the transistor at a given frequency the amount of energy stored in the inductor during each ON cycle can be controlled. This allows the output of the SMPS to be controlled and changed. This basic circuit can be developed into practical circuit using an inductor with two windings (Fig. 3.)

In a flyback converter, all the energy to be transferred to the output capacitor and load is, at first, stored in the inductor. It is therefore possible to obtain line isolation by adding a secondary winding to the inductor. Another advantage of the flyback converter is that no smoothing choke is required in the output circuit. This is important in high-voltage supplies and in power supplies with a number of output circuits.

A disadvantage of this type of converter is that the output capacitor is changed only during the transistors OFF cycle. Hence the output capacitor ripple current is high when compared with the other types of converters. Another disadvantage of the flyback converter concerns the energy stored in the inductor. The inductor is driven in one direction only; this requires a larger core in a flyback design than for an equivalent.

Fig. 3. Practical flyback converter
Switched Mode Power Supply (SMPS) Circuit Design

design using a forward or push-pull converter.

**Forward Converter**

The basic circuit of the forward converter, together with its associated voltage and current waveforms is shown in Fig. 4.

*Fig. 4. Basic circuit of a forward converter*

When the switch is closed (transistor conducts), the current rises linearly and flows through the inductor into the capacitor and the load. During the ON cycle, energy is transferred to the output and stored in inductor. When the switch is opened, the energy stored in the inductor causes the current to continue to flow to the output via the diode.

As with the flyback converter, controlling the ON/OFF cycles can vary the amount of energy stored in the inductor. This provides control of the output of the forward converter. A more practical forward converter circuit with a line isolation transformer is shown in Fig. 5.

*Fig. 5. Forward converter with line isolation*
Push-Pull Converter

The basic circuit of the push-pull converter is shown in Fig. 6.

Fig. 6-1.

Fig. 6-2.

Fig. 6-3.

Fig. 6. Basic circuit of a push-pull converter
The push-pull converter is an arrangement of two forward converters operating in antiphase (push-pull action). With switch S1 closed (Fig. 6-1) diode D2 conducts and energy is simultaneously stored in the inductor and supplied to the load. With S1 and S2 open (Fig. 6-2), the energy stored in the inductor continues to support the load current via the parallel diodes D1 and D2, which are now acting as flywheel diodes. When switch S2 closes (Fig. 6-3), diode D1 continues to conduct, diode D2 stops conducting and the process repeats itself. A push-pull converter circuit doubles the frequency of the ripple current in the output filter and, therefore, reduces the output ripple voltage. A further advantage of the push-pull operation is that the transformer core is excited in both directions in contrast to both the forward and flyback converters. Therefore, for the same operating conditions and power throughput, a push-pull converter design can use a smaller transformer core.

Multiple outputs can be constructed by using several secondary windings, each with its own output diodes, inductor and smoothing capacitor.

**Converter Selection**

In each of the three basic converter designs there are several different circuit possibilities. In the flyback and forward converters, single and two-transistor designs can be used. If two transistors are used, they will switch simultaneously. This type of circuit preference is determined by the allowable collector-emitter voltage and collector current of the transistor. In push-pull converter designs, the primary of the transformer can be connected in several ways (Fig. 7.)

![Fig. 7-1 Push-pull converter circuit of single-ended.](image-url)
Depending upon how the transformer primary is driven, it is possible to differentiate between single-ended (Fig. 7-1), push-pull (Fig. 7-2), and full-bridge circuits (Fig. 7-3). Decisions on circuit details are determined by the transistor capabilities. For a practical converter design, the first selection that should be considered is the type of converter circuit to use. To aid in this initial converter circuit selection, its output voltage and power capability. This selection has to be considered along with other requirements, including line isolation, ripple content, overall efficiency, multiple outputs, etc.

For a high performance, high power, single output supply, where ripple is well below 1%, the push-pull design is the obvious choice. For smaller power versions of this type of supply, the forward, or double-forward converter provides a useful alternative to push-pull converter. In high-voltage supplies, the flyback converter is the most suitable circuit and should be considered as a preference. In multiple-output supplies, the
flyback converter is again normally the first choice because it avoids the necessity of providing a number of output windings on the inductor, together with a single diode and capacitor for each.