UNIT-II

Basic Electronics circuits and Instrumentation

* DC Power Supply :-

- A D.C Power supply, which converts a.c. into d.c. and maintains the output voltage constant irrespective of a.c. mains fluctuations or load variations is known as regulated d.c. Power supply.
- The block diagram of regulated Power supply is shown in ~~fig~~.

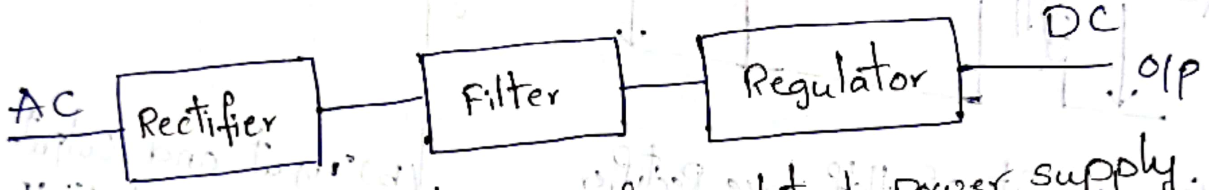


fig: Block diagram of regulated power supply.

- A power supply consists of rectifier, filter and regulator.
- The conversion of alternating voltage into steady voltage is carried out means of rectifier.
- In order to remove the alternating component of the rectified output (ripple), we need a filter.
- To obtain constant O/P voltage irrespective of load variations or a supply variations we need a regulator.

* Rectifier :-

- Rectifier is defined as an electronic device used for converting AC voltage into unidirectional voltage.
- A rectifier utilises unidirectional conduction device like a vaccum diode or PN Junctional diode.
- Rectifiers are classified depending upon the period of conduction as Half-wave Rectifier and Full-wave Rectifier

* Half wave Rectifier :-

It converts an Ac voltage into a pulsating Dc voltage using only one half of the applied Ac voltage. The rectifying diode conducts during one half of the Ac cycle only. The basic circuit and waveforms of a halfwave rectifier is as shown in below fig.

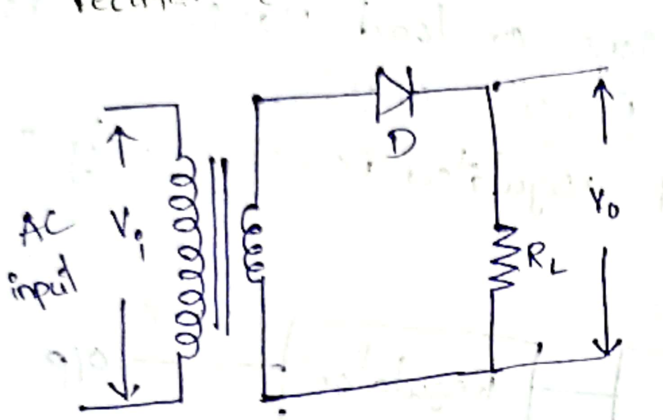
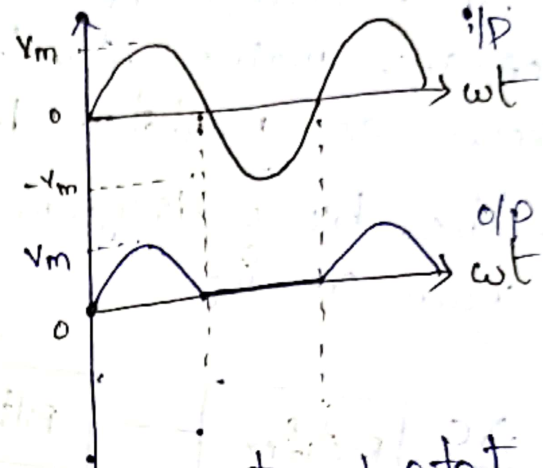


fig: circuit of Half-wave Rectifier



(b) Input and output waveforms of HWR

Let V_i be the Voltage to the primary of the transformer and given by the equation

$$V_i = V_m \sin\omega t \; ; \; V_m >> V_r$$

here V_r - cut-off voltage of diode

- During the positive half-cycle the i/p signal, the anode of the diode becomes more positive with respect to the cathode and hence diode D conducts. For an ideal diode the forward voltage drop is zero. so the whole input voltage will appear across the load. Resistance R_L.

- During the -ve half-cycle of the i/p sig, the anode of the diode becomes negative with respect to the cathode and hence diode D does not conduct. For an ideal diode the impedance offered by the diode is infinity. so the whole i/p voltage appears across diode D. Hence the voltage drop across R_L is zero.

