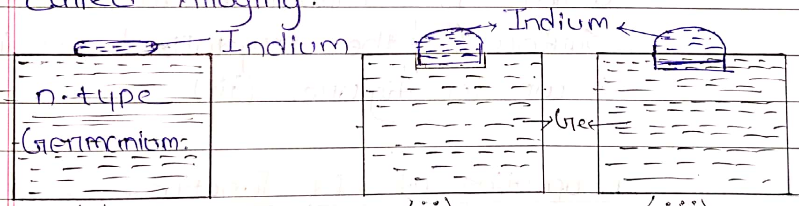
CHAPTER-1

P-N JUNCTION DIODE

- When a p-type semiconductor is suitably joined to n-type semiconductor, the contact surface is called p-n Junction

Formation of PN Junction:

- In actual practice, the characteristics properties of PN Junction will not be apparent if a p type block is just brought in contact with n-type block.
- It is fabricated by special and common techniques of making PN Junction is called Alloying.



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- In this method, a small block of indium (trivalent impurity) is placed on an n-type germanium slab as shown in fig (i). The system is then heated to a temperature of about 500°C. The indium and some of the germanium melt to form a small puddle of mollen germanium-indium mixture as shown in fig(ii).
- The temperature is then lowered and puddles begins to solidify.

- Under proper conditions. the atoms of indium impurity will be suitably adjusted in the germanium slab to form a single crystal.
- The addition of indium overcomes the excess of electrons in the n-type germanium to such an extent that it creates a p-type region.
- As the process goes on, the remaining molten mixture becomes increasingly rich in indium. When all germanium has been re-deposited, the remaining material appears as indium but-ton which is frozen on to the outer surface of the crystallized portion as shown in figure (iii)

Properties of PN Junction :-

- To explain PN junction, consider two types of materials :-
  1. P-type - Ptype semiconductor having -ve acceptor ions and +ve charged holes.
  2. N-type - Ntype semiconductor having +ve donor ions and -ve free electrons.
- P-type has high concentration of holes and N-type has high concentration of electrons.

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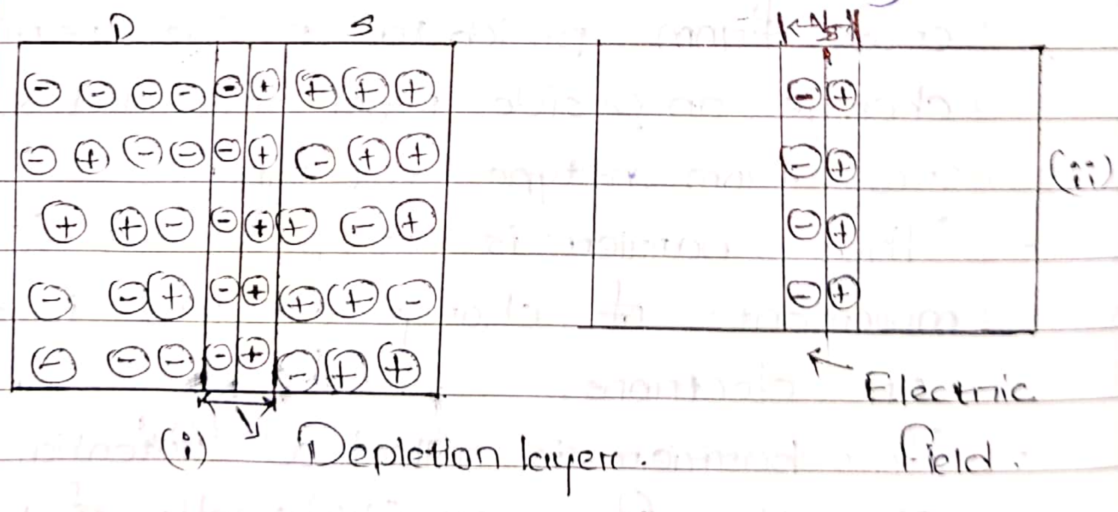
- The tendency for the free electron to diffuse over p-side and holes to n-side process is called Diffusion.
- When free electron move across the junction from n-type to p-type, positive donor ions are removed by the force of electrons. Hence positive charge is built on the n-side of the junction. Similarly negative charge establish on p-side of the junction.

- When sufficient no of donor and acceptor ions gathered at the junction, further diffusion is prevented.

- Since +ve charge on n-side repel holes to cross from p-side to n-side, similarly -ve charge on p-side repel free electrons to cross from n-type to p-type.
- Thus a barrier is set up against further movement of charge carriers is hole or electrons.
- This barrier is called as Potential Barrier/ Junction Barrier (V_0) and is of the order 0.1 to 0.3 volt. This prevents the respective majority carriers for crossing the barrier region. This region is known as Depletion layer.

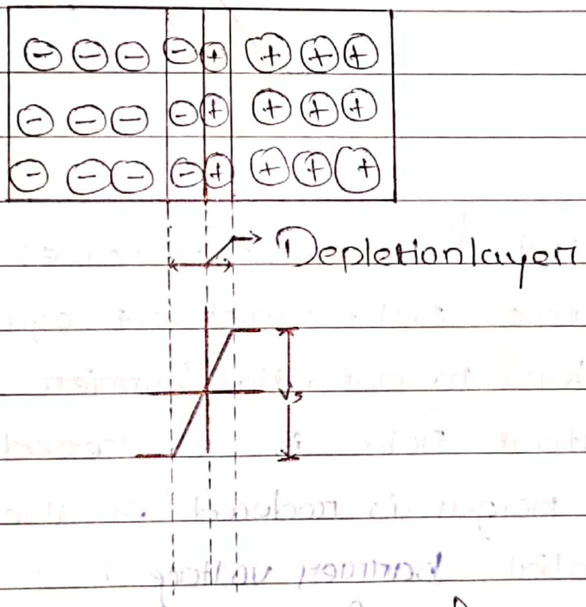
- The term depletion is due to the fact that near the junction, the region is depleted. It may be of charge carriers due to diffusion across the junction. It may be noted that depletion layer is formed very quickly and is very thin compared to the n region and the p-region.
- Once pn junction is formed and depletion layer created, the diffusion of free electrons stops. In other words the depletion region acts as a barrier to the further movement of free electrons across the junction.
- The positive and negative charges set up an electric field as shown in fig below.



- The electric field is a barrier to the free electrons in the n-region.
- There exists a potential difference across the depletion layer and is called barrier potential (V_0). The barrier potential

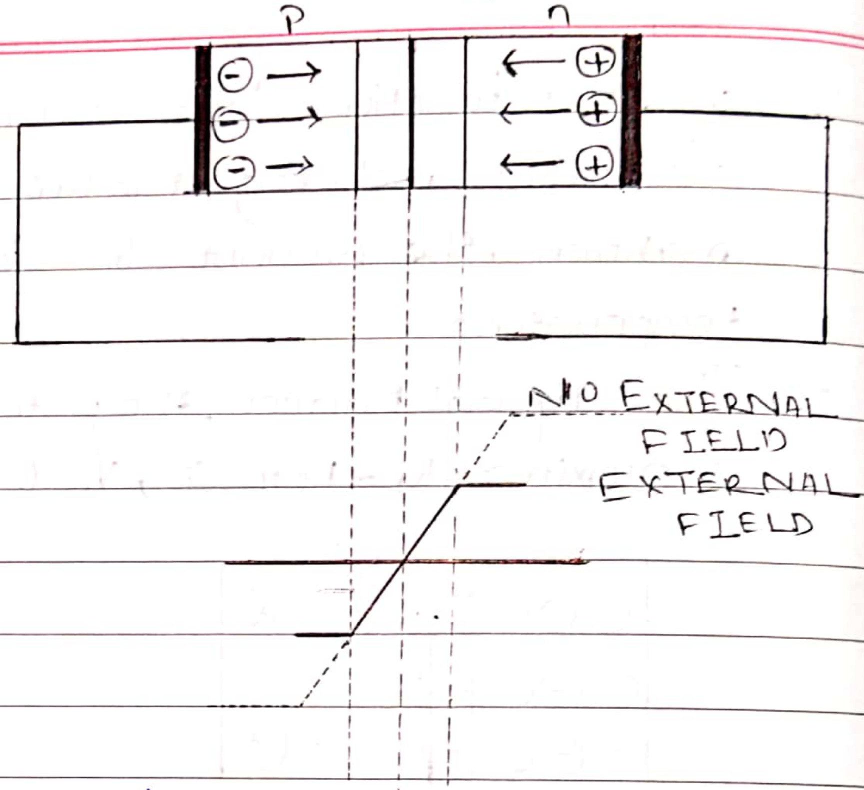
of a p-n junction depends upon several factors including the type of semiconductor material, the amount of doping and temperature.

- The typical barrier, the potential is approximately - For Si, $V_0 - 0.7V$, For Ge, $V_0 = 0.3V$



PN Junction under Forward Biasing

- When external D.C. voltage applied to the junction is in such a direction that it cancels the potential barrier, thus permitting current flow, it is called Forward Biasing.
- To apply forward bias, connect positive terminal of the battery to p-type and negative terminal to n-type as shown in Fig. below:-



- The applied forward potential establishes an electric field which acts against the field due to potential barrier. Therefore the resultant field is weakened and the barrier height is reduced at the junction.
- As potential barrier voltage is very small (0.1 to 0.3 V), therefore, a small forward voltage is sufficient to completely eliminate the barrier.
- Once the potential barrier is eliminated by the forward voltage, junction resistance becomes almost zero and a low resistance path is established for the entire circuit.
- Therefore, current flows in the circuit. This is called Forward Current.
- With forward bias to PN junction, the following points are worth noting:-

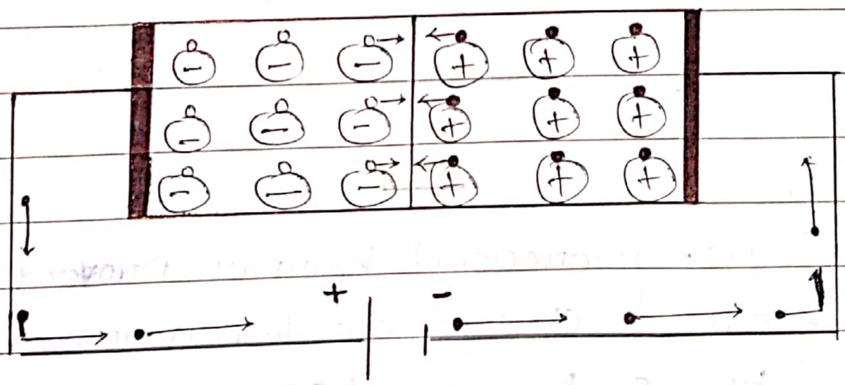
i) The potential barrier is reduced and at same forward voltage, it is eliminated altogether.

ii) The junction offers low resistance to current flow.

iii) Current flows in the circuit due to the establishment of low resistance path. The magnitude of current depends upon the applied forward voltage.

Current Flow in Forward Based PN Junction

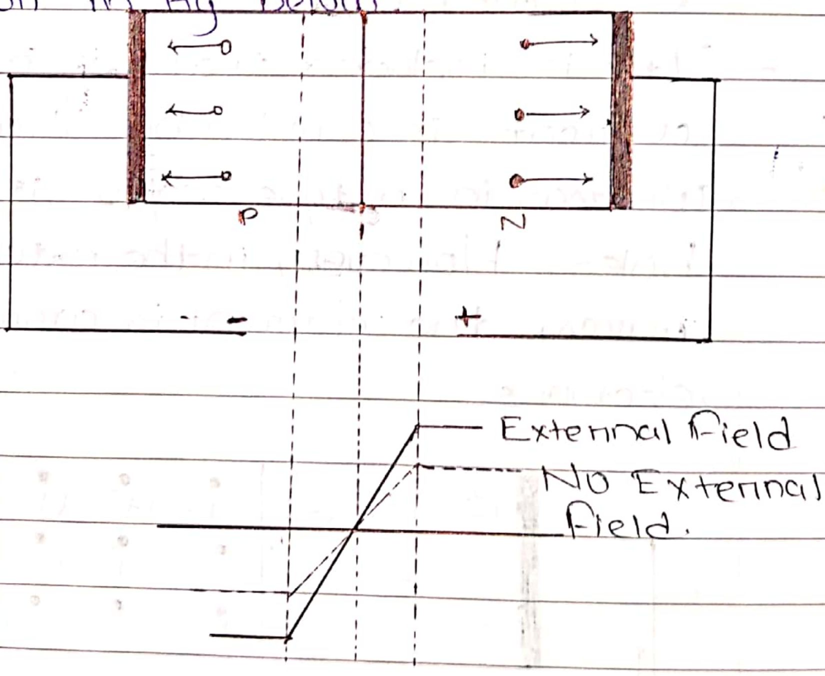
- It is included that in n-type region, current is carried by free electrons whereas in p-type region, it is carried by holes. However, in the external connecting wires, the current is carried by free electrons.



PN Junction under Reverse Biasing

- When the external DC voltage applied to the junction is in such a direction that potential barrier is increased, it is called Reverse Biasing.

- To apply reverse bias, connect negative terminal of the battery to ptype and positive terminal to n-type
- It is clear that applied reverse voltage establishes an electric field which acts in the same direction as the field due to potential barrier.
- Therefore, the resultant field at the junction is strengthened and the barrier height is increased as shown in fig below.



- The increased barrier prevents the flow of charge carriers across the junction
- Thus, a high resistance path is established for the entire circuit and hence the current does not flow.
- With reverse bias to PN junction, the following points are worth noting :-

i) The potential barrier is increased

ii) The junction offers very high resistance to current flow.

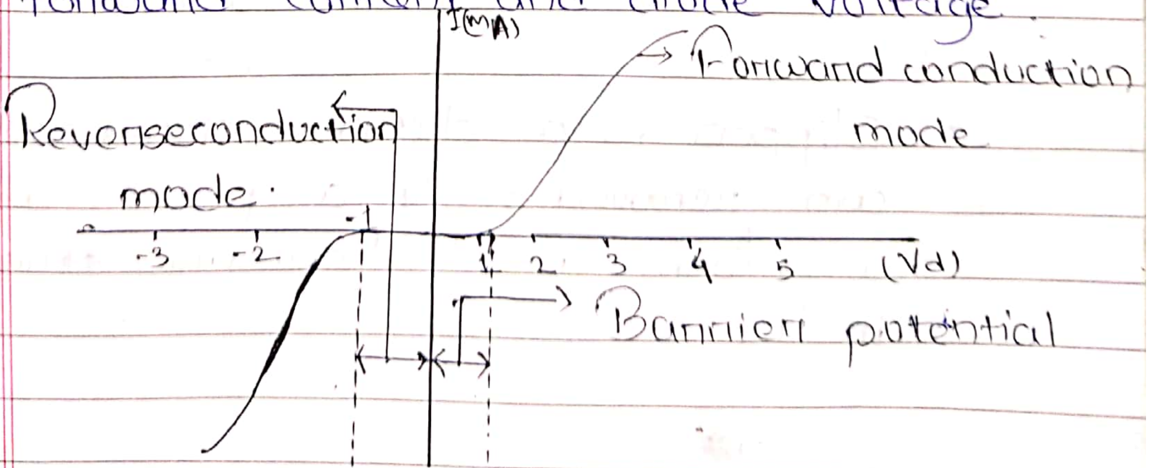
iii) No current flows in the circuit due to establishment of High resistance path.

Ideal diode :-

- The diode behaves its characteristics where as manufacture written the values of voltage current and power is called ideal diodes.
- In forward bias the diodes behaves as a conductor and in reverse Bias the diode behaves as a pure insulators.
- It is practically not applicable for theoritical we have assumed all the values of voltage current and power is constant.

DC load line

The graph is represented between diode forward current and diode voltage.



