Power Supplies

- The main function of a regulated power supply (DC) is to convert AC (alternating current) to a steady direct current (DC).

- Even if there are changes in input or load changes but the output will be a regulated DC. (stable).

- we have two varities of power supplies
  - → Linear type
  - → Switch mode type.

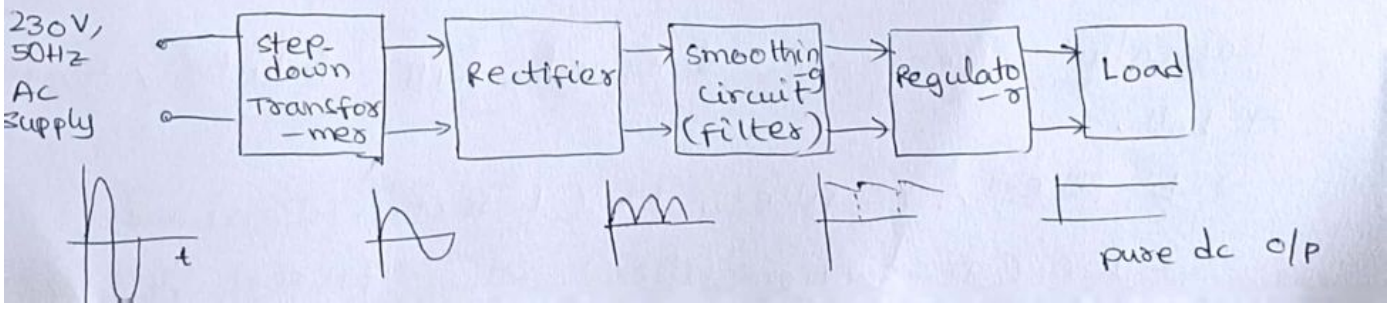
→ Linear type power supplies starts with a transformer, where as, switch mode power supplies start with a rectifier.

→ In practical applications switch mode power supplies are preffered over the linear mode supplies.

Block diagram of Regulated power supply.

- The regulated power supplies are designed in order to provide constant output voltage irrespective of the changes in the load or inputs.

- It consists of transformer (step-down), rectifier, filter (smoothing circuit) and regulator.



1) Transformer. it's a device which transfers the elec energy from one circuit to another by changing the volta level. A step down transformer is used here.

- It takes 230V as input and provides either 6V, 9V 12V or 24V etc as output accordingly.
- It's done by the change of turns ratio. N_2/N_1.

where N_2 = no. of turns in the secondary coil,
N_1 = no. of turns in the primary coil.

2) Rectifier - A rectifier is designed with diodes as basic building block to convert AC into pulsating DC. The output of rectifier is pulsating Dc, that means it consists of ripples (AC components) in the output.

- The rectifier is either Half wave rectifier or full wave rectifier (center tapped or Bridge FWR).
- where an HWR rectifies only one half cycle and its efficiency is very poor.
- but a full wave rectifier rectifies both the half cycles with very low power loss.
- Hence for this reason all the times we prefer FWR

3) Filter - as the output of the rectifier is not pur dc, that means it consists of AC components or ripples hence a filter is employed to remove those ripples from the rectifier's output.

⇒ the o/p of rectifier is connected to the i/p of filter.

- Basically filters are designed with inductors, capac or both.

→ L-filters, C-filters, LC (L-section filters) and C-L-C (Π-section filters) are different types of fil

→ Inductors can block AC and allows DC, on the other hand capacitors blocks DC and allows AC. which can be both employed for filtering purpose

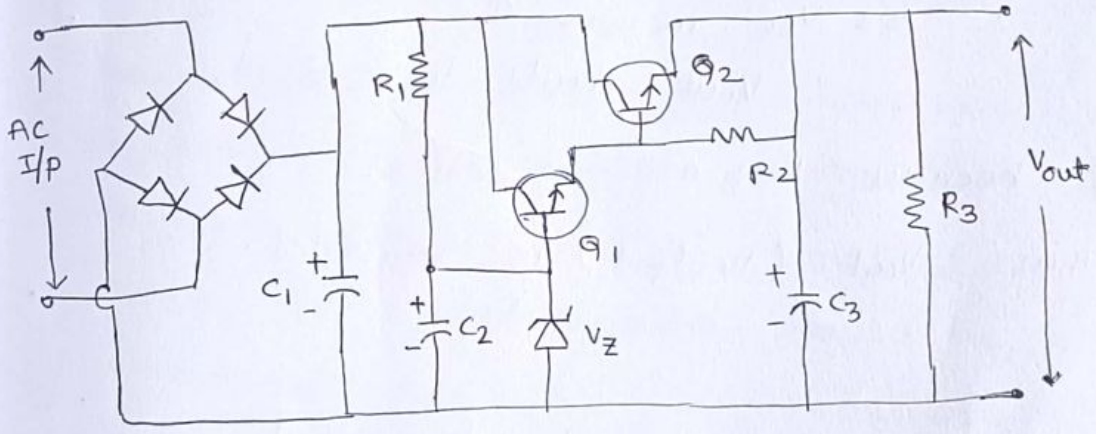
⇒ Inductors should be always conned in series and capacitors should be always connected in shunt.