Ripple Factor :- The ratio of rms value of ac component to the dc component in the o/p is known as ripple factor (r)

$$r = \frac{\text{RMS value of ac component}}{\text{dc value of component}} = \frac{V_{r,rms}}{V_{dc}}$$

here $V_{r,rms} = \sqrt{V_{rms}^2 - V_{dc}^2}$

$$r = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1}$$

$$V_{dc} = \frac{1}{2\pi}\left[\int_0^{\pi} V_m \sin\omega t \, d(\omega t) + \int_{\pi}^{2\pi} 0 \, . \, d\omega t)\right]$$

$$= \frac{V_m}{2\pi}\left[-\cos\omega t\right]_0^{\pi} = \frac{V_m}{\pi}$$

$$I_{dc} = \frac{V_{dc}}{R_L} = \frac{V_m}{R_L \cdot \pi} = \frac{I_m}{\pi}$$

∴ if the values of diode f/b resistance (r_f) and the transformer secondary winding resistance r_s are also taken into account then

$$V_{dc} = \frac{V_m}{\pi} - I_{dc}(r_s + r_f)$$

$$V_{RMS} = \sqrt{\frac{1}{2\pi}\int_0^{\pi} V_m^2 \sin^2\omega t \, d\omega t}$$

$$= V_m \sqrt{\frac{1}{2\pi}\int_0^{\pi}(1 - \cos 2\omega t) \, d\omega t)}$$

$$= V_m \cdot \frac{1}{4\pi}\sqrt{\int_0^{\pi}(1 - \cos 2\omega t) \, d\omega t} = \frac{V_m}{2}$$

$$\therefore r = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1} = \sqrt{\left(\frac{V_m/2}{V_m/\pi}\right)^2 - 1} = \sqrt{\left(\frac{\pi}{2}\right)^2 - 1} = \underline{\underline{1.21}}$$

Efficiency (η):- The ratio of dc output power to ac i/p power is known as rectifier efficiency (η).

$$\eta = \frac{P_{dc}}{P_{ac}} = \frac{\text{dc o/p power}}{\text{ac i/p power}}$$

$$= \frac{\frac{V_{dc}^2}{R_L}}{\frac{V_{rms}^2}{R_L}} = \frac{V_{dc}^2}{V_{rms}^2} = \frac{\left(\frac{V_m}{\pi}\right)^2}{\left(\frac{V_m}{2}\right)^2} = \frac{4}{\pi^2} = 40.6\%$$

Peak inverse voltage:- It is defined as the maximum reverse voltage that a diode can withstand destroying the junction. The peak inverse voltage across a diode is the peak of the negative half cycle. For half-wave rectifier PIV is V_m.

Transformer utilisation factor:- In the design of any power supply, the rating of the transformer should be determined.

$$TUF = \frac{\text{dc power delivered to the load}}{\text{AC rating of the transformer secondary}} = \frac{P_{dc}}{P_{ac\ rated}}$$

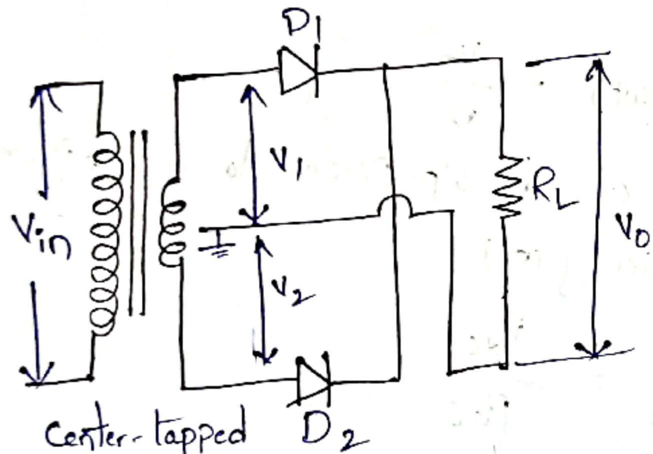
(0.287)
TUF value

Form Factor:- Form factor = $\frac{\text{rms value}}{\text{avg value}} = \frac{V_m/2}{V_m/\pi} = \frac{\pi}{2} = 1.57$

Peak factor:- Peak factor = $\frac{\text{Peak value}}{\text{rms value}} = \frac{V_m}{V_m/2} = 2$

* Full-wave Rectifier :-

- It converts an AC voltage into a pulsating dc voltage using both half cycles of the applied ac voltage. It uses two diodes of which one conducts during one half-cycle while the other diode conducts during the other half-cycle of the applied ac voltage.
- There are two types of full-wave rectifiers
  - (i) center tapped transformer full wave rectifier.
  - (ii) Bridge rectifier.
- The circuit diagram of Full-wave rectifier and waveforms are as shown in below fig.



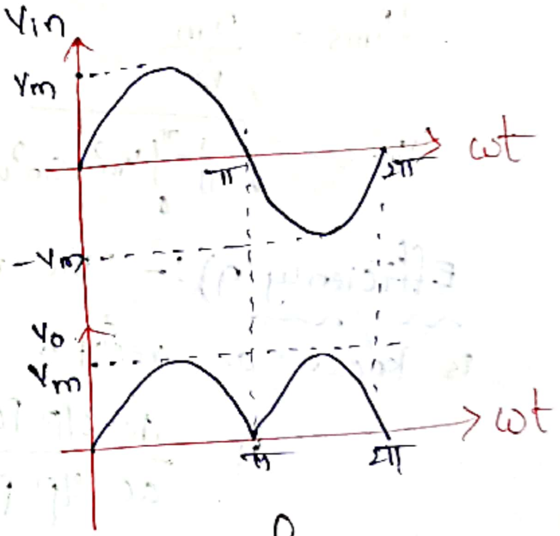


fig (a): Circuit of Full-wave Rectifier (b) waveforms

- During positive half of the i/p sig, anode of diode D_1 becomes positive and at the same time the anode of diode D_2 becomes negative. Hence D_1 conducts and D_2 does not conduct. The load current flows through D_1 and the voltage drop across R_L will be equal to the i/p voltage.
- During the negative half-cycle of the i/p, the anode of D_1 becomes negative and the anode of D_2 becomes positive. Hence D_1 does not conduct and D_2 conducts. The load current flows through D_2 and the voltage drop across R_L will be equal to the i/p voltage.

