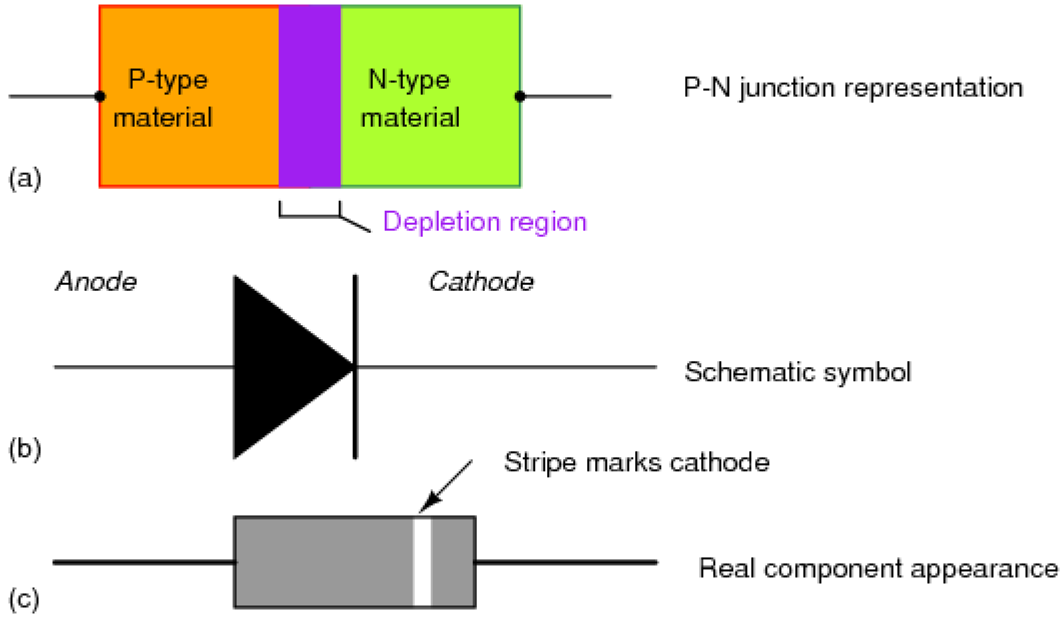
# PN-JUNCTION

## PN-JUNCTION :

*When a p-type & n-type material are suitably joined the contact region is called pn-junction.

*PN-junction is very important for manufacturing different electronic devices , like rectifier, LED, Zener diode.

* Structure :




## PROPERTIES OF PN-JUNCTION :

***Structure o**f p-type & n-type separately :

* The p-type material has majority holes & minority free electrons .Each hole is associated by a –ve ion. Similarly the n-type material has majority free electrons & minority holes. Each free electrons is associated by +ve ion.

*When this p-type & n-type material are joined to form pn-junction, at the junction the +ve hole on p-side & the –ve free electron on n-side attract each other & cancel after combination.Due to this combination a net –ve charge develops on p-side & net +ve charge develops on n-side near the junction. The net –ve charge on p-side develops due to –ve ions & the net +ve  charge on n-side due to +ve ion.

* Due to charge difference across the junction a potential exist across the junction.When this potential is greater than 0.2V it opposes further diffusion of free electrons from n-side to p-side & holes from p-side to n-side.This potential is called barrier potential.

*Due to barrier potential, there is no movement of charge carrier across the junction & no current flow through the pn-junction. The pn-junction is said to be non-conducting.

*Figure shows the characteristic of pn-junction :

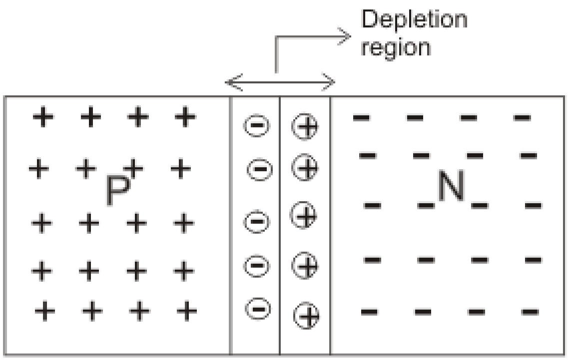
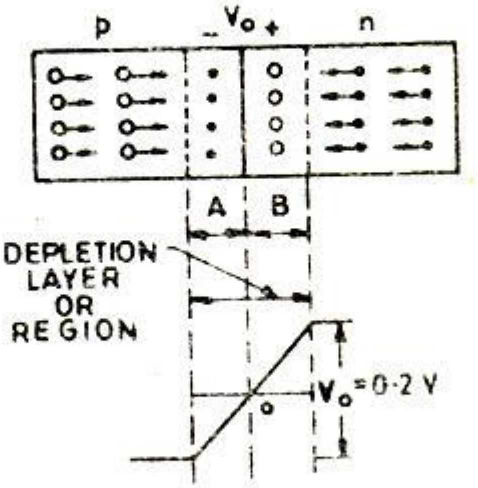


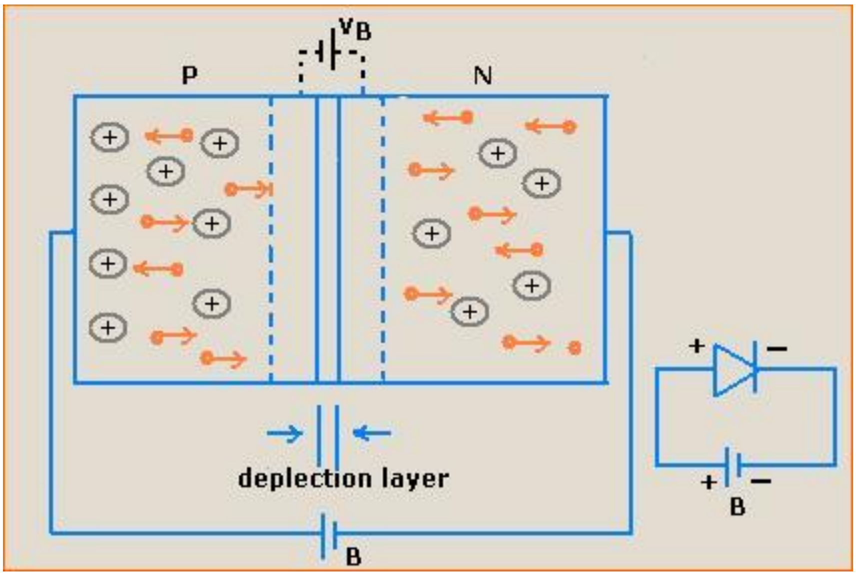

Figure. P-N junction showing depletion region



* The region across which barrier potential exist is called depletion layer, because this layer is depleted of charge carrier.

**WORKING PRINCIPLE OF PN_JUNCTION :**

* For proper operation of pn-junction an external supply should be used. The external supply magnitude should be greater than barrier potential & applied in forward condition i.e. +ve terminal is connected to p-type & -ve to n-type as shown in figure below :




*If there is no external voltage applied across the pn-junction, a barrier potential exists across the junction & due to this the pn-junction is not conducting & current through pn-junction is zero.

*When external voltage is applied, the majority holes in p-type are repelled by the +ve terminal of the source & free electrons in n-type are repelled by the –ve terminal of the sources. As an result both free electrons & holes move towards the junction & cancels barrier potential. This movement produces current flow through the pn-junction.