4) Regulator - It's the most important block of the regulated power supply. In order to regulate the voltage we need to employ zener as voltage regulator. Now IC voltage regulators are also available 78xx, 79xx which are +ve voltage regulators & -ve regulators respectively.

⇒ Transistorized Regulated power supply -

→ A transistorized regulated power supply is intended for providing low ripple regulated DC voltage, mostly suitable for high out put current applications.

→ generally an IC voltage regulators like 7805 which can deliver upto 1A.
where as a series - transistor (pass) regulators circuits can deliver more currents than 1A.



In this circuit, the transistors Q_1 and Q_2 are used. They are provided with resistors R_1 for Q_1 and the Base current is provided to Q_1.

The working of this transistorized - Regulated power supp
is explained in two conditions.
They are when the rectifies output ⇒ increases
when it decreases.

Case-1 when the rectifier o/p increases.
⇒ then V_{out} should increase (V_{out} ↑)

when (V_{out} ↑) increases ⇒ (V_{BE} ↓) decreases

$\because$ $V_{out} = V_Z - V_{BE}$

here V_Z is always constant.

$\therefore$ when (V_{BE} ↓) decreases ⇒ I_B ↓ decreases

if I_B ↓ decreases ⇒ I_C ↓ also decreases

$\because$ (In transistor
o/p current & i/p current)
$\because$ it's a current controlled device.

$\therefore$ I_C ↓ decreases.

⇒ V_{CE} of Q_2 decreases ($\because V_{CE} = V_{CC} - I_C R_C$)

$\therefore$ as V_{CE} increases ↑
$\therefore$ V_{out} should decrease ↓

because they are in series.

thus V_{out} (voutput) is regulated.

Case-2:

when the rectified o/p decreases ↓
$\therefore$ V_{out} is decreased (V_{out} ↓)

if V_{out} ↓ ⇒ V_{BE} ↑ will increase

if V_{BE} ↑ ⇒ I_B ↑ increases

if $I_B \uparrow$ increases $\Rightarrow$ $I_C \uparrow$ increases

(∵ transistor is a current controlled device)

∴ if $I_C \uparrow$ $\Rightarrow$ $V_{CE} \downarrow$ decreases (∵ $V_{CE} = V_{CC} - I_C R_C$

∵ If V_{CE} decreases then V_{out} should increase (∵ V_{CE} & V_{out} are in series)

∴ $V_{out} \uparrow$ increases.

⇒ thus the output voltage is again regulated in case-2.

This the way a transistorized-regulated power supply will provide a regulated (V_{out}) output voltage irrespective of changes in the i/p and load.

⇒ Switch Mode power supply - (SMPS) -

Generally SMPS are designed in order to overcome the draw backs of Linear Regulated power supplies. SMPS are highly efficient and suitable for higher output currents and higher voltage applications.

an smps is a device which performs voltage regulation of unregulated voltage with the help of an semiconductor switching method.

⇒ Here the semiconductor switch is either a transistor (BJT) or MOSFET. for the purpose of switching.

The transistor operates as ON switch and conducts fully the current and when its OFF switch it completely blocks the current.

⇒ Thus the SMPS has got the name switch mode power supply because of this semiconductor switching.

⇒ Because of the usage of fast acting switches like MOSFET (power-MOSFET), the overall size of the power supply will be less. over the linear regulated power supplys.