Ripple factor:- $r = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1}$

$$r = \sqrt{\frac{(V_m/\sqrt{2})^2}{2V_m/\pi} - 1} = \sqrt{\frac{\pi^2}{8} - 1} = \underline{0.482}$$

$$V_{dc} = \frac{1}{\pi}\int_0^{\pi} V_m \sin\omega t \, d\omega t)$$

$$= \frac{V_m}{\pi}[-\cos\omega t]_0^{\pi} = \frac{2V_m}{\pi}$$

$$I_{dc} = \frac{V_{dc}}{R_L} = \frac{2V_m}{\pi R_L} = \frac{2I_m}{\pi}$$

$$I_{rms} = \frac{I_m}{\sqrt{2}}$$

$$V_{rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi} V_m^2 \sin^2\omega t \, d(\omega t)} = \frac{V_m}{\sqrt{2}}$$

Efficiency (η):- The ratio of dc o/p power to ac i/p power is known as rectifier efficiency (η)

$$\eta = \frac{\text{dc o/p Power}}{\text{ac i/p Power}} = \frac{P_{dc}}{P_{ac}}$$

$$\eta = \frac{(V_{dc})^2/R_L}{(V_{rms})^2/R_L} = \frac{(2V_m/\pi)^2}{(V_m/\sqrt{2})^2} = \frac{8}{\pi^2} = 0.812 = \underline{81.2\%}$$

Transformer utilisation factor (TUF):- The average TUF in a full-wave rectifying circuit is determined by considering the primary and secondary winding separately and it gives a value of 0.693.

Form Factor:- $\text{form factor} = \frac{\text{rms value of the o/p voltage}}{\text{avg value of the o/p voltage}}$

$$= \frac{V_m/\sqrt{2}}{2V_m/\pi} = \frac{\pi}{2\sqrt{2}} = \underline{1.11}$$

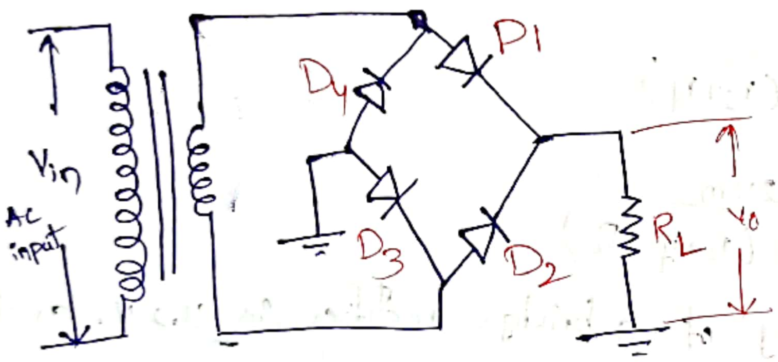
Peak factor :-

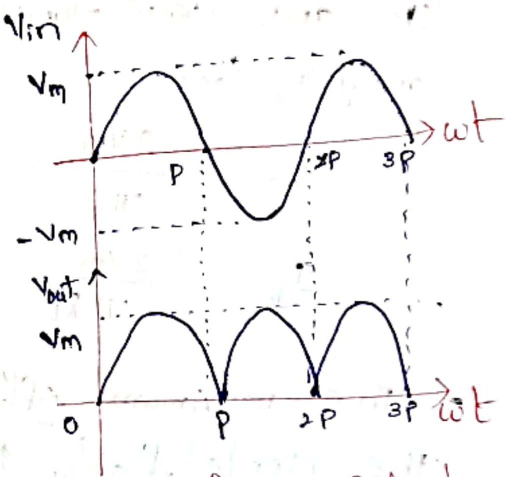
$$\text{Peak factor} = \frac{\text{Peak value of the o/p voltage}}{\text{rms value of o/p voltage}} = \frac{V_m}{V_m/\sqrt{2}} = \sqrt{2}$$

Peak Inverse voltage : it is $2V_m$ because the entire secondary voltage appears across the non-conducting diode.

* Bridge Rectifier :-

- The need for a center tapped transformer in a full-wave rectifier is eliminated in the bridge rectifier. As shown in fig(a) the bridge rectifier has four diodes connected to form a bridge.





fig(a): Circuit diagram of Bridge Rectifier

(b) waveforms of bridge rectifier

- The ac input voltage is applied to diagonally opposite ends of the bridge. The load resistance is connected between the other two ends of the bridge.
- For the positive half-cycle of the i/p ac voltage, diodes D_1 and D_3 conduct, where as diodes D_2 and D_4 do not conduct. The conducting diode will be in series through the load resistance R_L. So the load current flows through R_L.
- During the negative half-cycle of the i/p ac voltage, diodes D_2 and D_4 conduct, where as diode D_1 and D_3 do not conduct. The conducting diode D_2 and D_4 will be in series through the load R_L and the current flows through R_L in the same direction as in the previous

half-cycle. Thus a bidirectional wave is converted into a unidirectional one.