*It is clear from the figure that current flow inside the pn-junction is due to two types of charge carrier, i.e. free electrons & holes, but outside the junction current is due to only free electrons.

**BIASING OF PN_JUNCTION :**

*The process of applying external voltage across the pn-junction is called biasing.

*Types of biasing :

a) Zero bias

b) Forward bias

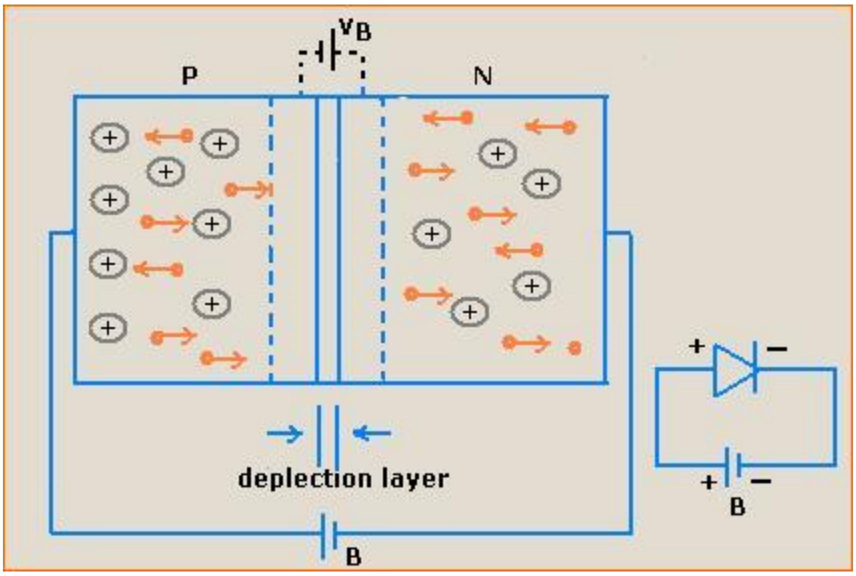
c) Reverse bias

***ZERO BIAS:** The pn-junction without any external supply is called zero bias. Under this condition the pn-junction is not conducting due to existence of barrier potential.

***FORWARD BIAS :**

> If p-type material is connected to +ve & n-type to –ve of external supply, yhe pn-junction is said to be forward bias.

> FIGURE :




>Due to forward biasing the +ve terminal of external supply repels the holes towards the junction. Similarly the majority free electrons in n-region repelled by the –ve terminal of the supply. As a result there is a continuous movement of free electrons & holes across the junction. The pn-junction is now conducting.

>It is clear from the figure that current inside the pn-junction is due to two types of charge carriers, that is free electrons & holes, but out side the junction current is due to only free electrons.

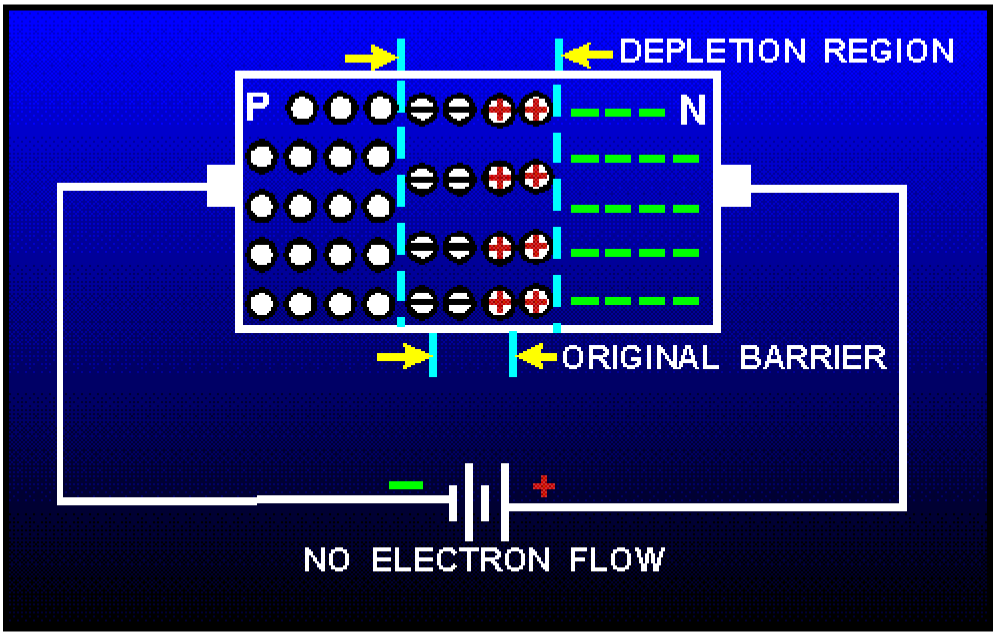
>Due to forward biasing the barrier potential is eliminated. Depletion width decreases.

>Due to forward biasing resistance of pn-junction decreases & conductivity increases.

*** REVERSE BIASING :**

> When p-type is connected to –ve & n-type to +ve of external supply the pn-junction is said to be reverse biased.

>Figure :




>Under reverse biased condition the majority holes of p-type are attracted by -ve terminal of the supply & majority free electrons of n-type are attracted by +ve terminal of supply. As a result the majority free electrons & holes are moving away from the junction. No majority carriers cross the junction. The PN-junction is said to not conducting & no current flow through the pn-junction.

>due to minority carrier very small current , in the range of micro ampere flows across the pn-junction. This small minority current sometimes assumed as approximately zero.

> Due to reverse biasing the resistance of pn-junction increases & conductivity decreases to very small value.

> Due to reverse biasing depletion width increases. The barrier potential actsin the same direction as the external supply . Hence it can not be cancelled.

**<u>V~I CHARACTERISTIC OF PN-JUNCTION :</u>**

* The graph which shows the relation between voltage applied across a pn-junction & current flowing through it is called V~I characteristic.

* Two types of V~I characteristic :

a)Forward V~I characteristic

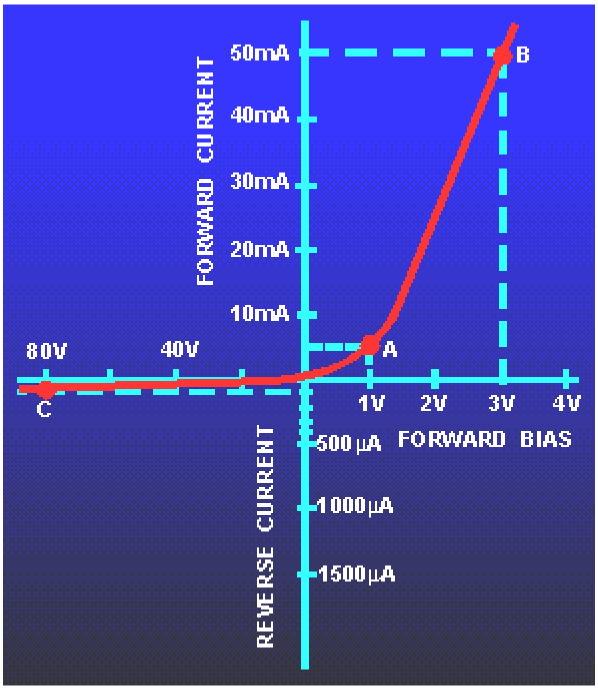
b)Reverse  V~I characteristic

**<u>*Forward V~I Characteristic :</u>**

> The characteristic under forward bias condition of pn-junction is called forward characteristic.

