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EST 130 - BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING

Module-5 - Basic Electronic Circuits and Instrumentation

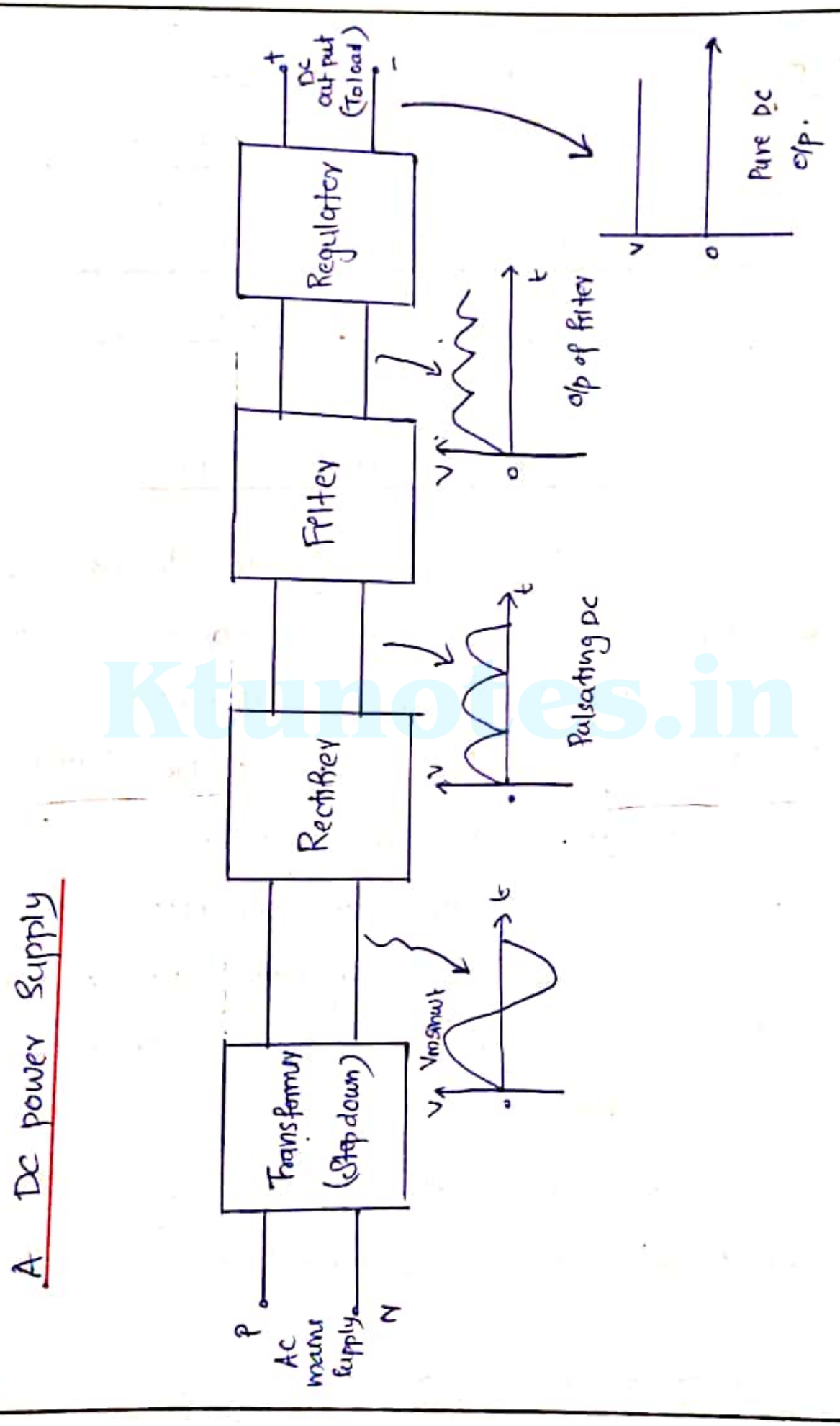
* Block diagram of a D.C power supply

↳ Today almost every electronic device needs a DC supply for its smooth operation and they need to be operated within certain power supply limits. This required DC voltage or DC supply is derived from Sigle phase ac mains.

↳ A regulated power supply can convert unregulated AC to a constant DC. A regulated power supply is used to ensure that the output remains constant even if the input changes.

↳ Figure below shows the block diagram of a typical regulated DC power supply.

A Dc power supply



* Step down transformer :

A step down transformer will step down the voltage from the ac mains to the required voltage level. The turn's ratio of the transformer is so adjusted such as to obtain the required voltage level.

* Rectification

Rectifier is an electronic circuit consisting of diodes which carries out the rectification process. Rectifcation is the process of converting an alternating voltage or current in to corresponding direct (DC) quantity.

* DC filtration

The rectified voltage from the rectifier is a pulsating DC voltage having very high ripple content Different types of filters are used such as capacitor filter, LC filter, π type filter etc.

* ## Voltage Regulator:

It maintains a constant output DC voltage irrespective of the variation in load current at the output or variation in ac mains input. Different types of regulators are available such as Zener voltage regulator, transistor series regulator, fixed and variable IC regulators (IC's like 7805).

* ## Rectifier

↳ Rectifiers are electronic ckt which converts input ac signal in to pulsating DC

↳ Fan, heater, bulbs, airconditioner etc are runs with the help of ac signal. But there are some devices which cannot be run with the help of ac signal such as mobile phones toys, ~~etc~~ walk-man, mini emergency light torch light etc. These equipments can be run with the help of dc supply.

