

# Difference Between SMPS and Linear Power Supply

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## Key Difference - SMPS vs Linear Power Supply

Most electronic and electrical devices require [DC voltage](#) in order to function. These devices, especially electronic devices with integrated circuits, should be supplied with a reliable, distortion-less DC voltage for them to work without malfunctioning or burning. The purpose of a DC power supply is to supply clean DC voltage to these devices. DC power supplies are categorized into linear and switched-mode, which are the topologies involved to make AC mains supply into smooth DC. **Linear power supply uses a transformer to directly step-down the AC mains voltage into a desired level while SMPS converts AC to DC using a switching device which helps to obtain an average value of the desired voltage level.** This is the key difference between SMPS and linear power supply.

## What is a Linear Power Supply?

In a linear power supply, the mains AC voltage is converted to a lower voltage directly by a step-down transformer. This transformer has to handle a large power since it works at the AC mains frequency 50/60Hz. Therefore, this transformer is bulky and large, making the power supply heavy and large.

Stepped-down voltage is then rectified and filtered to get the DC voltage required for the output. Since the voltage at this level is subjected to vary depending on the distortions of the input voltage, a voltage regulation is done before the output. The voltage regulator in a linear power supply is a linear regulator, which is usually a [semiconductor](#) device that acts as a variable resistor. The output resistance value changes with the output power requirement, making the output voltage constant. Thus, the voltage regulator operates as a power dissipating device. Most of the time, it dissipates excess power to make the voltage constant. Therefore, the voltage regulator should have large heatsinks. As a result, the linear power supplies become much heavier. Furthermore, as a result of power dissipation by the voltage regulator as heat, the efficiency of a linear power supply drops as much as about 60%.

However, linear power supplies do not produce electrical noise on the output voltage. It provides isolation between the output and input because of the transformer. Therefore, linear power supplies are used for high-frequency

applications such as radio frequency devices, audio applications, laboratory tests which require noise-free supply, signal processing, and amplifiers.

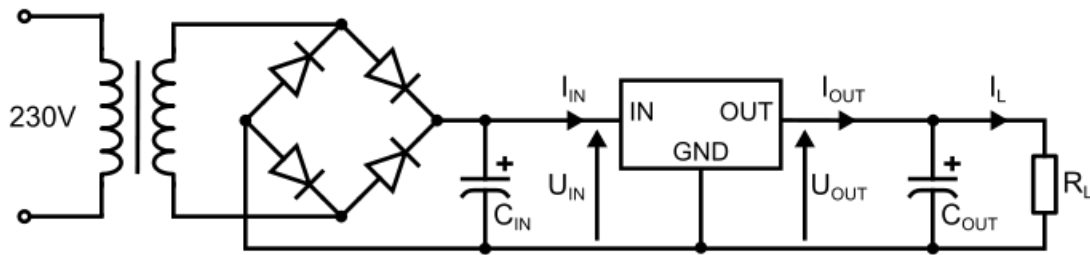


Figure 01: Power Supply with a Linear Voltage Regulator

## What is SMPS?

SMPS (switched-mode power supply) operates on a switching transistor device. At first, the AC input is converted to DC voltage by a rectifier, without reducing the voltage, unlike in a linear power supply. Then the DC voltage undergoes a high-frequency switching, typically by a [MOSFET transistor](#). That is, the voltage through the MOSFET is turned on and off by MOSFET Gate signal, usually a pulse-width-modulated signal of about 50 kHz (chopper/inverter block). After this chopping operation, the waveform becomes a pulsated-DC signal. After that, a step-down transformer is used to reduce the voltage of the high-frequency pulsated DC signal to the desired level. Finally, an output rectifier and a filter are used to make back the output DC voltage.

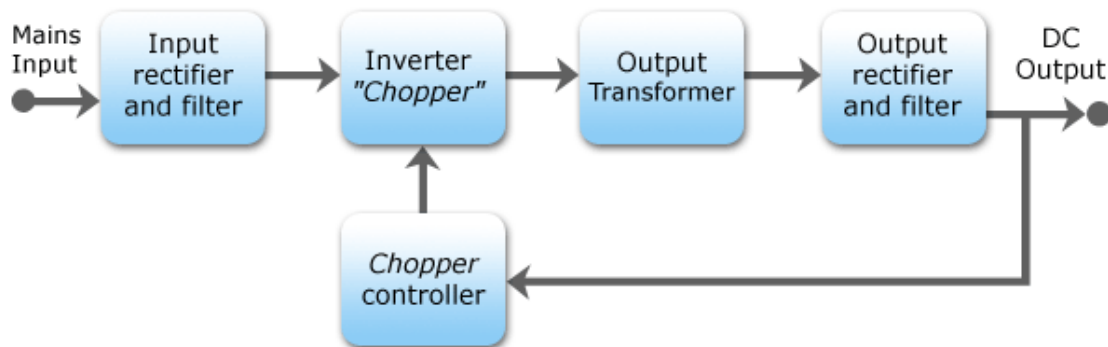


Figure 02: Block Diagram of an SMPS

The voltage regulation in SMPS is done via a feedback circuit that monitors the output voltage. If the power requirement of the load is high, the output voltage tends to increase. This increment is detected by the regulator feedback circuit and is used to control the on-to-off ratio of the PWM signal. Thus, the average signal voltage changes. As a result, the output voltage is controlled to keep constant.

