UNIT 1 # POWER SUPPLIES **12 Hrs**

DC Regulated power supply

1. **Appreciate the need for DC regulated power supplies.**
2. **Describe block diagram of regulated power supply.**

Rectifiers

3. **Define ripple factor, ripple frequency, efficiency, peak inverse voltage with expression of rectifiers.**
4. **Describe operation of Half wave rectifier with wave forms**
5. **Describe the operation of Full Wave (Centre –Tap transformer & Bridge) rectifier with waveforms.**
6. **Compute ripple factor and efficiency of HWR and FWR and solve simple problems.**

Filters

7. **Explain the need of filters in power supplies**
8. **Working of C and PI filter along with waveforms.**

Regulators

9. **Understand the purpose of voltage regulators in power supplies.**
10. **Explain working of voltage regulator using Zener diode and explain load and line regulation.**

IC Voltage Regulators

11. **Study of IC regulators 78XX, 79XX, LM 317.**

Basic Switching Regulators

12. **Explain basic switching regulator – Step down and Step up configuration.**
13. **Explain block diagram of SMPS and mention its advantages.**
14. **Explain block diagram of UPS and explain ON – Line and OFF – Line UPS.**

Reference – Electronic Devices and circuits.
By – Anil K. Maini
Varsha Agarwal.

DC Regulated power supply

Appreciate the need for DC regulated power supplies.

All electronic devices and circuits require DC source for their operation. The behavior and characteristics of devices and circuits depend on purity and constant DC voltage with which they operate.

A slight variation in operating DC voltage causes an undesirable effect resulting in malfunction.

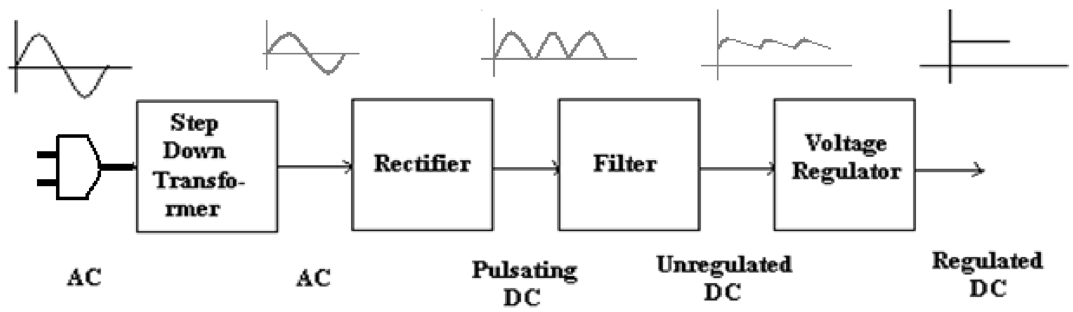
Thus the DC source power supply must have some means to make the variations negligible. This is achieved by introducing the regulator circuit to power supply which maintains constant DC voltage irrespective of line and load variations. Such a power supply is called Regulated Power Supply.

Block diagram of Regulated Power Supply.

An unregulated power supply is one whose terminal DC voltage is affected significantly by the amount of load. A regulated power supply is one whose terminal DC voltage remains almost constant regardless of amount of current drawn from it.

An unregulated supply is converted into a regulated supply by adding a voltage regulating circuit.

Figure below shows block diagram of regulated power supply. It consists of a transformer, rectifier , filter and voltage regulator.



Transformer : A step down transformer is used to convert high level AC input signal to a low level AC signal as required. It provides isolation from supply line.

Rectifier : It is a circuit that uses diodes to convert AC voltage into a pulsating DC voltage.

Filter : It removes fluctuations or pulsations also called as ripple that is present in the pulsating DC output of rectifier. A filter circuit composes of resistor , inductor or capacitor.

Regulator : The output of a filter is not (free from ac components) a pure DC, it significantly varies with amount of load. Thus a regulator circuit is used to keep terminal voltage constant irrespective of changes in line voltage or load current.

Rectifiers

Define ripple factor, ripple frequency, efficiency, peak inverse voltage with expression of rectifiers.

Ripple Factor (γ) : It is defined as ratio of root mean square (rms) value ofripple voltage(ac component) in the output to average / dc component in the output voltage.

“The variation of the amplitude of DC due to improper filtering of AC power supply”.

$$\text{Ripple factor } \gamma = \frac{\text{RMS value of ac component of output}}{\text{Average or dc component of output}}$$

Let I_{AC}= rms value of ac component present in output

I_{DC} = dc component present in output

I_{RMS} = RMS value of total output current $= \sqrt{(I^2_{AC} + I^2_{DC})}$

$$\therefore \; I_{AC} = \sqrt{(I^2_{RMS} - I^2_{DC})}$$

$$\text{We have Ripple Factor } \gamma = \frac{I_{AC}}{I_{DC}}$$

$$\therefore \; \gamma = \frac{\sqrt{(I^2_{RMS} - I^2_{DC})}}{I_{DC}} = \sqrt{\left(\frac{I_{RMS}}{I_{DC}}\right)^2 - 1}$$

Ripple Frequency : The lowest frequency of the ripples (ac content) in the output of a rectifier is called Ripple frequency . Frequency of rectifier output is called as ripple frequency.

Efficiency (η) : It signifies as how efficiently the rectifier converts the ac power into dc power . It is defined as ratio of DC output power to AC input power. It is the ratio of DC power delivered to the load to the AC input power from secondary winding of transformer.

Efficiency $\eta = \frac{P_{DC}}{P_{AC}}$

PIV : It is the maximum reverse voltage that occurs across diode in reverse condition.

Half Wave Rectifier

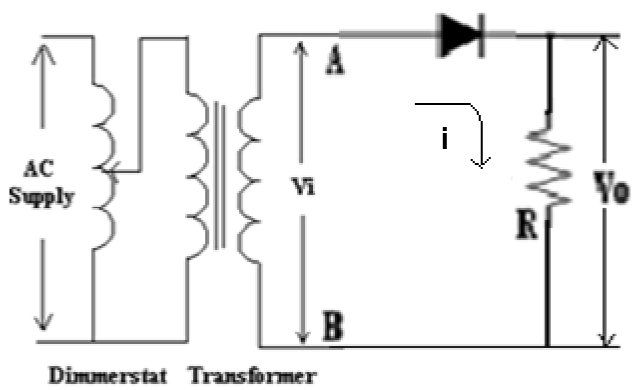


fig a

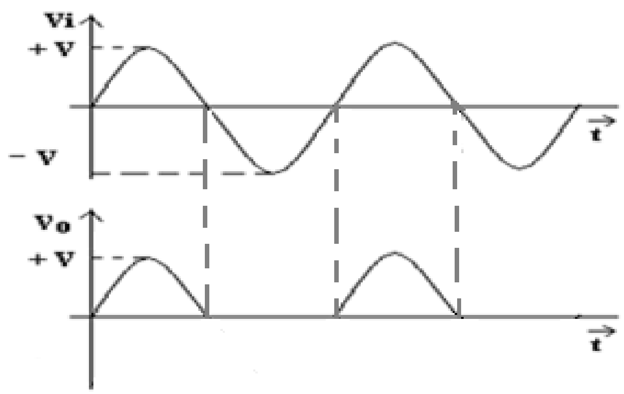


fig b

- During positive half cycle of input ac voltage , point A is positive w. r. t point B . The diode is forward biased and current flows through R as shown in fig a.
- During negative half cycle of input ac voltage , point A is negative w. r. t point B. The diode is reverse biased and hence no current flows through the load R.
- Thus the load current through R is half sinusoidal pulses. Hence the load voltage across R is also half sinusoidal pulses.
- Fig b shows the wave form of a HWR.