>By changing the position of variable resistor R number of readings are taken from voltmeter & ammeter. All readings are plotted on a graph paper & the resulting graph is called forward V~I characteristic.

>Graph:




>When the voltage across the pn-junction is zero, no current flows. If we increase the voltage across pn-junction in forward direction, at first current increases very slowly with voltage, but after certain voltage, current increases very rapidly with voltage. This voltage is called Knee voltage.

>Below Knee voltage current is very small due to barrier potential, because supply voltage is trying to cancel the barrier potential. But  after knee voltage, barrier potential completely cancelled & current rises very rapidly.

**<u>*REVERSE CHARACTERISTIC:</u>**

>The characteristic under reverse condition of pn-junction is called reverse characteristic.

>The characteristic can be drawn by taking readings for different position of variable resistor.

>Graph:

>If the voltage increases from zero to onwards in –ve direction, at first current rises very slowly with voltage. This process continues upto a certain voltage known as avalanche breakdown voltage $V_{B.}$

>At VB current suddenly increases to a very high value.

>Above break down voltage if voltage across pn-junction increases further, then it has no effectover the current .

At break down voltage the pn-junction may burnt due to excess heat.

**<u>*Complete V~I Characteristic:</u>**

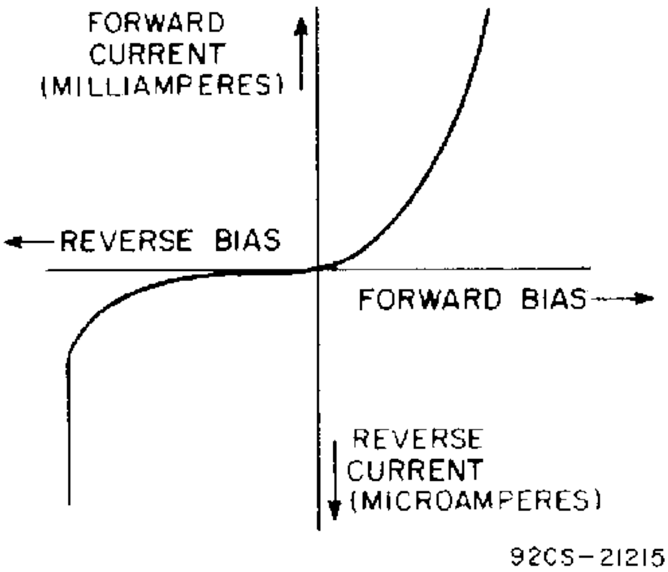



*Fig. 8—Voltage-current characteristic for a p-n junction.*

# TRANSISTOR

## *TRANSISTOR:

>The electronic device in which a dissimilar type of semiconductor material is sandwiched between two similar type of semiconductor is called transistor.

>In this either a p-type is sandwiched between two n-type or an n-type is sandwiched between two p-type material.

>Transistor consists of two words: trans & istor. Trans means the signal transfer property of the device & istor means resistor property of the device.

>A transistor transfers a signal from a low resistance to high resistance.

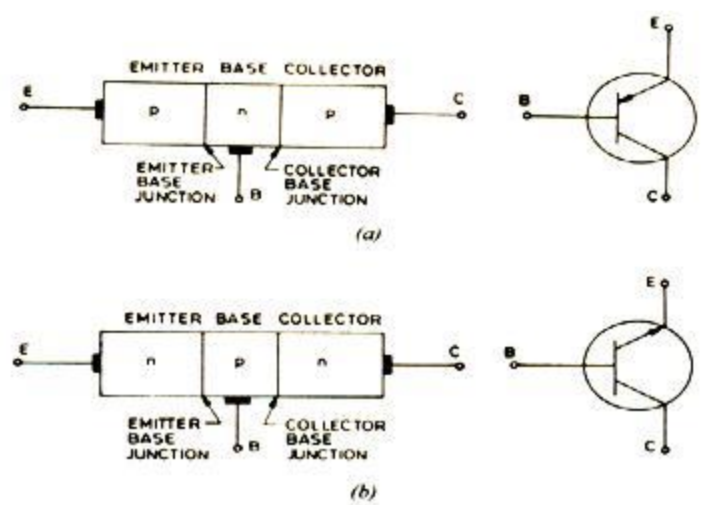
>**TYPES OF TRANSISTOR:**

There are two types of transistors:

a)n-p-n transistor

b)p-n-p transistor

>Structure & Symbol:



>It has three terminals, one taken from each type of semiconductor. The terminals are named as base(B), emitter(E), collector(C).

>It has two pn-junction & three semiconductor layers.

TERMINALS OF TRANSISTOR:

It has three terminals, named as base, emitter & collector. The two end terminals are known as emitter(E) & collector(C), middle is called as base.

>Emitter:

a)This layer provides charge carriers.

b)It is always forward biased w.r.t. base.

c) It is wider than base.

d)It is heavily doped. Hence it provides large numbers of charge carriers into base.

>Base:

a)This layer controls the amount of charge carrier flow from emitter to collector.

b)It is forward connected w.r.t. emitter & reverse biased w.r.t. collector.

c)It is much thinner than emitter.

d)It is lightly dopped. Hence it passes most of the charge carriers coming from emitter to collector.

>Collector:

a)This layer removes charges from its junction with the base.

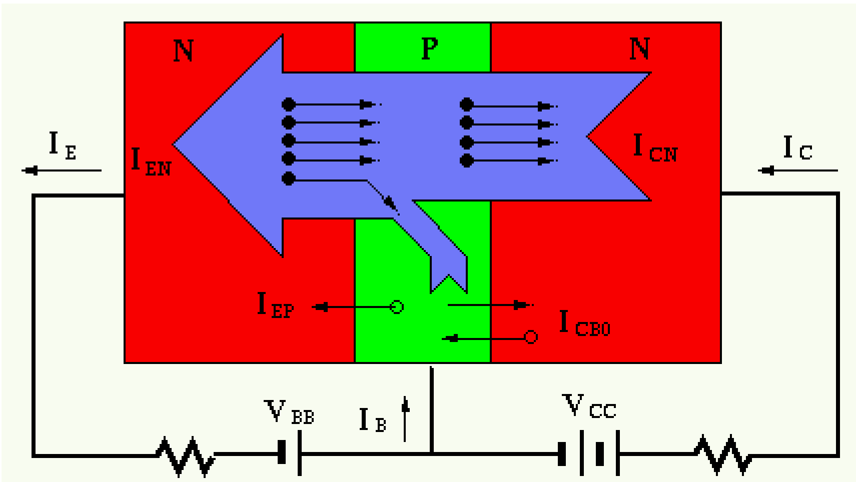
b)It is reverse biased w.r.t. base.

c)It is wider than emitter & base.

d)It is moderately doped.

**WORKING PRINCIPLE OF NPN TRANSISTOR:**

*Figure shows the circuit for showing the working principle.




*For proper operation of transistor, base emitter junction is forward biased by $V_{EE}$ & base-collector is reverse biased by $V_{CC}$.

*The n-type emitter has majority free electrons. The forward bias on emitter, causes the free electrons in the n-type emitter to flow towards the base.This constitutes the emitter current $I_E$.