↳ As ac signals is generally available to run the equipments (electronic equipments), ac is converted to dc

* Different types of rectifiers used are,

↳ Half wave rectifier (HWR)

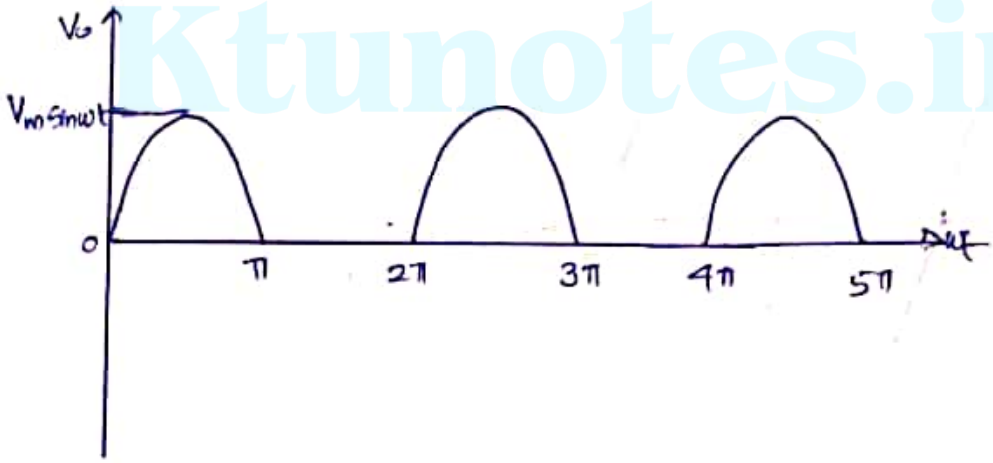
↳ Full wave rectifier (FWR)

