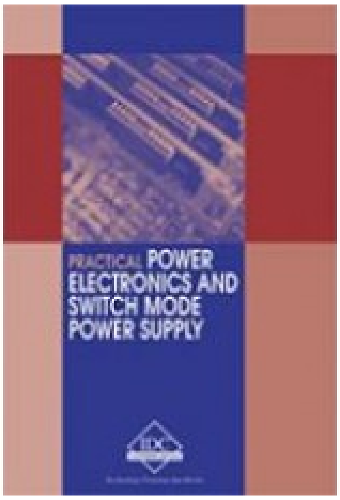
PE-E - Power Electronics and Switch Mode Power Supply



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Short Description

Switch mode power supplies (SMPS) have become an important part of equipment design in all types of industrial equipment and an understanding of the different types and designs has become essential for reliable operation of complex equipment. This manual gives you a fundamental understanding of the basic components that form a SMPS design. You will understand how the selection of components affects the different performance parameters and operation of the SMPS.

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1 Introduction

This is the introductory chapter which first gives the basic idea of Power Supply and Switch Mode Power Supply. The comparison between SMPS and Linear supply is also provided. The chapter mentions the power supply specifications. It also emphasizes on Buck and Boost type of Switch-Mode Regulators.

Learning objectives

- Understand the basic principle of Power Supply Unit
- Study Series and Shunt Regulators
- Know what are the implications of Power supply
- Study Linear Regulator
- Know the power supply specifications
- Understand the block diagram of SMPS
- Explore Heater as SMPS
- Compare SMPS and Linear Supplies
- Study Buck and Boost Types of Switch-mode regulators

1. Basic principles of PSU circuits

1.1.1 What is a power supply?

A Power Supply is a buffer circuit or Electronic Device that provides power with the characteristics required by the load from a primary source with characteristics incompatible with the load. It makes the load compatible with its power source.

It is the device that transfers electric power from a source to a load using electronic circuits. It is designed to control and to regulate the power delivered to the load.

For electronic circuits the power supply is designed to approximate an Ideal Voltage Source. A typical application of power supply is to convert utility's AC input power into regulated DC voltage required for electronic component.

In a "Stabilized Power Supply", a certain amount of regulation is maintained by controlling the output voltage and current of the power supply to a specific value. In spite of variations in the load at output side of power supply, or voltage variations at the input side of the power supply, the above mentioned specific value is maintained closely. This is achieved by adopting some circuitry.

1.1.2 Block diagram of power supply unit

The block diagram of a Power Supply Unit is shown in Figure 1.1

Figure 1.1

Block diagram of PSU

Most of the electronic devices or circuits require a DC supply for its operation. The DC supply can be a battery. The AC mains supply has to be converted to DC using a power supply.

In the above figure, the main blocks are Transformer, Rectifier, Filter and Regulator. The AC mains supply is isolated from the PSU with the help of a "ON / OFF Switch", and a fuse is used for safety.

The transformer can be a step-up or a step-down transformer. Many electronic circuits need lesser voltage than the high voltage mains supply. So, the voltage is stepped down to a lesser value using step-down transformer. When high DC voltages are required, the mains voltage is raised using step-up transformer.

The primary function of rectifier is to convert AC voltage to DC voltage. The rectifier circuit consists of one or more diodes. The output AC voltage of the transformer is fed to the rectifier circuit.

The next stage is filter which is a combination of capacitor and resistor. It filters the ripples present in the DC voltage which is the output of the rectifier circuit. The filter works as a smoothing circuit because it removes the pulsations present in the DC output of the rectifier.

The regulator circuit is used to remove any remaining small variations. It gives out a very steady voltage. Sometimes there can be variations in DC voltage output which are caused due to the changes in the AC mains voltage. These variations are removed by the regulator.