*When the free electrons flows through p-type base, they try to combine with majority holes in base resion. Since the base is lightly doped & very thin, only a few electrons combine with holes & constitute base current $I_B$.

*The remaining free electrons flows towards the collector attracted by strong positive terminal of the biasing supply $+V_{cc}$. This constitute the collector current $I_C$.

*It is clear that almost the entire emitter current flows in the collector circuit. Hence emitter current is the sum of collector & base current i.e.

$$I_E=I_B+I_C$$

*The current conduction within the transistor is due to free electrons & also through the external circuit is due to free electrons.

*For proper operation of transistor, base emitter junction is forward biased by $V_{EE}$ & base-collector is reverse biased by $V_{CC}$.

*The p-type emitter has majority holes. The forward bias on emitter, causes the holes in the p-type emitter to flow towards the base.This constitutes the emitter current $I_E$.

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*The remaining holes flows towards the collector attracted by strong negative terminal of the biasing supply $-V_{cc}$. This constitute the collector current $I_C$.

*It is clear that almost the entire emitter current flows in the collector circuit. Hence emitter current is the sum of collector & base current i.e.

$$I_E=I_B+I_C$$

*The current conduction within the transistor is due to holes & through the external circuit is due to free electrons.

TRANSISTOR CONNECTION:

There are three types of connections:

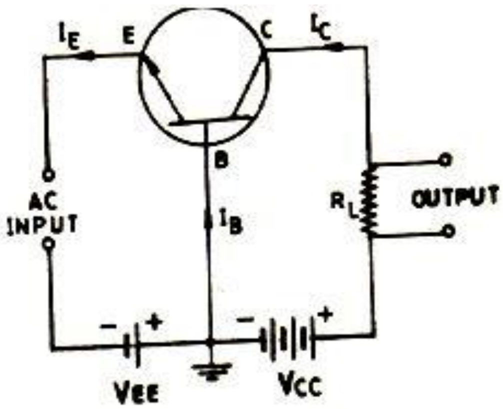
a) Common- Base Connection(CB)
b) Common-Emitter Connection(CE)
c) Common-Collector Connection(CC)

**COMMON-BASE CONNECTION:**

* The transistor connection in which base is common for both input & output circuit is called common-base connection.

*In this input is applied between emitter & base & output is taken from collector & base.

*Circuit Diagram:



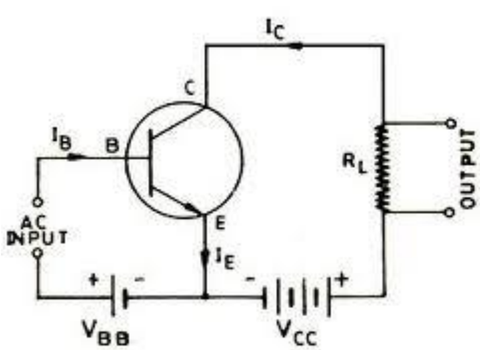

*D.C. supply $V_{EE}$ provides forward biasing & $V_{cc}$ provides reverse biasing.

**COMMON-EMITTER CONNECTION**

* The transistor connection in which emitter is common for both input & output circuit is called common-emitter connection.

*In this input is applied between emitter & base & output is taken from collector & emitter.

*Circuit Diagram:



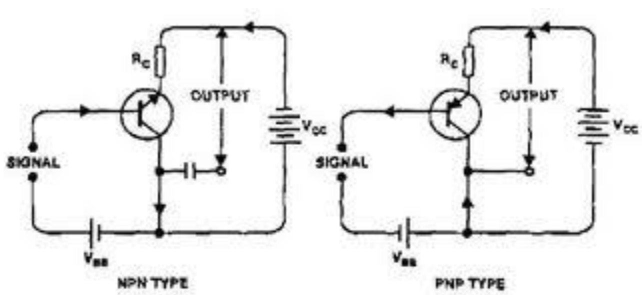
*D.C. supply $V_{BB}$ provides forward biasing & $V_{cc}$ provides reverse biasing.

**COMMON-COLLECTOR CONNECTION:**

* The transistor connection in which collector is common for both input & output circuit is called common-collector connection.

*In this input is applied between base & collector & output is taken from collector & emitter.

*Circuit Diagram:




*D.C. supply $V_{BB}$ provides forward biasing across base to collector & $V_{cc}$ provides reverse biasing across emitter to collector.

**CURRENT AMPLIFICATION FACTOR IN COMMON BASE CONNECTION(α):**

*The ratio between change in collector current to change in emitter current at constant collector to base voltage $V_{CB}$ is called current amplification factor α.

*Mathematically, $\alpha=\Delta I_C/\Delta I_E$ at constant $V_{CB}$

*Its value is less than unity. Practical values of α ranges from 0.9 to 0.99.

**CURRENT AMPLIFICATION FACTOR IN COMMON EMITTER (β):**

*The ratio between change in collector current to change in base current at constant collector to emitter voltage $V_{CE}$ is called current amplification factor β.

*Mathematically, $\beta=\Delta I_C/\Delta I_B$ at constant $V_{CE}$

*Its value is greater than 20. Practical values of β ranges from 20 to 500.

**CURRENT AMPLIFICATION FACTOR IN COMMON COLLECTOR(Y)**

*The ratio between change in emitter current to change in base current at constant collector to emitter voltage $V_{CE}$ is called current amplification factor β.

*Mathematically, Y =$\Delta I_E/\Delta I_B$ at constant $V_{CE}$

*Its value is greater than 20. Practical values of β ranges from 20 to 500 i.e. same as common emitter value.

RELATION BETWEEN α & β:

We know $\beta=\Delta I_C /\Delta I_B$ ………….(1)

$\alpha=\Delta I_C/\Delta I_E$ ……………(2)

$I_E=I_B+I_C$

$\Delta I_E=\Delta I_B+\Delta I_C$

Hence $\Delta I_B=\Delta I_E-\Delta I_C$

Substituting the values of $\Delta I_B$ in equation (1), we get,

$\beta=\Delta I_C / \Delta I_E-\Delta I_C$ …………….(3)

Dividing both numerator & denominator by $\Delta I_E$ of R.H.S. in eqn.(3),

$\beta=(\Delta I_C/ \Delta I_E)/ (\Delta I_E/ \Delta I_E)-(\Delta I_C/ \Delta I_E)=\alpha/(1-\alpha)$

$\beta=\alpha/1-\alpha$

**RELATION BETWEEN Y & α:**

We know

Y =$\Delta I_E/\Delta I_B$ ………(4)

$\alpha=\Delta I_C/\Delta I_E$ ………(5)

$\Delta I_E=\Delta I_B+\Delta I_C$

Hence $\Delta I_B=\Delta I_E-\Delta I_C$

Substituting the value of $\Delta I_B$ in eqn. (4),

Y =$\Delta I_E/\Delta I_B= \Delta I_E/ \Delta I_E-\Delta I_C$ ………..(6)

Dividing both numerator & denominator by $\Delta I_E$ of eqn. (6),

$Y = \Delta I_E/\Delta I_B = (\Delta I_E/ \Delta I_E )/( \Delta I_E/ \Delta I_E )-(\Delta I_C /\Delta I_E)=1/1-\alpha$

$Y = 1/1-\alpha$

**RELATION BETWEEN α, β & Y:**

We know

$\alpha=\Delta I_C/\Delta I_E$ ……..(7)