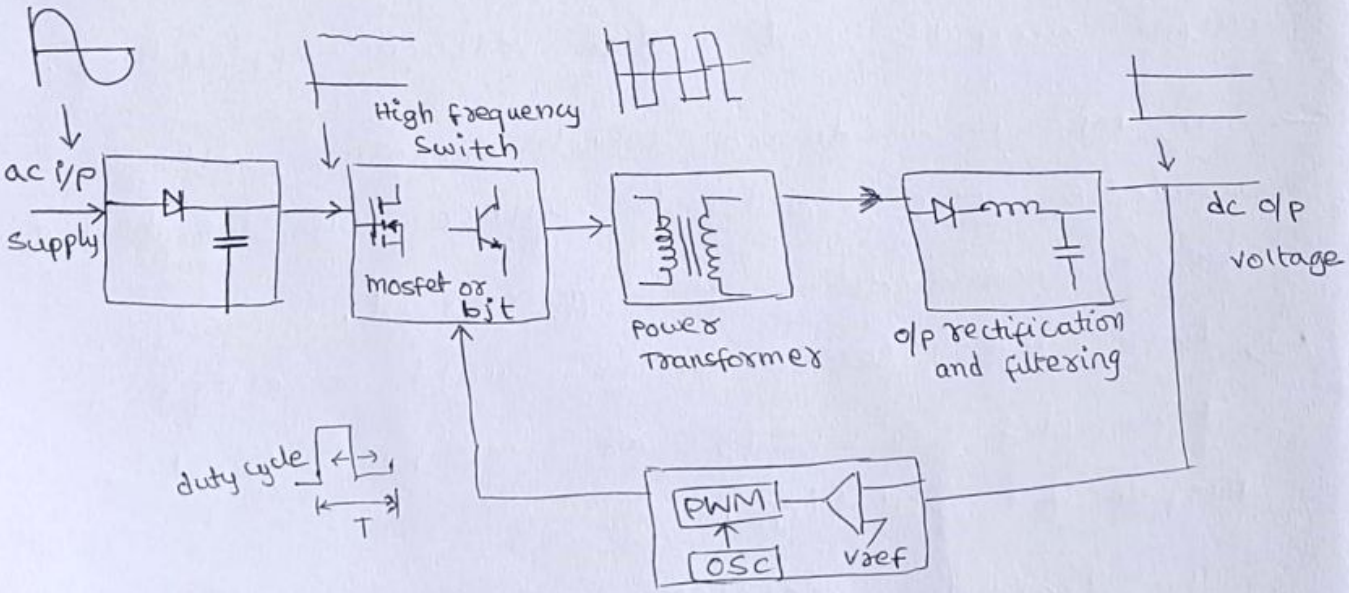
→ Types of SMPS -

In the linear mode we used only the step-down transformers; where as in the SMPS we can implement both step-down and step-up transformers.

They are as follows.

(1) BUCK switch mode power supply → (step-down)
(2) BOOST switch mode power supply → (step-up)
(3) BUCK-BOOST SMPS. → (both)

Block-diagram of switch mode power supply -



The above figure represents the internal block diagram of an SMPS.

It comprises of 4 different blocks -

1) Input rectifier & filter (Diode rectifier & capacitor filter).
Initially the unregulated AC input signal is fed to the i/p rectifier and filter circuit block. where the AC to DC rectification and filtering is done. (High frequency noise is removed thus the DC is smoothened by capacitor filter).

2) High-frequency Switch (power Transistor or MOSFET) and Power transformer -

The DC (unregulated) is fed to the power-transistor which acts as high frequency switch, so that the DC signal undergoes switching (chopping). This circuit acts as an ideal ON/OFF switch acting at a faster rate.

→ when transistor is ON it acts as short circuit and allows current fully with a very negligible drop in the voltage, and dc signal is obtained at the o/p of the transistor.

→ when transistor is OFF it acts as open circuit and no current flows through it and total voltage is droped in it; thus the output of the transistor is zero '0' Volts.

→ Thus depending on the switching speed or frequency of the transistor DC voltage is obtained at its o/p.

→ So the switching frequency (chopping frequency) is very important in producing DC output.

→ The obtained DC o/p is fed to the power-transforme which operates at high frequency.

→ It's a step-down high frequency power-transformer hence high voltage is converted to low voltage level, which is further fed as input to the output rectifier and filter circuit block.

3) output rectifier and filter (Diode rectifier & capacitor filter)

This output rectifier and filter circuit removes the unwanted residuals from the ~~unregulo~~ i/p signal to provide a regulated DC signal as the output.

4) control circuit (comparator & Pulse Width Modulator)

The control circuit block consists of comparator and a pulse width modulator (PWM). It acts as a feed back circuit between the output and switching unit.

→ The dc o/p from the output rectifier & filter block is fed to the control unit, where an error amplifier acts as comparator, which compares the DC voltage with a refereee voltagee

⇒ if the DC o/p is > reference voltage then the switching frequency is decreased.

thus due to decrease in the switching frequency the DC voltage is decreased.

⇒ if the DC o/p voltage < reference voltage, then the switching frequency is increased.

∴ with the increase in the switching frequecy the DC voltage is increases.

The pulse width modulator (PWM) is responsible for generation of fixed frequency PWM waves, whose duty cycle controls the chopping frequency (switching frequency)

$$\text{The Duty cycle ratio} = \frac{\text{ON time}}{\text{OFF time}}$$

Thus by controlling the switching frequency ⇒ we produce a regulated DC output voltage by an SMPS.

Advantages of SMPS :-

→ It's efficient than linear mode regulated DC power supplies.

→ Efficiency of SMPS is between 60 – 95%.

→ Because of High frequency operation of SMPS, the overall circuit size is very small & compact.

→ Less heat is dissipated.