1.1.3 Dissipative Power Supplies

Dissipative regulators achieve regulation by a purposeful conversion of excessive power to heat, unlike switching mode supplies which do not rely on a heat conversion for regulation. SMPS would be 100% efficient if components were ideal. Dissipative regulators convert heat with either a series or a shunt element.

Regulation is nothing but making the output voltage independent of the line and load variations. Following is the explanation of series and shunt regulators.

Series Regulators

We start out investigation of simple topologies by selecting a variable resistor and connecting it between the power source and the load. What we get is a simple open-loop series regulator shown in figure. R1 is often a transistor. You can see a series regulator in Figure 1.2.

Figure 1.2

Series Regulator

Given:

- Vin = 12V dc
- R2 = 0.25 ?
- Vo = 5V dc

Solving and listing the parameters of interest

- I = 20 A
- R1 = 0.35 ?
- Pin = 240 W
- Pout (R2) = 100W
- Power R1 = 140W
- Efficiency = Pout/Pin = 0.417 => 42 %

R1 is varied to obtain 5 V dc at Vo resulting in 20A current flowing in the loop and the load resistor R2. Notice that the 5V output is obtained by dropping voltage across the resistor R1, hence the name series regulator. To provide 100W to the load, 240W is required of the source and 140 W of power is wasted in R1 – not very efficient. If the load power is reduced, so is the input power and the efficiency remains the same for all loads. Since the current cancels when made explicit in the efficiency equation, the efficiency of this circuit simplifies to Vo / Vin. As we shall see in the next section, this is not true of shunt regulators.

Notice that the topology is that of a voltage divider. Voltage and current dividers are used extensively in power supply circuit design and modeling.

Shunt regulators

We now add a breakdown diode across the load in figure of series regulator to get the shunt regulator shown in Figure 1.3.

Figure 1.3

Shunt Regulator

This is a very popular topology because it provides voltage regulation with only two parts, a fixed value R1 and the breakdown diode. The circuit also has inherent short circuit protection as long as the wattage of R1 is selected so that it can operate into a short circuit. The major disadvantage of the circuit is poor efficiency, especially at higher that full load. If the load power is small fraction of total system power, this can often be tolerated.

It should be noted tat the topology is also the same as a series regulator using a breakdown diode as over voltage protection. As we will see in the section of SMPS topologies, over voltage protection is very important consideration.

Assume the same condition as Figure 1.1 (Series Regulator) and the breakdown diode breaks an infinitesimal amount above 5V dc so it draws no current. Then the efficiency of the circuit is the same as the 42% of the series regulator circuit.

Now reduce the load to one half by increasing the load resistor R2 from 0.25 ? to 0.5 ? so only 10A current flows in the load and the load power is 50W. The voltage would rise, but the breakdown diode constrains it to 5V and the excess current flows in the breakdown diode. The efficiency is now 50/240 W => 21% compared to 42% for the series regulator example. At zero load current, the efficiency is 0%.

In practice, some current always flows in the breakdown diode. This leads to the conclusion that a series dissipative regulator is always more efficient than a shunt dissipative regulator, everything else being equal.

One interesting observation about the shunt regulator is the maximum efficiency occurs at an input voltage that is only a function of input voltage tolerance and independent of R1 and R2. By setting up the power loss as a function of the circuit parameters and the input voltage tolerance, taking the partial and setting to zero, the following equation is obtained.

Vin = Vo * (1 + SQRT (1-a)) / a

Where a = 1-tolerance and

R2 = a * (Vin – Vo) / Imax

Where Imax is the maximum load current

For our example and a 20% input voltage tolerance (a = 1-0.2 = 0.8), the input voltage that yields the maximum efficiency and the value of R1 are:

Example:

Vin = 5 * (1 + SQRT (1 – 0.8)) / 0.8

= 5 * (1 + 0.447) / 0.8

= 9.05V dc

R1 = 0.8 * (9.05 – 5.0) / 20

= 0.162 ?