$\beta=\Delta I_C /\Delta I_B$ …………(8)

$Y =\Delta I_E/\Delta I_B$ …………(9)

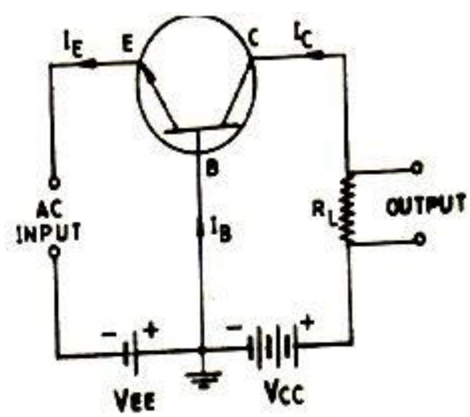
Multiplying $\Delta I_E / \Delta I_E$ in R.H.S. of eqn. (8),

$\beta=(\Delta I_C /\Delta I_B )x (\Delta I_E/ \Delta I_E)= (\Delta I_C /\Delta I_E )x (\Delta I_E/ \Delta I_B)=\alpha .Y$

$\beta= \alpha .Y$

**COMMON BASE TRANSISTOR AMPLIFIER:**

*Circuit diagram:




*Circuit Details:

It consists of transistor Q, load resistor $R_l$ , biasing supply $V_{EE}$ & $V_{CC}$.

Transistor Q used for amplification. Amplified output develops across load resistor Rl.

$V_{EE}$ provides proper forward biasing across emitter to base.

$V_{CC}$ provides proper reverse biasing across collector to base.

Vi is the input supply to be amplified.

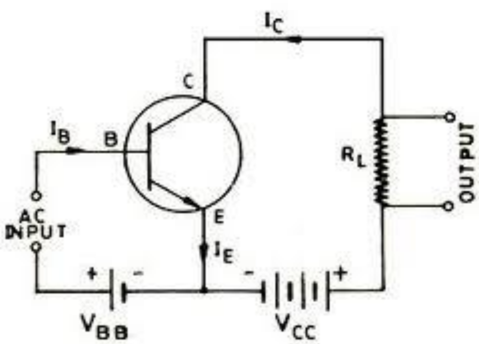
Vo is the amplified output.

*Circuit operation:

When the input signal to be amplified is applied across the emitter to base, for a small change in input we get a large change in output current. This large change in current when flows through a high load resistance Rl, produces a large voltage drop across Rl. Now if we compare the input voltage & output voltage, output is more than the input. In this way we get amplified output.

**COMMON EMITTER AMPLIFIER:**

*Circuit diagram:




*Circuit details:

It consists of transistor Q, load resistor $R_l$ , biasing supply $V_{BB}$ & $V_{CC}$.

Transistor Q used for amplification. Amplified output develops across load resistor Rl.

$V_{BB}$ provides proper forward biasing across emitter to base.

$V_{CC}$ provides proper reverse biasing across collector toemitter.

$V_i$ is the input supply to be amplified.

$V_o$ is the amplified output.

*Operation:

1)During the positive half cycle of the input signal , forward bias across the emitter-base junction is increased. Hence more electrons flow from the emitter to the collector through the base. This causes an increase in collector current. The increased collector current when flows through a high load resistance $R_l$, produces high voltage drop.

2) During the negative half cycle of the input signal, the forward bias across emitter-base junction is decreased. Hence collector current decreases. This decreased collector current when flows through load resistance, produces decreased output voltage in opposite direction. Hence an amplified output is obtained across the load.

**V-I CHARACTERISTIC OF COMMON BASE TRANSISTOR CONNECTION:**

Two types of V-I characteristic,

a)Input V-I characteristic

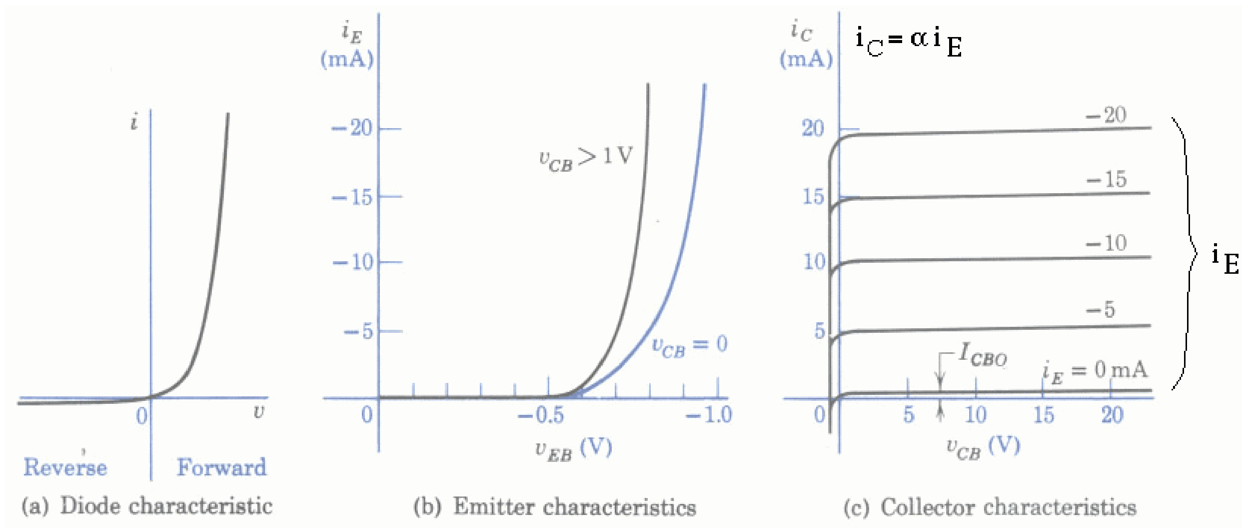
b)Output V-I characteristic

**INPUT V-I CHARACTERISTIC:**

*The graph which shows the relation between emitter current $I_E$ & emitter-base voltage $V_{EB}$ at constant collector-base voltage $V_{CB}$ is called input characteristic.

*$V_{EB}$ is taken along x-axis & $I_E$ is taken along y-axis.

*Graph:




*It is clear from the graph that , emitter current $I_E$ increases rapidly with small increase in emitter-base voltage $V_{EB}$.

*The emitter current is almost independent of collector-base voltage $V_{CB}$.

OUTPUT V-I CHARACTERISTIC OF CB:

*The graph which shows the relation between collector current $I_c$ & collector-base voltage $V_{CB}$ at constant emitter current $I_E$ is called output characteristic.

*$V_{CB}$ is taken along x-axis & $I_c$ is taken along y-axis.

*Graph:

*It is clear from the graph that,

a)Collector current $I_C$ varies with $V_{CB}$ only at very low voltage(<1V).

b)For $V_{CB}$ greater than 1V, collector current remains constant.

c)A very large change in collector-base voltage produces only a small change in collector current.