Ripple factor for HWR (γ)

Ripple factor is given as $\boldsymbol{\gamma} = \sqrt{\left(\frac{I_{RMS}}{I_{DC}}\right)^2 - 1}$

For HWR $I_{RMS} = \frac{I_m}{2}$ and $I_{DC} = \frac{I_m}{\pi}$

Hence $\gamma = \sqrt{\left(\frac{\frac{I_m}{2}}{\frac{I_m}{\pi}}\right)^2 - 1} = \sqrt{\left(\frac{\pi}{2}\right)^2 - 1} = \sqrt{1.4674}$

$\therefore \; \gamma = 1.21$

Efficiency for HWR (η)

Efficiency is given as $\eta = \frac{P_{DC}}{P_{AC}} = \frac{\frac{I_m^2 \; R_L}{\pi^2}}{\frac{I_m^2}{4}(R_L + R_f + R_s)}$

$$\eta = \frac{4 \; R_L}{\pi^2 (R_f + R_L + R_s)}$$

Divide both numerator and denominator by R_L $\eta = \frac{0.406}{1 + \left(\frac{R_f + R_s}{R_L}\right)}$

If $(R_f + R_s) << R_L$ then % **η** = 0.406 *100 = **40.6%.**

PIV for HWR

For a HWR the Peak Inverse Voltage is V_m at secondary of transformer.

Thus PIV = V_{sm}

Full Wave Rectifier (Centre Tap Transformer)

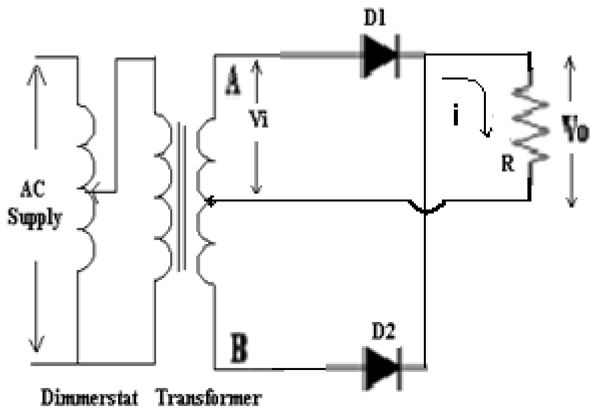


fig a

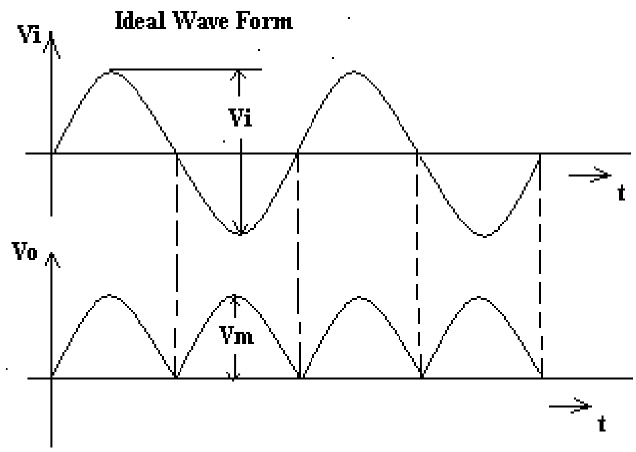


fig b

Here two diodes are used to rectify both half of cycles. The centre tap transformer is used to feed a common load R.

- During positive half cycle of ac input voltage point A is positive and point B is negative due to centre tap transformer.
- Diode D_1 is forward biased and hence conducts , while the diode D_2 is reverse biased and does not conduct.
- The current through the load R is due to D_1 alone as shown in fig a.
- During negative half cycle of ac input voltage point A is negative and point B is positive.
- Diode D_2 is forward biased and hence conducts , while the diode D_1 is reverse biased and does not conduct.
- The current through the load R is due to D_2 alone. The current through the load is still in the same direction. The load current is sum of individual diode currents. The load current is a pulsating dc and not a pure dc

Ripple factor for FWR (γ)

Ripple factor is given as $\boldsymbol{\gamma} = \sqrt{\left(\frac{I_{RMS}}{I_{DC}}\right)^2 - 1}$

For FWR $I_{RMS} = \frac{I_m}{\sqrt{2}}$ and $I_{DC} = \frac{2\,I_m}{\pi}$

Hence $\gamma = \sqrt{\left(\frac{\frac{I_m}{\sqrt{2}}}{\frac{2\,I_m}{\pi}}\right)^2 - 1} = \sqrt{\left(\frac{\pi}{2\sqrt{2}}\right)^2 - 1} = \sqrt{0.2337}$

$\therefore\ \gamma = 0.48$

Efficiency for FWR (η)

Efficiency is given as $\eta = \frac{P_{DC}}{P_{AC}} = \frac{\frac{4\,I_m^2\ R_L}{\pi^2}}{\frac{I_m^2}{2}(R_L + R_f + R_s)}$

$$\eta = \frac{8\,R_L}{\pi^2(R_f + R_L + R_s)}$$

If $(R_f + R_s) << R_L$ then $\%\,\eta = \frac{8}{\pi^2} * 100 = 81.2\ \%$

PIV for Centre tap FWR

PIV = 2 V_{sm}

<u>Bridge Rectifier</u>

Figure shows the circuit and wave forms of a full wave bridge rectifier. It consists of a step down transformer and four diodes constructed in the form of a bridge.