- The average values of o/p voltage and load current for bridge rectifier are the same as for a center-tapped fullwave rectifier.

$$V_{dc} = \frac{2V_m}{\pi}$$

$$I_{dc} = \frac{V_{dc}}{R_L} = \frac{2V_m}{\pi R_L} = \frac{2I_m}{\pi}$$

- If the value of the transformer secondary winding resistance (r_s) and diode forward resistance (r_f) are considered in the analysis, they

$$V_{dc} = \frac{2V_m}{\pi} - I_{dc}(r_s + r_f)$$

$$I_{dc} = \frac{2V_m}{\pi R_L} = \frac{2V_m}{\pi(r_s + r_f + R_L)}$$

- The maximum efficiency of a bridge rectifier is 81.2% and the ripple factor is 0.48. the PIV is V_m.

Particulars	Type of rectifier		
	Half-wave	Full-wave	Bridge
1. No. of diodes	1	2	4
2. Max. efficiency	40.6%	81.2%	81.2%
3. V_{dc} (no load)	V_m/π	$2V_m/\pi$	$2V_m/\pi$
4. Avg current/diode	I_{dc}	$I_{dc}/2$	$I_{dc}/2$
5. Ripple factor	1.21	0.48	0.48
6. Peak Inverse voltage	V_m	$2V_m$	V_m
7. o/p frequency	f	$2f$	$2f$
8. TUF	0.287	0.693	0.812
9. Form Factor	1.57	1.11	1.11
10. Peak factor	2	$\sqrt{2}$	$\sqrt{2}$

* Filters :-

- The output of a rectifier contains dc component as well as ac component. Filters are used to minimise the undesirable ac i.e., ripple leaving only the dc component to appear at the o/p.
- Fig(a) shows the concept of a filter, where the full wave rectified ~~only~~ o/p voltage is applied at its i/p. The o/p of a filter is not exactly a constant dc level. But it also contains a small amount of ac component.

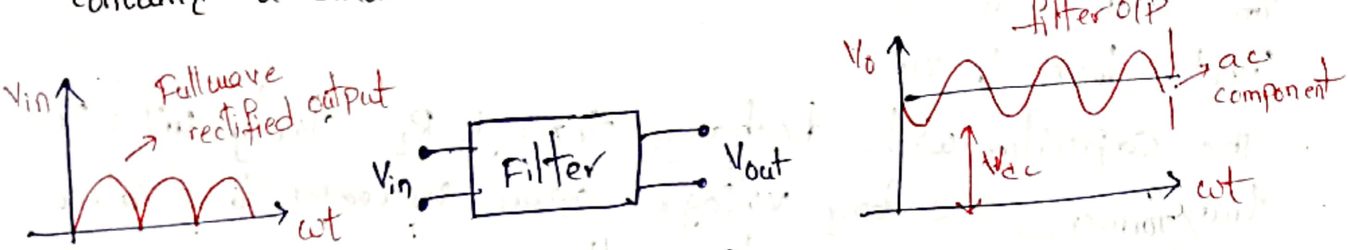


fig:- concept of filter

The types of filters are

(a) Inductor filter
(b) capacitor filter
(c) LC or L-section filter
(d) CLC or π-type filter.

* Capacitor filter :- (You have only basics)

An inexpensive filter for light loads is found in the capacitor filter which is connected directly across the load as shown in fig.

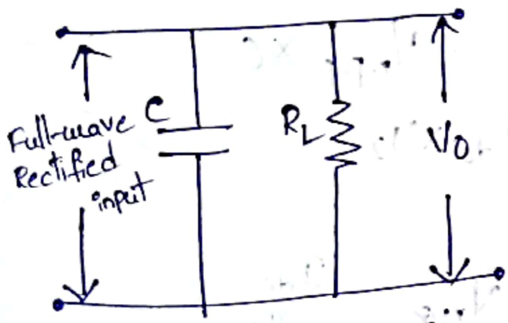
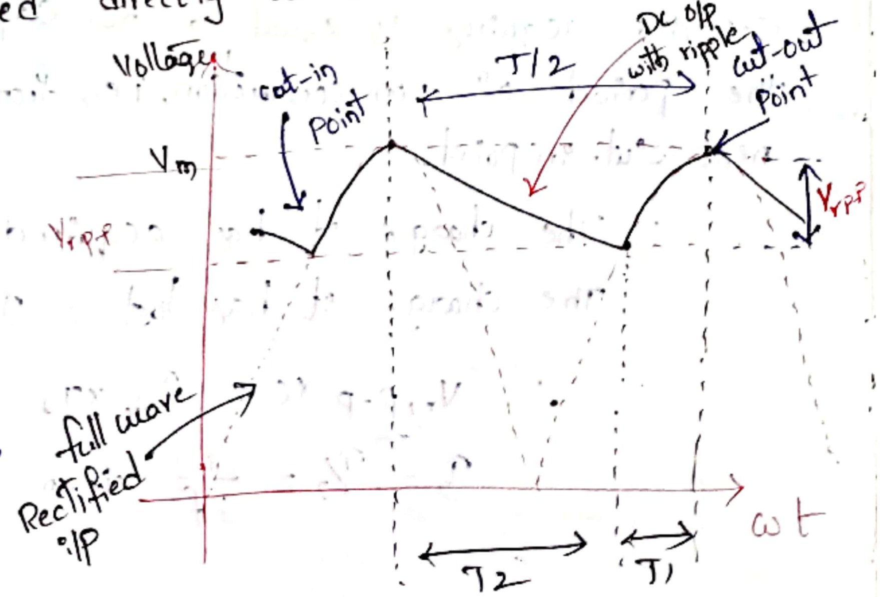


