Switch Mode Power Supply

Definition: SMPS, an acronym for **S**witch **M**ode **P**ower **S**upply is a type of power supply unit that produces regulated dc output by using semiconductor switching techniques. Basically, here the regulated dc output signal is converted form of ac or dc unregulated input signal. It is sometimes also known as switched mode power supply or switching mode power supply.

This power supply unit is designed to provide the energy to load from source by using switching devices. Before elaborating more on SMPS, first, let us have an idea about-

What is Power Supply?

A power supply or power supply unit is an electrical device that takes the power from the source and supplies it to the load. Sometimes people use the terms, power source and power supply interchangeably. So, is that correct?

Obviously not. A power source is an entity that stores the power for the purpose of supplying it to various units when needed like a **battery**. However, a power supply is a device that converts the obtained energy from any power source into a form that can be used for the operation of electrical or electronic circuits. Thus, it forms a connection between the source and the load.

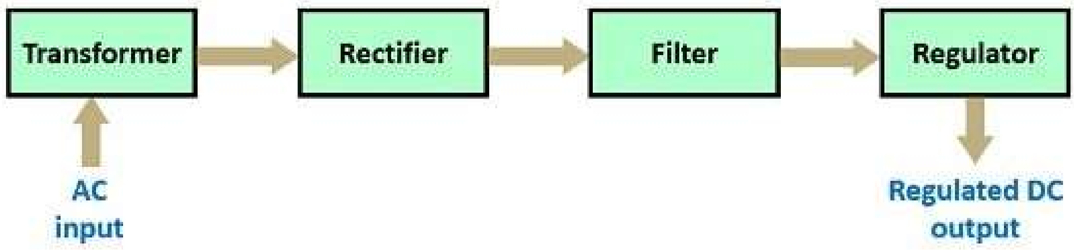
Though the electrical power sources have energy in form of quantities like voltage or current, the use of a power supply is necessary. This is so because it changes these electrical quantities in the form suited for the operation of the load.

Majorly power supply is classified into two categories namely,

- Linear power supply
- Switched mode power supply

A **linear power supply** is the one that is used to convert the unregulated ac or dc input signal into regulated dc output. But the principle of operation of LPS and SMPS is different. Also, it is considered to be a less efficient approach in which continuous heat generation causes wastage of power. It incorporates a voltage regulator in series that suits low output power applications.

In a linear power supply, the applied ac input voltage is initially stepped down using a transformer. Further diode rectifier is used to perform the rectification of the ac signal.



Block diagram of Linear Power Supply

After rectification, the signal is filtered using a capacitor filter. Though filtered, the unregulated dc signal is then given to the linear voltage regulator circuit that produces a regulated dc signal as its output.

Basically, SMPS was invented to overcome the drawback of LPS as it is highly efficient. Also, unlike linear power supply, it is suitable for applications where higher output current or voltage is required as it incorporates switching regulators. This is the reason the switch mode power supply is named so.

Introduction to SMPS

Various electrical and electronic loads are provided power using batteries. But batteries do not provide regulated power as they offer voltages of value either very high or very low. So, to obtain regulated dc output, SMPS is used.

Unlike linear power supply, which uses the standard linear method of voltage regulation, a switch mode power supply is a device that performs voltage regulation of unregulated signal by using **semiconductor switching** methods. It is considered to be highly efficient because it lessens power consumption thereby showing a decrease in the amount of heat dissipated. Thus, has replaced traditional linear power supply units.

SMPS includes a switching transistor (power MOSFET) for the purpose of voltage regulation. During operation, the transistor switches between **on state** and **off state** in a way that when it is on, it fully conducts current with the negligible voltage drop across it. While when it is off, it tries to completely block the flow of current. Thus, switching between on state (saturated) and off state (cut-off) occurs at high frequency, and in this way, the device acts as an **ideal switch**.

It is to be noted here that if the transformer operates at high frequency, so the device size is reduced. Hence, the overall size of the SMPS is small with less weight which is another advantage over linear power supplies.

Types of Switch mode power supply

Linear regulators always provide the step-down type of voltage regulation. However, this is not the case with switch mode power supply, as it can provide both step up as well as step down type of voltage regulation. This leads to further classification of SMPS as:

- **Buck switch mode power supply**: It consists of step-down type of regulator circuit that performs dc to dc conversion. The word '*buck'* corresponds to *reduction* or *subtraction*. It basically performs the conversion of high-value dc voltage into the low value of the same polarity.
- **Boost switch mode power supply**: It has the step-up type of regulator circuit to convert the low-level dc signal into a high level. The word '*boost'* means to *add up* or *increase* thus a boost switching regulator increases the level of the supply voltage keeping the polarity same as that of the input signal.
- **Buck-Boost switch mode power supply**: This SMPS performs combined operation of buck as well as boost regulator. In this topology, the output produced is inverted in nature whose voltage can be either more or less than the supply input depending on the duty cycle.

