Contents

Power supply:

A power supply is an electrical device that supplies electric power to an electrical load. The primary function of a power supply is to convert electric current from a source to the correct voltage, current, and frequency to power the load. As a result, power supplies are sometimes referred to as electric power converters.

Linear Power supply (LPS):

Definition: Linear regulated power supplies gain their name from the fact that they use linear, i.e. non-switching techniques to regulate the voltage output from the power supply. The term linear power supply implies that the power supply is regulated to provide the correct voltage at the output.

Linear power supply basics: A linear power supply typically uses a large transformer to drop voltage from an AC line to a much lower AC voltage, and then uses a series of rectifier circuitry and filtering process to produce a very clean DC voltage. In this process, the circuit is continuously converting the AC to DC supply. And the output is constant DC, hence the name linear. Linear power supplies are designed for low noise and are often considered quiet since there is no high-frequency switching. Linear power supplies can only step−down an input voltage to produce a lower output voltage. Linear regulated power supplies also have very little ripple and very little output noise.

Linear power supplies are widely used because of the advantages they offer in terms of overall performance, and also the technology is very well established because it has been available for very many years. While linear power supplies may not be as efficient as switch mode power supplies, they offer the best performance and are therefore used in many applications where noise is of great importance. One major area where linear power supplies are almost always used is for audio visual applications, hi-fi amplifiers and the like. Here the noise and switching spikes from switch mode power supplies can cause issues - that said SMPSs are improving in performance all the time, but linear supplies tend to be used most of the time.

Fig 1: Typical variable linear power supply for bench laboratory use

Working Principle:

The main component that allows a linear regulator to function is a transformer. This transformer provides two functions:

- It acts as a barrier to separate high voltage AC input from low voltage DC input, which also filters out any noise getting into the output voltage.
- It reduces AC input from 115V/230V to approximately 30V which can then be converted to a steady DC voltage.

AC voltage is first lowered by the transformer and then rectified by several diodes. It's then smoothed into a low DC voltage by a pair of large electrolytic capacitors. This low DC voltage is then regulated as a steady output voltage with the use of a transistor or integrated circuit.

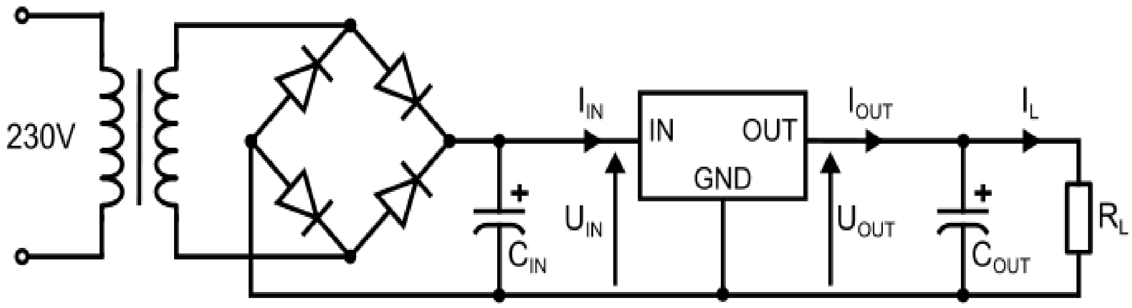
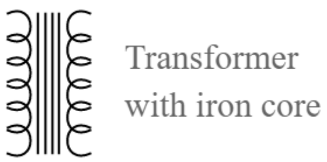


Fig 2: Linear power supply diagram

Transformer:

As many regulated power supplies take their source power from an AC mains input, it is common for linear power supplies to have a step down or occasionally a step-up transformer. This also serves to isolate the power supply from the mains input for safety.



The transformer is typically a relatively large electronic component, especially if it is used in a higher power linear regulated power supply. The transformer can add significant weight to the power supply, and can also be quite costly, especially for the higher power ones.

Dependent upon the rectifier approach adopted, the transformer may be a single secondary, or it may be center tapped. Also, additional windings may be present if further voltages are required.