**V-I CHARACTERISTIC OF COMMON-EMITTER CONNECTION:**

There are two types of V-I characteristic:

1)Input V-I Characteristic

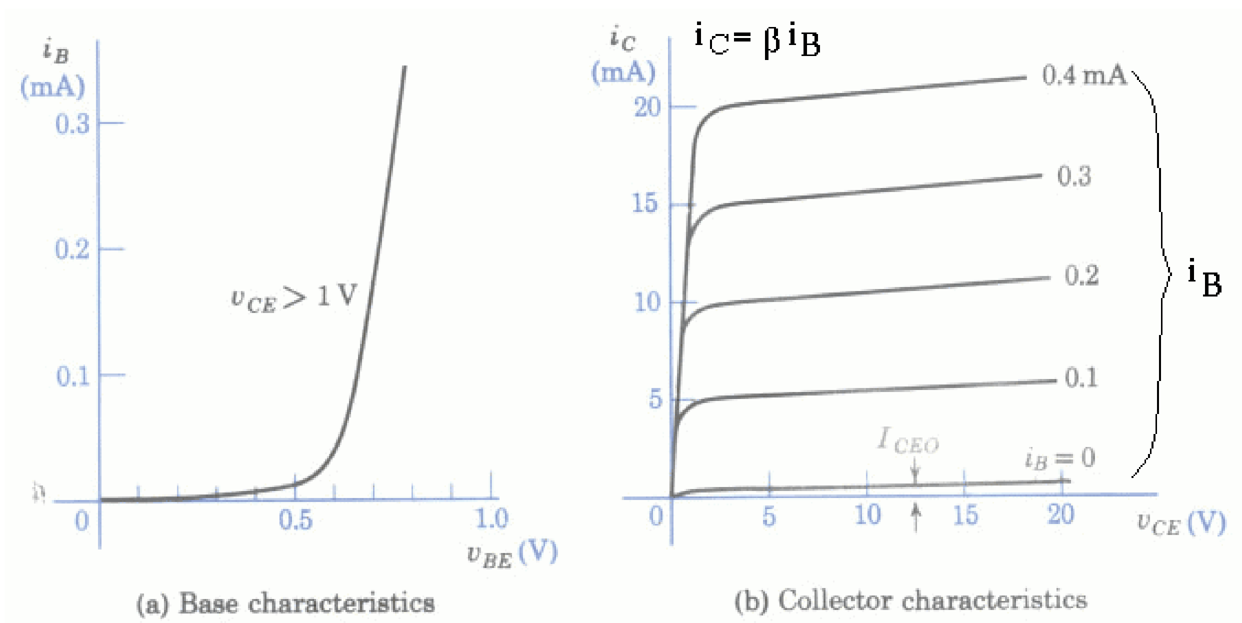
2)Output V-I characteristic

**INPUT V-I CHARACTERISTIC OF CE:**

*The graph which shows the relation between base current $I_B$ & base-emitter voltage $V_{BE}$ at constant collector emitter voltage $V_{CE}$ is called input characteristic.

*$V_{BE}$ is taken along x-axis & $I_B$ is taken along y-axis.

*Graph:




*It is clear from the graph that,

a)The characteristic is similar to characteristic of forward biased pn-junction.

b)At first current IB increases very slowly. After certain voltage known as knee voltage, the current increases rapidly.

OUTPUT V-I CHARACTERISTIC OF CE:

*The graph which shows the relation between collector current $I_c$ & collector-emitter voltage $V_{CE}$ at constant base current $I_B$ is called output characteristic.

*$V_{CE}$ is taken along x-axis & $I_c$ is taken along y-axis.

*Graph:

*It is clear from the graph that,

a)Collector current $I_C$ varies with $V_{CE}$ only at very low voltage(<1V).

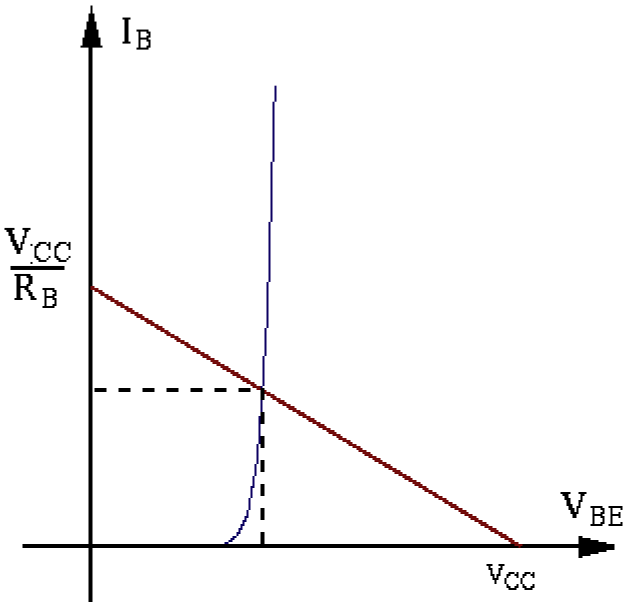
b)For $V_{CE}$ greater than 1V, collector current remains constant.

c)A very large change in collector-emitter voltage produces only a small change in collector current.

**TRANSISTOR DC LOAD LINE:**

*It is a method of measuring collector current IC for different values of collector-emitter voltage accurately.

*Circuit for getting dc load line:




*Appling output KVL:

$V_{CC}=V_{CE}+I_CR_C$

$V_{CE}=V_{CC}-I_CR_C$ ……..(10)

This equation is in the form of a straight line. Hence its graph is a straight line & can be drawn on output characteristics. The graph can be drawn as follows:

a)If IC=0, then equation (10) is: VCE=VCC

This forms the coordinate $(V_{CE},I_C)=(V_{CC},0)$.This point is indicated by the point A on $V_{CE}$ axis.

b)Putting $V_{CE}=0$ in eqn. (10):

$$0=V_{CC}-I_CR_C$$

i.e. $I_C=V_{CC}/R_C$

This forms the coordinate $(V_{CE},I_C)=(0,V_{CC}/R_C)$.This point is indicated by the point B on $I_C$ axis.

By joining the points A & B, the straight line AB is called dc load line.

**OPERATING POINT:**

*The zero signal values of collector current $I_C$ & collector –emitter voltage $V_{CE}$ is called operating point.

*The intersection of output V-I characteristic & dc load line is also called operating point.

*Also named as Q-point or quiescent point.

IMPORTANT SITUATIONS OF TRANSISTOR:

**a)CUT OFF:**

The point where the load line intersects the $I_B$=0 curve is known as cut off. The region below this point is called cut off region.

At cut off both input & output side is reverse biased & transistor action is lost.

**b)Saturation :**The point where the load line intersects the $I_B$=$I_B$(sat) curve is called saturation .The region above this is called saturation region.

At saturation both input & output side is forward biased & normal transistor action is lost.

**c)ACTIVE REGION:** The region between cut off & saturation is called active region. In this region input is forward biased & output is reverse biased. The transistor action is normal.

## TRANSISTOR BIASING

**Transistor biasing:**

*The proper flow of zero signal collector current & the maintenance of proper collector-emitter voltage during the passage of signal is called as transistor biasing.

*The purpose of biasing is to make base-emitter junction properly forward biased & collector-base junction reverse biased during the application of signal.

**STABILISATION:**

*The process of making operating point independent of temperature changes or variation in transistor parameters is known as stabilisation.

**NEED OF STABILISATION:**

Stabilisation of the operating point is necessary due to the following reasons:

a)Temperature dependence of IC.

b)Individual variations.

c)Thermal runaway.