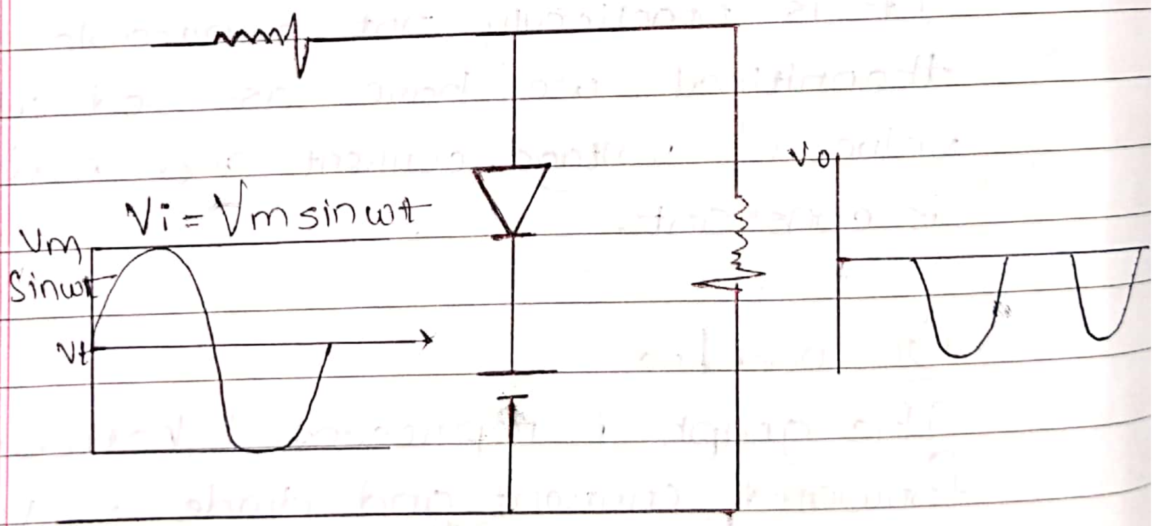
- The graph gives all the characteristics that is forward conduction / Active mode, Barrier potential and Reverse Conduction or active mode of all types of diodes.

Clipper circuit:-

• The clipper ~~type~~ circuit is of two types :-

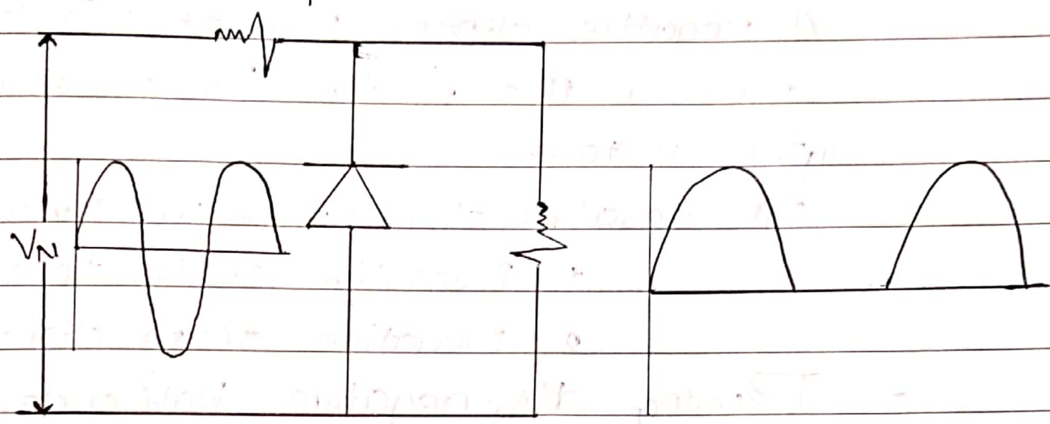
i) Positive type clipper
ii) Negative type clipper

i) Positive type clipper:-



- Clipper is a electronic circuit which can removed safely a portion of the waveform which harmonic strength in it.

ii) Negative type clipper:-



i) Positive clipper:-

- A positive clipper is that which removes the positive half cycles of the input voltage.
- The positive clipper is of two types.
  1. Positive series clipper.
  2. Positive shunt clipper.

- Here the diode is kept in parallel with the load.
- During the positive half cycle, the diode 'D' is forward biased and the diode acts as a closed switch. This causes the diode to conduct heavily.
- This causes the voltage drop across the diode or across the load resistance R_L to be zero. Thus output voltage drop ~~across~~ during the positive half cycles is zero.

ii) Negative Clipper Circuit :

A negative clipper is that which removes the positive half cycles of the input voltage.

The negative clipper is of two types.

1. Negative series clipper.
2. Negative shunt clipper.

- During the negative half cycles, the diode 'D' is forward biased and the diode acts as a closed switch. This caused the diode to conduct heavily.

- This causes the voltage drop across the diode or across the load resistance R_1 to be zero. Thus output voltage during the negative half cycles is zero.

• Biased positive clipper :-

- When a small portion of the positive half cycle is to be removed, it is called a biased positive clipper.
- During negative half cycle, when the input signal voltage is negative, the diode 'D' is reverse-biased. This causes it to act as an open-switch. Thus the entire negative half cycle appears across the output.

- Biased negative clipper:-
- When a small portion of the negative half cycle is to be removed, it is called a biased negative clipper.
- During positive half cycle when the input signal voltage is positive, the diode 'D' is reverse biased. This causes it to act as an open-switch. Thus the entire positive half cycle appears across the load, as illustrated by output waveform.
- During negative half cycle, when the input signal voltage is negative but does not exceed battery the voltage 'V', the diode 'D' remains reverse-biased and most of the input voltage appears across the output

Fig:- Biased positive clipper

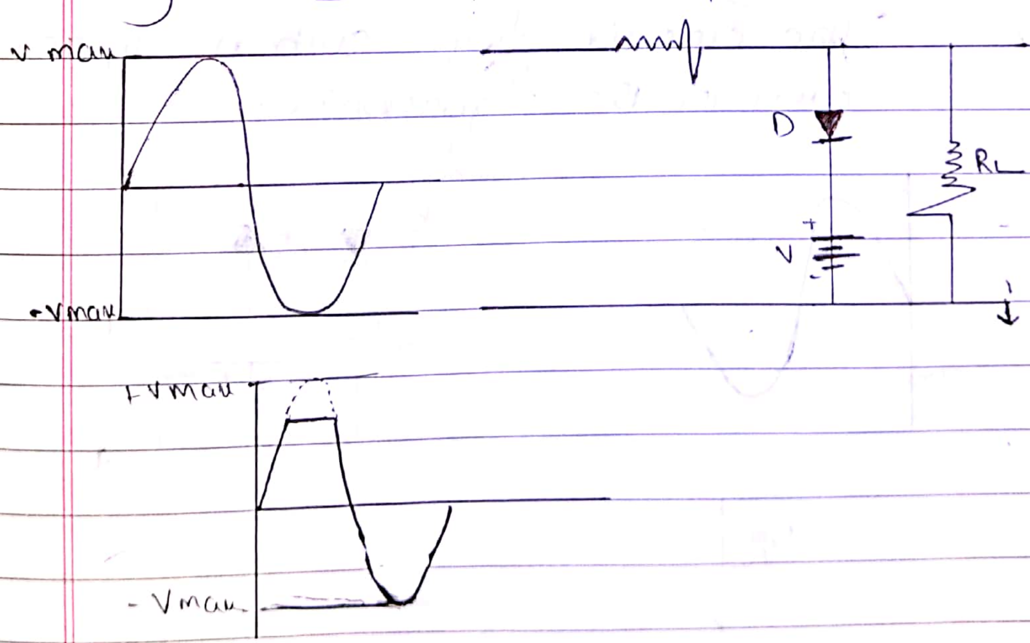
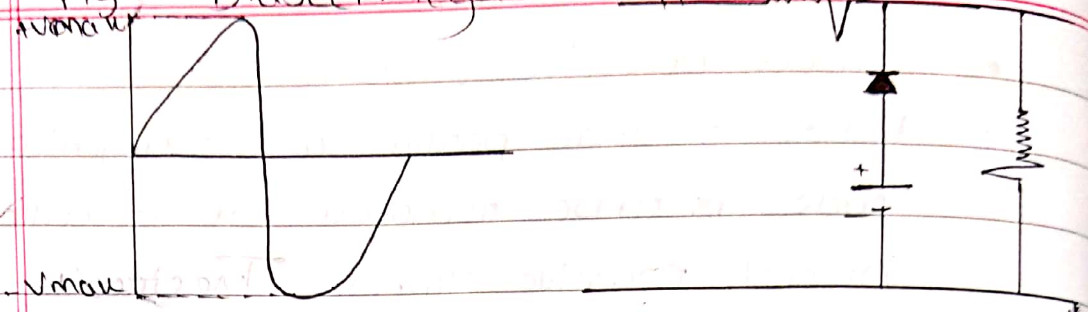
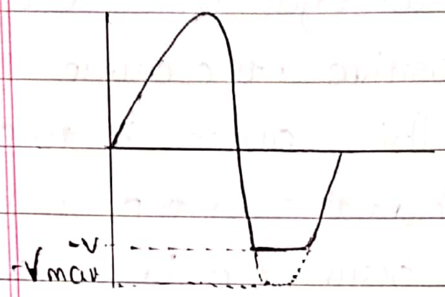


Fig 6 — Biased Negative Clipper

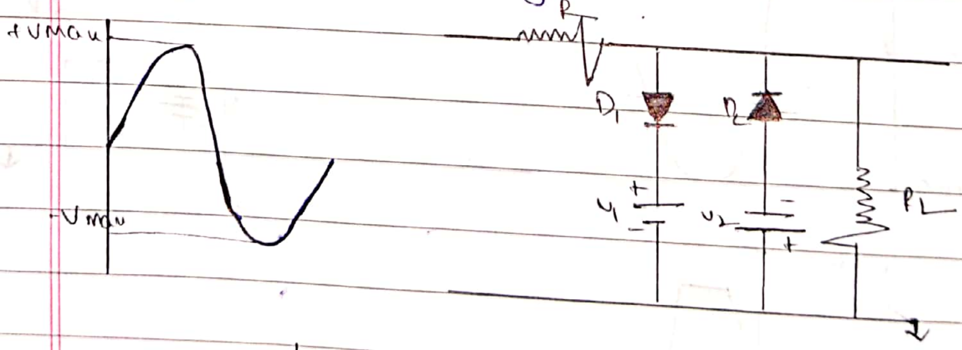


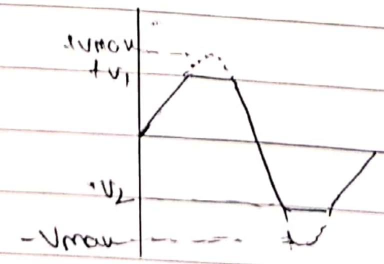


Combination of Clipper :—

- Combination clipper is employed when a portion of both positive and negative of each half cycle of the input voltage is to be clipped using a biased positive and negative clipper together.

The circuit for such a clipper is given in the figure below:—





Applications of clipper circuit :-

- There are numerous clipper applications however, in general, clippers are used to perform one of the following two functions :-

i) Changing the shape of waveform :-
Clipper can alter the shape of a waveform. For example, a clipper can be used to convert a sine wave into a rectangular wave, square wave etc. They can limit either the negative or positive alternation or both alternations of an a.c. voltage.

ii) Circuit Transient Protection :- Transient can cause considerable damage to many type of circuits e.g. a digital circuit. Incase, a clipper diode can be used to prevent the transient form reaching that circuit.

CLAMPER CIRCUITS :-

- A clamping circuit is used to place either the positive or negative peak of a signal at a desired level. The dc component is added to ~~the~~ form the input signal
- The clamper is also reffered to as an Ic restorer and ac signal level shifter.
- The clamper is of two types :-
    1. Positive clamper
    2. Negative clamper.

CHAPTER-2

Special Semiconductor Devices

Thermister:-

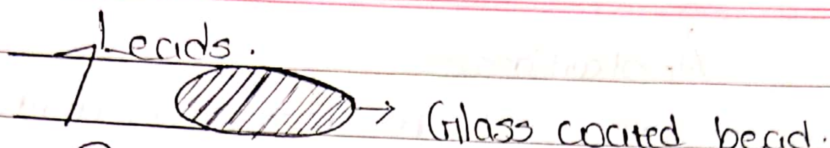
- Thermister is the contraction of the term Thermal Resistor.
- It is generally composed of semiconductor materials. Most thermistors have a negative coefficient of temperature that is their resistance decreases with the increase of temperature.
- The high sesitivity to temperature changes makes thermistors extremely useful for precision temperature measurement, control and compensation.

- The temperature measurement of thermister ranges from -60°C to 150°C and the resistance of thermistor ranges from 0.5Ω to 0.75 MΩ.
- It exhibits highly non-linear characteristics of resistance versus temperature.

Construction:-

- These thermistors are composed of sintered mix of metallic oxides such as Manganese, Nickel, Cobalt, Copper, Iron and Uranium.

- These may be in the form of beads or rods or discs or probes.



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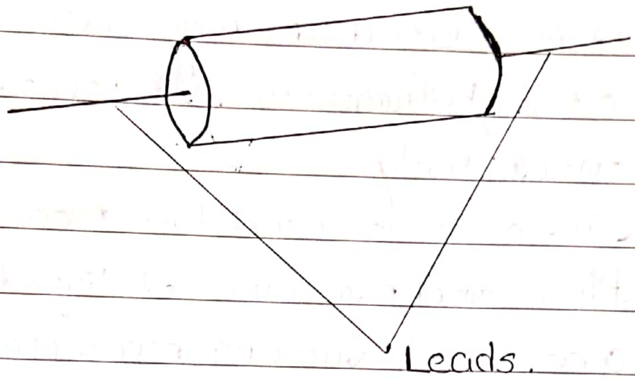

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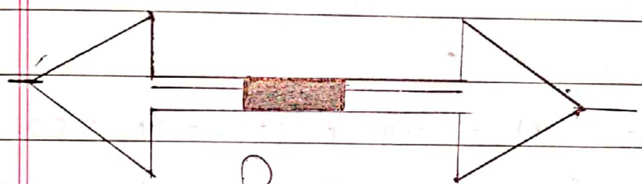

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* **Features**

- These are compact, rugged and inexpensive and have good stability when properly aged.
- Measuring current is maintained at a value as low as possible so that self-heating of thermistors is avoided otherwise errors are introduced on account of changes of resistance caused by self heating.

Applications:-

- It is used to measure and control of temperature and for temperature compensation
- It is used for measurement of power at high frequency. It is also used for thermal conductivity.
- Thermistor is used for measurement of level. flow and pressure of liquid, composition of gases and vaccum measurement. It is used for providing time today.

Barreters

Barretors are the short lengthe wires with fine diameters with operating range around 1500C.

Sensor:-

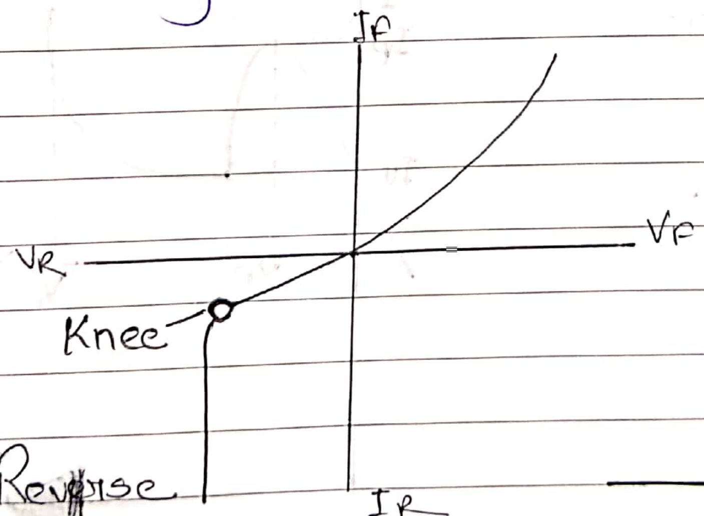
- A sensor is a device that detects events or changes in quantities and provides an corresponding output, generally as an electrical or optical signal,
  for example :- a thermocouple converts temperature to an output voltage.
- Sensors are used in everyday objects such as ~~an electrical~~ or optical signal touch sensitive elevator buttons and lamps which dim or brighten by touching the base, besides innumerable applications.

of which most people are never aware.

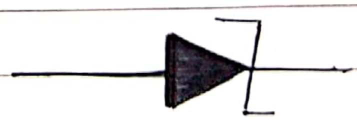
- With advances in micro machinery and easy to use microcontroller platforms, the uses of sensors have expanded beyond the more traditional fields of temperature, pressure or flow measurement.

Zener Diode :-

- A properly doped crystal diode which has a sharp breakdown voltage is ~~down~~ Known as a zener diode.
- It is already been discussed that when the reverse bias on a crystal diode is increased, a critical voltage, called Breakdown Voltage, is reached where the ~~bias~~ reverse current increases sharply to a high value.