Full wave rectifier

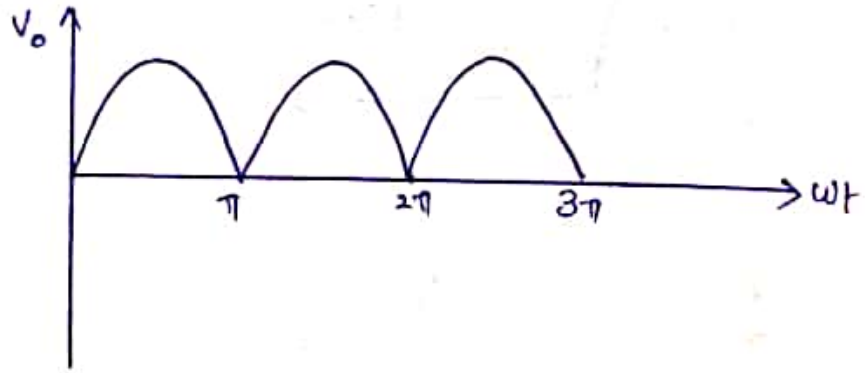
↳ Centre tap full wave rectifier

↳ Full wave bridge type rectifier

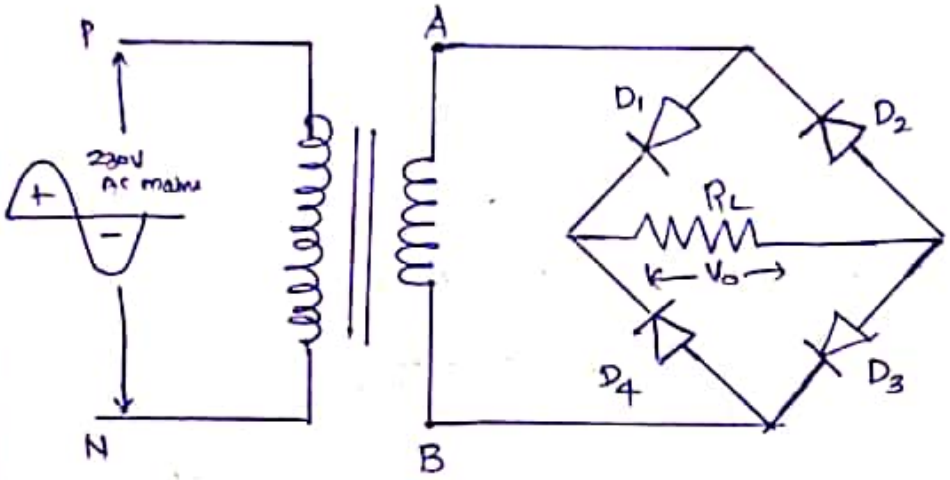
o/p of half wave rectifier



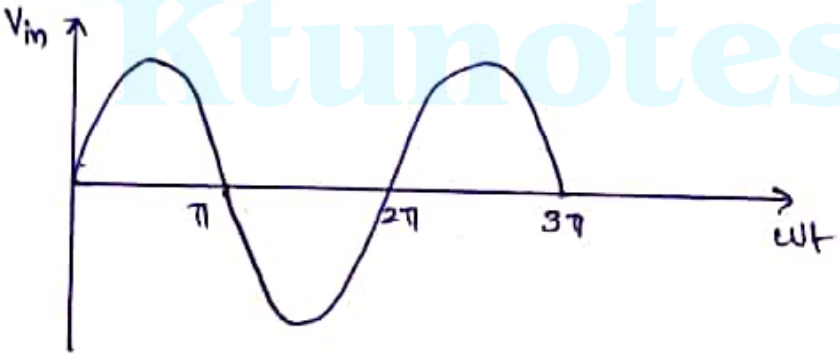
o/p of full wave rectifier

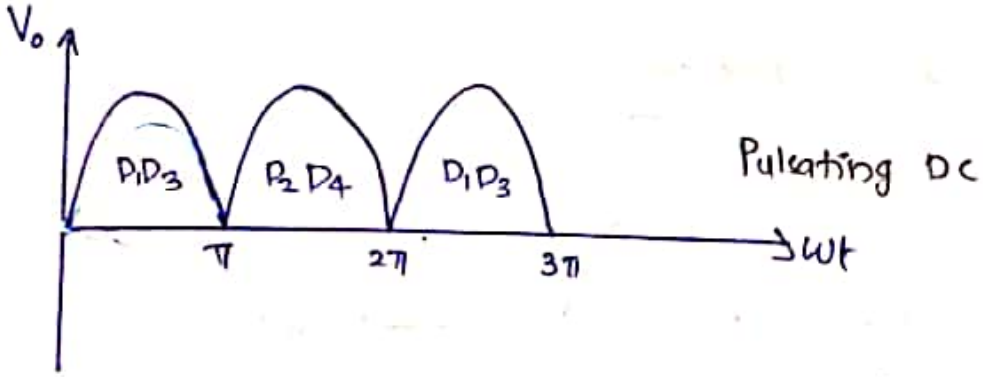


* Bridge type Full wave Rectifier



Waveforms





$$V_{avg} = \frac{2V_m}{\pi} = 0.636\, V_m.$$

Construction

↳ It consist of 4 diodes that D_1, D_2, D_3 and D_4 which are connected to form a bridge.

↳ The ac supply to be rectified is supplied to the diagonally opposite ends of the bridge through the transformer

↳ Between other two ends of the bridge, the load resistor R_L is connected.

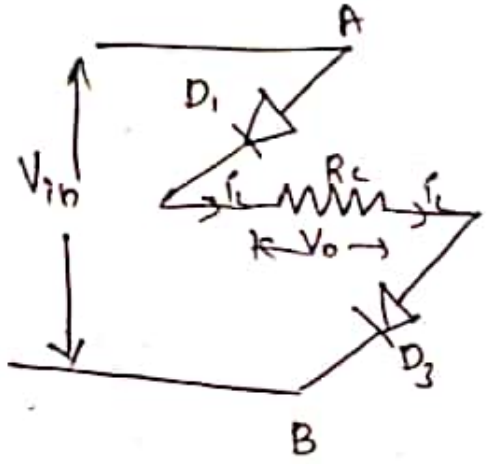
Working:

↳ **During the +ve half cycle of ac:**

↳ During the +ve half cycle of secondary voltage, the end 'A' of the secondary winding becomes +ve w.r.t. other end 'B'.

↳ Now the diodes D_1 and D_3 are forward biased and hence the conventional current flow through the circuit across the R_L.

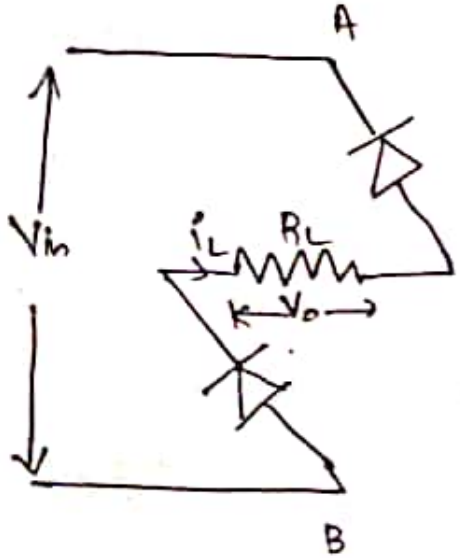
As a result the o/p voltage will be obtained across R_L.



During negative half cycle of ac:

↳ During negative half cycle of secondary voltage, the end A becomes -ve w.r.t the other end 'B'.

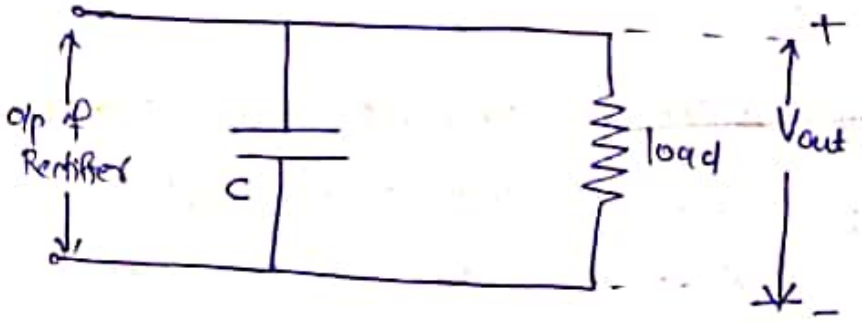
↳ Now the diodes D_2 and D_4 conduct current due to forward biasing. Hence the o/p voltage will be obtained across R_L.