Efficiency = Pout / Pin

- 100W / 181 W
- 55%

By selecting the optimum input voltage (instead of 12 V) for a 20% tolerance, the maximum efficiency of the shunt regulator has been increased from 42% to 55%. However, note that the efficiency of a series regulator for the same lower input voltage (5 / 9.05 => 55%) is also increased to the 55% maximum efficiency of the shunt regulator, as would be expected.

This finishes our look at dissipative regulators. In our examples, the power losses were always greater than the load power for a 12 V dc input and 5 V dc output – a terrible waste of power.

What are the system implications of this power loss?

Implications of power loss

Two factors influence the size of power supply, the size of the components and packaging and the thermal density. The latter is the very useful measure. It is used to discuss the system impact of efficiency on system size, weight, reliability, cost of power, and cost of cooling.

Assume that an electronic load and its cooling system operate at a power density that limits the temperature rise above ambient to a fixed value. If the power supply uses the same of components and is limited to the same component rise, then the size of the power supply is determined by its efficiency – assuming you can package the parts in the thermal density volume, which is usually the case.

Figure 1.4 shows the three systems with the same electronic load with power supplies of three different efficiencies, 35%, 65%, and 83%. The volume of the load is shown in blue and the relative volume of the power supply is shown in red. For equal thermal density design, a 35% efficient power supply is 1.86 times the size of load, 1 65% efficient supply is 0.54 the size, and a 83% efficient supply is only the 0.20 the size of the load. These efficiencies are not arbitrary but represent the history of power supply design for 5 V DC logic circuits.

Figure 1.4

Equal Thermal Density Vs Efficiency

The first supplies for 5 V dc logic circuits used transformer-rectifier sets followed by series dissipative regulators. The efficiency of power conversion was about 35% and the power supplies were larger than the load and the required more cooling than the load. This was totally unacceptable to systems engineers and considerable pressure was applied to designers to reduce the size of the power supply.

The initial approach was to increase the power density of the power supply, by running the components hotter, taking out design margin, and packaging the power supply differently than the rest of the load. This reduced the size of the power supply but increased the cost and greatly reduced the reliability due to higher component temperatures. In fact, power supply reliability got so bad it was usually the major reason for system failure. Switching-mode power supplies were avoided since they were perceived (erroneously) as an electromagnetic interference problem.

Finally, after successful use of 20 kHz switching mode power supplies in several systems, they became the norm. Far more than a decade, these power supplies ranged from about 62% to 71% efficient. Even though the power supply was only 0.54 the volume of the load, the pressure remained for smaller power supplies, hence more efficiency. This was achieved with Schottkey Diodes, synchronous rectifiers, and power MOSFET Transistors to get to the present 83% efficiency for

5V logic. The power supply is about 0.2 the volume of the load and is shown in above figure. Efficiency keeps improving and you now see efficiency of greater than 90% for 5V power supplies.

Unfortunately, the trend for logic circuits is to use lower voltages. For 1.8 to 2.0 V dc supplies used for 0.25 um logic, even using all techniques to get 83% efficiency for 5V dc logic only results in 65% efficiency for a 1.8 V dc power supply. Again efficiency keeps improving with time for low voltage power supplies.

The system implications of poor efficiency not only include size and the associated weight but the cost of the electrical power and cooling added to the system due to poor efficiency. Of equal or greater impact is the cost of cooling, it is often greater than the cost of the wasted electrical power and is often left out of trade studies.

The bottom line of this discussion is that there are overwhelming system reasons to use power conversion techniques that are ideally100 % efficient and to constantly work on less than ideal components to get as close to 100% efficiency as possible. For the most part this means dissipative techniques are out of favor and lossless techniques, including switching mode power supplies, are in favor.

Linear Regulators

a b c

Figure 1.5

Linear Regulator

Linear Regulator is a voltage divider circuit as shown in network Figure 1.5 (a). Here the output voltage is

$$V_o = V_i (R2/R1 + R2)$$

Transistor in series actually works like a variable resistor that adjusts the resistance to maintain a constant voltage on the output.