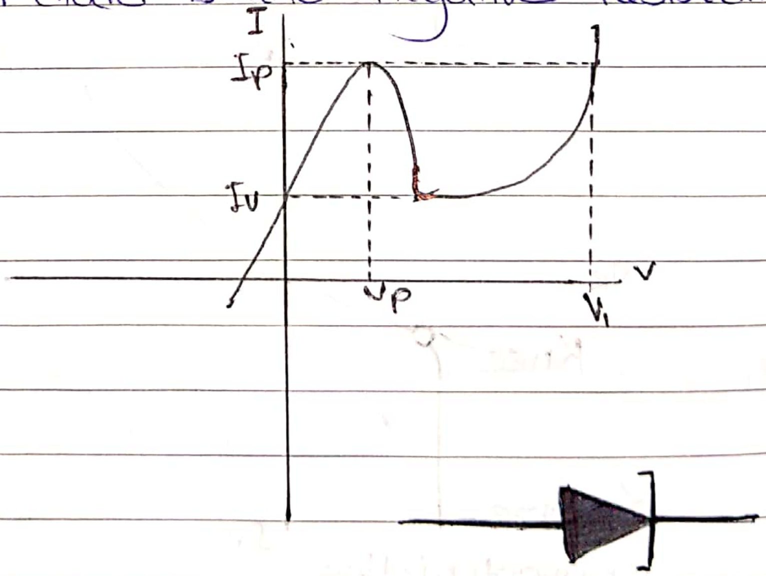


Reverse characteristics



Tunnel Diode :—

- Under normal forward bias operation, as voltage begins to increase, electrons at first tunnel through the very ~~high~~ narrow p-n junction barrier because filled electron states in the conduction band on the n-side become aligned with empty valence band hole states on the p-side of the p-n junction.
- A voltage increases further these states become more misaligned and the current drops this is called negative resistance because current decreases with increasing voltage.
- The most important operating region for a tunnel diode is the negative resistance region.



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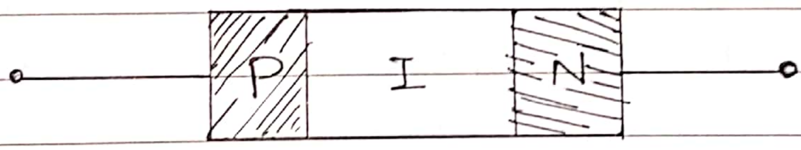
PIN Diode:-

- The PIN Diode can be shown diagrammatically, as being an PN junction, but with an intrinsic layer between the PN and layers.
- The intronsic layer of the PIN diode is a layer without doping, and as a result this increases the size of the depletion region - the region between the P and N layers where there are no majority carries.
- This change in the structure gives the PIN diode its unique properties.
- The PIN diode operates in exactly the same way as a normal diode



CHAPTER-3
RECTIFIERS

Introduction:-

- For reasons associated with economic and transmission, the electric power available is usually an AC Supply. The supply voltage varies sinusodial and has a frequency of 50Hz. It is used for lighting, heating and electric motors.
- But there are many applications where DC supply is needed. When such a DC supply is required, the mains A.C. supply is rectified by using Crystal Diodes.
- The following two rectifiers circuit can be used:-

i) Half wave rectifier
ii) Full wave rectifier.

i) Half wave rectifier

- In half-wave rectifier ~~as~~, the rectifier conducts current only during the positive half cycles of input. AC supply.
- The negative half cycles of A.C. Supply is suppressed i.e. during negative half cycles, no current is conducted and hence no voltage appears across the load.
- Therefore current always flows in one

direction through the load through after every half cycle.

Disadvantages:-

i) The pulsating current in the load contains alternating component whose basic is equal to the supply frequency.
Therefore, an elaborate filtering is required to produce steady direct current.

ii) The A.C supply delivers power only half the time. Therefore, the output is low.

ii) Full wave rectifier:-
In full-wave rectification, current flow through the load in the same direction for both half cycles of input A.C voltage. This can be achieved with two diodes working alternately.
This is of two types:-
a) Centre tap full wave rectifier:-
Advantages:-
i) The DC output voltage and load current values are twice than that of a half wave rectifier.
ii) The ripple factor is much less (0.482) than that of half rectifier (1.21)
iii) The efficiency is twice (81.2%) than that of half wave rectifier (40.6%)

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Disadvantages:-

- It is difficult to locate the centre tap on the secondary winding.
- The D.C output is small as each diode utilizes only one-half of the transformer secondary voltage.
- The diodes used must have high peak inverse voltage.

b) Fullwave Bridge Rectifier:-

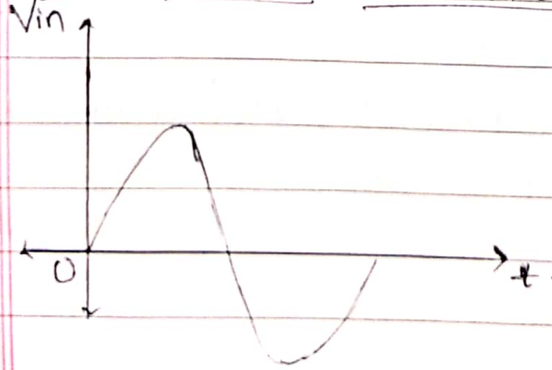
Advantages

i) The need for centre-taped transformer is eliminated
ii) The output is twice that of the centre tap circuit for the same secondary voltage.
iii) The PIV is one-half that of the centre tap circuit.

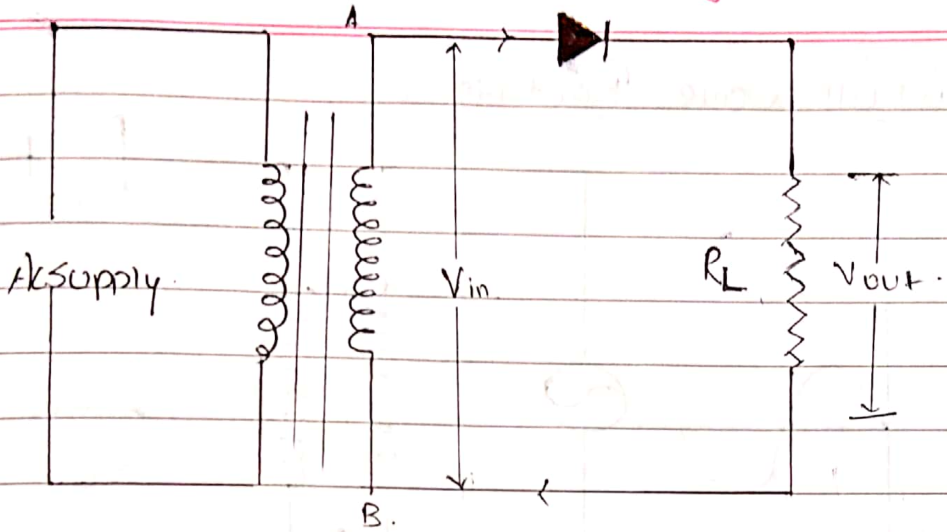
Disadvantages:

i) It requires four diodes
ii) Internal resistance is high.

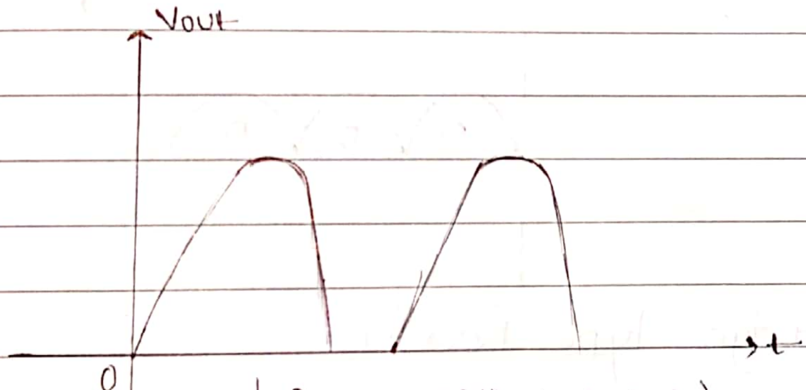
a) HALF WAVE RECTIFIER:-



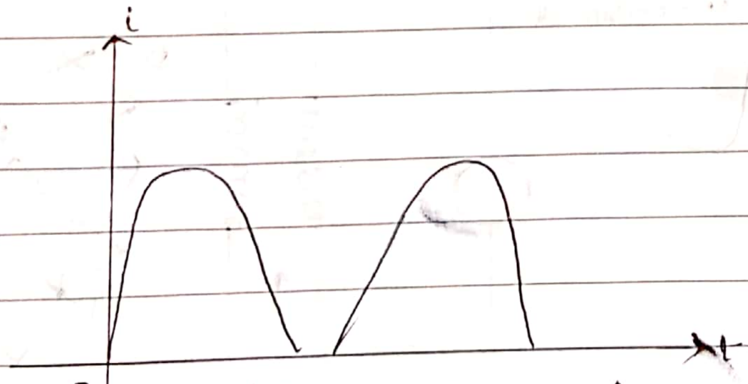
(Input wave form).



(Half wave Rectifier Circuit)

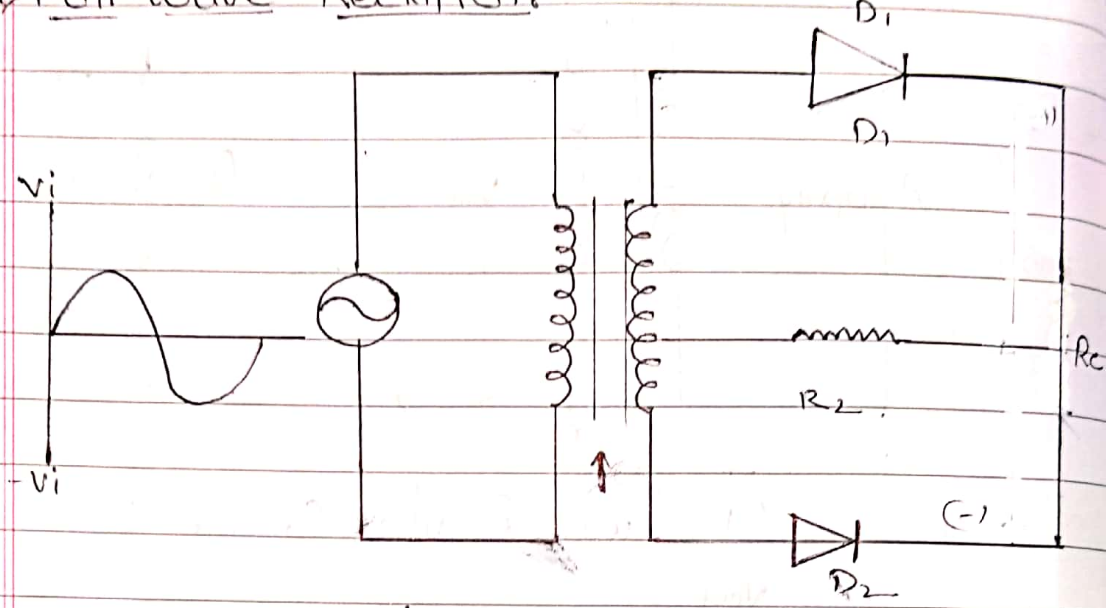


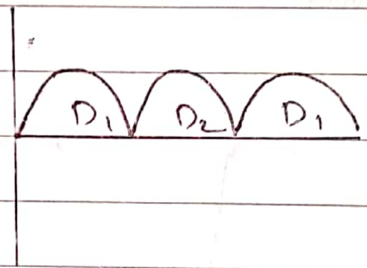
(Output voltage wave)



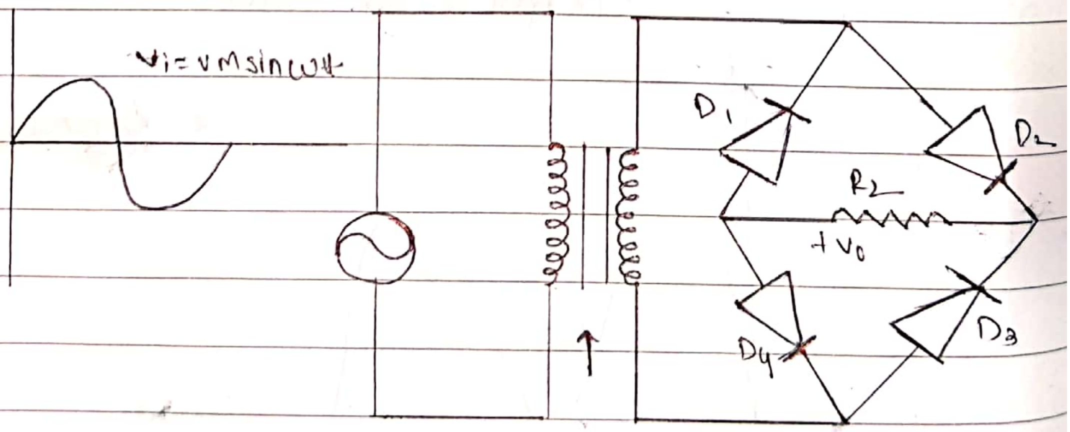
(Output Current)

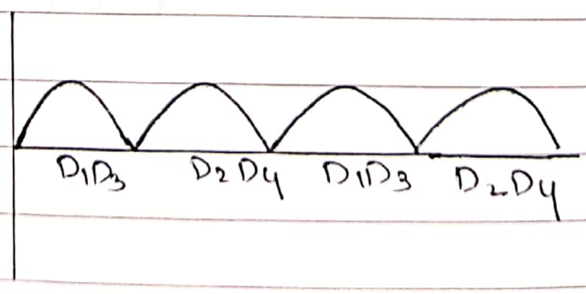
b) i) Full Wave Rectifier:-





ii) Bridge Type Rectifier.





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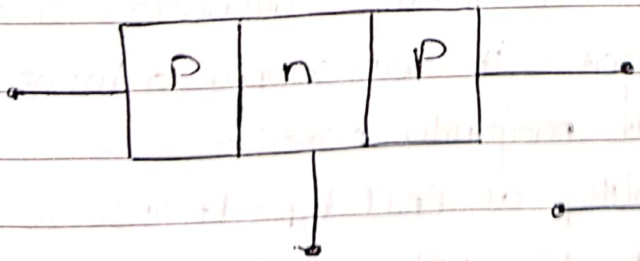
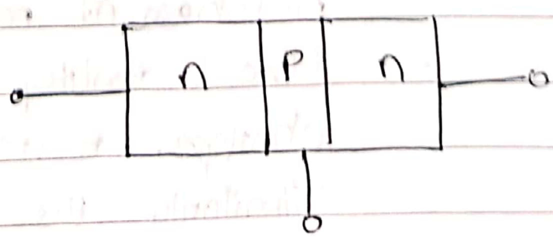
CHAPTER-4
Transistors

- When a third doped element is added to a crystal diode in such a way that two PN junction are formed the resulting device is known as a Transistor.
- This is a new type of electronic device which can able to amplify a weak signal in a fashion comparable and often superior to that realized by vaccum tubes.
- A transistor consist of two PN junctions formed by sandwiching either p-type or n-type semiconductor between a pairs of two PN junctions of opposite types.
- Hence the transistor is classified into two types, namely :-
  i) npn transistor and ii) pnp transistor.
- An transistor consist of two n-type semiconductors separated by a thin section of p-type.
- However a p-n-p transistor is formed by two p-sections separated by a thin section of n-type as shown in figure below:-





- A transistor has two pn junctions. As discussed later, one junction is forward biased and the other is reverse biased.

- The forward bias junction has a low resistance path whereas a reverse biased junction has a high resistance path
- The weak signal is introduced in the low resistance circuit and output is taken from the high resistance circuit. Therefore a transistor transfers a signal from low resistance to high resistance.
- Here trans - means the signal transfer property. and "istor" classifies as a solid element.