fig:- capacitor filter



(b) Ripple voltage triangular waveform

Scanned with OKEN Scanner

- The property of a capacitor is that it allows ac component and blocks the dc component.
- The operation of a capacitor filter is to short the ripple to ground but leave the dc to appear at the O/P when it is connected across a pulsating dc voltage.
- During the positive half-cycle, the capacitor charges up to the peak value of the transformer secondary voltage, V_m and will try to maintain this values as the full-wave input drops to zero.
- The capacitor will discharge through R_L slowly until the transformer secondary voltage again increases to a value greater than the capacitor voltage.
- To diode conducts for a period which depends on the capacitor voltage. The diode will conduct when the transformer secondary voltage becomes more than the cut-in voltage of the diode. The diode stops conducting when the transformer voltage becomes less than the diode voltage. This is called cut-off voltage.
- From the cut-in point to cut-out point, what ever charge the capacitor acquires is equal to the capacitor has lost during the period of non-conduction, i.e., from cut-out point to the next cut-in point.

$\therefore$ The charge it has acquired $= V_{r,p\text{-}p} \times C$

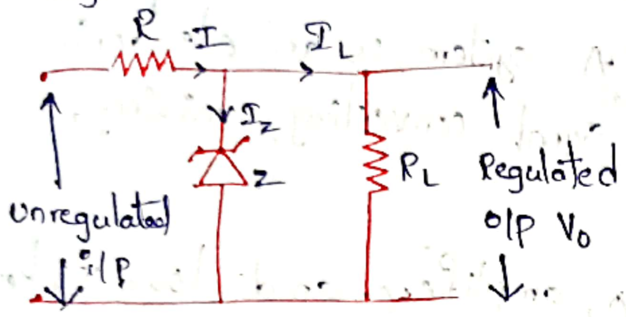
The charge it has lost $= I_{dc} \times T_2$

$$\therefore V_{r,p\text{-}p} \times C = I_{dc} \times T_2$$

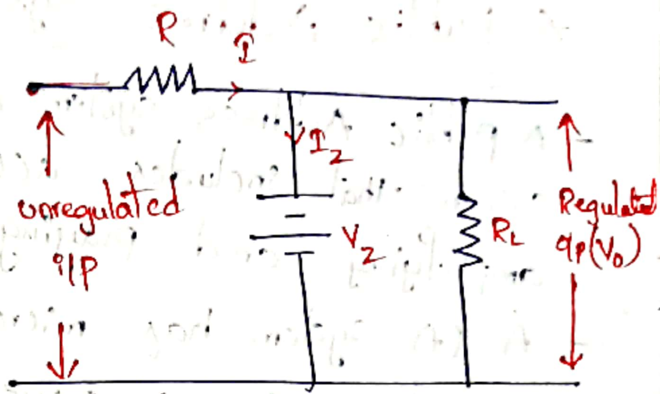
$$T_2 = T/2 = \frac{1}{2f} \quad \text{then} \quad V_{rpp} = \frac{I_{dc}}{2fC}$$

* Zener Diode voltage Regulator :-

- When the i/p of a zener diode is greater than the zener voltage, works in breakdown region, provided it is connected in the reverse bias. This principle is used in the regulator circuit.
- The zener regulator along with its equivalent circuit is shown in fig.



(a) Equivalent circuit



(b) Zener Regulator

- Suppose the i/p voltage increases since the zener is in the breakdown region, the zener diode is equivalent to a battery V_Z as shown in fig.
- It is clear that o/p voltage remain constant at V_Z.
- The excess voltage is dropped across the series resistance R.
- This will cause an increase in the value of total current I.
- The zener will conduct the increase of current in I while load current remain constant.
- Hence the o/p voltage V_0 remains constant irrespective of the changes in the i/p voltage V_i.
- Now suppose that i/p voltage is constant but the load resistance R_L decreases. This will cause an increase in load current.
- The extra current can not come from the source because in drop in R.
- The additional load current will come from a decrease in zener current I_C.
- Consequently the o/p voltage V_0 remains essentially constant equal to V_Z, even ~~through~~ though the i/p voltage V_i and load resistance R_L may vary over a wide range.

Limitations of zener regulator :-

- It has low efficiency for heavy load currents.
- o/p voltage slightly changes due to zener impedance as $V_0 = V_z + I_z V_z$.