Rectifier:

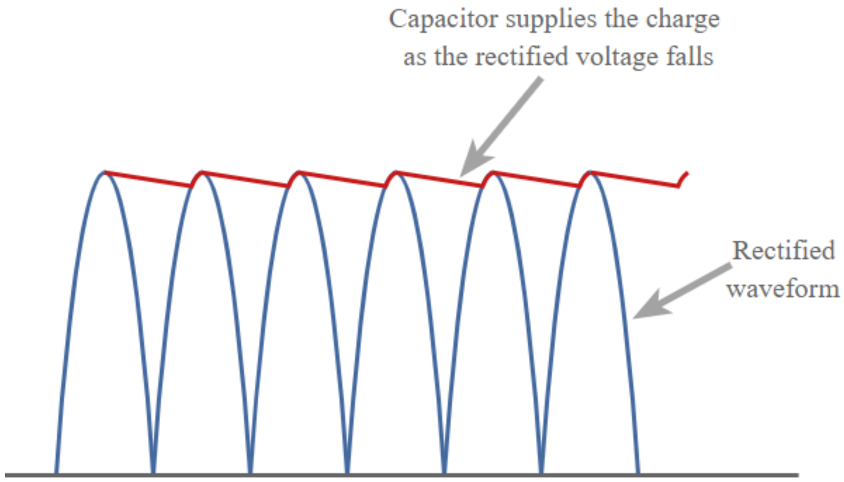
As the input from an AC supply is alternating, this needs to be converted to a DC format. Various forms of rectifier circuit are available. The simplest form of rectifier that could be used in a power supply is a single diode, providing half wave rectification. This approach is not normally used because it is more difficult to satisfactorily smooth the output.

Normally full wave rectification, using both halves of the cycle is used. This provides a waveform that can be more easily smoothed.

There are two main approaches to providing half wave rectification. One is to use a center tapped transformer and two diodes. The other is to use a single winding on the power supply transformer and to use a bridge rectifier with four diodes. As diodes are very cheap, and the cost of providing a center tapped transformer is more, the most common approach these days is to use a bridge rectifier.

Filter:

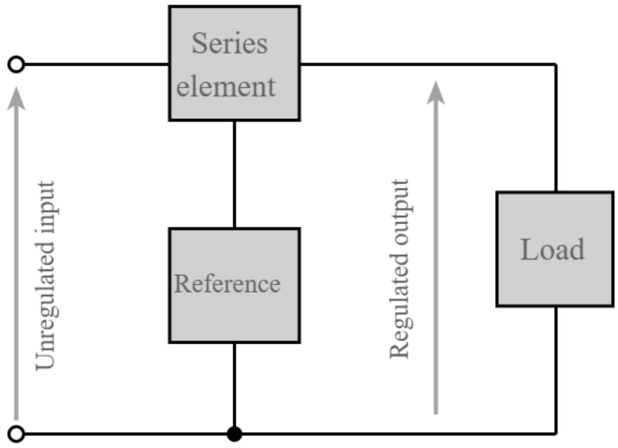
Once rectified from an AC signal, the DC needs to be smoothed to remove the varying voltage level. Large reservoir capacitors are used for this.



The smoothing element of the circuit uses a large capacitor. This charges up as the incoming waveform from the rectifier rises to its peak. As the voltage of the rectified waveform falls away, once the voltage is below that of the capacitor, the capacitor starts to supply charge, holding the voltage up, until the next rising waveform from the rectifier.

Regulator:

This is the most widely used format for a linear voltage regulator. As the name implies a series element is placed in the circuit, and its resistance varied via the control electronics to ensure that the correct output voltage is generated for the current taken.



In this block diagram, a reference voltage is used to drive the series pass element which may be a bipolar transistor or a FET. The reference may just be a voltage taken from a reference voltage source, e.g. an electronic component such as a Zener diode.