Naming the Transistor Terminals :-
- A transistor has three sections of doped semiconductors.

i) Emitter:-
- The section on one side that supplies charge carriers is called the emitter.
- The emitter is always forward biased w.r.t base so that it can supply a large number of majority carriers.
- The emitter of PNP type transfers holes charges. to its junction with base.
- Similarly the emitter of NPN transistor has

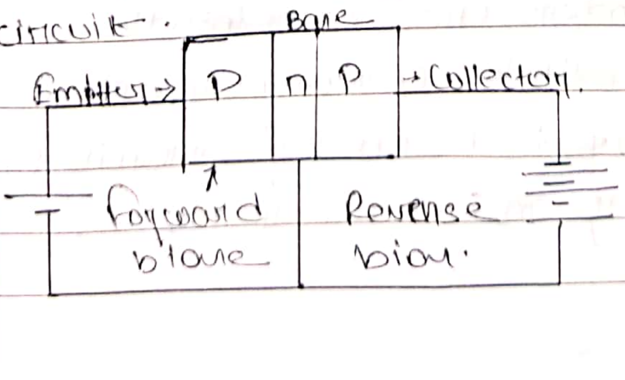
a forward bias and supplies free electrons to its junction with the base.

ii) Collector:-

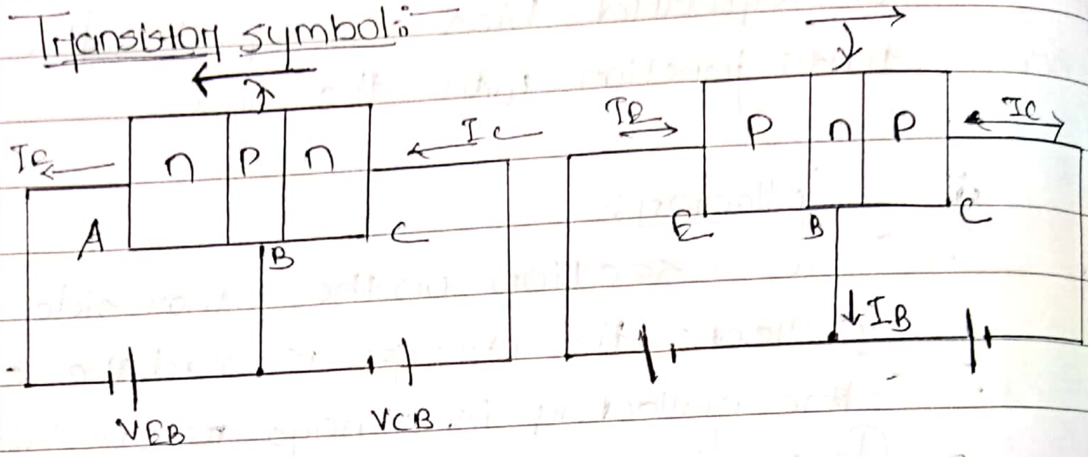
- The section on the other side that collects the charges is called the collector.
- The collector is always reverse biased.
- Its function is to remove charges from its ~~base and supp~~ junction with the base.
- The collector of PNP transistor has a reverse bias as receives hole charges that flow in the output circuit. Similarly the collector of NPN transistor has reverse bias & receives electrons.

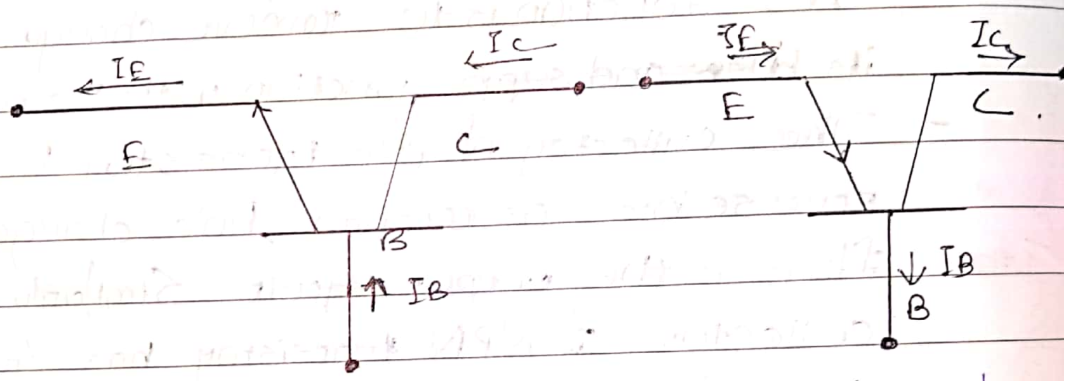
Base:-

- The middle section which forms two PN junctions between emitter and collector is called the base.
- The base emitter junction is forward biased, allowing the low resistance for the emitter circuit.
- The base collector junction is reverse biased and provides high resistance in the collector circuit.



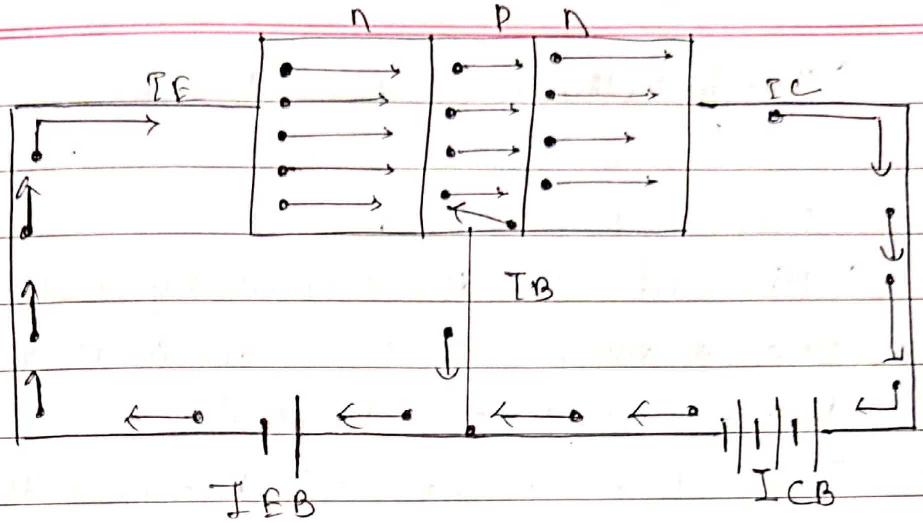
Transistor symbol:-





Working of NPN Transistor (NPN)

- The forward bias causes the electrons in the n-type emitter to flow towards the base.
- This constitutes the emitter current I_E. As these electrons flow through the p-type base, they tend to combine with holes.
- As the base is lightly doped and very thin therefore, only a few electrons combine with holes to constitute base current I_B.
- The remainders cross over into the collector region to constitute collector current I_C.
- It is clear that emitter current is the sum of collector and base currents $I_E = I_B + I_C$



Working of PNP Transistor (PNP):-

- The forward bias causes the holes in the p-type emitter to flow towards the holes in the p-type emitter to flow towards the base.
- This constitutes the emitter current IE.
- As these holes across into n-type base, they tend to combine with the electrons
- In this way, almost the entire emitter current flows in the collector circuit.
- It may be noted that current conduction within PNP transistor is by holes. However in the external connecting ~~sett~~ wires, the current is still by electrons.

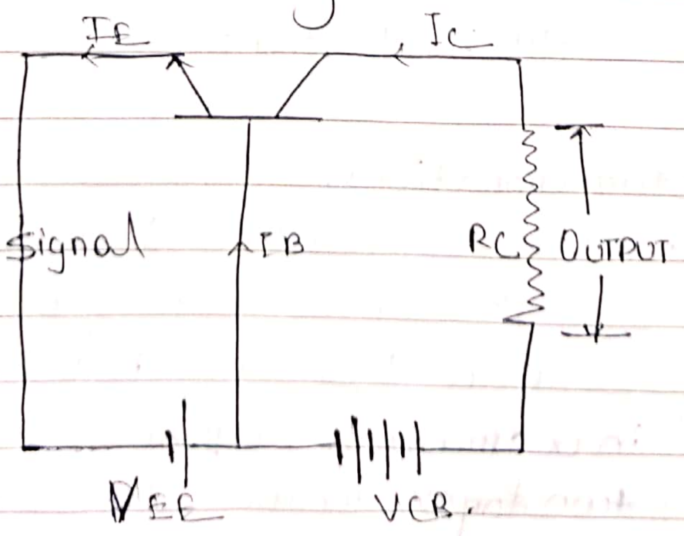
Transistor Connections:-

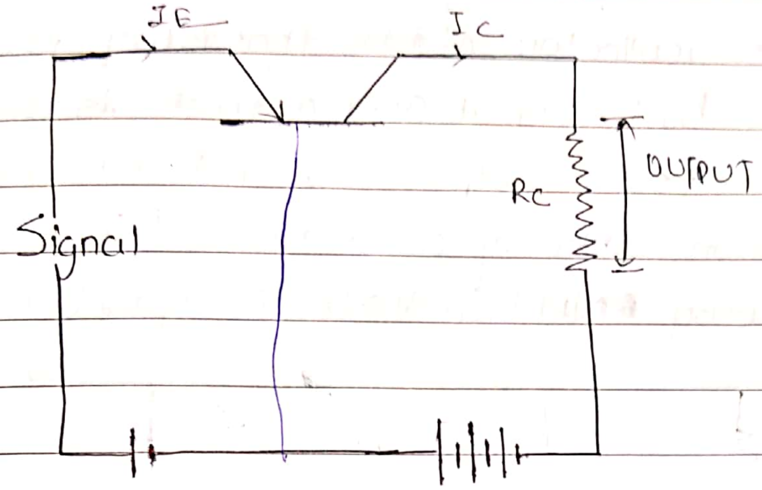
- There are three leads in a transistor such as emitter, base and collector terminals.
- However, when a transistor is to be connected in a circuit, we require for terminals; two for the input and two for the output.

- This difficulty is overcome by making one terminal of it in common to both input and output terminals.
- The difficulty is overcome by making one terminal of it in common to both input and output terminals.
- The output is obtained between the common terminals and the remaining terminal.
- So a transistor can be connected in a circuit in the following types:-
  - i) Common Base connection
  - ii) Common Emitter connection,
  - iii) Common Collector connection.

i) Common Base connection:-

- Here base of the transistor is common to both input and out circuits and hence the name Common Base connection. A Common Base NPN and PNP in figure below.



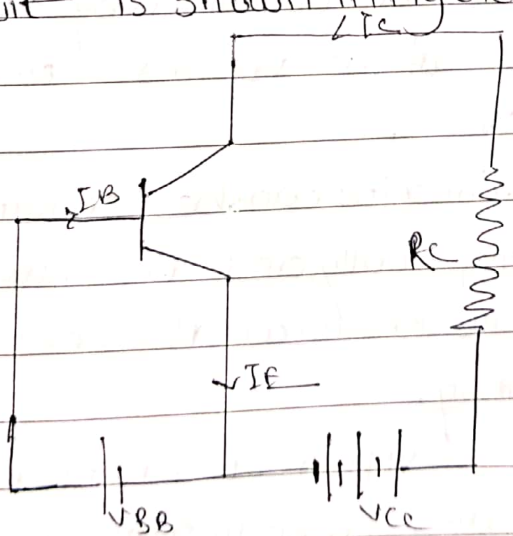


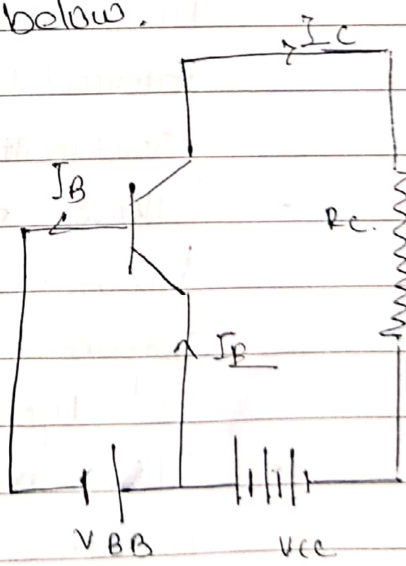
ii) Common Emitter Connection :-

In this circuit arrangement, input is applied between base and emitter and output is taken from the collector and emitter.

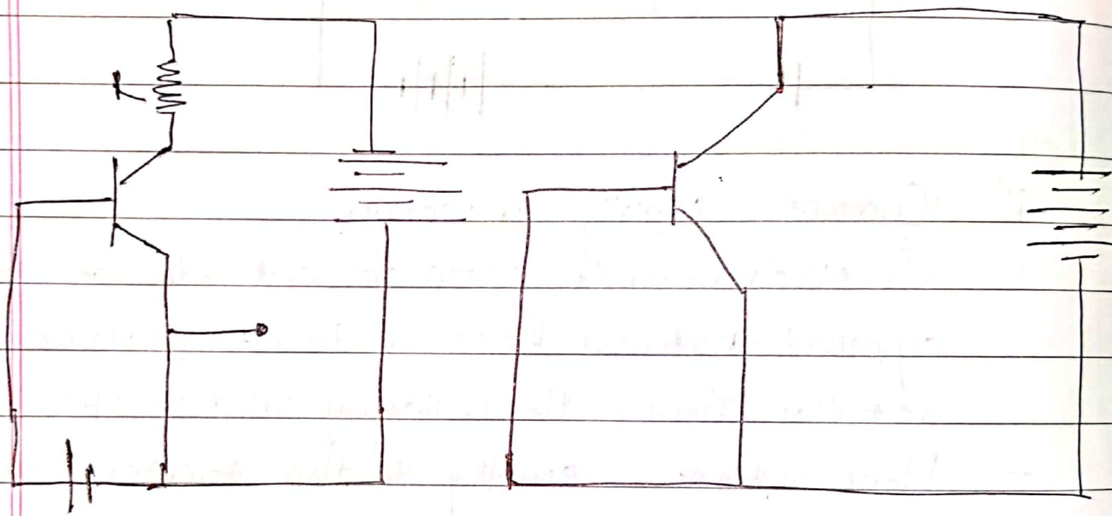
- Here, the emitter of the transistor is common to both the circuits and base hence the name Common Emitter Connection.

A Common Emitter NPN and PNP transistor circuit is shown in figure below.





iii) Here, collector of the transistor is common to both input and output ~~is taken~~ circuits and output hence the name Common collector connection. A Common collector NPN and PNP in figure below:-



1 Transistor Connection characteristics :- Common Base

- The complete electrical behaviour of a transistor can be described by stating the interrelation of the various currents and voltages.
- These relationships can be conviniently deployed graphically and the curves thus obtained are known as the characteristics of transistor.
- The most important characteristics of common base connection are input characteristics and output characteristics.

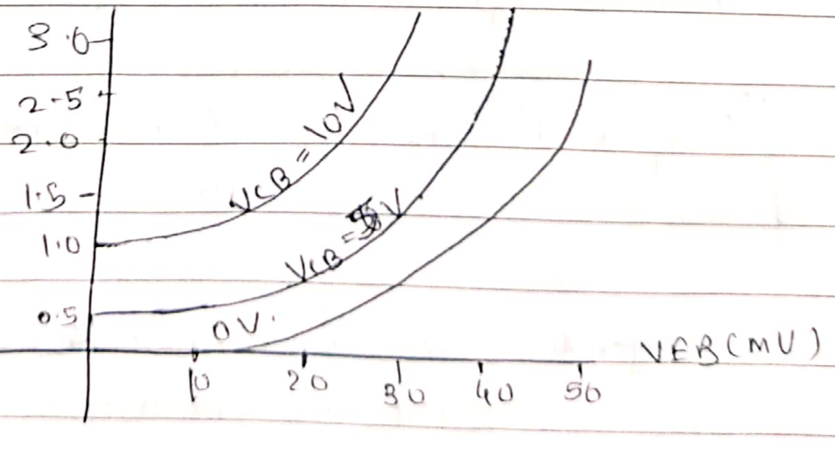
Input characteristics

- It is the curve between earlier emmiter I_E & emitter base voltage V_{BE} at constant collector base voltage V_{CB}.
- The emitter current is generally taken along y-axis and emitter voltage along x-axis.
- The following points may be noted from these characteristics :—

i) The emitter current I_E increases rapidly with ~~on~~ small increase in emitter-base voltage V_{EB}. It means that input resistance is very small.

ii) The emitter current is almost independent of collector-base voltage V_{CB}. This leads to the conclusion that emitter current is almost independent of collector voltage.

- Input resistance :- $\dfrac{\Delta V_{BE}}{\Delta I_E}$ at constant V_{CB}.