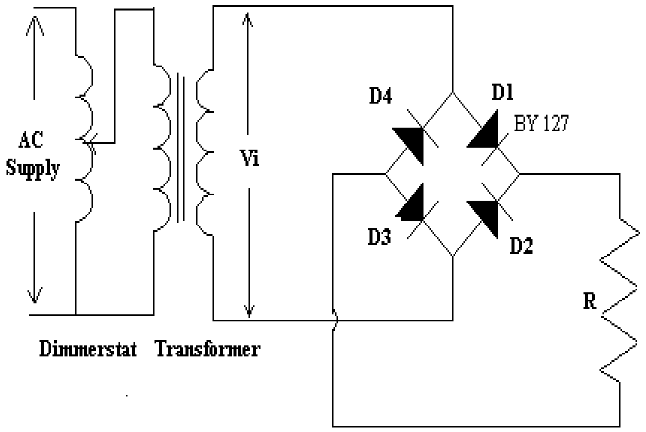


fig a

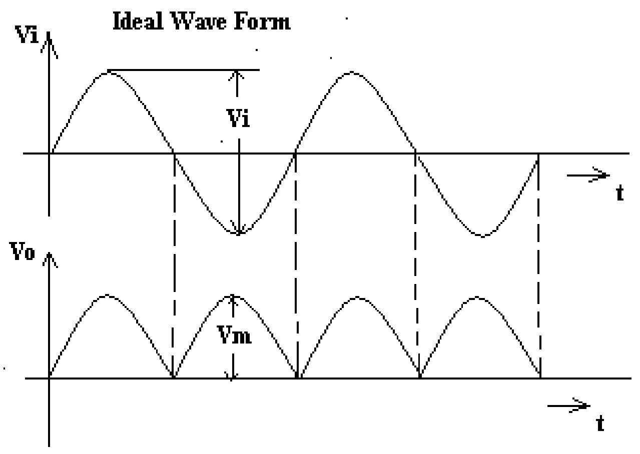


fig b

- During positive half cycle of input AC signal, the end A of secondary is positive and end B is negative. The diodes D1 and D3 are forward biased and hence conduct. The diodes D2 and D4 are reverse biased . The current through load resistor is due to D1 and D3.
- During negative half cycle of input AC signal, the end A of secondary is negative and end B is positive. The diodes D2 and D4 are forward biased and hence conduct. The diodes D1 and D3 are reverse biased .The current through load resistor is due to D2 and D4.
- The current through the load is in the same direction for both half cycles. Thus the output is a pulsated DC with full wave rectification.

Ripple factor for FWR (γ)

Ripple factor is given as $\boldsymbol{\gamma} = \sqrt{\left(\frac{I_{RMS}}{I_{DC}}\right)^2 - 1}$

For FWR $I_{RMS} = \frac{I_m}{\sqrt{2}}$ and $I_{DC} = \frac{2\,I_m}{\pi}$

Hence $\gamma = \sqrt{\left(\frac{\frac{I_m}{\sqrt{2}}}{\frac{2\,I_m}{\pi}}\right)^2 - 1} = \sqrt{\left(\frac{\pi}{2\sqrt{2}}\right)^2 - 1} = \sqrt{0.2337}$

$\therefore\ \gamma = 0.48$

Efficiency for FWR (η)

Efficiency is given as $\eta = \frac{P_{DC}}{P_{AC}} = \frac{\frac{4\,I_m^2\ R_L}{\pi^2}}{\frac{I_m^2}{2}(\,R_L + R_f + R_s\,)}$

$$\eta = \frac{8\,R_L}{\pi^2(\,R_f + R_L + R_s)}$$

If $(R_f + R_s) << R_L$ then $\%\,\eta = \frac{8}{\pi^2} * 100 = 81.2\ \%$

PIV for Bridge FWR

PIV = V_{sm}

Problems

1. In a bridge rectifier the diodes are assumed to be ideal. Find DC output voltage , peak inverse voltage, output frequency for a load of 200Ω and input of 230V 50 Hz. Assume primary to secondary turns ratio to be equal to 4.

Given $R_L = 200\Omega$, $V_p = 230v$, 50 Hz and $\frac{N_S}{N_P} = \frac{V_S}{V_P} = \frac{1}{4}$

To Find V_{dc} = ? PIV = ? f_o = ?

Soln :

$$V_{rms} = V_s = V_P * \frac{N_S}{N_P} = 230 * \frac{1}{4} = 57.5 \text{ v}$$

$$V_m = V_{rms} * \sqrt{2} = 57.5 * \sqrt{2} = 81.3 \text{ v}$$

PIV = $V_m = 81.3$ v

$$V_{dc} = \frac{2 V_m}{\pi} = \frac{2 * 81.3}{\pi} = 51.76 \text{ v}$$

Output frequency $f_O = 2 f_i = 2 * 50 = 100$

2. For a bridge rectifier the transformer turns ratio is 5 : 1 and primary is connected to 230v,50Hz, with a load of 100Ω. Find DC voltage and PIV.

Given $R_L = 100\Omega$, $V_p = 230v$, 50Hz , $\frac{N_S}{N_P} = \frac{V_S}{V_P} = \frac{1}{5}$

To find V_{dc} = ? PIV = ?

Soln :

$$V_s = V_P * \frac{N_S}{N_P} = 230 * \frac{1}{5} = 46 \text{ v}$$

$$V_{rms} = V_s = 46 \text{ v}$$

$$V_m = V_{rms} * \sqrt{2} = 46 * \sqrt{2} = 65.05 \text{ v}$$

$$V_{dc} = \frac{2\,V_m}{\pi} = \frac{2 * 65.05}{\pi} = 41.41\text{ v}$$

PIV = $V_m = 65.05$ v

Filters

Need for Filter

A rectifier output is a pulsating DC , consisting of both Ac and DC components. The presence of AC components is undesirable and hence must be removed. This is achieved by a circuit called the filter. Thus a filter minimizes the unwanted AC component of rectified output and allows only DC component to reach the load.

Types of Filter

1. Capacitor filter 2. Inductor Filter3. PIE (π) OR(Capacitor input filter)
4. LC filter [Choke filter]

Capacitor Filter

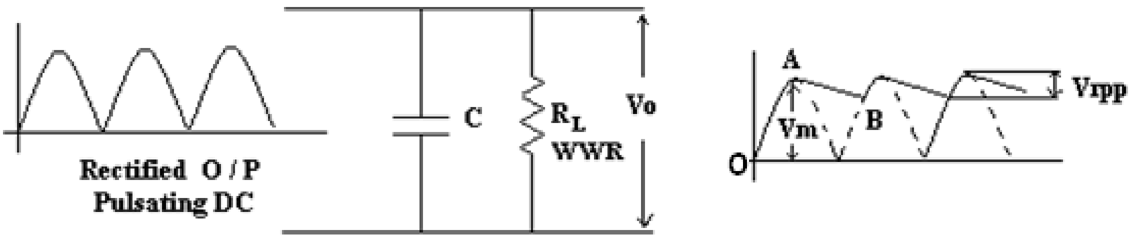


Figure shows a capacitor filter where a capacitor of large value is connected across the load. A capacitor easily bypasses AC components and blocks DC components.

During positive half cycle of AC input voltage the diode is forward biased and allows the capacitor to charge quickly to its maximum voltage V_m. as indicated by curve OA. When output of rectifier reduces below V_m the capacitor begins to discharge as indicated by curve AB. The capacitor does not discharge completely because its time constant is very large. Thus a large voltage across R_L is maintained.