Passive Linear Regulators using zener as a constant voltage at the output. Refer Figure 1.5 (b).

$$V_o = V_z – V_{be}$$

$$= 12V – 0.6V$$

$$= 11.4V$$

Active Linear Regulators are more precise and offer extremely well control and low ripple output and high ripple rejection. Refer Figure (c).

$$V_o = V_{ref} (R4 / R5)$$

Advantages

- Extremely low ripple and noise
- Tight regulation
- Fast Transient Response
- No RFI and EMI

Disadvantages

- Efficiency Main regulator 45% (depending of Vi)
- Large heat sink required
- Lower power supply density
- Cost and efficiency are the limitations for applications where high current levels are required.

1.2 Power supply specifications

- DC Output Voltage(s) V_O (range)
- DC Output Current(s) I_O (range)
- Load regulation % or mV
- Line Regulation % or mV
- Ripple / Wideband noise mV
- Temperature Coefficient µV / º C
- Load Transient Recovery time µs
- Short Circuit protection SCP
- Over voltage protection OVP
- Under voltage protection
- Temperature Rating 0 – 17 º C or -55 to 100 º C
- RFI suppression +EMI shielding
- DC output isolation
- Input voltage range
- Size and shape
- Weight
- Connectors
- Turn on / turn off spikes
- Voltage rate-of-rise at turn on
- Vibration resistance
- Shutdown mode supply current

Some of the most common parameters found on power supply specification sheet are explained below.

Input Range

Generally the input range is nothing but the range of voltages that the power supply is prepared to accept from the AC power source. For 110V AC current, an input range of 90V – 135V is common. For a 220V current, a range of 180V –

270V is typical.

MTBF and MTTF

Mean Time between Failure (MTBF) and Mean Time to Failure (MTTF) are the two parameters related to the failure of the power supply. These are the calculated average interval, in hours that the power supply is expected to operate before failing. Power supplies typically have MTBF rating as 100,000 hours or more. MTBF figures of power supplies often include the load to which the power supply was being subjected and the temperature of the environment in which the tests were performed.

Peak Inrush Current

It is defined as the greatest amount of current drawn by the power supply at a given moment immediately after it is turned on, expressed in turns of amps at a particular voltage. The system would experience less thermal shock if this current rating is lower.

Transient Response

The transient Response is defined as the amount of time (typically in microseconds) taken by a power supply to stabilize the output power levels after a device in the system starts or stops drawing power. When a device stops drawing power, the power supply might supply too high a voltage to the output for a brief time. This excess voltage is called overshoot, and the transient response is the time that it takes for the voltage to return to the specified level. This is seen as spike in voltage by the system and can cause glitches and lockups. The transient response values are sometimes expressed in time intervals also.

Load Current

The load can have its minimum and maximum value. The maximum load current is the largest amount of current in amperes that can be safely delivered through a particular output. The minimum load current is the smallest amount of current in amperes that must be drawn from a particular output for that output to function. The power supply can be damaged when these maximum and minimum load current ratings are exceeded.

Hold-up Time

Hold-up time is defined as the amount of time (in milliseconds) that a power supply can maintain output within the specified voltage ranges after a loss of input power.

Over-voltage Protection

It defines the trip points for each output at which the power supply shunts down. The values can be expressed as percentage (120%) or as raw voltages (+4.6V).

Load Regulation

Load regulation is the change in the voltage for a particular output as it transitions from its minimum load to its maximum load (or voce versa). The values typically range from +/- 1% to +/- 5% for 3.3, 5 and 12 V outputs.

Line regulation

It is the change in the output voltage as the AC input voltage transitions from the lowest to the highest value of the input range. A power supply should be capable of handling any AC voltage in its input range with a change in its output of 1% or less.