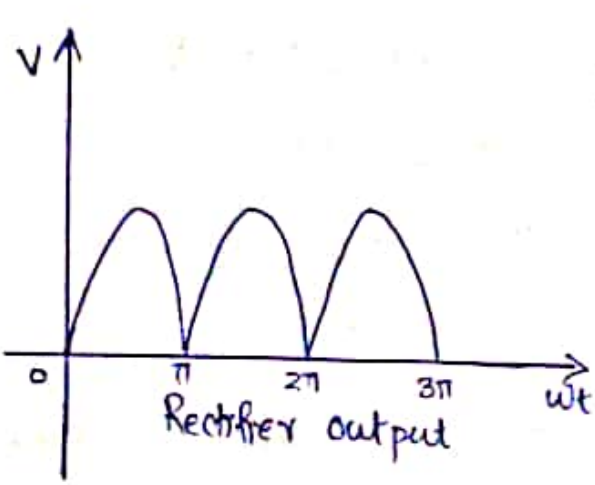


Capacitor Filter

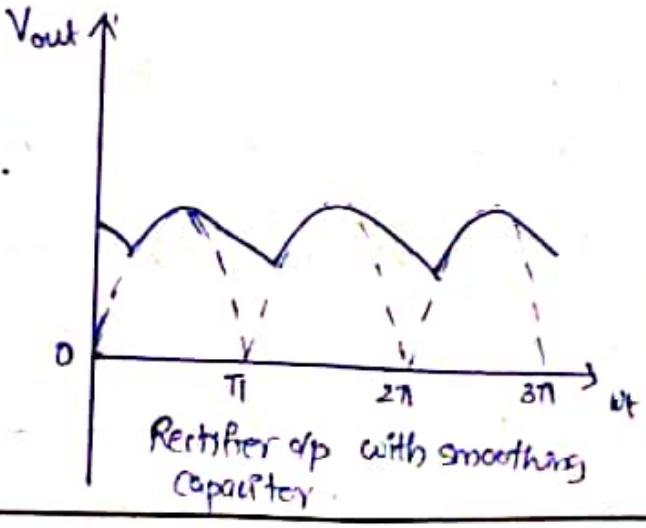
↳ Out put of a rectifier circuit is a pulsating DC. In electronics applications use of dc voltage with ripple content impacts its performance (reduces performance). Therefore in most applications we require ripple free pure DC output voltage.

↳ Ripple content from the dc voltage is reduced by connecting an electrolytic capacitor in parallel with load as shown below.





Rectifier output



Rectifier o/p with smoothing capacitor

* ## Zener Voltage Regulator

↳ Zener Diodes can be used to produce a stabilised voltage output with low ripple under varying load current conditions.

↳ Zener diode behaves just like a normal general purpose diode consisting of a silicon PN junction and when biased in the forward direction, that is Anode positive with respect to it's cathode. It behaves just like a normal signal diode passing the rated current.

↳ However, unlike a conventional diode that blocks any flow of current through itself when reverse biased, that is the cathode becomes more positive than the Anode, as soon as the reverse voltage reaches a pre-determined value, the zener diode begins to conduct in the reverse direction.

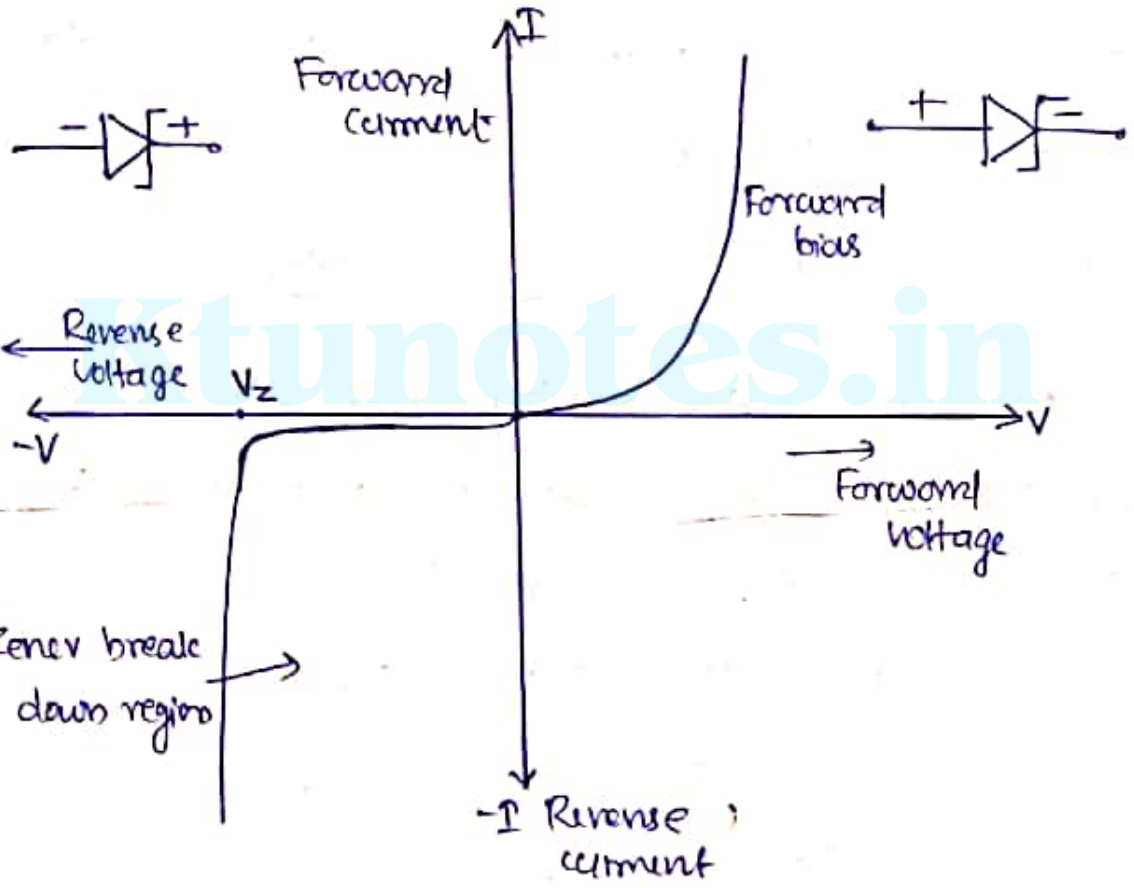
↳ This is happened when the voltage is above the break down voltage or zener voltage.