* Public Address System :-

- A public Address system or PA system is an electronic system that includes acoustic (sound) signal converting, mixing, amplifying and playing.
- A PA system has microphones, amplifiers and loudspeakers as its main components or equipment.
- The intensity of the sound decreases with the distance. Also, a particular sound can be affected or distorted by the other sound if the level or volume of the sound is the same.
- The PA system provide the amplification of the sound for comfortable listening.
- The PA system helps to amplify as well as record the voice of any human being or the sound of any musical instrument. Also it helps to communicate between a group.
- The block diagram of PA system is as shown in below fig.

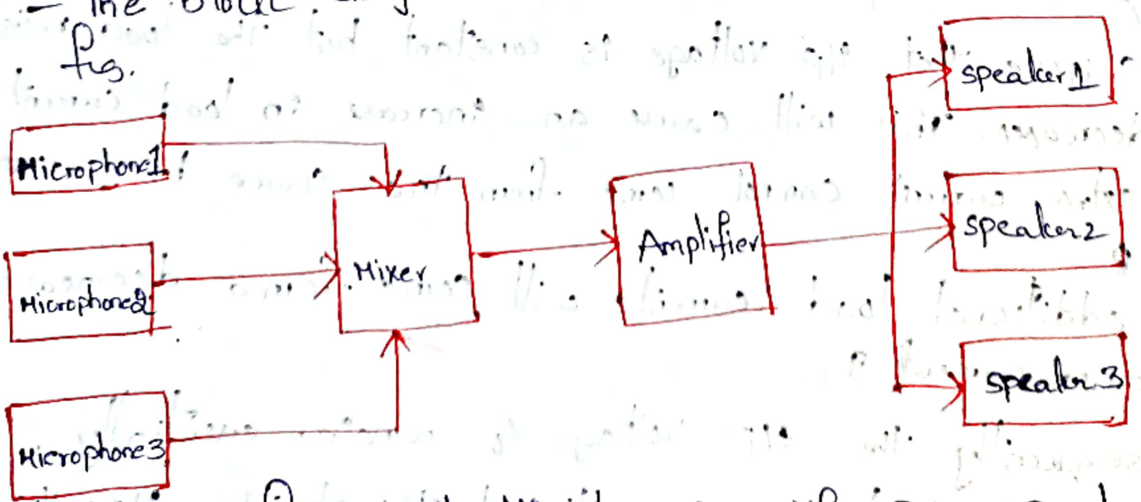


fig:- Block diagram of PA System.

- There are so many devices or components are used in PA system that depends upon their applications and other factors. The main components of any public address system is as following.

1. Microphone
2. Mixer
3. Amplifier
4. speaker

1. Microphone :- The microphone is a transducer that converts acoustic energy or sound energy into electrical energy. It continuously generates the pulsating electrical voltage according to the frequency of the sound energy applied to it.

- The basic two types of microphones are

1. Handheld microphone
2. Lapel Microphone

other different types of microphones are

1. Wired microphone
2. wireless microphone.

- A wired microphone can be connected by a wire to the mixer or amplifier. It is very simple.
- But wireless microphone needs a battery and the frequency of its signal is also a very important factor. The wireless microphones cannot be connected directly to the mixer or amplifier.

2. Mixer :- Multiple audio sources or multiple microphones used in a the PA system then a mixer is must required. The mixer is an electronic device that can control multiple sound sources simultaneously. It can mix all the sound sources together and play with a single loudspeaker with the help of an amplifier.

3. Amplifier:- The main function of the amplifier is to amplify or increase the volume level of the audio signal that can drive a loudspeaker. The requirement or size of the amplifier depends upon the number and size of the loudspeaker.

4. Loud speaker:- Loudspeaker play a very important role in the PA System. It converts electrical energy into acoustic energy or sound energy. The loudspeakers are generally connected to the amplifier and it generates sound according to the audio signal provided by the amplifier.

- There are different types of loudspeakers are available according to their operating frequency.

(16-250 Hz) 1. Woofer:- it operates at the lowest frequency audio signal such as Bass (low sound voice)

2. Sub woofer:- it also operates with low frequency but more than woofer such as bass and deep vocals.

3. Squawker:- it operates with medium frequency audio sigs such as vocals (~~human voice~~ sound)

4. Tweeter:- it operates with high-frequency audio sigs such as tone.

* Common Emitter Amplifier (RC Coupled Amplifier):-

- The resistance - capacitance coupling is in short termed as RC coupling. This is the mostly used coupling technique in amplifier.
- The two stage amplifier circuit has two transistors, connected in CE configuration and a common power supply V_{cc} is used.
- The potential divider network R_1 and R_2 and the resistor R_e form the biasing and stabilization network.
- The emitter by pass capacitor C_e offers a low reactance path to the sig. The resistor R_L is used as a load impedance.
- The input capacitor C_{in} present at the initial stage of the amplifier couples AC sig to the base of the transistor.
- The capacitor C_c is the coupling capacitor that connects two stages and prevents DC interference between the stages and controls the shift of operating point.
- The circuit diagram of RC coupled Amplifier is as shown in fig.