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Output characteristics

- It is the curve between collector current I_C & collector base voltage V_{BC} at constant emitter current I_E.
- Generally, collector current is taken along y-axis and collector-base voltage along x-axis.
- The following points may be noted from characteristics:-

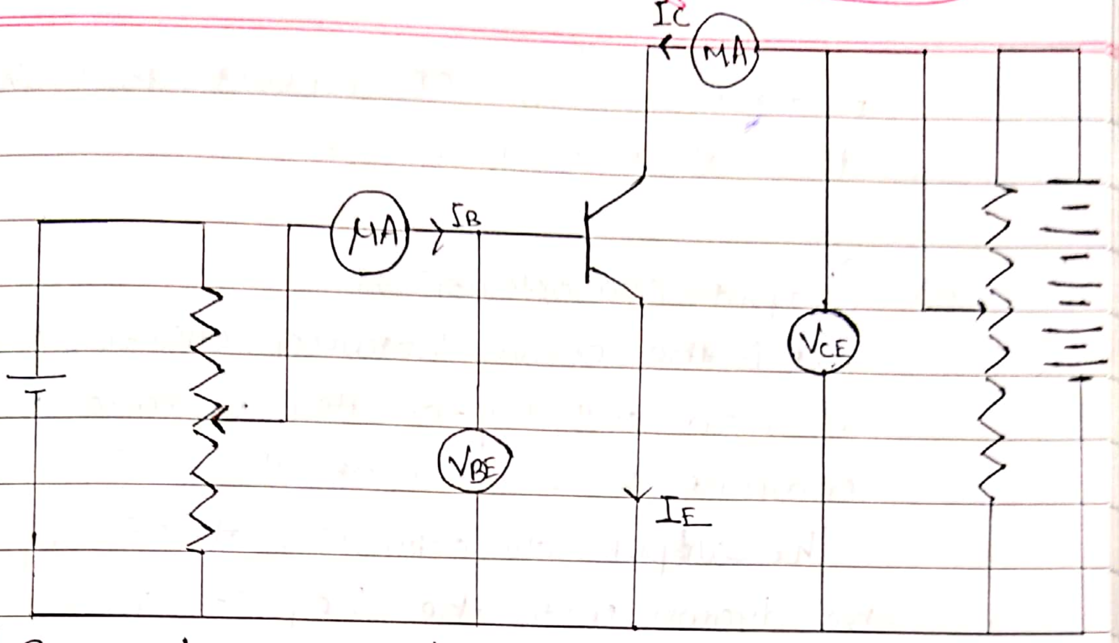
i) The collector current I_C varies with V_{CB} only at very low voltages. The transistor is never operated in this region.

ii) When the value of V_{CB} is raised above 1-2V, the collector current becomes constant as indicated by straight horizontal curves. It means that now I_C is independent of V_{CB} and depends upon I_E only. This is consistent with the theory that the emitter current flows almost entirely to the collector terminal. The transistor is always operated in this region.

$$\boxed{\text{Output Resistance:-} \ \frac{\Delta V_{CB}}{\Delta I_C} \ \text{at constant } I_E}$$

2. Characteristics of common emitter connection

- The important characteristics of this circuit arrangement are the input characteristic and output characteristic.



(Circuit Arrangement for studying Common Emitter Connection of Transistor)

A) Input Characteristics:-

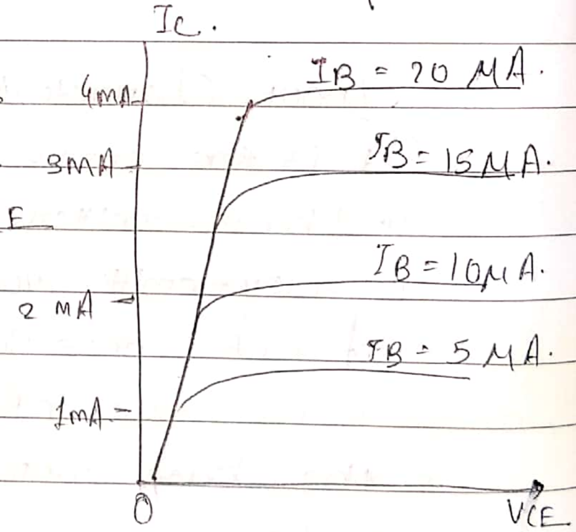
- It is the curve between base current I_B and base-emitter voltage V_{BE} at constant collector-emitter volt V_{CE}. The input characteristics of a CE connection can be determined by the circuit shown in fig. Keeping V_{CE} constant, note the base current I_B for various values of V_{BE}.
- The following points may be noted from the characteristics:-

i) The characteristics recembles that of a forward biased diode curve. This is expected since the base emitter section of transistor is a diode and it is forward biased.

ii) As compared to CB arrangement I_B increases less rapidly with V_{BE}. Therefore, input resistance of a CE circuit is higher than that of CB circuit.

B). Output characteristics:-

- It is the curve between collector current I_C and collector-emitter voltage V_{CE} at constant base current I_B.
- The output characteristics of CE circuit can be drawn with the help of above circuit arrangement.
- Keeping the base current I_C for various value of V_{CE}.
- Then plot the readings on a graph, taking I_C along y axis and V_{CE} along x-axis.



The following points may be noted from the characteristics:-

i) The collector current I_C varies with V_{CE} for V_{CE} between 0 and 1V only. After this I_C becomes almost constant & independent of V_{CE}.

- ii) The value of V_{CE} upto which I_C changes with V_{CE} is called the Knee voltage (V_{Knee}). The transistors are always operated in the

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region above Knee voltage.

ii) Above Knee voltage, Ic changes with VCE is ~~called the knee voltage~~ & is almost constant. However, a small increase in Ic with increasing VCE is caused by the collector depletion layer getting wider and capturing a few more majority carriers before electron depletion layer getting wider and capturing a few more majority carriers before electron hole combination occur in the base area.

iii) For any value of VCE above Knee voltage, the collector current Ic is approximately equal to $\beta \times I_B$.

Output Resistance:-

- It is the ratio of change in collector-emitter voltage to the change in collector current (ΔI_C) at constant I_B.
- It may be noted that whereas the output characteristics are plot of I_E versus V_{CE} for a constant value of I_B.
- There is an almost unnoticeable change in the vertical scale of I_C of the CE connection if I_C is replaced by I_E for CC connection.
- The input circuit of CC connection, the CE characteristics is sufficient to obtain the required information.

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3) Characteristics of common collector connection.

- In a common collector circuit connection the load resistor connected from emitter to ground, so the collector tied to ground even though the transistor is connected in a manner similar to the CE connection.
- Hence there is no need for a set of common - collector characteristics to choose the parameters of the circuit. The output characteristic of the C.C configuration is same as CE configuration.
- For C.C Connection the output characteristics are plot of I_E versus V_{CE} for a constant value of I_B.

- Current Amplification Factor

1 Common Base Connection:-
In a Common base connection, the input current is the Emitter Current I_E and output current is the Collector current I_C.
~~Hence~~ $\boxed{\alpha = \Delta I_C / \Delta I_E}$

2.) Common Emitter Connection:-
In a common emitter connection, the input current is the base Current I_B and output current is the Collector Current I_C.

$$\boxed{\beta = \frac{\Delta I_C}{\Delta I_B}}$$

3. Common Collector Connection:-
In a common collector connection the input current is the Emitter Current I_B and output current is the Emitter Current I_E.

$$\boxed{\gamma = \frac{\Delta I_E}{\Delta I_B}}$$

• Relation Among Different current Amplification Factors:-

1. Relation between α and β:-

$$\beta = \frac{\Delta I_C}{\Delta I_B} = \frac{\Delta I_C}{\Delta I_E - \Delta I_C} = \frac{\Delta I_C / \Delta I_E}{1 - \Delta I_C/\Delta I_E} = \frac{\alpha}{1-\alpha}$$

$$\alpha = \frac{\Delta I_C}{\Delta I_B} = \frac{\Delta I_C}{\Delta I_B + \Delta I_C} = \frac{\Delta I_C / \Delta I_B}{1 + \Delta I_C/\Delta I_B} = \frac{\beta}{1+\beta}$$

2. Relation between α and γ:-

$$\gamma = \frac{\Delta I_E}{\Delta I_B} = \frac{\Delta I_E}{\Delta I_E - \Delta I_C} = \frac{\Delta I_E / \Delta I_E}{1 - \Delta I_C/\Delta I_E} = \frac{1}{1-\alpha}$$

$$\alpha = \frac{\Delta I_C}{\Delta I_E} = \frac{\Delta I_E - \Delta I_B}{\Delta I_E} = \frac{\Delta I_E/\Delta I_B - 1}{\Delta I_E/\Delta I_B}$$

$$= \frac{\gamma - 1}{\gamma}$$

3. Relation between β and γ:-

$$\gamma = \frac{\Delta I_E}{\Delta I_B} = \frac{\Delta I_B + \Delta I_C}{\Delta I_B} = \frac{\Delta I_B}{\Delta I_B} + \frac{\Delta I_C}{\Delta I_B}$$

$$= 1 + \beta$$

$$\beta = \frac{\Delta I_C}{\Delta I_B} = \frac{\Delta I_E - \Delta I_B}{\Delta I_B} = \frac{\Delta I_E}{\Delta I_B} - \frac{\Delta I_B}{\Delta I_B} = \gamma - 1$$

4 Relation between α, β and γ :-

$$A_S = \beta = \frac{a}{1-a} = a \times \frac{1}{1-\alpha} = a \times y$$

$$\boxed{\beta = a \times \gamma}$$

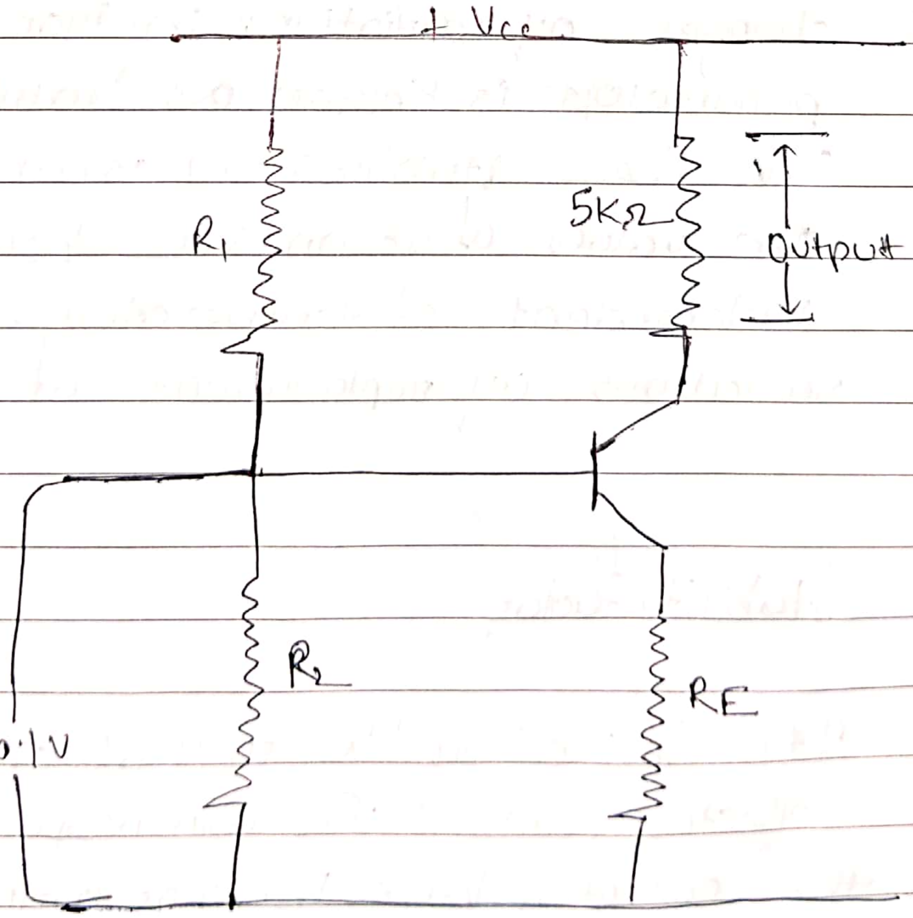
$$\therefore \boxed{\alpha = \frac{\beta}{1+\beta}} \qquad \boxed{\therefore \beta = \frac{a}{1-\alpha}}$$

$$\boxed{\therefore \gamma = \frac{1}{1-\alpha}} \qquad \boxed{\alpha = \frac{\gamma-1}{1}}$$

$$\boxed{\therefore \gamma = 1+\beta} \qquad \boxed{\therefore \beta = \gamma+1}$$

Sl No	Characteristic	Common base	Common emitter	Collector Common
1.	Input resistance	Low	Low	V. High
2.	Output resistance	Very high	high	Low.
3	Voltage gain	about 150	about 500	about 1
4.	Amplification	For hig freq.	For audio freq	For Impe-matin.
5.	Current gain.	No (less than 1)	High (β)	Appre-ciable.

- **Amplifier:-**
The device which increases the strength of a weak signal is known as Amplifier. This can achieve by use of Transistor. It may be classified according to the number of stage of amplification. such as.
- **Single stage Transistor Amplifier:-** when only one transistor with associated circuitry is used for
- **Multi stage Transistor Amplifier:-**
When a transistor Amplifier circuit containing more than one stage of amplification is known as Multistage Amplifier.



CHAPTER-5

Transistor biasing :-

Transistor Biasing is the process of setting a transistors DC operating voltage or current conditions to the correct level so that any AC input signal can be amplified correctly by the transistor.

Stabilization :-

The process of making the operating point independent of temperature changes or variations in transistor parameters is known as Stabilization. Once the stabilization is achieved, the values of I_C and V_{CE} become independent of temperature variations or replacement of transistor

Stability factor

It is defined as the rate of change of collector current I_C with respect to the collector base leakage current I_{CO}, Keeping both the current I_B and the current gain β constant.

Different method of Transistors Biasing

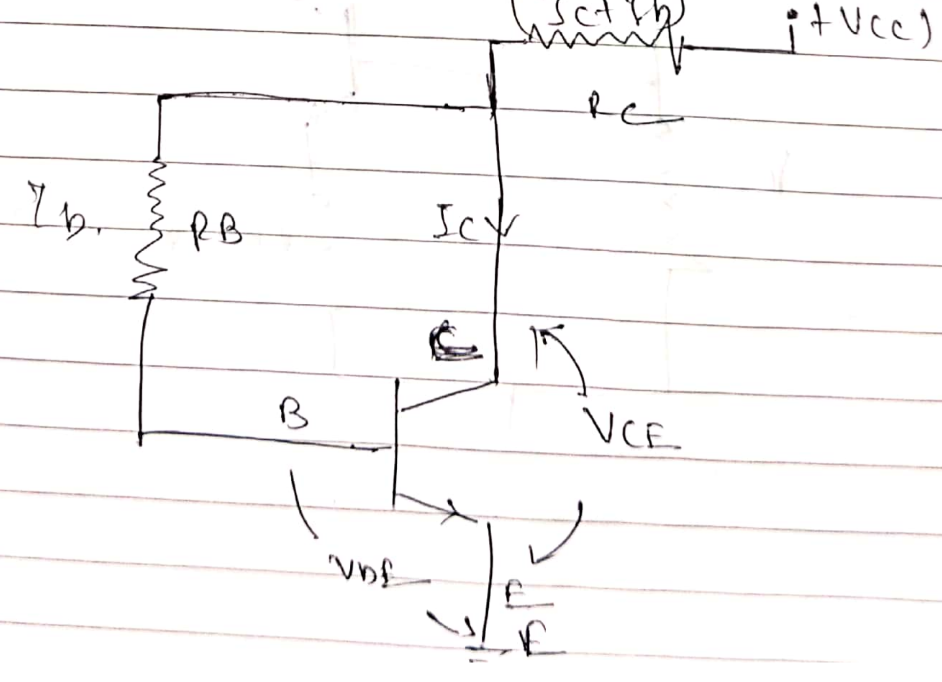
There are three types of Translators Biasing :

i) **Base resistor method :-**

In this method a resistor R_B of high resistance is connected in base, as the name implies. The required zero signal base current is provided by V_{CC} which flows through R_B. The base emitter junction is forward biased, as base is positive with respect to emitter

ii) **Collector to Base Bias :-**

Collector to base bias with voltage feedback. It is also called as collector to base bias circuit. It is an improvement over fixed method. In this biasing resistor is connected between collector and base of the transistor to provide feedback path.