↳ A reverse biased zener diode exhibits controlled break down and the potential drop across the diode

remains constant regardless of the magnitude of the current flowing through it without damage.

Symbol of zener diode

Zener Diode I-V characteristics.



↳ From the I-V characteristics curve above, we can see that the zener diode has a region in it's reverse bias characteristics of almost a constant negative voltage regardless of the value of the current

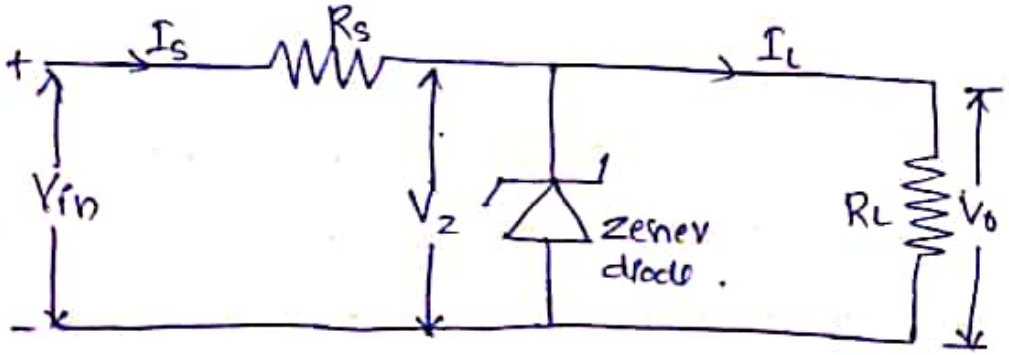
flowing through the diode.

↳ This voltage remains almost constant even with large changes in current provided the zener diodes current remains between the breakdown current and its maximum current rating.

↳ This ability of the zener diode to control itself can be used to regulate or stabilise a voltage sourc against supply or load variations.

* Zener diod as a voltage regulator.

↳ Because of the ability of a Zener diode to maintain a constant potential drop across it (during reverse breakdown) they are extensively used to produce a regulated voltage out put. Zener voltage stabilizer ckt is shown below.



↳ Resistor R_s, is connected in series with the zener diode to limit the current flow through the diode with the voltage source V_s being connected.

↳ The stabilised output voltage V_{out} is taken from across the zener diode.

↳ The zener diode is connected with its cathode terminal connected to the positive rail of the DC supply so it is reverse biased and will be operating in its breakdown condition.

↳ Resistor R_s is selected so to limit the maximum current flowing in the ckt.

↳ The load is connected in parallel with the zener diode, so the voltage across R_L is always the same as the zener voltage. ($V_R = V_z$)

↳ Due to steep zener diode characteristics during zener breakdown, the voltage V_z does not change there by the output voltage $V_o = V_z$ remains same irrespective of variation in load current (I_L) or input voltage (V_{in}).