The charging and discharging of capacitor causes the ripple present at the output. The ripple at output of filter is less than the ripple at output of rectifier.

PIE Filter (Π) (Capacitor input filter)

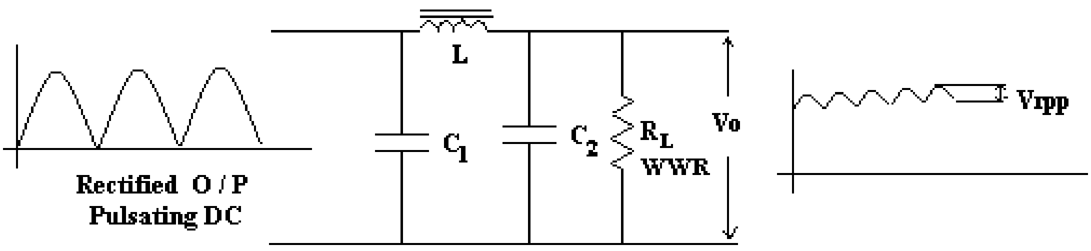


Figure shows a PIE filter also called capacitor input filter. IT consists of C_1connected across the rectified output, the choke L in series and another capacitor C_2 connected across the load. This filter arrangement is used for smoothing action.

Capacitor C_1 : The rectified output is applied to the capacitor C_1 which offers low reactance to AC and infinite reactance to DC. Thus C_1 bypasses the AC components and blocks the DC components, allowing it to pass towards choke.

Inductor / Choke L : It offers low reactance for DC and high reactance for AC. Thus inductor blocks AC components and allows the DC components.

Capacitor C_2 : It bypasses AC component which the choke had failed to block. Thus only DC component appear across the load as it is desired.

Regulators

Need for Voltage Regulator

A rectifier with a filter serves as a good source of DC output. However the output voltage of a power supply changes with variations in input voltage or load.

If the input voltage increases the output DC voltage also increases. If I_L increases the output DC voltage decreases. It is desired that the output voltage should remain constant regardless of the variations in the input voltage or load. This is achieved by a voltage stabilizing device called a voltage stabilizer or voltage regulator.

A voltage regulator maintains constant DC voltage irrespective of changes in the input AC voltage or load current. Regulation is always expressed in terms of percentage. Hence voltage regulation is given as

$$\text{Voltage Regulation} = \frac{V_{NL} - V_{FL}}{V_{FL}} * 100$$

Where V_{NL} = DC output voltage at No Load

V_{FL} = DC output voltage at Full Load.

Types of voltage regulation : There are two types of voltage regulation namely

Line Regulation

A regulator that maintains constant output voltage irrespective of changes in input AC voltage.

Load Regulation

A regulator that maintains constant output voltage irrespective of changes in load current.

Types of Regulator :

Zener Shunt regulator	Transistor Series regulator	Transistor Shunt regulator
Transistor Current regulator	Op – Amp Series regulator	Op – Amp Shunt regulator
Switching regulator	Monolithic regulator.	

Zener Diode as Voltage regulator

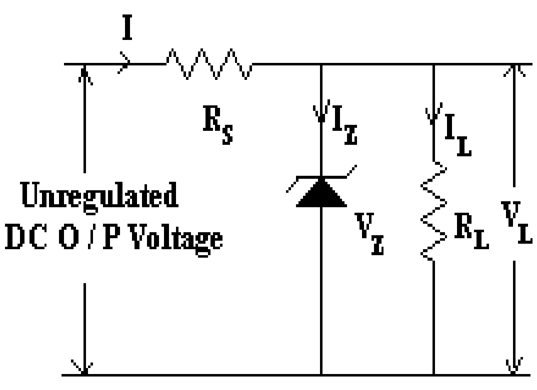


Figure shows a zener diode as shunt regulator. The resistor R_S connected in series with the zener to limit the current I in the circuit. Thus R_S is known as series current limiting resistor. The output voltage is taken across R_L. The input voltage V_i must be greater than V_z for the zener to operate in reverse breakdown region.

Line regulation : (Varying input voltage with constant load R_L)

The load resistance R_L is fixed. The input voltage V_i is varied within limits.

1. If input voltage V_i increases , the input current (I) also increases resulting in the increase of current through the zener without effecting the load current I_L .
2. The increase in input current (I) also increases the drop across the resistance R_S there by keeping the load voltage constant.
3. If input voltage V_i decreases , the input current (I) also decreases resulting in the decrease of current through the zener..
4. The decrease in input current (I) also decreases the drop across the resistance R_S thus making the load current (I_L) and load voltage (V_L) remain constant.

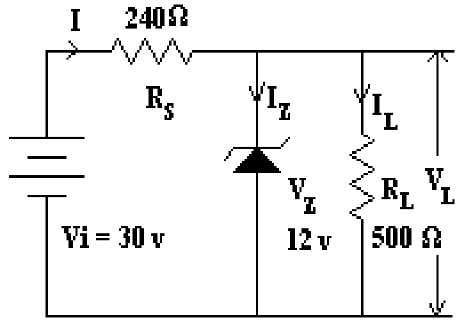
Load Regulation : (Varying load R_L with fixed input voltage)

The input voltage V_i is kept constant . The load R_L is varied.

1. The variations in R_L changes the current I_L there by changing V_L across it.
2. When R_L decreases , the current I_L increase causing the zener current I_Z to decrease. As a result the input current I and voltage drop across R_S remains constant there by load voltage V_L is also kept constant.
3. If R_L increases I_L decreases resulting in increase of I_Z . This keeps the value of input current and voltage drop across R_S to remain constant and thus V_L and I_L remain constant.

Problems

1. Figure shows the zener diode shunt regulator. Find load voltage, current through zener diode and voltage drop across it.



Given : R_S = 240Ω, R_L = 500Ω, V_i = 30v, V_z = 12v

To find : V_L = ? , I = ? , I_z= ?

Soln:

$V_L = I_L R_L = V_z = 12$ v

$$I = \frac{V_i - V_Z}{R_S} = \frac{30-12}{240} = 0.075 \text{ A}$$

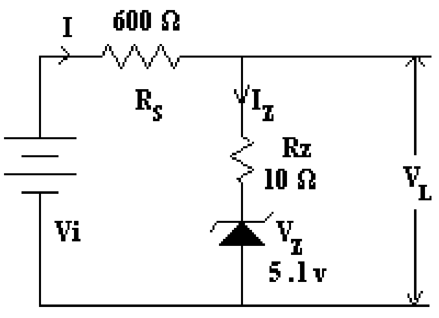
$$I_L = \frac{V_L}{R_L} = \frac{12}{50} = 0.024 \text{ A}$$

$$I = I_L + I_Z \rightarrow I_Z = I - I_L$$

$I = I_L + I_Z \Rightarrow I_Z = I - I_L$

$= 0.075 - 0.024 = 0.051$ A $= 51$ mA

2. A zener diode has breakdown voltage of 5.1v and $R_z = 10\Omega$. The minimum and maximum value of current through zener is 1mA and 15mA respectively. Determine the minimum and maximum value of input voltage that can be regulated.