The step-down transformer used in the SMPS operates at a high-frequency; thus, the volume and weight of the transformer are much less than those of a linear power supply. This becomes a major reason for an SMPS to be much smaller and lighter than its linear type counterpart. Moreover, the voltage regulation is done without dissipating excess power as Ohmic-loss or heat. The efficiency of the SMPS gets as high as 85-90%.

At the same time, an SMPS generates high-frequency noise due to the switching operation of the MOSFET. This noise can be reflected in the output voltage; however, in some advanced and expensive models, this output noise is mitigated to some extent. Furthermore, the switching creates electromagnetic and radio frequency interference as well. Hence, it is required to use RF shielding and EMI filters in SMPSs. Therefore, SMPS are not suitable audio and radio frequency applications. Less noise-sensitive equipment such as mobile phone chargers, [DC motors](#), high power applications, etc. can be used with SMPSs. Its lighter and smaller design makes it convenient to be used as portable devices as well.

## What is the difference between SMPS and Linear Power Supply?

### SMPS vs Linear Power Supply

SMPS directly rectifies the mains AC without reducing the voltage. Then the converted DC is switched in high-frequency for a smaller transformer to reduce it to the desired voltage level. Finally, the high-frequency AC signal is rectified to the DC output voltage.

Linear power supply reduces the voltage to the desired value at the beginning by a bigger transformer. After that, the AC is rectified and filtered to make the output DC voltage.

### Voltage Regulation

Voltage regulation is done by controlling the switching frequency. The output voltage is monitored by the feedback circuit and the variation of voltage is used for the frequency control.

The rectified and filtered DC voltage is subjected to an output resistance of a voltage divider to make the output voltage. This resistance is controllable by a feedback circuit that monitors the output voltage variation.

### Efficiency

The heat generation in SMPS is comparatively low since the switching transistor operates in the cut-off and starvation regions. The small size of the output transformer also makes the heat loss small.

The excess power is dissipated as heat to make the voltage constant in a linear power supply. Moreover, the input transformer is much bulkier; thus transformer losses are higher.

Therefore, the efficiency is higher (85-90%).	Therefore, the efficiency of a linear power supply is as low as 60%.
<b>Build</b>	
Transformer size of an SMPS does not need to be large as it operates in high-frequency. Therefore, the weight of the transformer will also be less. As a result, the size, as well as the weight of an SMPS is much lower than a linear power supply.	Linear power supplies are much bulkier since the input transformer has to be large due to the low frequency it operates on. As more heat is generated in a voltage regulator, heat sinks should be used as well.
<b>Noise and Voltage Distortions</b>	
SMPS generates a high-frequency noise due to switching. This passes into the output voltage, as well as to input mains sometimes. Harmonic distortion in mains power could be also possible in SMPSs.	Linear power supplies do not produce noise in the output voltage. Harmonic distortion is much less than that of SMPSs.
<b>Applications</b>	
SMPS can be used as portable devices due to the small build. But as it generates a high-frequency noise, SMPSs cannot be used for noise-sensitive applications such as RF and audio applications.	Linear power supplies are much larger and cannot be used for portable devices. Since they do not generate noise and the output voltage is also clean, they are used for most of the electrical and electronic tests in laboratories.

## Summary - SMPS vs Linear Power Supply

SMPS and Linear power supplies are two types of DC power supplies in use. The key difference between SMPS and linear power supply is the topologies used for voltage regulation and voltage stepping down. While the linear power supply converts AC to low voltage at the beginning, SMPS first rectifies and filters the mains AC and then switch to a high-frequency AC before stepping down. Since the transformer weight and size increases as the operating frequency decreases, the linear power supplies' input transformer is much heavier and larger unlike in the SMPS. In addition, as the voltage regulation is done with heat dissipation through resistances, linear power supplies should have heat sinks that make them even heavier. The regulator of SMPSs controls the switching frequency to control the output voltage. Therefore, SMPS are smaller in size and lighter in weight. As the heat generation in SMPS is lower, their efficiency is also higher.

**Reference:**

1. "Linear Power Supplies and Regulators." Electronics Repair And Technology News. N.p., n.d. Web. [Available here](#). 14 June 2017.
2. "Switched-mode power supply." Wikipedia. Wikimedia Foundation, 17 May 2017. Web. [Available here](#). 14 June 2017.

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**APA:** Difference Between SMPS and Linear Power Supply. (2017, June 14). Retrieved (date), from <http://www.differencebetween.com/difference-between-smps-and-vs-linear-power-supply/>

**MLA:** "Difference Between SMPS and Linear Power Supply." *Difference Between.Com*. 14 June 2017. Web.

**Chicago:** " Difference Between SMPS and Linear Power Supply." *Difference Between.Com*. <http://www.differencebetween.com/difference-between-smps-and-vs-linear-power-supply/> (accessed [date]).



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