Efficiency

It is defined as the ratio of power input to power output expressed in terms of percentage. It can be in the range of 65% - 85% for power supplies. The remaining 15% - 35% of the power input is converted to heat during the AC/DC conversion process.

Power Density

It is defined as watts per cubic inch. It is based on the maximum power rating of the power supply and the volume of space it occupies.

Dimension

Normally the physical dimensions are specified as W (width) x D (depth) x H (Height). The dimensions can be given in inches (in) or millimeters (mm).

Weight

The weight of the power supply is specified in pounds (lb) or kilograms (kg).

Fan Characteristics

The Fan characteristics which one needs to know about the power supply are Fan Size, Fan Bearing Type, Voltage, and Capacity. Some specs on the fan are commonly provided on spec sheets, but many are not: For example, most manufacturers do not say explicitly whether ATX power supplies blow into the case or out of it. You will have to figure this out from the illustration, or ask them. Here are some items you may see listed:

- **Fan Size:**Size of the power supply fan, usually given in mm. Fans are normally square, and this is the nominal length of one side of the fan. (Sometimes the thickness of the fan is also specified, but usually not.)
- **Fan Bearing Type:**Whether the fan's motor uses sleeve or ball bearings.
- **Voltage:**The voltage used to power the fan. If not specified, the default is +12 V.

- **Capacity:**How much air the fan can move, usually specified in CFM (cubic feet per minute). Larger numbers are better and mean the fan has more cooling power.

1.3 SMPS block diagram

1.3.1 What is a switching-mode power supply?

It is a switching power supply which uses a switch as a series element. It is also called as Chopper Controlled Power Supply. We can vary the average voltage at the DC output level by controlling the on and off time.

The SMPS functions through low loss components such as capacitors, inductors, transformers and switches. The switches dissipate very little power in either of the two states (on and off) and hence there is a minimal power loss during power conversion.

As mentioned above, it uses low loss components; therefore, the design minimizes the use of lossy components such as resistors. This gives rise to the design problem while interconnecting these components and controlling the switches in order to obtain the desired results. In order to make the design process successful, proper topology method and control has to be chosen.

Switch mode supplies are found in all TVs, computers, laptops, camcorders printers, fax machines, VCRs, portable CD players etc.

1.3.2 Functional block diagram of SMPS

The functional block diagram of a switch mode power supply is shown in Figure 1.6.

As seen in the figure, there are four major blocks of a typical SMPS. They are:

- Input section: rectifier and filter
- High frequency inverter section
- Output section: rectifier and filter
- Feedback and control circuit

Figure 1.6

Functional Block diagram of SMPS

The AC mains is rectified and filtered. The high voltage DC is then fed to the high frequency inverter. The operating frequency range is from 20 KHz to 1 MHz. The high frequency square wave thus generated is stepped down by the high frequency transformer and then rectified and filtered to produce the required DC output.

The output is compared with a reference and pulse width modulated to get the desired regulation by the control circuit. The regulation of the output voltage is achieved by varying the duty cycle of the square wave. When the load is removed or input increases, the slight rise in the output voltage will signal the control circuit to deliver shorter pulses to the inverter. Conversely, as the load is increased or input is decreased, wider pulses are fed to the inverter.

The efficiency of an SMPS is higher than a series type regulator. It is physically smaller and lighter than linear regulators. SMPS is noisy electrically. Thus it is unsuitable for powering circuits that are sensitive to electrical noise unless adequate filtering and shielding is provided.

1.3.3 Switching mode power supplies

The primary advantage of switch mode power supplies is they can accomplish power conversion and regulation at 100% efficiency – given ideal parts. All power loss is due to less than ideal parts and the power loss in the control circuitry. In this section we will explore some of the switching-mode power supplies.

Heaters

One of the simpler switching-mode power supplies is one that is used to control a heater. For example, an inexpensive space heater applies full household ac voltage to a heater element when the temperature is less than that set by a simple thermostat and turns the ac power off when the temperature is above set point. The heater turns on and off every several minutes to keep the room temperature constant.