* Block diagram of Public Address System

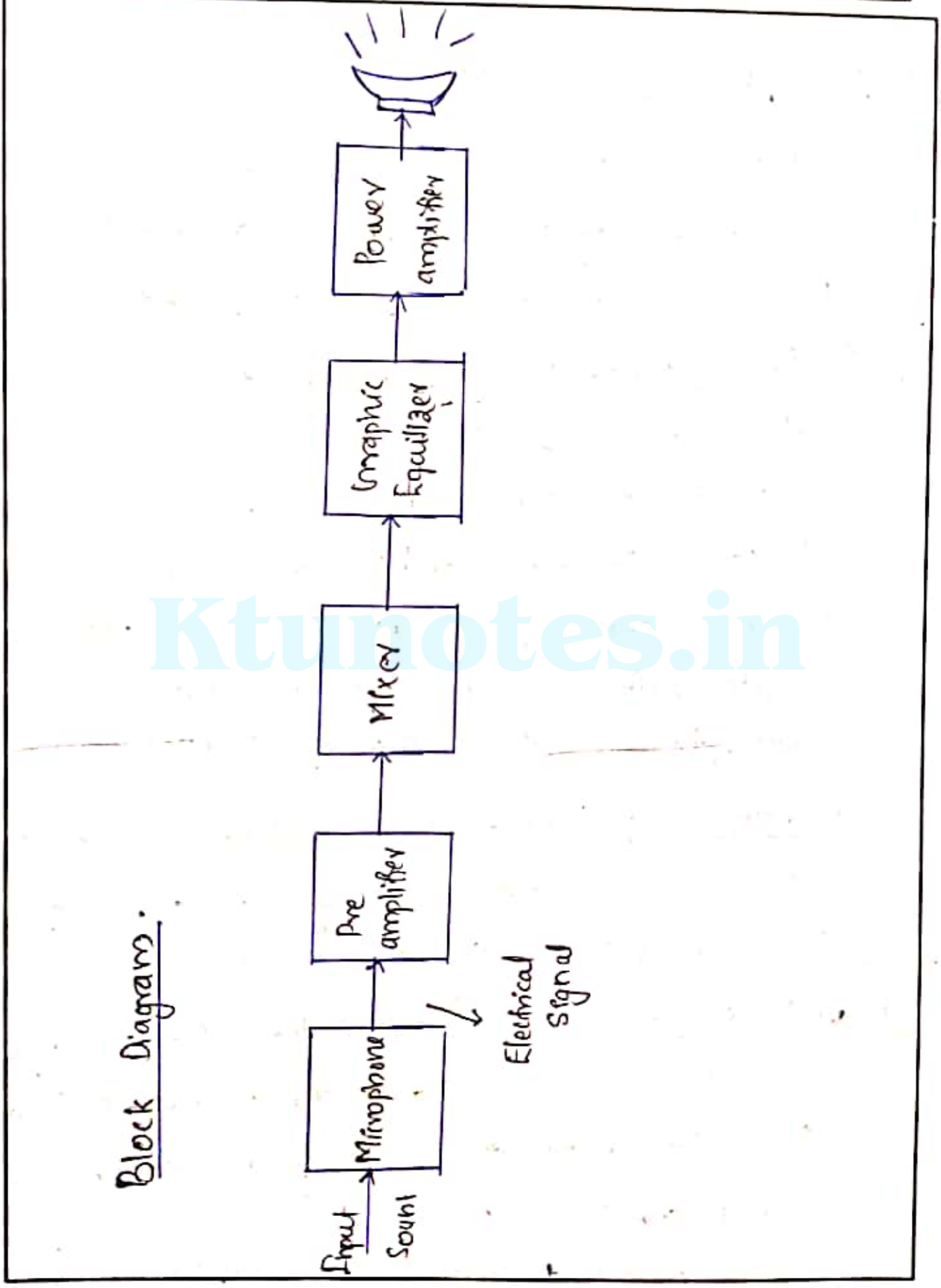
↳ When a large gathering of people is to be addressed, the sound must be amplified so that people away from the stage can listen to it comfortably. This type of system is called public address system.

↳ It increases the loudness of a human voice, musical instrument or recorded music etc.

* Requirements of public address system

1. It must avoid the acoustic feedback
2. Distribute the sound intensity uniformly
3. Reduce reverberations
4. It must use proper speaker orientation
5. Select proper microphones and loud speaker
6. It should create a sense of direction
7. Loud speaker impedances should be matched properly.

Block Diagram.



* Different components are

(i) Microphone :- It is a transducer which converts sound to an equivalent electrical signal. Generally two or three microphones can be connected.

(ii) Preamplifier :- Purpose of preamplifier is to increase the amplitude of signal coming from microphone enabling for further processing.

(iii) Mixer :- The output of the microphone is fed to the mixer stage. The mixer stage is used to isolate different channels from each other before they are fed to the amplifier.

(iv) Graphic Equalizer :- It is used to adjust the balance between different frequency components within an electrical signal.

(v) Power amplifier :- Power of the electrical signal is boosted by power amplifier so that, it becomes strong enough to drive the loud speaker.

(vi) Loud speaker :- It convert the electrical signal back in to a sound signal. The output

Sound should be ~~under~~ amplified version of the original input sound.

* Working of an R-C coupled amplifier

↳ Amplification is a process of increasing the signal strength by increasing the amplitude of a given signal without changing its characteristics

↳ An RC coupled amplifier is a part of a multistage amplifier wherein different stages of amplifiers are connected using a combination of resistor and a capacitor.

↳ Common emitter configuration of an NPN transistor under proper biasing conditions will works as an amplifier. It will have high voltage gain and current gain.

↳ The input signal may be a current signal, voltage signal or a power signal.

↳ Amplifiers are mainly used in audio and video instruments communications, controllers etc.