**METHODS OF TRANSISTOR BIASING:**

a)Base resistor method

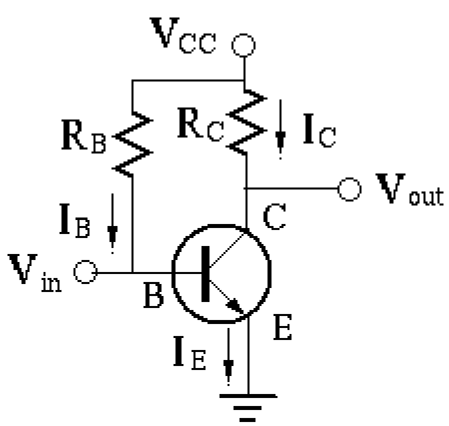
b)Emitter bias method

c)Feedback resistor method

d)Voltage divider bias method

**BASE RESISTOR METHOD:**

*Circuit diagram:




*Circuit detail:

In this method a high resistance $R_B$ is connected between the base & +ve end of supply for npn transistor & between base & negative end of supply for pnp transistor. This provides the input biasing.

$+V_{CC}$ is the biasing supply. $R_C$ is the collector load.

*Circuit Analysis:

The required zero signal base current is provided by $+V_{CC}$ & it flows through $R_B$. This makes base terminal positive & produces proper forward biasing across base –emitter junction. The proper zero signal base current $I_B$ & also collector current $I_C$ depends on proper value of base resistor $R_B$.

$I_C=\beta.I_B$

Applying input KVL,

$V_{CC}=I_BR_B+V_{BE}$

$R_B=(V_{CC}-V_{BE})/I_B$

**Advantages:**

1-The circuit is very simple.

2-Requirs simple calculations.

3-There is no loading of the source, because no resistor is employed across base-emitter junction.

**Disadvantages:**

1-This method provides poor stabilization.

2-This method isles stable.

3-There is a chance of thermal runway.

**EMITTER BIASING:**

*Circuit diagram:

*Circuit detail:

In this method a high resistance $R_B$ is connected between the base & +ve end of supply for npn transistor & between base & negative end of supply for pnp transistor. This provides the input biasing.

$+V_{CC}$ is the biasing supply. $R_C$ is the collector load. $R_E$ is the emitter resistor & it provides stabilisation.

Circuit analysis:

The required zero signal base current is provided by $+V_{CC}$ & it flows through $R_B$. This makes base terminal positive & produces proper forward biasing across base –emitter junction. The proper zero signal base current $I_B$ & also collector current $I_C$ depends on proper value of base resistor $R_B$.

$I_C=\beta.I_B$

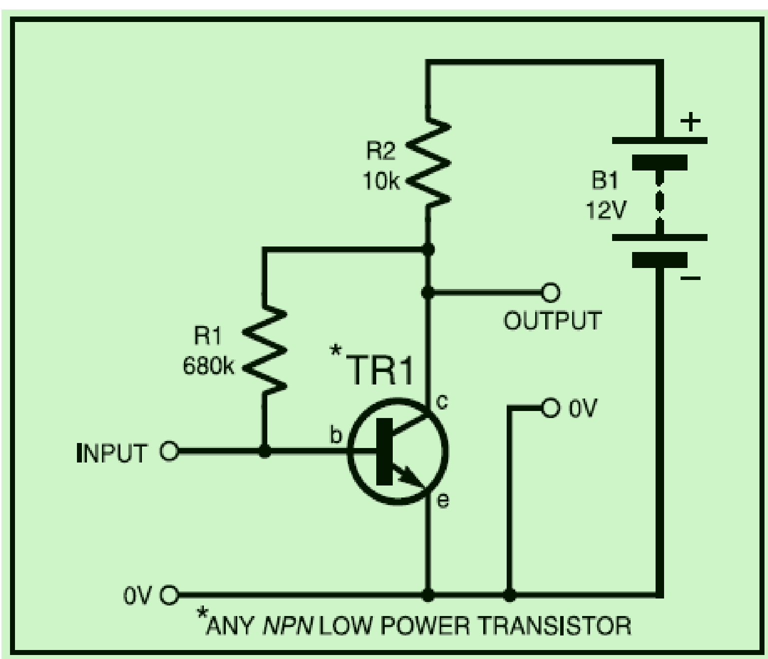
Applying input KVL,

$V_{CC}=I_BR_B+V_{BE}+I_ER_E= I_BR_B+V_{BE}+(\beta+1)I_BR_E= I_BR_B+V_{BE}+\beta I_BR_E$

$I_B=(V_{CC}-V_{BE})/R_B+R_E$

**FEEDBACK RESISTOR METHOD:**

*Circuit diagram:




*Circuit Details:

In this method a high resistance $R_B$ is connected between the base & collector of transistor. This provides the input biasing.

$+V_{CC}$ is the biasing supply. $R_C$ is the collector load.

*Circuit analysis:

The required zero signal base current is provided by collector-base voltage $V_{CB}$ but not by $+V_{CC}$ & it flows through $R_B$. This makes base terminal positive & produces proper forward biasing across base –emitter junction. The proper zero signal base current $I_B$ & also collector current $I_C$ depends on proper value of base resistor $R_B$.

$I_C=\beta.I_B$

Applying input KVL,

$V_{CC}=(I_C+I_B)R_C+I_BR_B+V_{BE}$

$R_B=(V_{CC}-V_{BE-I}I_CR_C)/I_B$

**ADVANTAGES:**

1-It is a simple method.

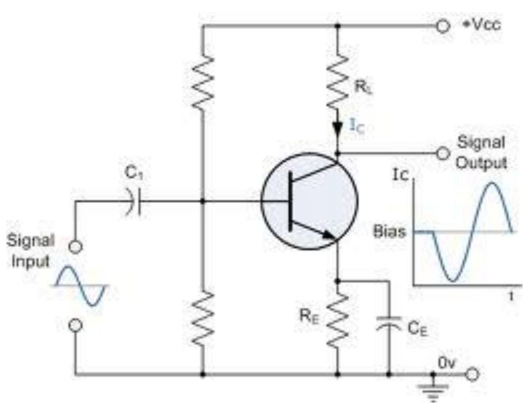
2-It provides better stabilization than fixed bias method.

**DISADVANTAGES:**
1-This circuit does not provide good stabilization.

2-It provides negative feedback which reduces the gain of amplifier.

**VOLTAGE DIVIDER METHOD OF BIASING:**

*Circuit diagram:




*Circuit details:

In this a single battery supply VCC is used to provide biasing to both input & output side. Resistor R1-R2 provides proper forward biasing to base. Biasing supply VCC provides directly biasing to collector. Emitter resistance RE used for biasing & stabilization. Emitter bypass capacitor CE bypasses the a.c. component of emitter current.

*Circuit analysis:

In this $V_2= (V_{CC}/R_1+R_2)x\ R_2$

$V_{BE}= V_2-I_ER_E$

$I_E=V_2-V_{BE}/R_E$

$V_{CE}=V_{CC}-I_C(R_C+R_E)$

# OSCILATOR CIRCUITS

## SINUSOIDAL OSCILLATOR:

*An electronic device that generates sinusoidal oscillations of desired frequency is called as sinusoidal oscillator.

*It is also known as an energy converter. But can not create energy. It is known as dc to ac converter. Because it receives only dc biasing supply &changes it into ac energy of desired frequency.

*Frequency of oscillation depends upon the circuit constants of the device.