Given :$V_z = 5.1$v , $R_z = 10\Omega$. ,

I_{min}= 1mA, I_{max} = 15mA

To find : $V_{i\,min}$ = ? $V_{I\,max}$ = ?

Soln :

$V_{Lmin} = (I_{Lmin} * R_Z) + V_Z$

$V_{Lmin} = (1 * 10^{-3} * 10) + 5.1$

$V_{Lmin} = 5.1\ 1$v

$V_{Lmax} = (I_{Lmax} * R_Z) + V_Z$

$V_{Lmax} = (15 * 10^{-3} * 10) + 5.1$

$V_{Lmax} = 5.25$ v

$V_{i\,min} = (I_{Z\,min} * R_s) + V_{Lmin}$

$V_{i\,min} = (1 * 10^{-3} * 600) + 5.11$

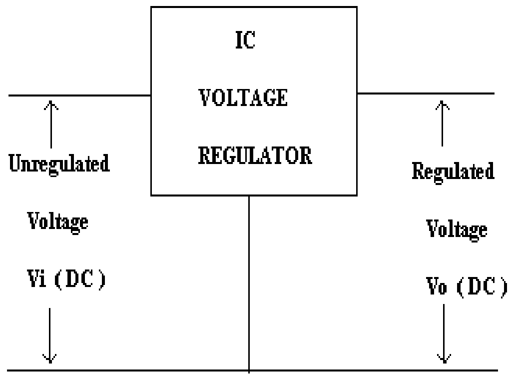
$V_{i\,min} = 5.71$ v

$V_{i\,max} = (I_{Z\,max} * R_s) + V_{Lmax}$

$V_{i\,max} = (15 * 10^{-3} * 600) + 5.25$

$V_{i\,max} = 14.25$ v

IC Voltage Regulator

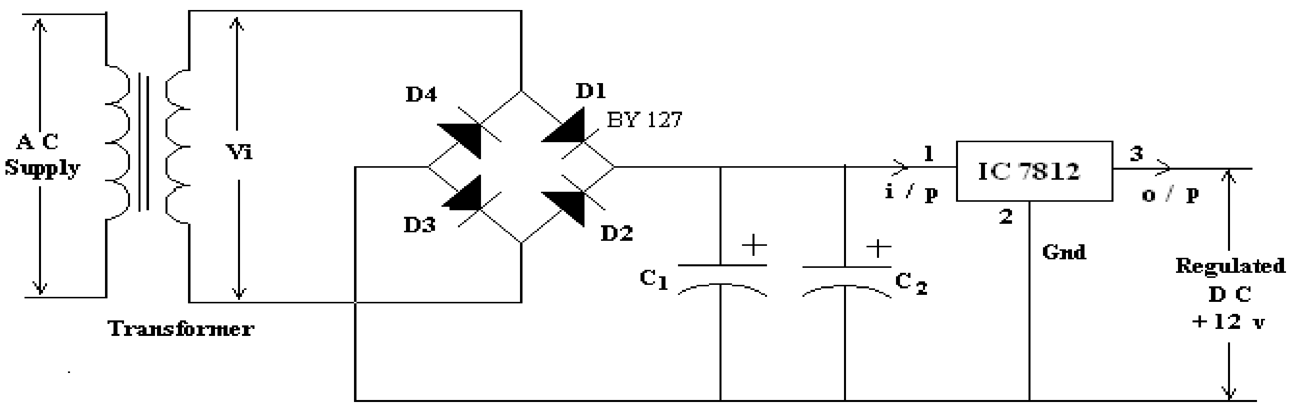


IC regulator is a three terminal regulator with three pins being input, output and ground . It regulates upto 10 mA. The advantage being that less weight , inexpensive and easy to use. These are also called fixed power supplies.

Sl.No	IC Series	Explanation
1	78XX	78 implies positive voltage , XX implies output voltage. It is a groupof positive voltage regulators with preset voltage of + 5 v , + 9 v , + 12 v , + 15 v and + 24 v.
2	79XX	79 implies negative voltage , XX implies output voltage. It is a group of negative voltage regulators with preset voltage of – 5 v , – 9 v , –12 v ,– 15 v , –18 v and – 26 v.
3	LM 317 series	It is a three terminal positive voltage regulator. These are adjustable regulator whose output voltage range from 1.25 v to 37 v and supplies a load current of 1.5A mps.
4	LM 723 series	These can be operated as positive as well as negative voltage regulators. The output voltage varies from 2v to 37 v and supplies a load current upto 150 mA.

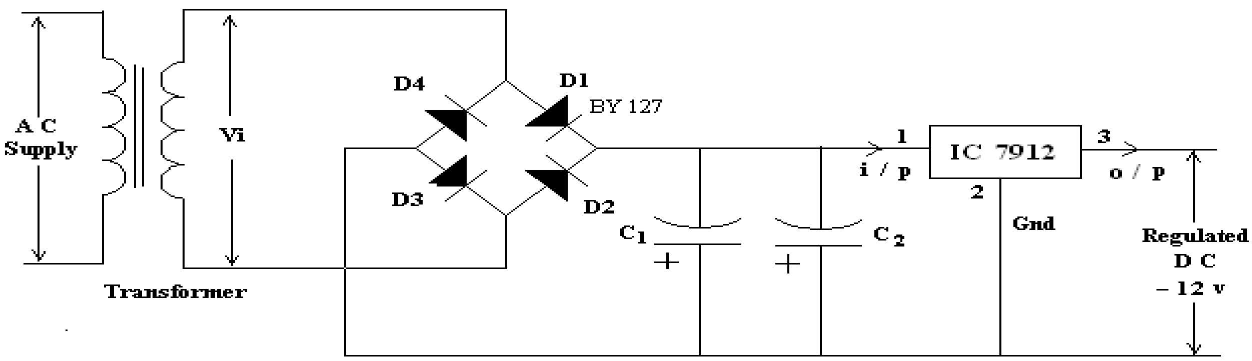
Study of IC regulators 7812, 7912, LM 317.

7812 – three terminal IC Voltage Regulator.



It is positive voltage regulator providing + 12 v regulated DC output. Fig above shows a power supply of + 12 v regulation. The input AC supply signal is applied to the rectifier through a step down transformer. The rectifier converts AC into a pulsating DC voltage. The output of the rectifier is fed to the filter circuit containing two capacitances C_1 and C_2 . The output of filter circuit is fed to the input of IC regulator 7812. This provides a constant output voltage of + 12 v at pin no. 3.