Closer to our example might be a heater in a crystal oscillator oven used to keep the temperature of the crystal within narrow limits. For this circuit we only need to use the switch from our list of components. The schematic is shown in Figure 1.7.

Figure 1.7

Heater schematic

As with our previous examples, Vin is 12 V dc and the load resistor R2 is 0.25 ?. The objective is to open and close the switch so that the average voltage across R2 is 5 V dc. The waveform of the voltage across R2 is shown below in Figure 1.8.

Figure 1.8

Heater Waveform

This is the first waveform we have encountered in this tutorial. In your design of SMPS you will have to work with many waveforms and calculate properties such as period, frequency, duty cycle, harmonics, average and rms (root-mean-square) values – both with and without the dc component, etc. Unless you really like solving integrals and doing Fourier analysis, you will want a handbook that gives characteristics of common pulse and periodic waveforms.

In the Heater waveform figure, T of the waveform is Ton + Toff, and by definition, the reciprocal of the period is the frequency. For example, a period of 50 µs results in a frequency of 20 KHz. The ratio of Ton / (Ton + Toff) is called Duty Cycle.

Duty Cycle = Ton / (Ton + Toff)

D is a parameter much used in switching mode power supply calculations. The average value of the waveform over a period is shown by a dotted line.

For those who have had calculus, you will remember the average value of a function is (1 / T) * (integral zero to T of the function). In this case you have to evaluate the integral from 0 to Ton and from Ton to T and add them. Or you can look it up in the handbook to see the RMS is Vin * SQRT (D).

Example:

Vin = 12 V dc

Vo = 5 V dc

D = (5v) / (12 V)

= 0.417

Vrms = (12V) * SQRT (0.417)

= (12 V) * 0.645

= 7.75 Vrms

Iaverage = (0.417) * (12V) / (0.25 ?)

= 20 A

Pin = (12V) * (20 A)

= 240 W

These are the answers we got in our series and shunt regulator example and are no surprise.

We might expect that the power in R2 is the same as before, (5 V) * (20 A) = 100W, but doesn’t make sense, since we are taking 240W from the source and nowhere it can go except into R2. Recalling that power in a resistor is

Power in a resistor = (Vrms * Vrms) / R

And the RMS voltage is 7.75 Vrms, then we get

Power in a resistor = (7.75 * 7.75) / 0.25 ohms

= 240 W in R2.

With this everything balances. Notice that the rms value of the waveform is higher than the average value. This is true in all duty cycle controlled SMPS. Also notice that all the power taken from the source is delivered to the load assuming ideal components.

1. Linear and SMPS comparison

Let us discuss following points in order to compare Linear and Switch Mode Power Supplies.

- Efficiency
- Cost
- Volume / Weight
- Adjustable frequency
- Flexibility
- Noise
- Transient Response

1.4.1 Efficiency

In linear supply, power losses are much higher because of the continuous operation of the series pass regulating transistor in its active region. Consequently its power efficiency is relatively poor, 10 % to around 50%.

In the switching supply, though, the regulating transistor is either saturated or cut-off. Power losses are held to minimum, and power efficiency is very good, ranging anywhere from approximately 60% to a better than 90%. The efficiency comparison is explained in Figure 1.9.

Figure 1.9

Efficiency comparisons between series pass and switch mode power supply

For P_{out} = 500 watts

-Series pass consumption = 750 watts

-Switch mode consumption = 125 watts

= 625 watts saved.

1.4.2 Cost

At the 100W level, the switching supplies cost more to build than series pass supplies, but at 200W, the figure is reversed. The parts cost only the electronic components and heat sinks. Because “switch mode” costs drop faster, they are more economical than series pass regulators at high power levels and cost about the same at 200W level. A couple of years ago, this break-even point were at 50W level. Figure 1.10 shows the cost comparison between series pass and SMPS.