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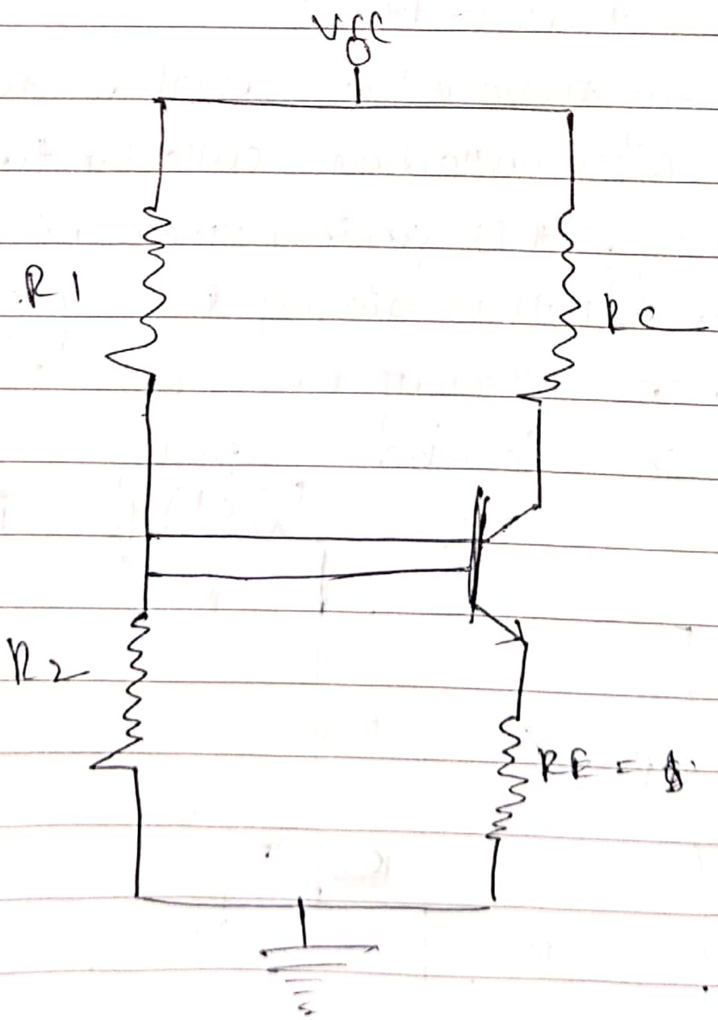
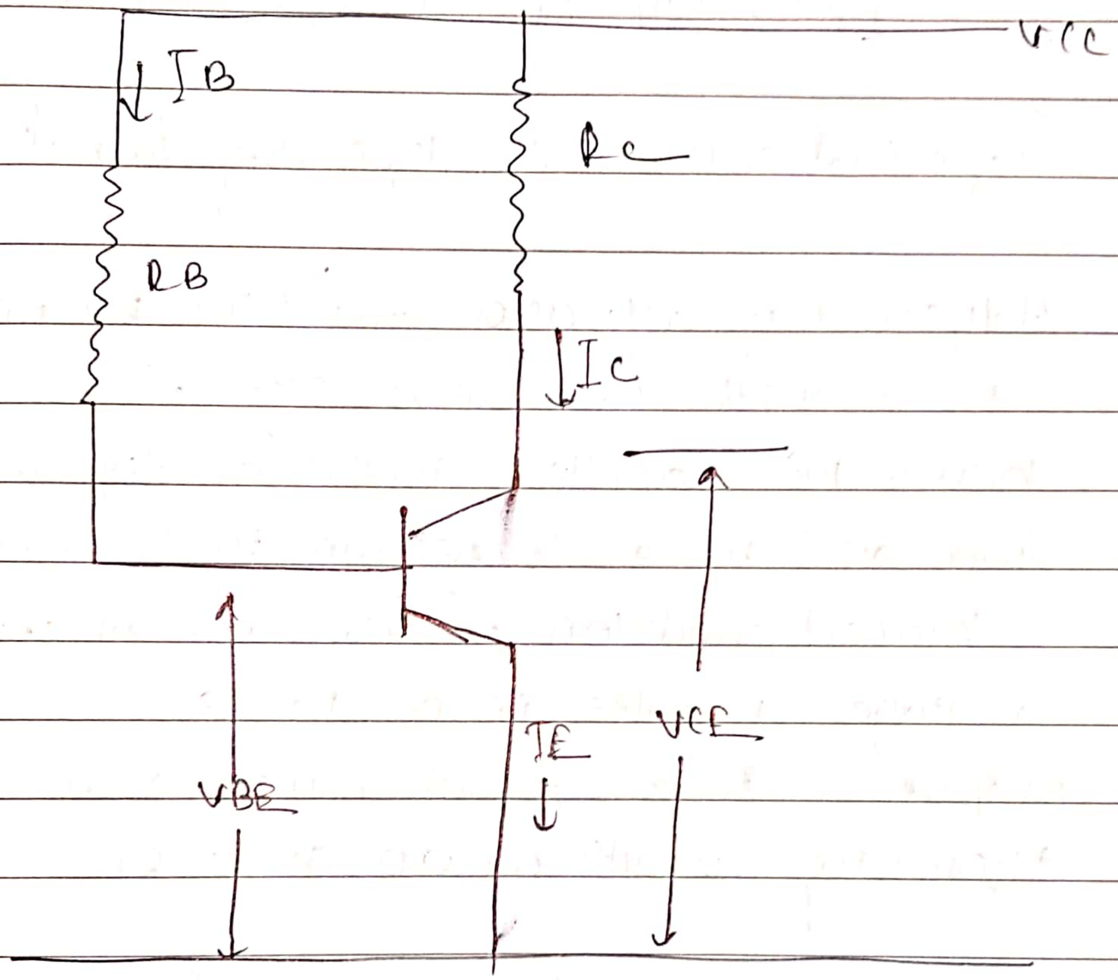
iii) Voltage Divider Bias

A potential divider bias also known as voltage divider bias, is ~~the~~ a method used for the dc biasing of ~~biasing~~ bipolar junction transistors (BJT) in a ~~~~ simple amplifier circuit. The circuit usually consists of biasing resistors in a voltage divider network. whose values are determined through circuit analysis.



Base resistor Bias diagram :-



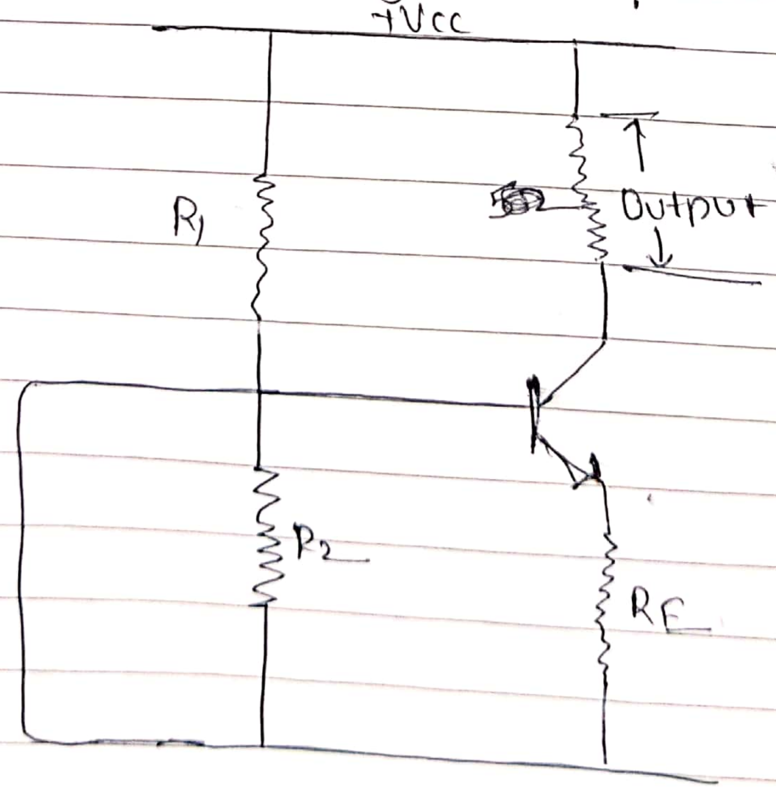
Chapter - 5

Transistor Amplifiers & Oscillators.

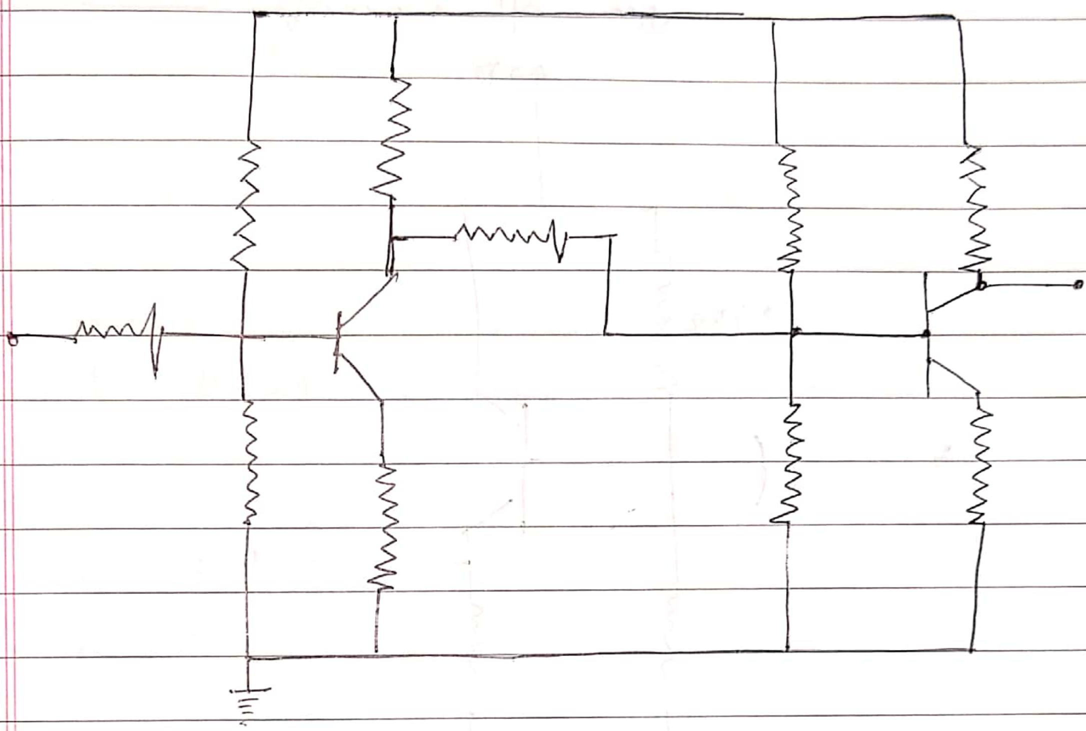
Practical circuit of transistor Amplifier:-

A transistor acts as a amplifier by raising the strength of a weak signal. The DC bias voltage applied to the emitter base junction, makes it remain in forward biased condition. Thus a small input voltage results in a large output voltage, which shows that the transistor works as an amplifier.

Single Stage Transistor Amplifier:-



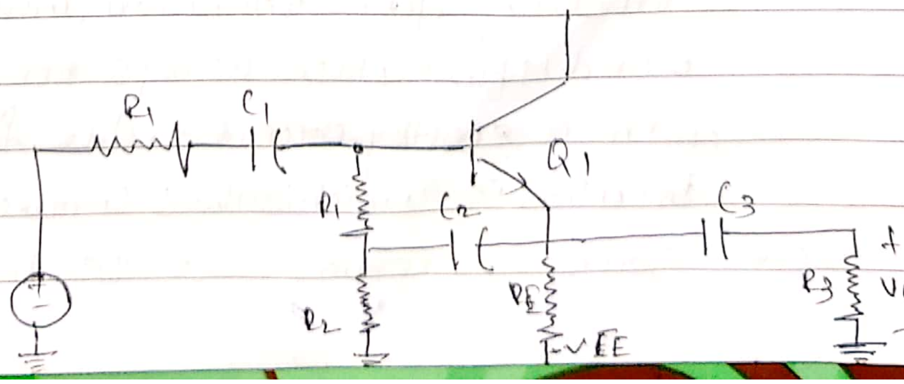
Multistage Transistor Amplifiers:—



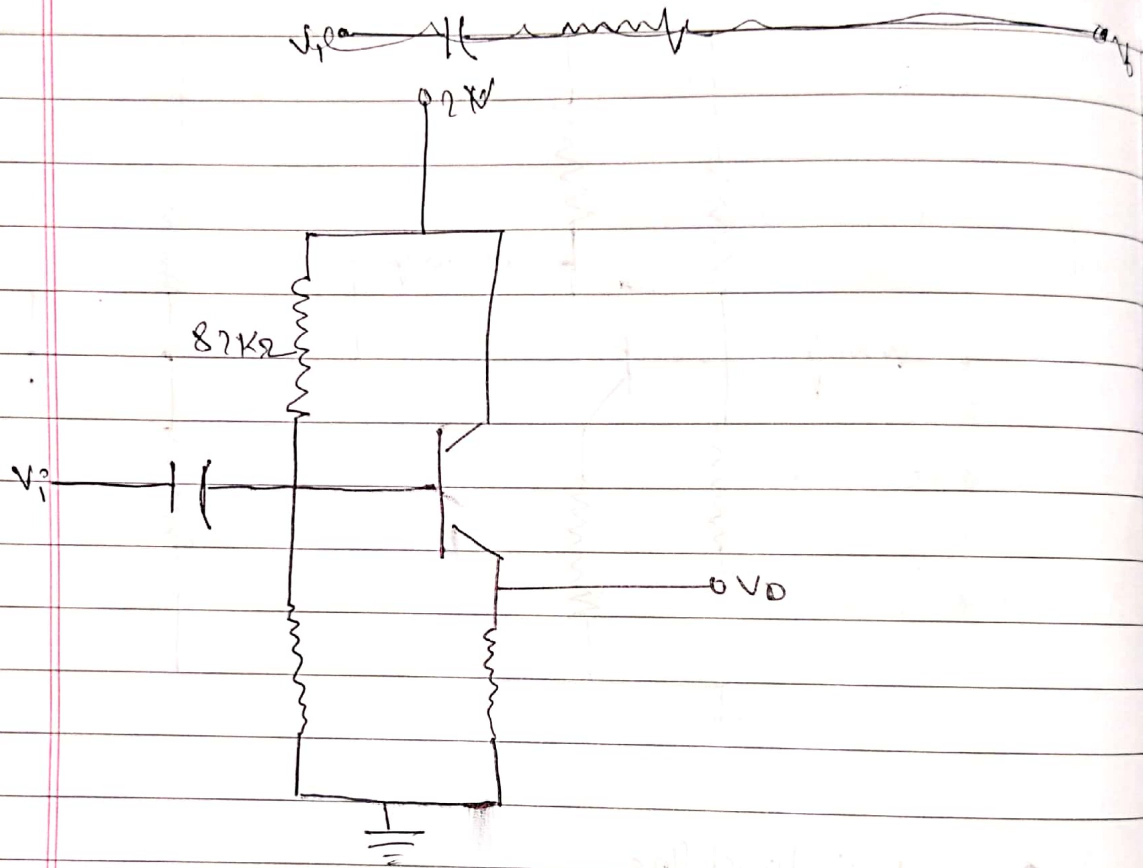
DC load line

The DC load line is the load line of the DC equivalent circuit, defined by ~~reading~~ reducing the reactive components to zero. It is used to determine the correct DC operating ~~component~~ point, often called as the Q point.

DC equivalent Circuit:



AC load line



An AC load line is a straight line with a slope equal to the AC impedence facing the non-linear device, which is in general different from the DC resistance

Calculation of gain

Transistor gain derivation including β and HFE, hfe refers to the common emitter circuit. The factor $\alpha/(1-\alpha)$ is called β which is the common emitter current gain. For example if $\alpha = 0.98$, then the transistor Beta β can be calculated to be 49.

Phase Reversal

Phase reversal occurs when a common mode voltage, outside of the specified maximum range, causes the input stage to interact with the second stage causing an action that appears as if the input pins were reversed. Amplifiers with a biopolar transistor input stage are at high risk.

H - parameters of Transistor

- H parameters is a measure of how good a current source the transistor is at a particular fixed base current. The h-parameters of a transistor will give you a good idea of how to use it effectively in a circuit, and wheather it is appropriate for a particular circuit.

The h-parameters of a transistor used in a common emitter circuit are $h_{ie} = 1.0 k\Omega$, $h_{re} = 1.0 \times 10^{-4}$, $h_{fe} = 50$ and $h_{oe} = 100 \mu mhos$. The load resistor for the transistor is $1 K\Omega$ in the collector circuit. The transistor is

Supplied from a signal source of resistance 1000Ω.

Analysis of CE Amplifiers.