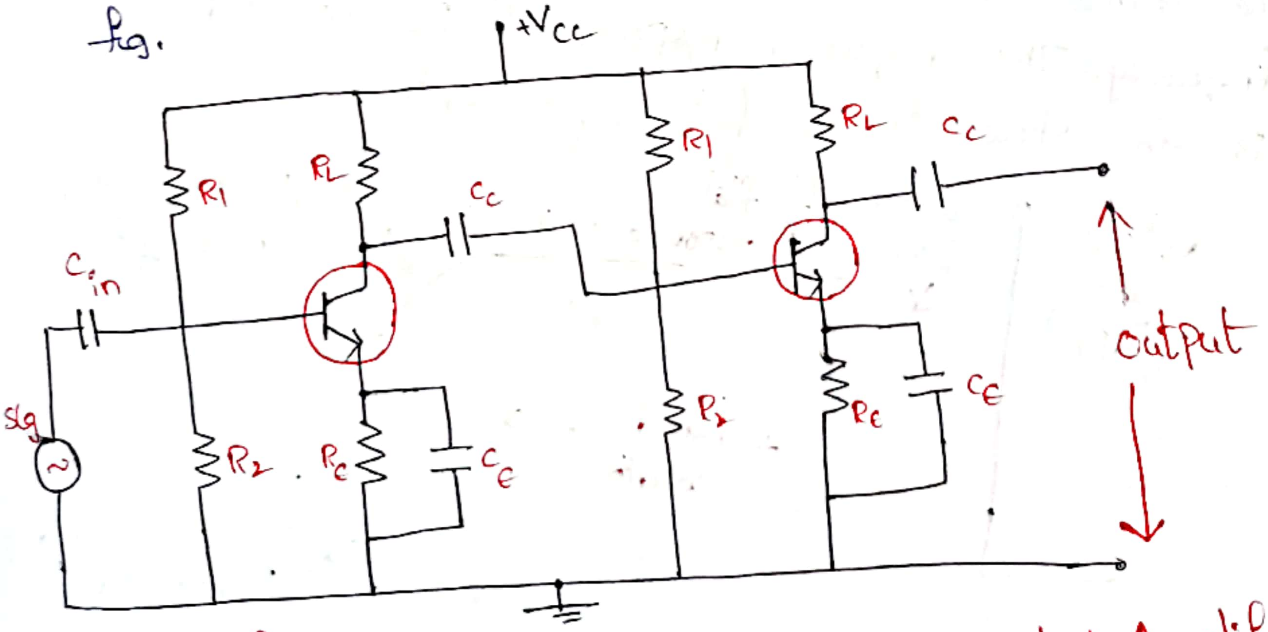


fig: Circuit diagram of RC coupled Amplifier

- When an AC i/p signal is applied to the base of first transistor, it gets amplified and appears at the collector load R_L which is then passed through the coupling capacitor C_c to the next stage. This becomes the i/p of the next stage, whose amplified o/p again appears across its collector load. Thus the sig is amplified in stage by stage action.
- The total gain is less than the product of the gains of individual stages.
- Because when a second stage is made to follow the first stage, the effective load resistance of the first stage is reduce due to the second stage.
- The o/p phase is same as i/p. Because the phase reversal is done two times by the two stage CE configured amplifier circuit.

→ Frequency Response of RC coupled Amplifier :-

Frequency response curve is a graph that indicates the relationship between voltage gain and function of frequency. The frequency response of RC coupled amplifier is as shown in the following graph.

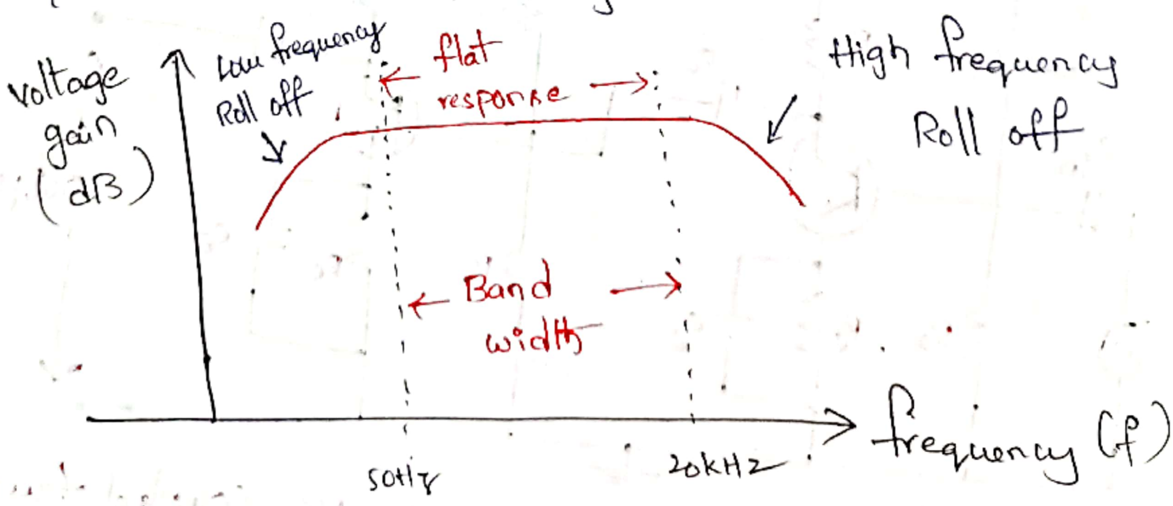


fig:- frequency Response of RC coupled Amp.