Advantages & Disadvantages

Linear regulated power supplies might be bulky and inefficient, but their low noise is ideal for noise-sensitive applications. Some advantages and disadvantages to consider for this topology include:

Advantages

- **Simple application:** Linear regulators can be implemented as an entire package and added to a circuit with only two additional filter capacitors. This makes them easy for engineers of any skill level to plan and design from scratch.
- **Low cost:** If your device requires a power output of less than 10W, then the component and manufacturing costs are much lower when compared to switching power supplies.
- **Low noise/ripple:** Linear regulators have a very low output voltage ripple and high bandwidth. This makes them ideal for any noise-sensitive applications including communication and radio devices.
- **Established technology:** Linear power supplies have been in widespread use for many years and their technology is well established and understood.

Disadvantages

- **Limited flexibility:** Linear regulators can only be used to step down voltage. For an AC-DC power supply, a transformer with rectification and filtering will need to be placed before the linear power supply which will add to overall costs and effort.
- **Limited outputs:** Linear regulated power supplies only provide one output voltage. If you need more, then you'll need to add a separate linear voltage regulator per required output.

- **Poor efficiency:** The average linear regulated device achieves an efficiency between 30%-60% due to heat dissipation. It also requires the addition of a heat sink which adds to the size and weight of the device.
- **Size:** The use of linear technology means that the size of a linear power supply tends to be larger than other forms of power supply.
- **Heat dissipation:** The use of a series or parallel (less common) regulating element means that significant amounts of heat are dissipated and this needs to be removed.

Uninterrupted Power supply (UPS):

Definition:

An Uninterruptible Power Supply (UPS) is defined as a piece of electrical equipment which can be used as an immediate power source to the connected load when there is any failure in the main input power source

Introduction:

In a UPS, the energy is generally stored in flywheels, batteries, or super capacitors. When compared to other immediate power supply system, UPS have the advantage of immediate protection against the input power interruptions. It has very short on-battery run time; however, this time is enough to safely shut down the connected apparatus (computers, telecommunication equipment etc) or to switch on a standby power source.

UPS can be used as a protective device for some hardware which can cause serious damage or loss with a sudden power disruption. Uninterruptible power source, Battery backup and Flywheel back up are the other names often used for UPS. The available size of UPS units ranges from 200 VA which is used for a solo computer to several large units up to 46 MVA.

Major Roles of UPS:

When there is any failure in main power source, the UPS will supply the power for a short time. This is the prime role of UPS. In addition to that, it can also able to correct some general power problems related to utility services in varying degrees. The problems that can be corrected are voltage spike (sustained over voltage), Noise, Quick reduction in input voltage, Harmonic distortion and the instability of frequency in mains.

Types of UPS:

Generally, the UPS system is categorized into

- On-line UPS
- Off- line UPS
- Line interactive UPS

Off-line UPS: This UPS is also called as Standby UPS system which can give only the most basic features. Here, the primary source is the filtered AC mains (shown in solid path in figure 1). When the power breakage occurs, the transfer switch will select the backup source (shown in dashed path in figure 1). Thus, we can clearly see that the stand by system will start working only when there is any failure in mains. In this system, the AC voltage is first rectified and stored in the storage battery connected to the rectifier.

When power breakage occurs, this DC voltage is converted to AC voltage by means of a power inverter, and is transferred to the load connected to it. This is the least expensive UPS system and it provides surge protection in addition to back up. The transfer time can be about 25 milliseconds which can be related to the time taken by the UPS system to detect the utility voltage that is lost. The block diagram is shown below.