CE Amplifier

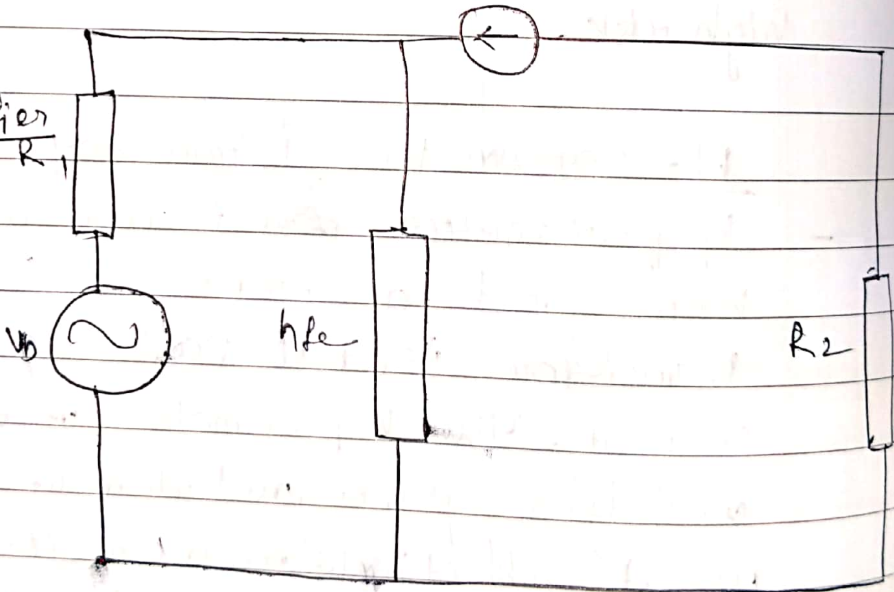
$A_1 = -h_{fe} \times \frac{I_b}{I_b} = -h_{fe}$.

Current gain = I_b

Input resistance

$A_V = A_1 \times \frac{R_L}{R_1} = \frac{-h_{fe} \times R_L}{h_{ie}}$.

CB Amplifier



Current gain.

$A_I = \frac{I_L}{I_e} = \frac{-h_{fe} \times I_b}{-(1+h_{fe}) \times I_b} = \frac{h_{fe}}{1+h_{fe}}$.

$I_e = \frac{(-I_b + h_{fe}) \times I_b}{-(1+h_{fe}) \times I_b} = \frac{h_{fe}}{1+h_{fe}}$.

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$$R_i = \frac{V_e}{I_e} = \frac{-I_b \times h_{ie}}{-I_b(1+h_{fe})} = \frac{h_{ie}}{1+h_{fe}}$$

Voltage gain. A_v.

$V_c = -h_{fe} \times I_b \times R_L$

$$A_v = \frac{V_c}{V_e} = \frac{-h_{fe} \times I_b \times R_L}{-I_b \times h_{ie}} = \frac{h_{fe} \times R_L}{h_{ie}}.$$

C.C. Amplifier

Current gain A_I =

Load Current $I_L = (1+h_{fe}) I_b$

$$A_L = \frac{I_L}{I_b} = (1+h_{fe})$$

Input resistance R_i

$V_b = I_b \times h_{ie} + (1+h_{fe}) I_b \times R_L$

$$R_i = \frac{V_b}{I_b} = h_{ie} + (1+h_{fe}) R_L$$

Voltage Gain A_v

$V_e = (1+h_{fe}) I_b \times R_L$

$$A_v = \frac{V_e}{V_b} = \frac{(1+h_{fe}) I_b \times R_L}{I_b \times h_{ie} + (1+h_{fe}) I_b \times R_L}$$

$$= \frac{(1+h_{fe}) R_L}{h_{ie} + (1+h_{fe}) R_L} = 1 - \frac{h_{ie}}{h_{ie} + (1+h_{fe}) R_L}$$

$$= 1 - \frac{h_{ie}}{R_i}$$

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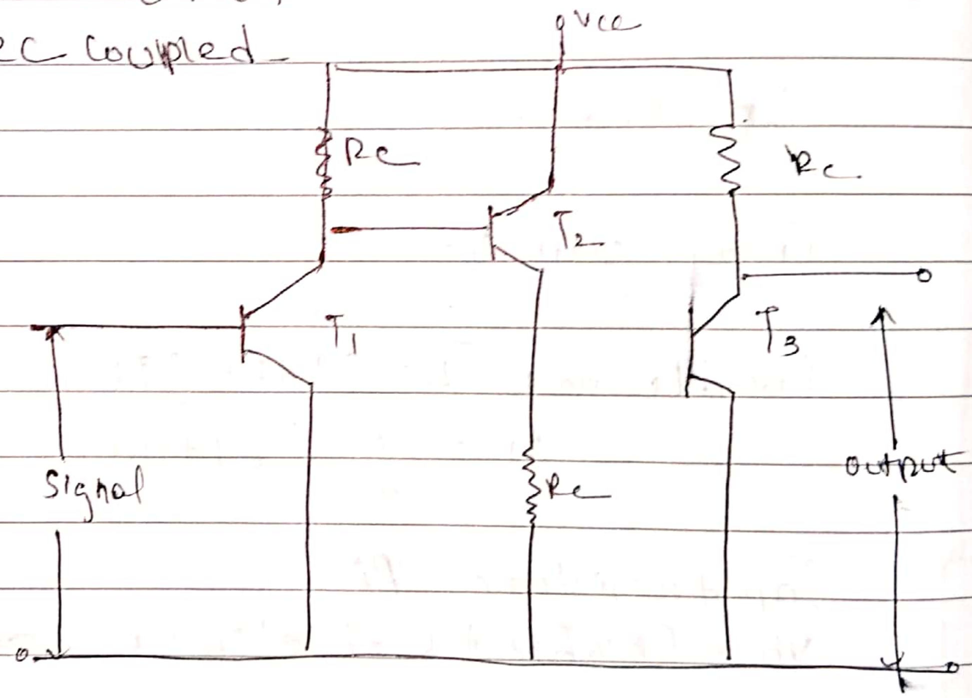
RC Coupled amplification.

It is basically a multistage Amplifier circuit extensively used in electronic circuits. Here the individual stages of the amplifier are connected together using a resistor - capacitor combination due to which it bears its name as RC coupled.



Transformer Coupled Transistor Amplifier.

By using impedence matching properties of Transformer, the low resistance of one stage or load canbe reflected as a high load resistance to the previous stage. Transformer coupling is normally used when the load is small.

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Feed Back Amplifier

A negative feedback amplifier is a electronic amplifier that substracts a fraction of it's output from it's input, so that negative feedback opposes the original signal. It is applied to improve the performance and reduces sensitivity to parameter variations due to manufacturing or environment.

Advantages:-

- Less frequency distribution,
- Less phase distortion,
- Increase stability,
- Increase bandwidth
- Decrease noise.

Power Amplifier

Power amplifier is an electronic amplifier that amplifies lowpower electronic audio signals such as the signal radio receiver or electronic guitar pick up to a level that is hig enough for driving loud speakers.

~~Pravott~~ Difference between Voltage amplifier and power amplifier

~~...~~ In voltage amplifier the amplitude of input AC signal is small.
In power ~~rectifier~~ amplifier the amplitude of input A.C signal is large. The transistor is used can dissipate more heat produced as compared to voltage amplifier during its operation.

Transformer Coupled Class A power amplifier

Transformer coupled ~~Class A~~ Class A amplifier :- Advertisements.
The class A power amplifier as discussed ~~in the previous~~ that it is the circuit in which the output current flows for the entire cycle of the AC input supply. We also have learnt about the disadvantages it has such as low output power and efficiency.

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Push-pull Amplifier

- A push pull amplifier is a type of electronic circuit that uses.

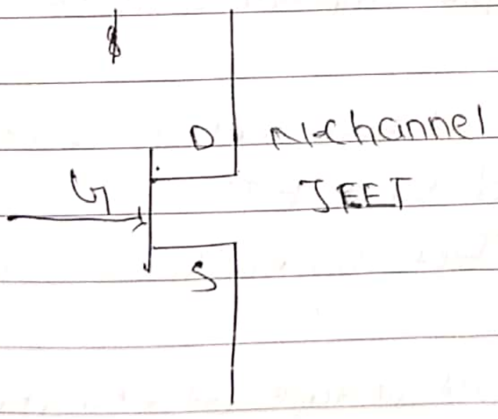
Ch-7

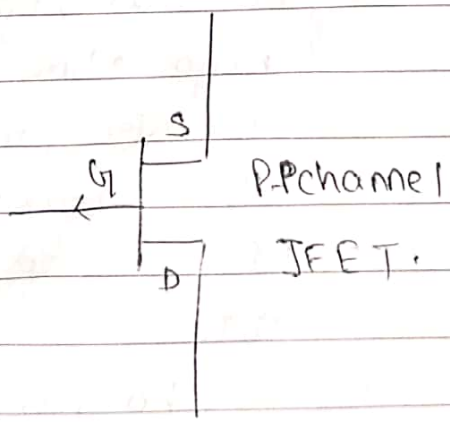
Field Effect Transistor :-

1. It is a type of transistor which uses an field to control the flow of current. FETs are devices with three terminals source, gate and drain. Field effect transistors generally display very high input impedence display very high input impedence at low resistance.

There are ~~three~~ two types of Fets
i) Junction Field Effect Transistor :-
ii) Insulated gate field Effect Transistor :-

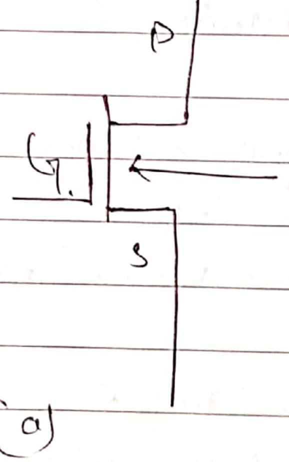
i) Junction Field Effect Transistor :-
JFETs are three terminals semiconductor devices that can be used as electronically controlled switches, amplifiers, or voltage controlled resistors.

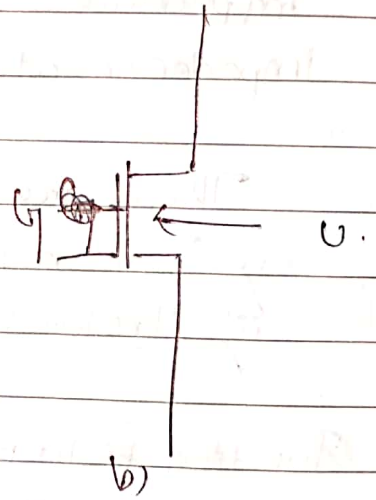




ii) Insulated-gate field effect Transistors:-

A. This type of transistor is also known as an Insulate Field - Effect Transistor, IGFET because the gate is separated from the body by an insulator. In a junction field-effect transistor or JFET, one or two pn junctions act as the gate that modulates the width of a conductive path between the source and drain.





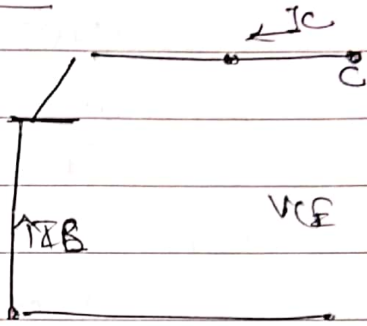
Advantages of FET over BJT.

- FET has high input impedance of several mega ohms.
- The noise produced by a FET is less than that produced by a BJT.
- FETs are less effect by radiation compared to BJT.
- FET has no offset voltage at zero drain

current and hence it forms an excellent signal chopper.

- FETs are voltage controlled devices.

Principle and Operation of BJT.



As the base is thin and lightly doped it consists of very few holes so some of the electrons from the emitter recombine with the holes present in the base region and flow out.

FET Parameters

There are three parameters of FET :—

i) **DC drain resistance** :—
It is defined as the ratio of change in drain to source voltage to the change in drain current at a constant gate to source voltage. It is defined as the rate of change of drain current with ~~cang~~ change in gate to source voltage by keeping the drain to source voltage constant. (It is denoted by 'gm.')

Its range 10 kΩ to 1 MΩ

ii) AC drain resistance :— (rd)
Corresponding to the A.C. plate resistance we have a.c drain resistance in a JFET. It may be defined as follows. It is the ratio of change in drain source voltage (VDS) to the change in drain current (ID) at constant gate source voltage.
It is also called as dynamic resistance.

iii) . Transconductance :-
Transconductance, also infrequently called mutual conductance, is the electrical characteristic relating the current through the output of a device to the voltage across the input of a device. ~~to the~~ Conductance is the reciprocal of resistance. Trans admittance is the AC equivalent of transconductance.

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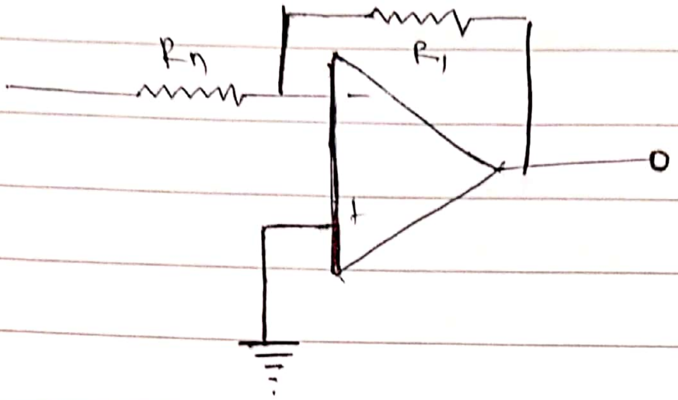
CHAPTER-8

General circuit simple of OP-AMP :-



The basic Op-amp construction is of a 3-terminal device, with 2- inputs and 1-output (excluding power connections). An operational Amplifier operates from either adual positive (+V) and an corresponding negative (-ve) supply, or they can operate from a single DC supply voltage.

Operational Amplifier stages:-

An operational amplifier consist of ~~three~~ two stages, they are:-

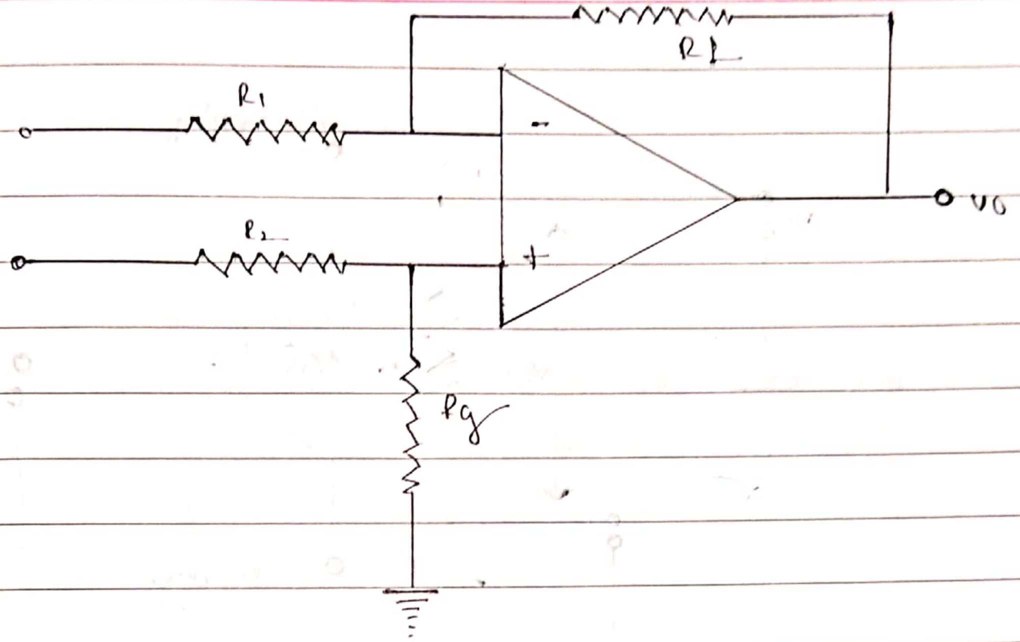
i) Differential Amplifier.

ii) Additional Amplifier stages.

iii)

i) Differential Amplifier:-

A differential amplifier is a type of electronic amplifier that amplifies the difference between two input voltages but suppresses any voltage common to the two inputs.