Figure 1.10

Cost comparison between series pass and switch mode power supply

1.4.3 Volume/weight

Because of the use of a 50 Hz transformer for isolation between the line and load series pass system have a disadvantage of large size ad weight. The switch mode regulators however operate above audio frequency and use small 20 KHz power transformers. Because of the present emphasis on energy conservation efficiency, and small size future appears bright for these switching supplies. Figure 1.11 and Table 1.1 display volume weight comparison.

Figure 1.11

Volume / Weight comparison between series pass and SMPS

Table 1.1

Weight comparison between series pass and SMPS

Feature	Series Pass	SMPS
Weight	10 kg	2 kg

1.4.4 Adjustable frequency

Switch mode allows adjusting the frequency from 1 to 300 kHz (following the product chosen and customer application)

1.4.5 Flexibility

Due to the capability of adjusting frequency from 1 to 300 kHz, the SMPS can solve many of the customer applications.

1.4.6 Noise

Because of the fairly high switching frequency 20 to 100KHZ the switch mode version may be troubled not only on its output but also by noise induced or conducted into AC input lines. The noise comparison is displayed in Figure 1.12.

Figure 1.12

Noise comparison between series pass and SMPS

1.4.7 Transient responses

The transient response is the time required for the output voltage to return within its regulation limits when there is an abrupt change in either the line voltage or load current. For a series pass this transient response is in a range of some microseconds instead of some milliseconds for the switch-mode. The trend for the next generation of switch-mode is faster response with use of feed forward compensation circuits.

Table 1.2 provides the comparison of 20 KHz switcher and linear performance

Table 1.2

20 KHz Switcher vs Linear Performance

Parameter	Switcher	Linear
Efficiency	75%	30%
Size	2.0 W / in^3	0.5 W / in^3
Weight	40 W / lb	10 W / lb
Cost (200 – 500 W)	$ 1.00 / W	$ 1.25 / W
Cost (50 – 150 W)	$ 1.50 / W	$ 1.50 / W
Line and Load Regulation	0.1 %	0.1%
Output Ripple Vp-p	50 mV	5.0 mV

Noise Vp-p	50 – 200 mV	20 mV
Transient Response	1 ms	20 µs
Hold-up Time	20 – 30 ms	1 – 2 ms
Design	Complex	Simple
Power Density	High	Low
Input Line Flter	Required	Not-required
EMI	High	Low

Switchers are inherently more complex than linear supplies, but they are absolutely required for the design of high power DC-DC converters (e.g. high power car audio applications), as well as for the execution of class D, H, and DAFPS amplifier designs.

Advantages:

- They offer better energy control (SMART POWER). The energy saving program requires less than 1 W of dissipation in stand-by mode. This can only be achieved by using SMART POWER technologies.
- It has less Weight
- It has higher density (Watts / in^3)
- It can provide modularization
- It provides additional alternatives to optimize audio design circuitry.

Disadvantages:

- EMI filtering is required.
- Shielding may be required to avoid HF
- Noise affects sensitive circuitry. Linear transformers / supplies are more tolerant of power line fluctuations and ESD. Power circuit design and bypassing can however make a switcher fairly bullet-proof to these occurrences.

Many companies have started using HF converters consumer products, such as VCRs, DSS systems, Audio mini systems, and of course audio amplifiers.

1. Summary

A Power Supply is a buffer circuit or Electronic Device that provides power with the characteristics required by the load from a primary source with characteristics incompatible with the load. It makes the load compatible with its power source.

Dissipative regulators achieve regulation by a purposeful conversion of excessive power to heat, unlike switching mode supplies which do not rely on a heat conversion for regulation.

Linear Regulator is basically a voltage divider circuit.

The SMPS functions through low loss components such as capacitors, inductors, transformers and switches. The switches dissipate very little power in either of the two states (on and off) and hence there is a minimal power loss during power conversion.