7912 – three terminal IC Voltage Regulator.



It is negative voltage regulator providing – 12 v regulated DC output. Fig above shows a power supply of – 12 v regulation. The input AC supply signal is applied to the rectifier through a step down transformer. The rectifier converts AC into a pulsating DC voltage. The output of the rectifier is fed to the filter circuit containing two capacitances C_1 and C_2 . The output of filter circuit is fed to the input of IC regulator 7912. This provides a constant output voltage of – 12 v at pin no. 3.

LM317 – Adjustable IC Voltage Regulator.

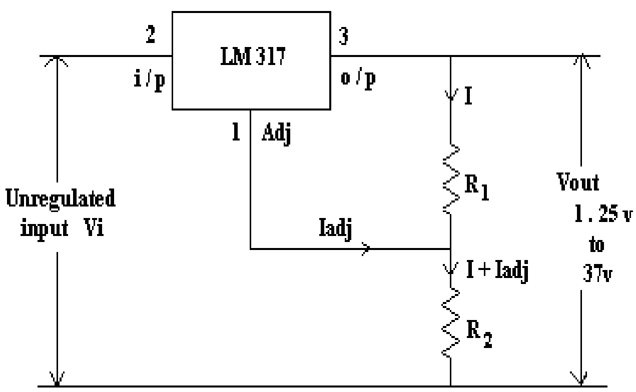


Figure shows an adjustable IC voltage regulator using LM 317 . The adjustable regulator can be adjusted to provide a DC output voltage from 1.25v to 37v. Pin 1 is adjustable terminal , Pin 2 is input terminal , pin 3 is output terminal.

It also consist of 2 resistor R_1 and R_2 to set the output voltage over the adjustable range. Always a reference voltage of 1.25v is built across the output terminal and adjustable terminal ,which is taken as the resistor R_1. Since R_1 is fixed the current through resistor $R_2$is $I + I_{adj}$.

Applying KVL to the output circuit , we have

$$V_{Out} = -IR_1 - \left(I + I_{adj}\right) R_2 \quad \Rightarrow \quad V_{Out} = IR_1 + \left(I + I_{adj}\right) R_2 \;--\rightarrow \text{Equ 1}$$

We know that $I = \frac{V_{ref}}{R_1} \;--\rightarrow \;\text{Equ 2}$

Substitute Equ 2. in Equ 1. and simplify

$$V_{Out} = \frac{V_{ref}}{R_1} * R_1 + \left(\frac{V_{ref}}{R_1} + I_{adj}\right) R_2$$

$$V_{Out} = V_{ref} + \left(\frac{V_{ref}\ R_2}{R_1} + I_{adj}\ R_2\right)$$

$\because$ I_{adj} is nearly 100 μA $I_{adj}R_2$ is negleted

Thus $V_{Out} = V_{ref}\left(1 + \frac{R_2}{R_1}\right)$

Since $V_{ref} = 1.25$ the output can be varied from 1.25 v to 37 v

Basic switching regulator

Switching regulators are Non – dissipative regulators. It is a simple switch which goes ON and OFF at fixed rate usually between 50 khz to 100 khz that is set by circuit.

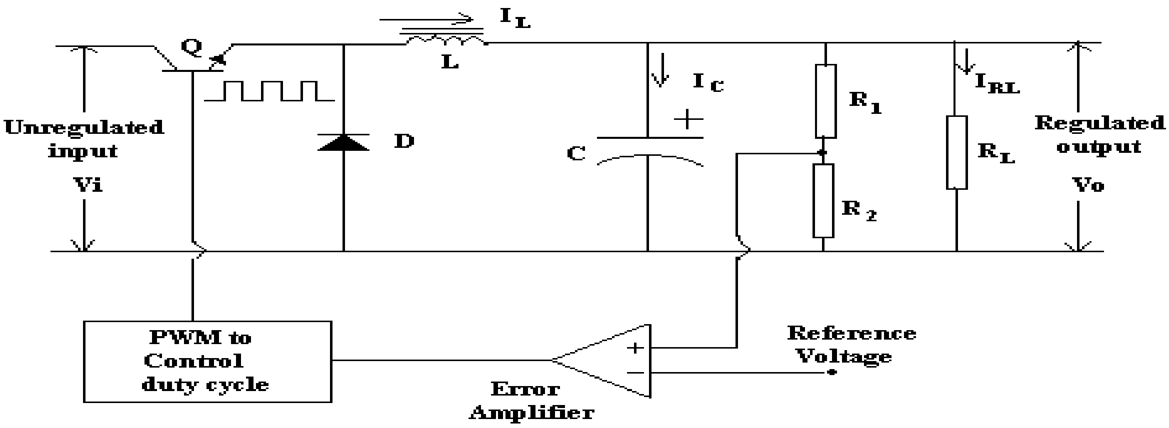
The time that the switch remains closed during each switch cycle is varied to maintain a constant output voltage.

A convertor is another category of switch mode supply that changes DC to AC and then back to DC. This allows to transform one DC voltage to another DC voltage.

Buck Convertor or Forward Convertor or Step down Convertor (Regulator)

It has output voltage less than input voltage (10 % to 90 % of input) , hence the name buck.

Fig below shows a buck convertor.



This switching regulator can be used as step – down transformer. The rectangular pulses from PWM on the base of transistor saturate or cut – off the switching transistor during each cycle.

Because of ON – OFF switching , the average value is always less than input voltage. The output of step – down regulator is compared with reference voltage and the error signal is amplified by the error amplifier. This amplified error signal is used to generate PWM waveform that controls the ON – OFF periods of switching transistor.

Operation .

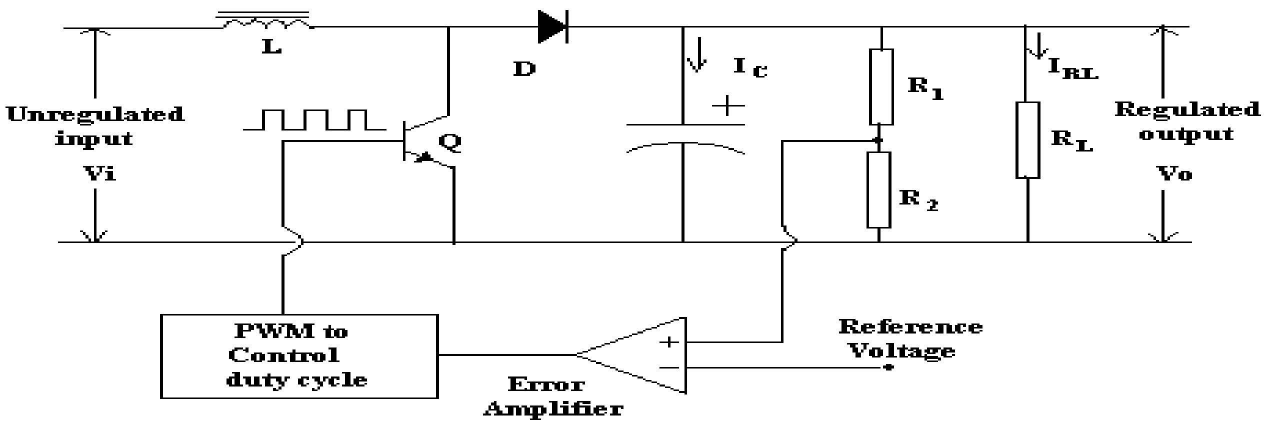
- The transistor Q is turned ON by the positive output pulse of PWM and current flows through L.
- The inductor current divides as I_c and I_{RL}.
- The induced voltage in inductor bucks (opposes) the input voltage.
- The transistor Q is turned OFF by the negative output pulse of PWM , When V_{out} exceeds V_i .
- The energy stored in the inductor L reverse polarity and send current to load through diode D, While maintaining the voltage by capacitor C.