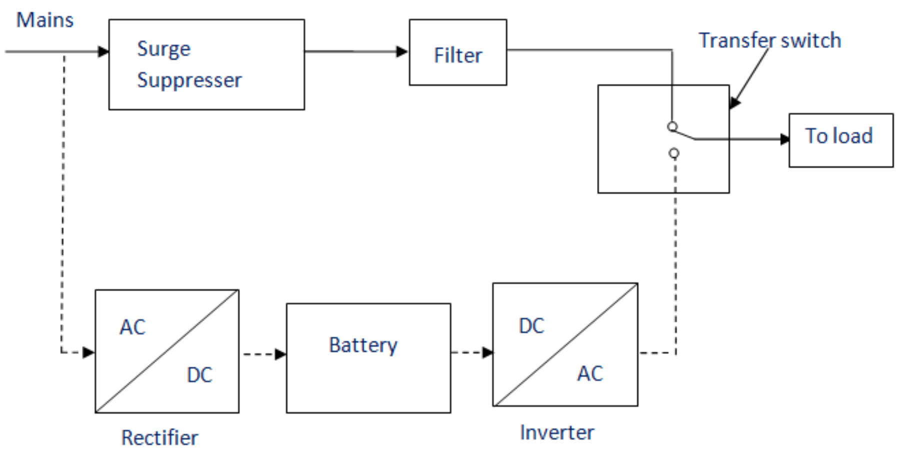


Figure 1

On-line UPS: In this type of UPS, double conversion method is used. Here, first the AC input is converted into DC by rectifying process for storing it in the rechargeable battery. This DC is converted into AC by the process of inversion and given to the load or equipment which it is connected (figure 2). This type of UPS is used where electrical isolation is mandatory. This system is a bit more costly due to the design of constantly running converters and cooling systems. Here, the rectifier which is powered with the normal AC current is directly driving the inverter. Hence it is also known as Double conversion UPS. The block diagram is shown below.

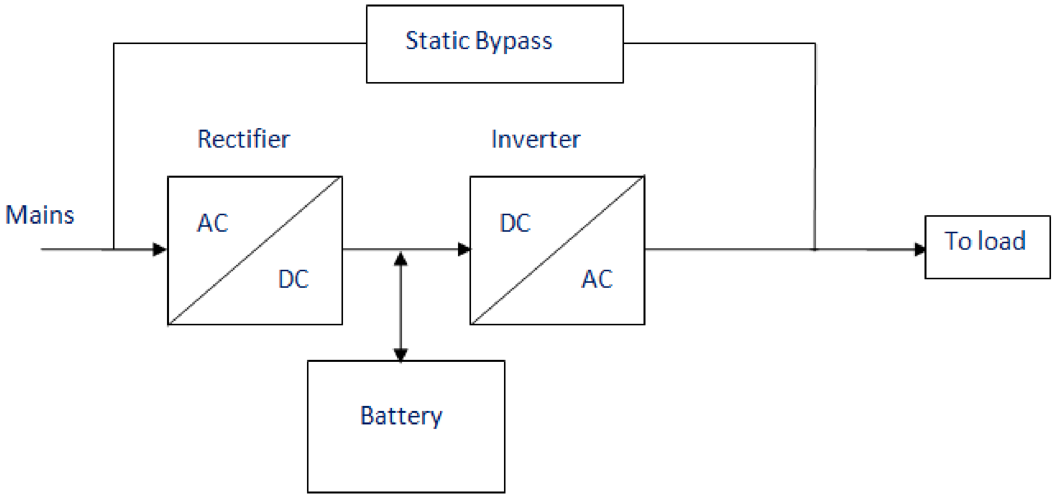


Figure 2

When there is any power failure, the rectifier has no role in the circuit and the steady power stored in the batteries which is connected to the inverter is given to the load by means of transfer switch. Once the power is restored, the rectifier begins to charge the batteries. To prevent the batteries from overheating due to the high-power rectifier, the charging current is limited. During a main power breakdown, this UPS system operates with zero transfer time. The reason is that the backup source acts as a primary source and not the main AC input. But the presence of inrush current and large load step current can result in a transfer time of about 4-6 milliseconds in this system.

Line Interactive UPS: For small business and departmental servers and webs, line interactive UPS is used. This is more or less same as that of off-line UPS. The difference is the addition of tap changing transformer. Voltage regulation is done by this tap-changing transformer by changing the tap depending on input voltage. Additional filtering is provided in this UPS result in lower transient loss. The block diagram is shown below.