Along with these three, two more types of considerable smps are flyback and forward converter.

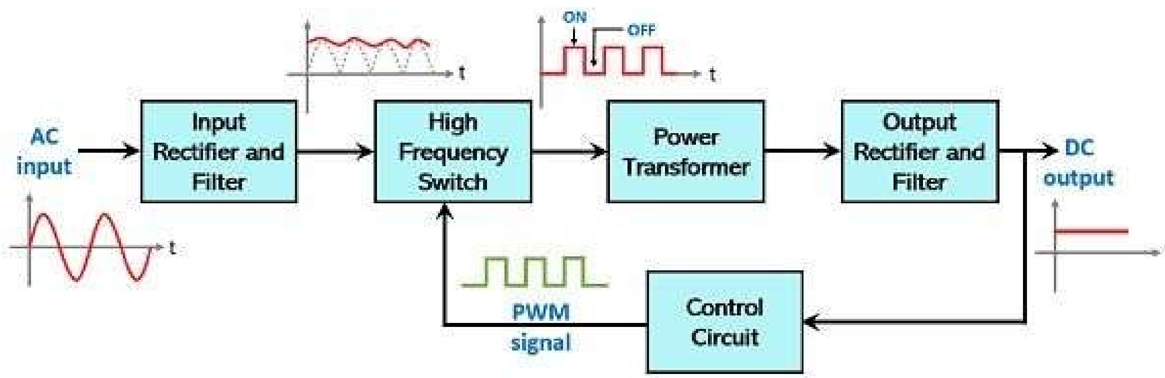
These are known to be three fundamental switching operations generally called **switch mode circuit topologies**.

Block Diagram and Working of SMPS

The major components that constitute SMPS are as follows:

1. Input rectifier and Filter (Diode rectifier and capacitor filter)
2. High-frequency switch (Power transistor or MOSFET)
3. Power transformer
4. Output rectifier and Filter (Diode rectifier and capacitor filter)
5. Control circuit (comparator and pulse width modulator)

The figure given below represents the functional block diagram of SMPS:



Block diagram of Switch Mode Power Supply

Initially, the unregulated ac input signal from the source is provided to the input rectifier and filter circuit. Here the ac input signal is rectified to generate a dc signal and further smoothened to remove high-frequency noise component from it. The dc output (still in unregulated form) is fed to the power transistor that acts as a high-frequency switch.

Here the dc signal undergoes **chopping** (switching). This circuit acts as an ideal switch i.e., when the power transistor (chopper circuit) is in on state, current passes through it with negligible voltage drop, and dc signal is obtained at the output terminal of the transistor. However, under the off state of the power transistor, no current passes through it and leading to cause maximal voltage drop within it. Thus, at the output side, no voltage will be present.

Hence, according to the switching action of the power transistor dc voltage will be obtained at its output side. **The chopping frequency plays a crucial role in maintaining the desired dc voltage level**.

The obtained dc signal at the output of the chopper circuit is then fed to the primary winding of the high-frequency power transformer. Here the step-down transformer converts the high voltage signal into a low voltage level which is further provided as input to the output rectifier and filter unit. This simply filters out the unwanted residuals from the signal in order to provide a regulated dc signal as the output.

The control circuitry present here acts as the feedback circuit for the complete unit. This involves a comparator along with a pulse width modulator (PWM). The dc output from the rectifier and filter is fed to the control circuit where the error amplifier which acts as a comparator, compares the obtained dc voltage with the reference value.

If the dc output is greater than the reference value then the chopping frequency is to be decreased. The decrease in chopping frequency will reduce the output power and so the dc output voltage. However, if the dc output is less than the reference value then the chopping frequency is increased. When chopping frequency is raised then the dc output voltage will get increased.

The pulse width modulator in the above circuit is responsible for generating a fixed frequency pulse width modulated waveform whose duty cycle controls the chopping frequency.

Basically, the **duty ratio** is the ratio of on-time to the overall cycle time (i.e., on + off) time. Hence, by making necessary adjustments in the width of the pulses, the chopping frequency gets adjusted hence, regulated dc output can be obtained.

Advantages

1. It is highly efficient than linear power supplies. Typically, the efficiency of SMPS lies between **60% – 95%**.

2. Due to the high-frequency operation of the device, the overall size is small and less bulky. Thus, is compact.
3. It is inexpensive because heat dissipation is less.
4. The obtained output voltage can be more or less than the supply input.

Disadvantages

1. The transient spike generation due to switching action is one of the major issues. This may lead to cause RF interference thus, isolation is mandatory.
2. The circuit is complex. Also, voltage regulation (controlling) is tricky.
3. Proper filtration is necessary to deal with noise and spikes.

Applications of SMPS

The devices invented under the latest technologies require a highly efficient power supply which is offered by SMPS. Thus, it finds applications in various power amplifiers, personal computers, security and railway systems, television sets, motor drives, etc.