- When all energy in inductor is used up, the capacitor discharges and output decreases. However the diode prevents the discharge of the capacitor.
- The transistor is turned ON and process continues.
- If output voltage increases , the error voltage increases and reduces the ON time of switching transistor Q and thereby reducing output voltage to desired value.

Boost Convertor or Step up Convertor (Regulator)

It has output voltage more than input voltage and hence the name Boost. Fig below shows a Boost convertor.

This switching regulator can be used as step up transformer. The rectangular pulses from PWM on base of transistor , saturate or cutoff the switching transistor during each cycle. Because of ON – Off switching , the average value is always more than input voltage.



The output of step – up regulator is compared with reference voltage and error signal is amplified by error amplifier. This amplified error signal is used to generate PWM waveform that controls the ON – OFF periods of switching transistor.

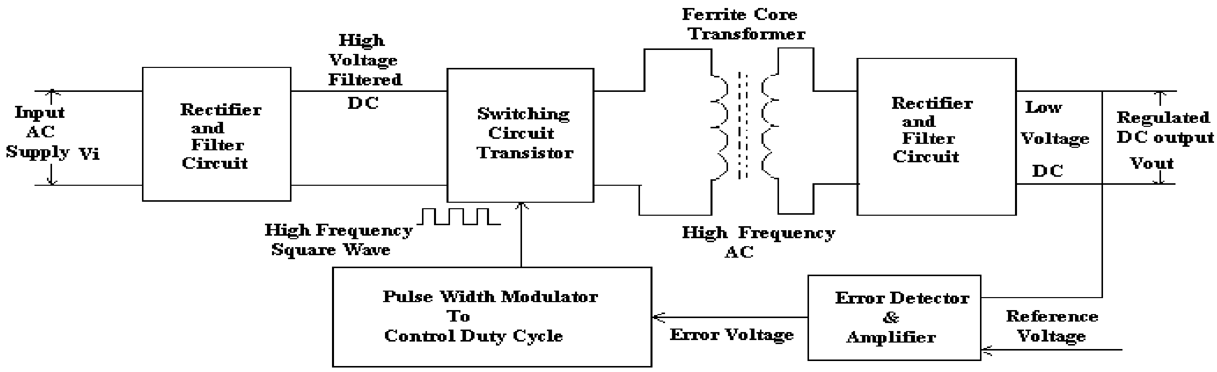
Operation .

- The transistor Q is turned ON by positive output of PWM and current flows through L.
- When switching transistor Q is turned OFF by negative output of PWM the inductor induces a large voltage that adds (boost) the input voltage.

- The diode is now forward biased , the voltage across inductor and input voltage are in series and together charges the capacitor C to a voltage higher than V_i .
- When transistor Q turns ON again ,diode D prevents discharging of capacitor C.
- The capacitor maintains the load voltage V_{out}. When the transistor Q is ON the output voltage increases and reduces the ON time of the switching transistor Q and thereby reducing output voltage to desired value.

Block diagram of SMPS

Figure shows block diagram of SMPS. It consists of Rectifier , Filter , High speed switching transistor, Error detector and pulse width modulator.



- The AC supply from the mains is applied to the rectifier and filter circuit, which converts AC into a high filtered DC voltage.
- The high filtered DC voltage is applied to the switching circuit which is made up of switching transistor that switches ON and OFF at very high speed by the Pulse Width Modulator (PWM).
- The PWM generates high frequency square pulses (20Khz to 50 Khz). Thus the switching transistor also switches the high DC voltage ON and OFF at the same frequency.
- The output of the switching circuit (square wave) are given to primary winding of transformer.
- These pulses induce a voltage in primary which in turn generates a voltage in secondary.
- The secondary voltage is then rectified and filtered to produce a rectified output.
- To regulate the output voltage V_{out} a part of rectified output is fed back to switching section through resistive attenuator and error amplifier.

- The error amplifier compares the feedback voltage with reference voltage and generates an error voltage.
- This error voltage is used to control the ON to OFF ratio of PWM.

If V_{out} increases because of decrease in load , the error voltage increases. The increased error voltage reduces the ON time of switching transistor and thus reducing the output voltage to desired level.

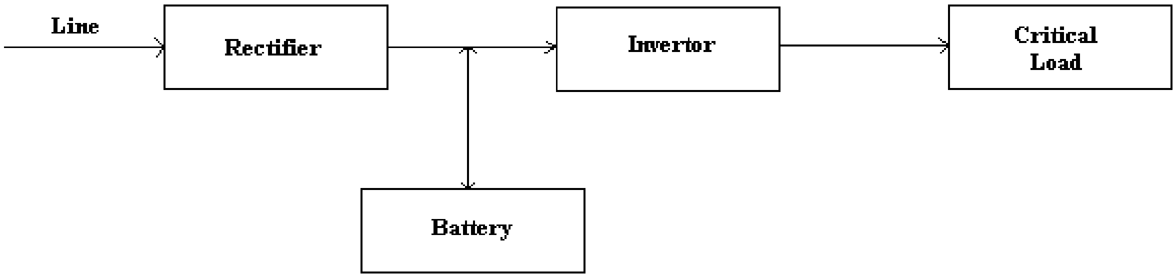
Advantages

1. Reduced Size
2. High efficiency (65 – 80 %)
3. Low cost and less weight.
4. Zero ripple contents because of high speed switching transistor.

Block diagram of UPS

There are situations in AC distribution where interruptions occur. Such interruptions are not allowed in computers because loss of data can occur that cannot be retrieved. The Uninterruptable Power Supply (UPS) is used to overcome this problem.

An UPS consists of a battery charger , a rechargeable battery , an inverter and a static contactor that connects load from inverter to AC supply. The batteries used are lead acid battery or nickel – cadmium battery. The block diagram of UPS is as shown



The rectifier is used for converting the AC input to DC. This is used to supply power to the inverter and the battery to keep it charged.