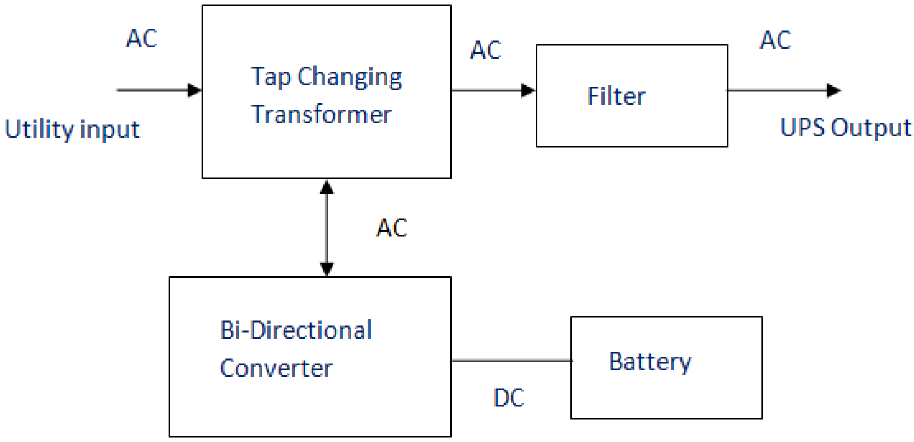


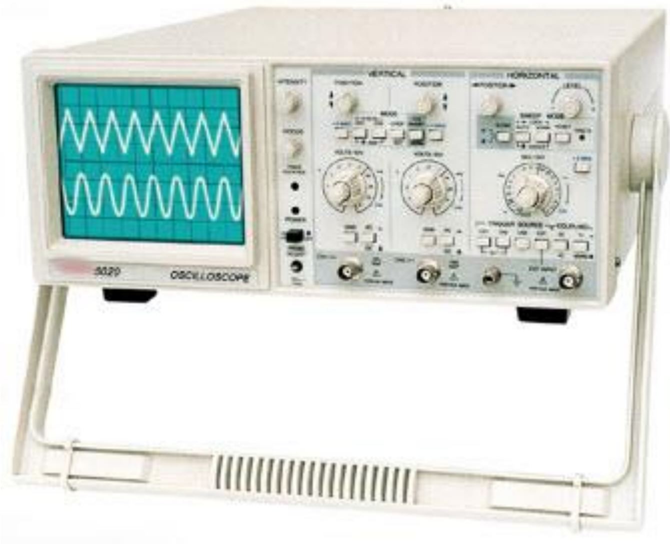
Figure 3

UPS Applications:

- Data Centers
- Industries
- Telecommunications
- Hospitals
- Banks and insurance
- Some special projects (events)

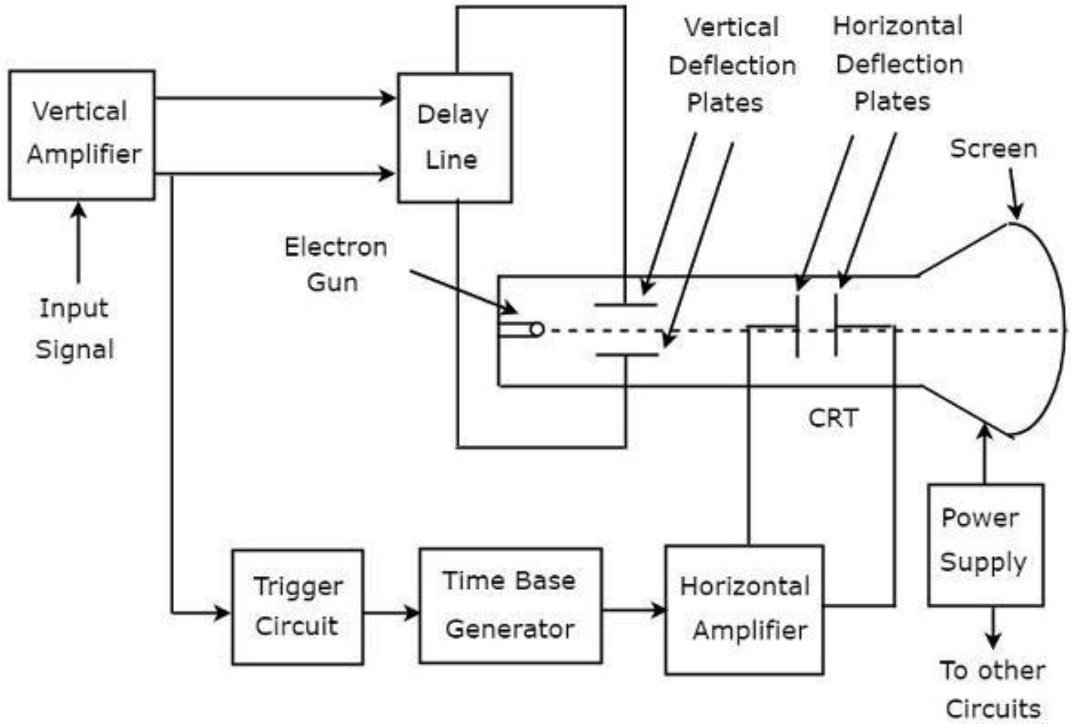
Cathode Ray Oscilloscope (CRO)