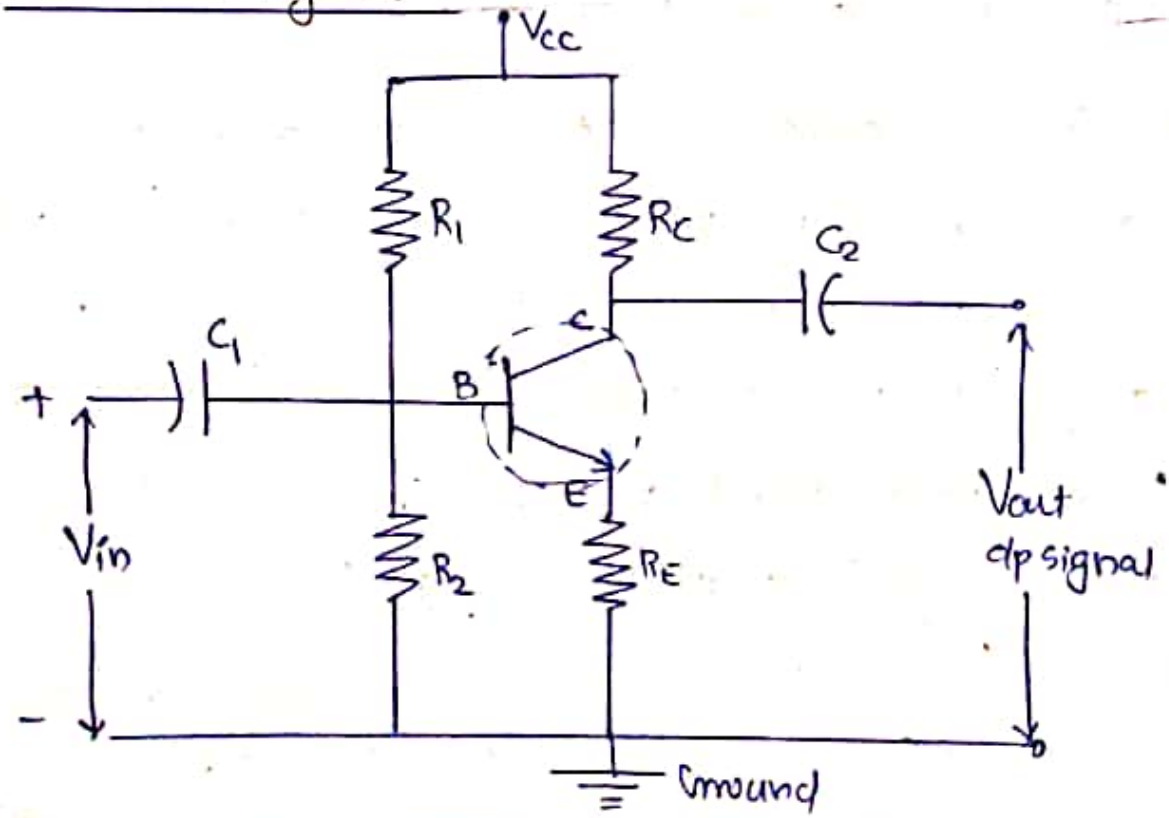
Common Emitter configuration of a transistor can be made to operate in active region by proper biasing

ie. → Emitter base junction must be forward biased.

→ Collector base junction must be reverse biased.

↳ Biasing can be obtained in many ways. Commonly used biasing is voltage divider biasing by resistors R_1 and R_2 and are given to emitter base and collector base junctions.

* Circuit Diagram.



↳ A single stage common Emitter RC coupled amplifier is a simple and elementary amplifier circuit.

↳ The capacitor C in at the input acts as a filter which is used to block the DC voltage and allow only AC voltage to the transistor.

↳ R_1 and R_2 resistors are used for providing proper biasing to the bipolar transistor. R_1 and R_2 forms a biasing network which provides necessary base voltage to drive the transistor in active region.

↳ The region b/w cut off and saturation region is known as active region. The region where the bipolar transistor operation is completely switched off is known as cut-off region and the region where the transistor is completely switched on is known as saturation region.

↳ Resistors R_C and R_E are used to drop voltage of V_{CC}. R_C → collector resistor

R_E → Emitter resistor

↳ R_C and R_E are selected in such a way that both should drop V_{cc} voltage by 50%. in the above circuit

↳ The emitter capacitor C_E and emitter resistor R_E makes a negative feedback for making the circuits operation more stable.

Advantages of R-C coupled Amplifier.

↳ The RC coupled amplifier offers a constant gain over a wide frequency range

↳ The circuits is very compact and extremely light.

↳ It used the resistor and the capacitor which are not expensive so the cost is low.

Disadvantages

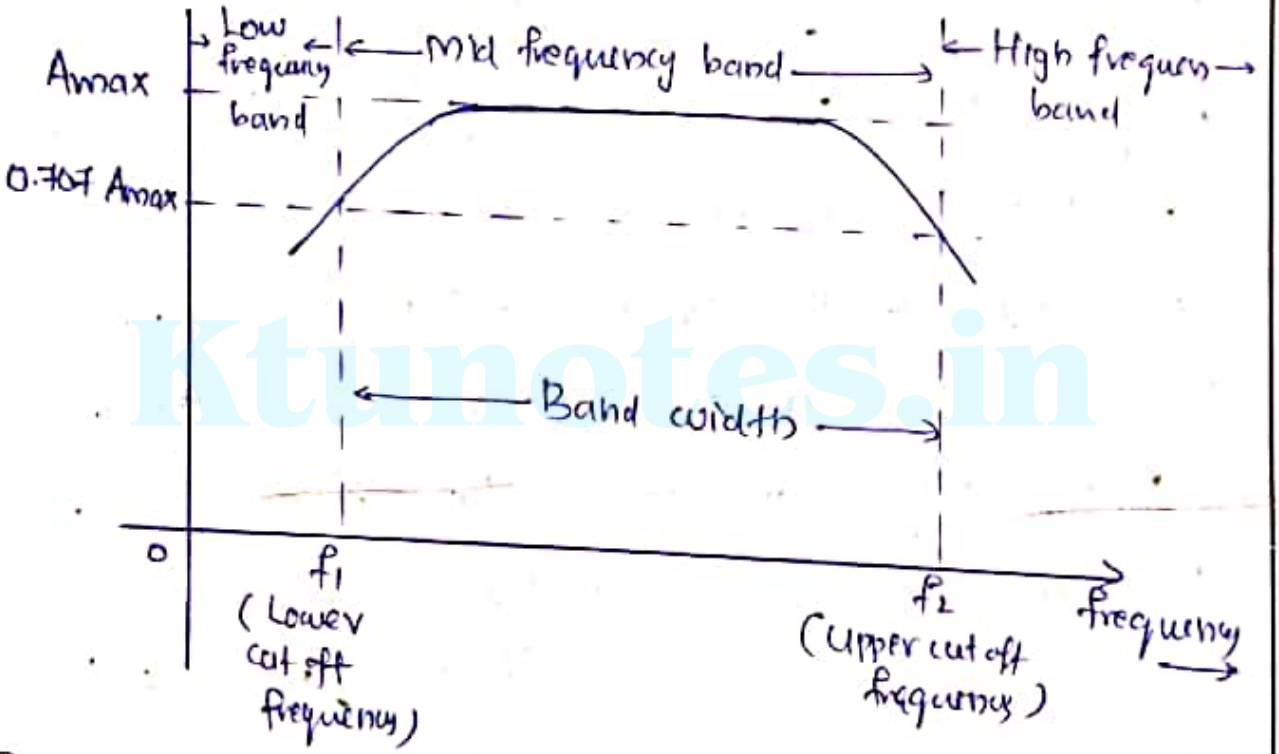
↳ The voltage and power gain are low because of the effective load resistance.