Normally the power to the inverter is provided by the rectifier. In case of power failure the power to the inverter is provided by the battery.

When AC power supply is working, the battery draws its charging current from it. This ensures that the battery is always ready to provide power to inverter in case of power failure.

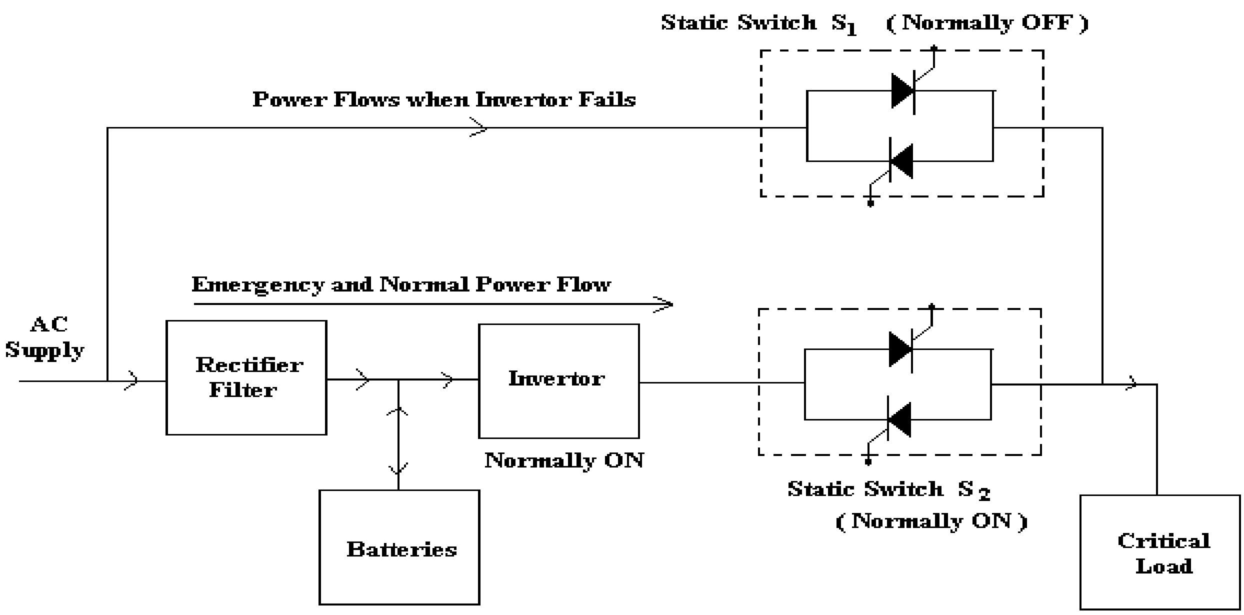
The inverter performs the task of converting the Dc power to its AC equivalent at desired output voltage and frequency statically.

There are two types of UPS namely,

1. ON Line UPS
2. OFF Line UPS

ON – Line UPS

Figure shows block diagram of ON Line UPS.

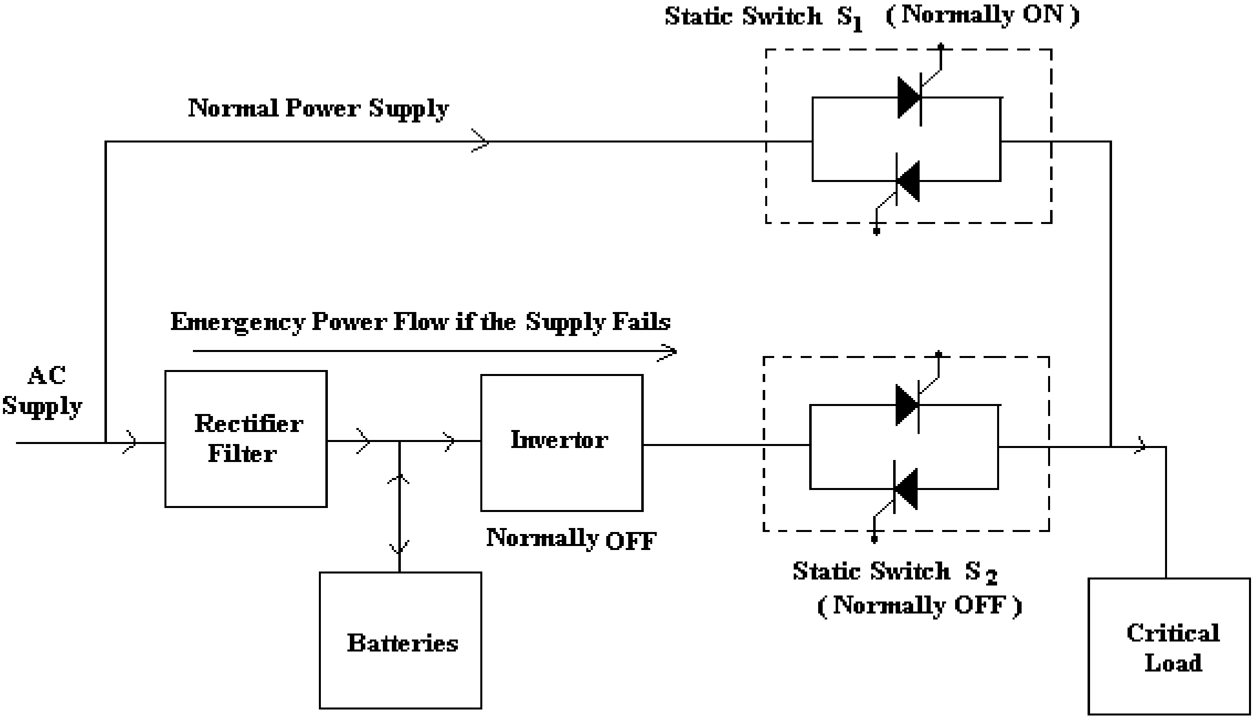


- Here the inverter operates continuously and its output is connected to load through static switch S_2 which is normally ON.
- The rectifier and filter circuit supplies voltage to inverter and also charges battery.
- The inverter converts DC to AC and supplies power to the load through the normally ON static switch S_2.

- If the AC supply fails , then the battery discharges through the inverter and provides the AC supply to the load through the same normally ON static switch S_2.
- If inverter fails , then the load is provided with the AC supply from the Ac mains through the normally OFF static switch S_1. The static switch S_1 turns ON in case of inverter failure.

OFF – Line UPS

Figure shows block diagram of OFF Line UPS.



- Here the inverter does not operate continuously. It remains normally OFF , and gets connected to load only when the AC mains fail.
- The rectifier and filter circuit charges the battery.
- The load gets its AC supply from AC mains through the normally ON switch S_1.
- If the AC mains fail , then the normally ON switch S_1 turns OFF , while turning ON the normally OFF switch S_2. The battery discharges through the inverter , which converts the DC into AC required by the load.