Oscilloscope is an electronic equipment, which displays a voltage waveform. Among the oscilloscopes, Cathode Ray Oscilloscope (CRO) is the basic one and it displays a time varying signal or waveform. In this section, let us discuss about the block diagram of CRO and measurements of some parameters by using CRO.



Block Diagram of CRO:

Cathode Ray Oscilloscope (CRO) consists a set of blocks. Those are vertical amplifier, delay line, trigger circuit, time base generator, horizontal amplifier, Cathode Ray Tube (CRT) & power supply. The block diagram of CRO is shown in below figure.



The function of each block of CRO is mentioned below.

- **Vertical Amplifier** − It amplifies the input signal, which is to be displayed on the screen of CRT.
- **Delay Line** − It provides some amount of delay to the signal, which is obtained at the output of vertical amplifier. This delayed signal is then applied to vertical deflection plates of CRT.
- **Trigger Circuit** − It produces a triggering signal in order to synchronize both horizontal and vertical deflections of electron beam.
- **Time base Generator** − It produces a sawtooth signal, which is useful for horizontal deflection of electron beam.
- **Horizontal Amplifier** − It amplifies the sawtooth signal and then connects it to the horizontal deflection plates of CRT.
- **Power supply** − It produces both high and low voltages. The negative high voltage and positive low voltage are applied to CRT and other circuits respectively.
- **Cathode Ray Tube (CRT)** − It is the major important block of CRO and mainly consists of four parts. Those are electron gun, vertical deflection plates, horizontal deflection plates and fluorescent screen.

The electron beam, which is produced by an electron gun gets deflected in both vertical and horizontal directions by a pair of vertical deflection plates and a pair of horizontal deflection plates respectively. Finally, the deflected beam will appear as a spot on the fluorescent screen.

In this way, CRO will display the applied input signal on the screen of CRT. So, we can analyze the signals in time domain by using CRO

Measurements by using CRO:

We can do the following measurements by using CRO.

- Measurement of Amplitude
- Measurement of Time Period
- Measurement of Frequency

Now, let us discuss about these measurements one by one.

Measurement of Amplitude:

CRO displays the voltage signal as a function of time on its screen. The amplitude of that voltage signal is constant, but we can vary the number of divisions that cover the voltage signal in vertical direction by varying volt/division knob on the CRO panel. Therefore, we will get the amplitude of the signal, which is present on the screen of CRO by using following formula.

$$A = j \times nv$$

Where,

- A is the amplitude
- j is the value of volt/division
- nv is the number of divisions that cover the signal in vertical direction.

Measurement of Time Period:

CRO displays the voltage signal as a function of time on its screen. The Time period of that periodic voltage signal is constant, but we can vary the number of divisions that cover one complete cycle of voltage signal in horizontal direction by varying time/division knob on the CRO panel. Therefore, we will get the Time period of the signal, which is present on the screen of CRO by using following formula.

$$T = k \times n_h$$

Where,

- T is the Time period
- j is the value of time/division
- n_h is the number of divisions that cover one complete cycle of the periodic signal in horizontal direction.

Measurement of Frequency:

The frequency, f of a periodic signal is the reciprocal of time period, T. Mathematically, it can be represented as

$$F = 1/T$$

So, we can find the frequency, f of a periodic signal by following these two steps.

- **Step1** − Find the **Time period(T)** of periodic signal
- **Step2** − Take **reciprocal** of Time period of periodic signal, which is obtained in Step1