↳ They become noisy with age.

↳ Due to poor impedance matching, power transfer will be low.

* Frequency response of an RC coupled amplifier.

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



↳ From the graph, it is understood that the frequency rolls off or decreases for the frequencies below 50 Hz and for the frequencies above 20kHz. ~~while~~ where as the voltage gain for the range of frequencies between 50 Hz and 20kHz is constant

We know that,

$$X_c = \frac{1}{2\pi f_c}$$

* At low frequencies (i.e below 50 Hz)

↳ The capacitive reactance is inversly proportional to the frequency. At low frequencies, the reactance is quite high. The reactance of input capacitor C_{in} and the coupling capacitor C_c are so high that only small part of the input signal is allowed.

↳ The reactance of the emitter by pass capacitor C_E is also very high during low frequencies.

↳ Hence it cannot shunt the emitter resistance effectively. With all these factors, the voltage gain rolls off at low frequencies.

* At high frequencies (i.e. above 20 Hz)

Again considering the same point, we know that the capacitive reactance is low at high frequencies. So, a capacitor behaves as a short ckt, at high frequencies. As a result of this, the

loading effect of the next stage increases which reduces the voltage gain. A

↳ Along with this, as the capacitance of emitter diode decreases, it increases the base current of the transistor due to which the current gain (β) reduces. Hence the voltage gain rolls off at high frequencies.

* At mid frequencies (ie, 50 Hz to 20KHz)

↳ The voltage gain of the capacitors is maintained constant in this range of frequencies. If the frequency increases, the reactance of the capacitor C_c decreases which tends to increase the gain.

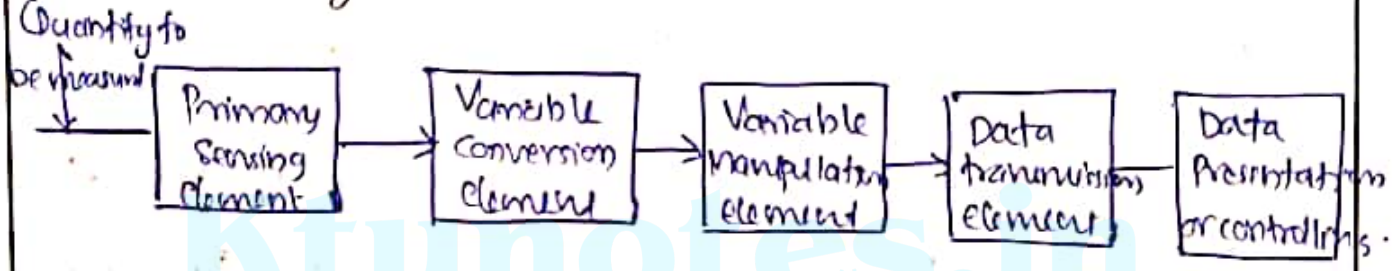
↳ But this lower capacitance reactive increases the loading effect of the next stage by which there is a reduction in gain.

↳ Due to these two factors, the gain is maintained constant.

* Block Diagram of Electronic Instrumentation System

↳ It is a collection of instruments to measure, monitor and control a process.

↳ It needs a sensing element, variable conversion (or) manipulation element, data transmission and data presentation system.



(i) Primary Sensing element

The primary sensing element also known as Sensor. Basically transducers are used as a primary sensing element. Here, the physical quantity are sensed and then converted in to analogues signal.

(ii) Variable conversion element

It converts the out put of primary sensing element in to suitable form without changing information. Basically these are secondary transducers.

(iii) Variable manipulation element

The output of transducer may be electrical signal ie, voltage, current or other electrical parameter. Here, manipulation means change in numerical value of signal. This element is used to convert the signal in to suitable range.

(iv) Data transmission element.

Some times it is not possible to give direct read out of the quality at a perticular place. In such a case, the data should transfer from one place to another place through channel which is known as data transmission element. Typically transmission path are pneumatic pipe, electrical cable and radio links.

(v) Data presentation or controlling element

Finally the output is recorded or given to the controller to perform action. It performs different functions like indicating, recording or controlling.