- The frequency rolls off or decreases for the frequencies below 50 Hz and for the frequencies above 20kHz, The voltage gain for the range of frequencies between 50Hz and 20kHz is constant.

$$X_C = \frac{1}{2\pi f c}$$

It means that the capacitive reactance is inversely proportional to the frequency.

→ At low frequencies, the reactance is quite high. The rectance of input capacitor C_{in} and the coupling capacitor C_c are so high that only small part of the i/p sig is allowed. The reactance of the emitter by pass capacitor C_e is also very high during low frequencies.

→ At high frequencies capacitive reactance is low. So a capacitor behaves as a short circuit. As a result of this, the loading effect of the next stage increases, which reduces the voltage gain.

→ At Mid-frequencies (50 Hz to 20kHz) the voltage gain of the capacitor is maintained constant in this range. if the frequency increases, the reactance of the capacitor C_c decreases, which tends to the increase the gain.

Advantages of RC coupled Amplifier :-

- provides constant gain over a wide frequency range.
- suitable for audio ~~app~~ applications
- Simple circuit and low cost.
- it becomes more compact with the upgrading technology.

Disadvantages :-

- The voltage and power gain are low because of the effective load resistance.
- They become noisy with age.
- Due to poor impedance matching, power transfer will be low.

Applications :-

- They have excellent audio fidelity over a wide range of frequency.
- used as voltage amplifiers.
- Due to poor impedance matching, RC coupling is rarely used in the final stages.

* Electronic Instrumentation System :-

- Electronic Instrumentation is about the design, realisation and use of electronic systems for the measurement of electrical and non-electrical quantities.
- The block diagram of electronic Instrumentation system is as shown below.

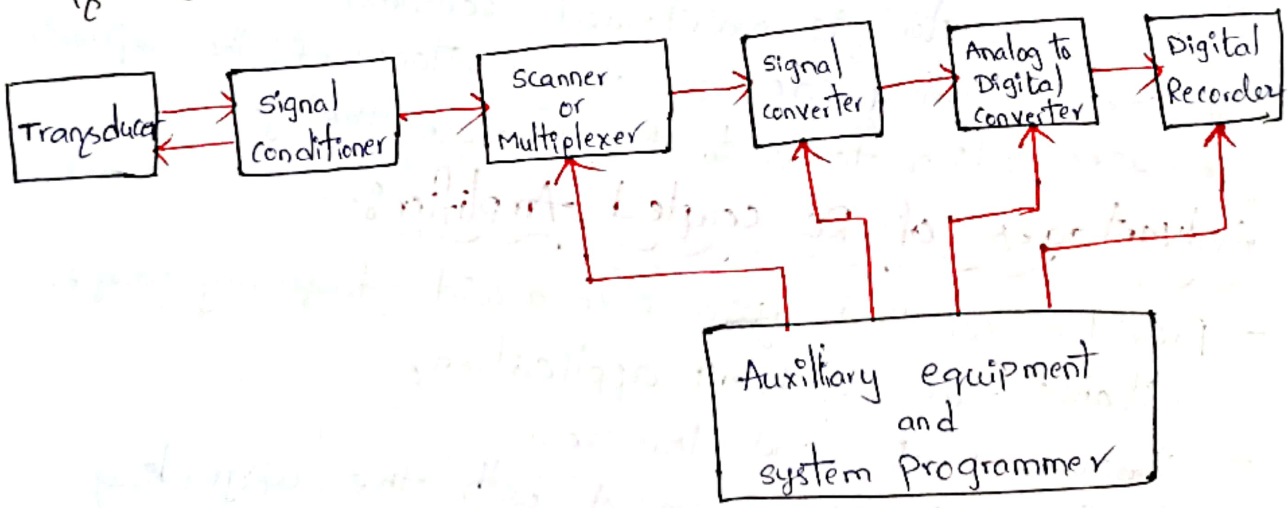


fig:- Block diagram of electronic Instrumentation system.

Transducer :- Transducer is a device that converts variations in a physical quantity, such as pressure or brightness, into an electrical signal or vice versa. All the physical input parameters such as temperature, pressure, displacement, velocity, acceleration, pressure or brightness etc will be converted into its proportionate electrical sig.

Signal conditioner :- This working of this unit is exactly the same as that of a sig processing unit in an analog instrumentation system. It includes all the balancing ckts and calibrating elements along with it.

Scanner (or) Multiplexer :- It accepts multiple analog inputs and sequentially connects them to an analog to digital convertor.

Signal converter :- A signal converter is a device that converts signals from sensors to industrial current, normalizes signals, analog to digitals.

Analog to Digital converter :- The ADC converts analog signals to digital signals.

Digital Recorder :- A digital recorder is an electronic device that records video in a digital format to a disk drive, USB flash drive, SD memory card, SSD or other local or networked mass storage device.

Auxilliary equipment and system programmer :- this includes instruments for system programming functions and digital data processing. ~~The~~ Typical auxiliary functions include linearising and limit comparison. All these functions may be performed by individual instruments or by a digital computer.

– The system programmer installs, ~~cons~~ customizes and maintains the operating system and also installs or upgrades products that run on the system.

— x —