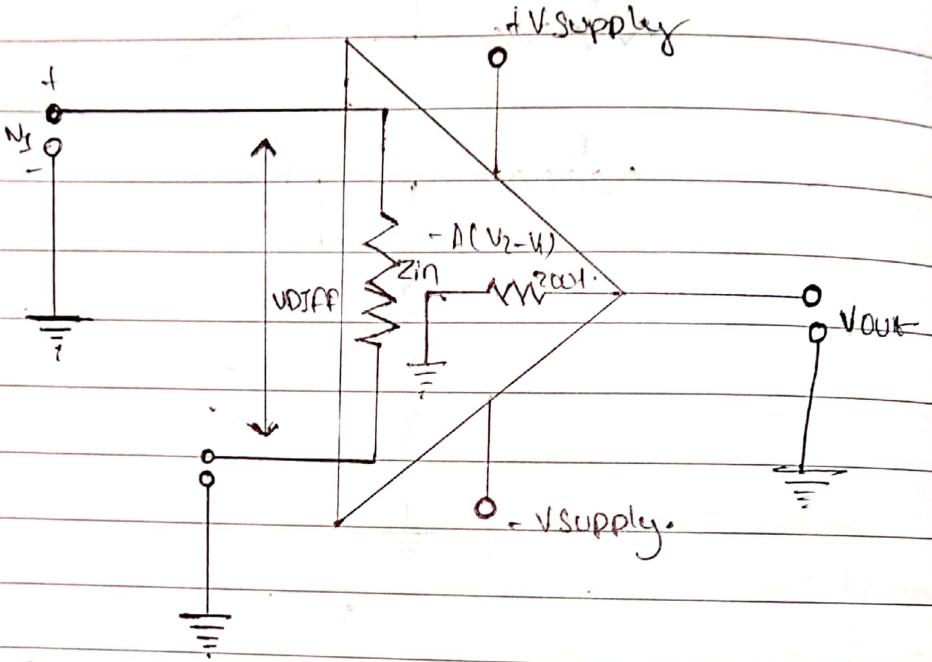


ii) Additional Amplifier :-

The additional amplifier is usally part of a separate device, a receiver, that allows the user to switch between the audio signals of home entertaiment equipment such as televisions, cable boxes are games consoles.

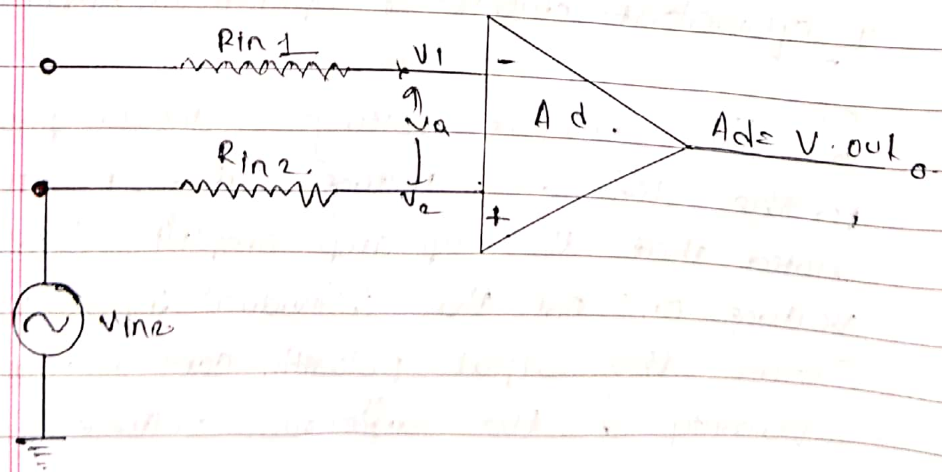
Equivalent circuit of Operational Amplifier :-

(a) The output voltage is directly proportional to the difference voltage Vd. It is to be noted that the Op-amp amplifies difference voltage and not the individual input voltages. Thus the output polarity gets decided by the polarity of the difference voltage Vd.



Open loop OP-Amp Configuration :

The basic Op-amp construction is of a 3-terminal device, with 2-inputs and 1-output. An Operational Amplifier operates from either a dual positive and an corresponding negative supply, or they can operate from a ~~cirle~~ Single DC supply voltage.



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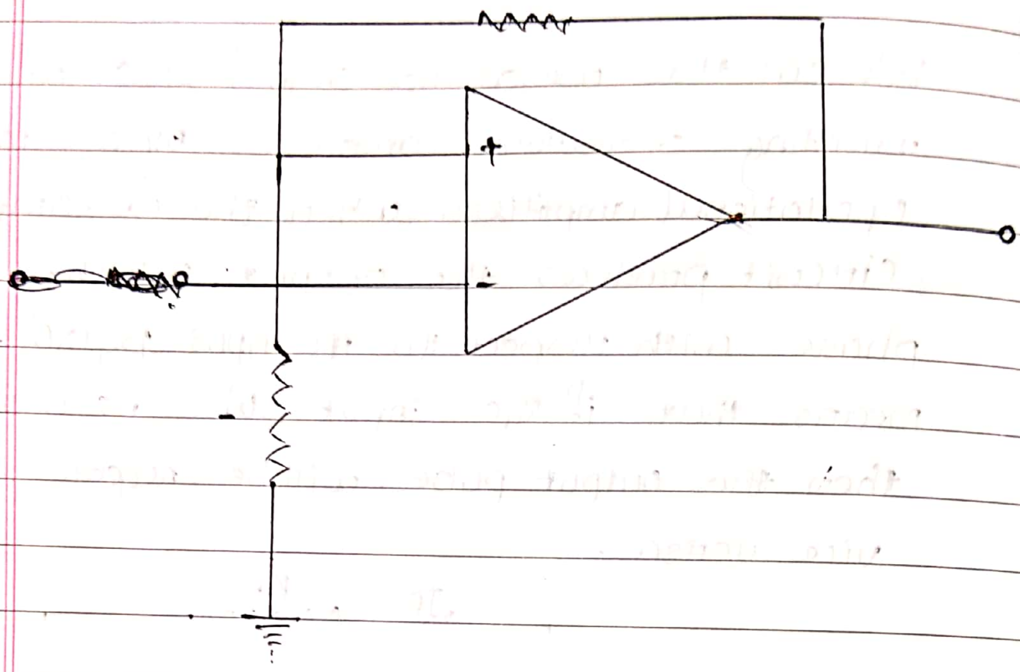
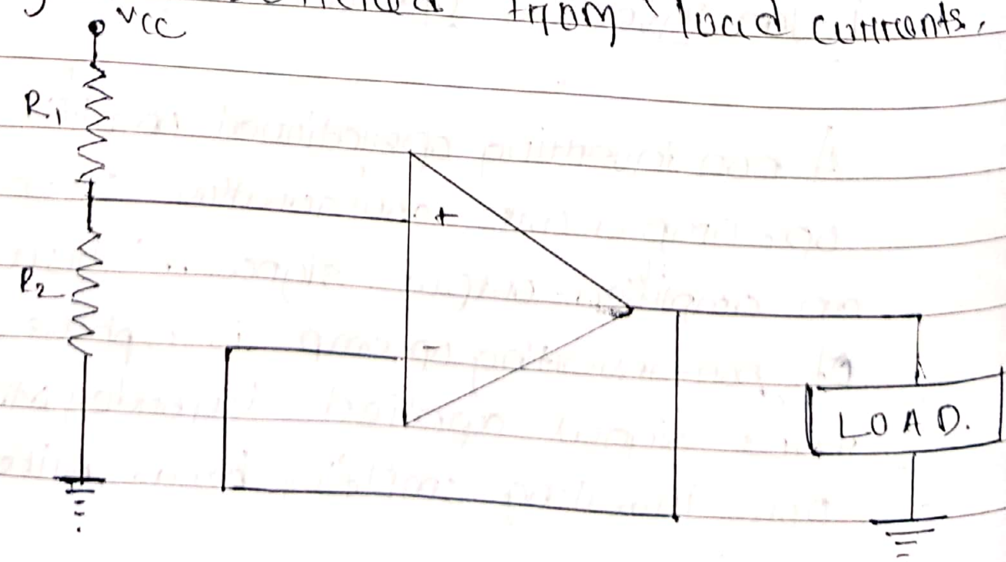
voltage Follower circuit.



Voltage follower and buffer:—

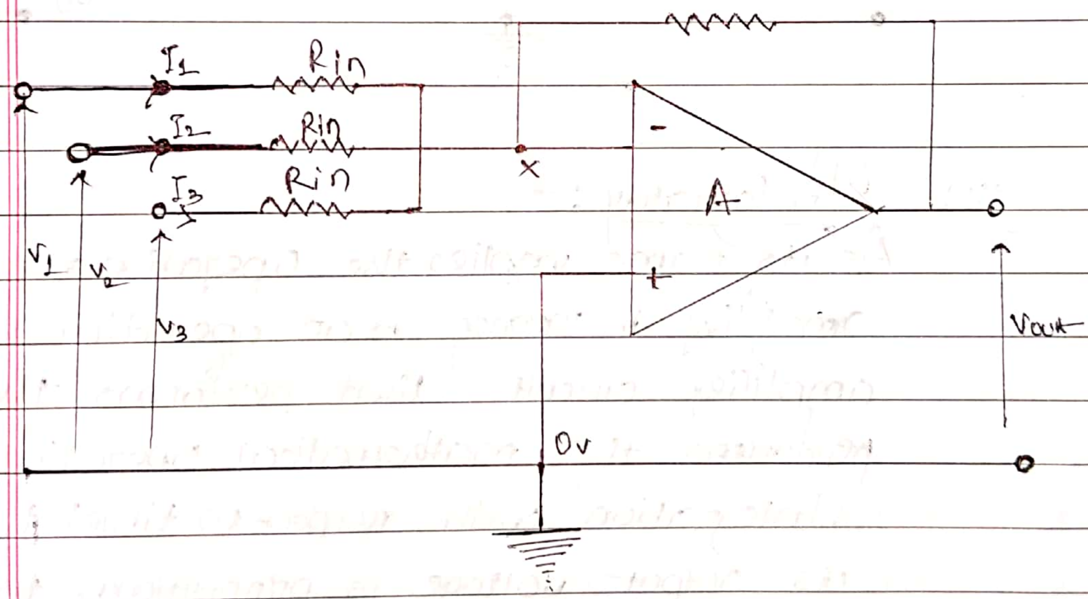
A buffer amplifier is ~~one~~ that provides electrical impedence transformation from one circuit to another with the aim of preventing the signal source from ~~the~~ being affected by whatever currents that the load may be produced with. The signal is buffered from load currents.



Differential amplifiers :-

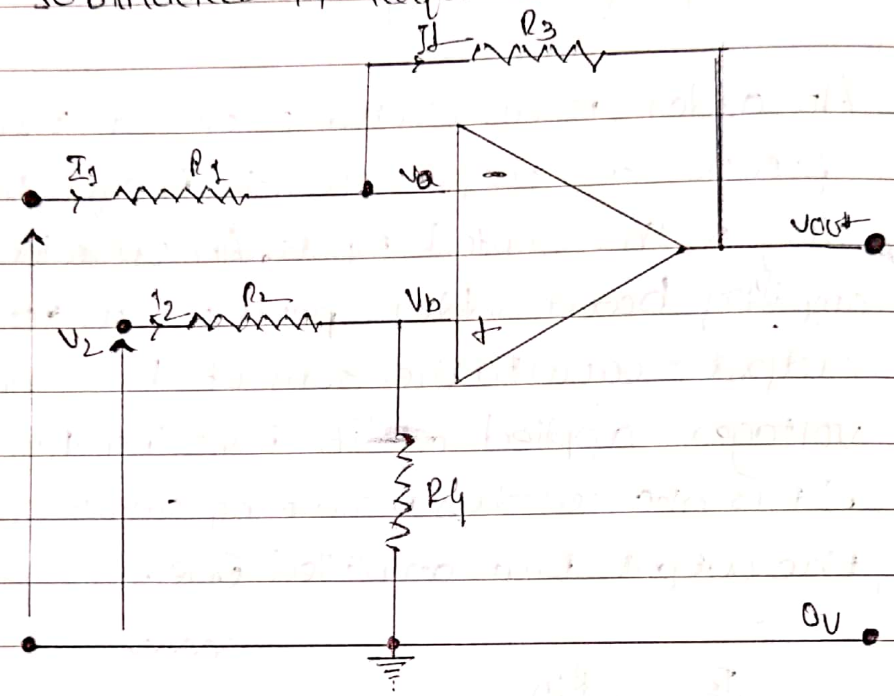
(1) Adder or Summing Amplifier :-

An adder is an electronic circuit that produces an output, which is equal to the sum of the applied inputs. An operational amplifier based adder produces an ~~account~~ output equal to the sum of the input voltages applied at its inverting terminal. It is also called as a summing amplifier, since the output is an amplified one.



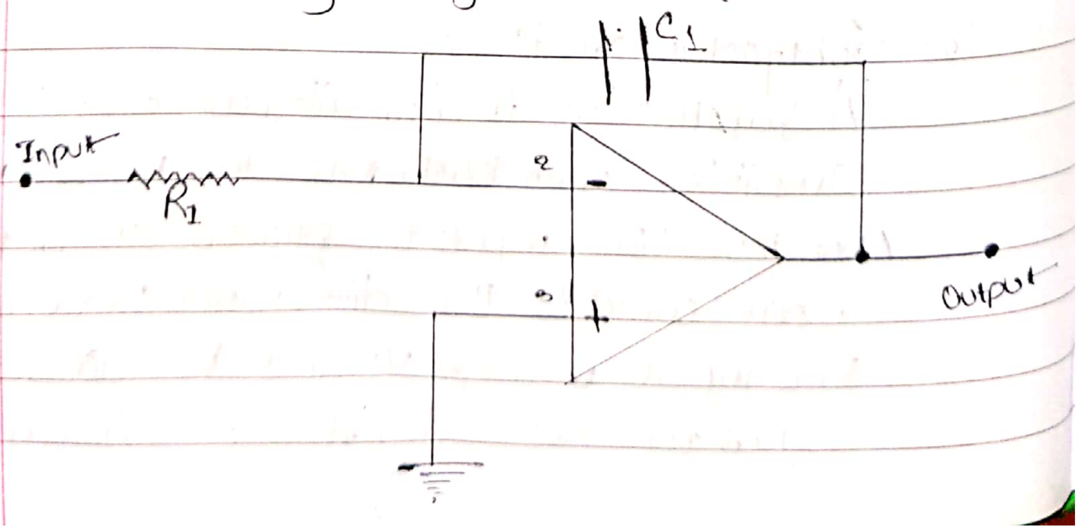
(2) Subtractor amplifier :-

A subtractor is also called as a differential amplifier, uses both the inverting and non inverting inputs to produce an output signal which is the difference between the two input voltages V1 and V_2 allowing one signal to be subtracted from another. More inputs can be added to be subtracted if required.



iii) Integrator :-

As its name implies the Operational amplifier integrator is an operational amplifier circuit that performs the performs the mathematical operation of Integration with respect to time; that is its output voltage is proportional to the input voltage integrated over time.



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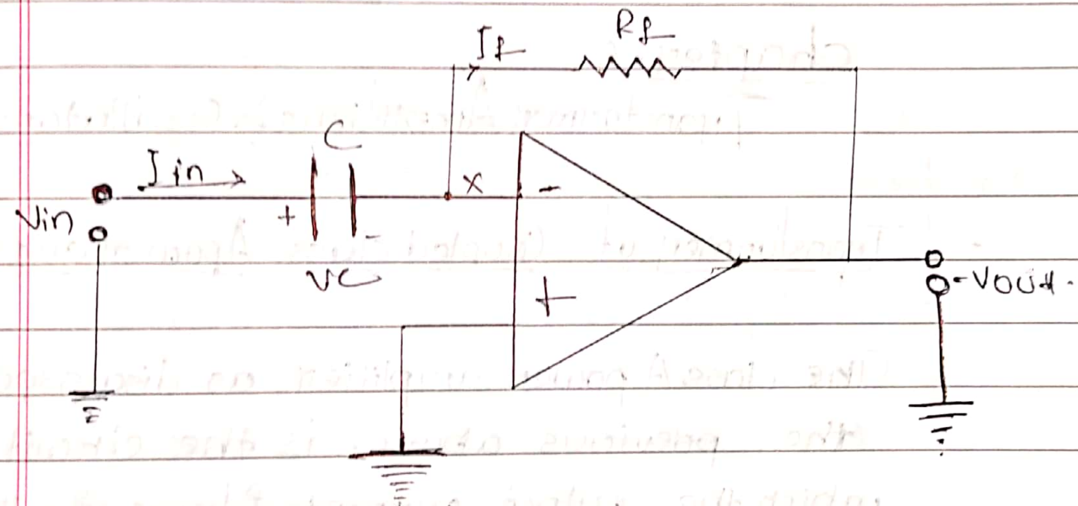
iv) Differentiator:

This operational amplifier circuit performs the mathematical operation of Differentiation, that is it "produces a voltage output which is directly proportional to the input voltage's rate of change with respect to time."... At higher frequencies the reactance of the higher frequencies the reactance of capacitor is much.



v) Comparator Amplifier:- The comparator is an electronic decision making circuit that makes use of an operational amplifiers very high gain in its open loop state, that is, there is no feedback resistor. In other words, the operational Amplifier voltage comparator compares the magnitudes of two voltage inputs and determines which is the largest of the two.

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