*It is used in different communication devices like radio, TV, computer & in different electronic devices.

## TYPES OF SINUSOIDAL OSCILLATIONS:

There are two types of oscillations:

a)Damped oscillations

b)Undamped oscillations

## DAMPED OSCILLATION:

*The electrical oscillations whose amplitude goes on decreasing with time is called damped oscillation.

*The system generating this type of oscillation has losses & no arrangement is provided to compensate the losses.

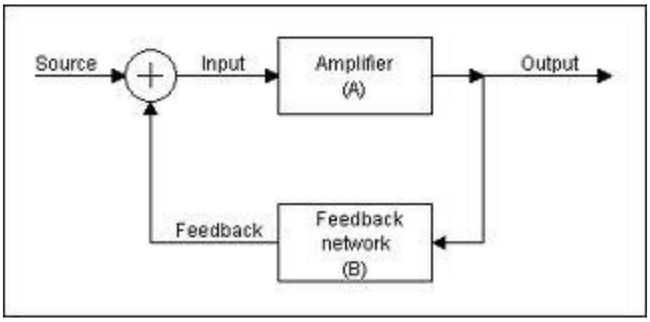
## UNDAMPED OSCILLATION:

The electrical oscillation whose amplitude remains constant with time is called undamped oscillation.

*The system generating this type of oscillation has losses but arrangement is done to overcome the losses.

## BLOCK DIAGRAM OF OSCILLATOR/ESSENTIALS OF OSCILLATORS:

*Figure shows the block diagram:




*It consists of three important sections.

a)Tank circuit

b)Transistor amplifier

c)Feedback circuit

**Tank circuit:**

It is a parallel LC circuit(L-inductor, C-Capacitor).The frequency of oscillation depends upon the value of inductor L & capacitor C. It produces the oscillations.

TRANSISTOR AMPLIFIERS:

It receives dc power from the biasing supply & changes it into ac power & supply this ac power to tank circuit. The oscillations produced in the tank circuit are applied to the input of the transistor amplifier & it is amplified by the amplifier.The amplified output is applied to the tank circuit to avoid the losses.

**FEEDBACK CIRCUIT:**

It supplies a part of collector energy to the tank circuit in correct phase to provide positive feedback.

**BARKHAUSEN CRITERION:**

*It states that for getting continuous undamped oscillation at the output of an amplifier, the positive feedback should be such that the loop gain mAv=1.

*Alternatively it states that sustained oscillation is possible, if the total phase shift associated with the oscillation while passing through amplifier, feedback circuit, & back to tank circuit is 00 or 3600.

## TYPES OF TRANSISTOR OSCILLATOR:

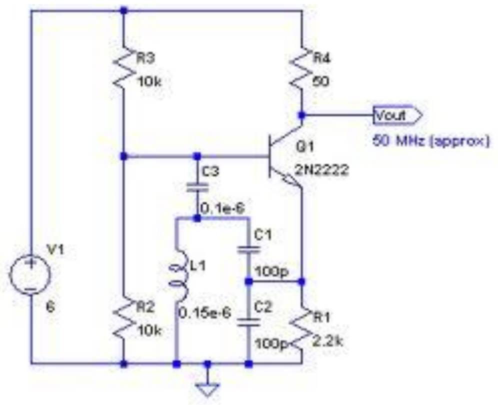
1)Tuned collector oscillator 4)Phase shift oscillator

2)Colpitt's oscillator 5)Wien bridge oscillator

3)Hartley Oscillator 6)Crystal oscillator

## COLPITT'S OSCILLATOR:

*Circuit diagram:




*Circuit Details:

It consists of tuned circuit, amplifier & feedback circuit.

CapacitorC1, C2 & inductor L constitute the tank circuit. Transistor Q, resistor R1, R2, RE, RC, capacitor C, CE, biasing supply +VCC constitute the amplifier. C1-C2-L is also the feedback circuit that produces a phase shift of 180 degree.

R1 & R2 provides biasing by voltage divider method. Capacitor C connected in base circuit provides low reactance path to the oscillations. The frequency of oscillation depends upon the value of C1, C2 & L & given by:

$$f=1/2\pi\sqrt{LC}$$

Where $C=C_1C_2/C_1+C_2$

*Circuit operation:

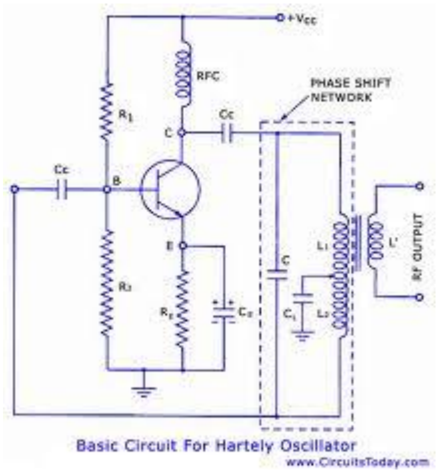
When the circuit is turned on, the capacitor $C_1$ & $C_2$ are charged. When the capacitors fully charged, they discharged through L. Due continuous charging & discharging, oscillations produce. This oscillations are simultaneously amplified by amplifier. The amplified output at collector develops across $C_1$. $C_1$-$C_2$ acts as a voltage divider. The voltage developed across C2 is the feedback voltage. The oscillator output is collected across L.

The voltage across $C_2$ is 180 degree out of phase with the voltage developed across $C_1$. Hence there is a !80 degree phase shift produced by $C_1$-$C_2$ voltage divider. Another 180 degree phase

Shift is provided by the transistor. Hence the total phase shift is 360 degree. This implies Barkhausen criterion is satisfied. Hence oscillation is possible.

## HARTLEY OSCILLATOR:

*Circuit diagram:




*Circuit details:

It consists of tuned circuit, amplifier & feedback circuit.

Capacitor C & inductor $L_1$ & $L_2$ constitute the tank circuit. Transistor Q, resistor $R_1$, $R_2$, $R_E$, RC, capacitor $C_c$, $C_E$, biasing supply +VCC constitute the amplifier. $L_1$-$L_2$-C is also the feedback circuit that produces a phase shift of 180 degree.

$R_1$ & $R_2$ provides biasing by voltage divider method. Capacitor Cc connected in base circuit provides low reactance path to the oscillations. The frequency of oscillation depends upon the value of $L_1$, $L_2$ & C & given by:

$$f=1/2\pi\sqrt{LC}$$

Where $L=L_1+L_2$

*Circuit operation;

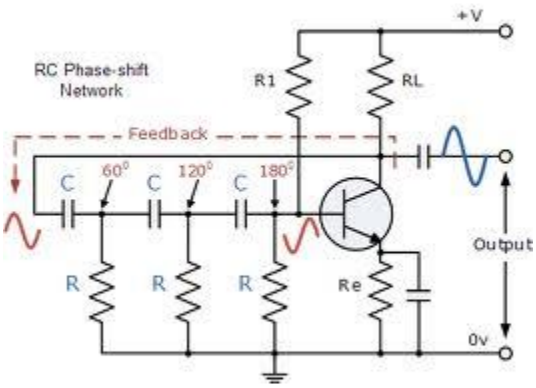
When the circuit is turned on, the capacitor C starts charging. When the capacitors fully charged, they discharged through $L_1$ & $L_2$. Due continuous charging & discharging, oscillations produce. This oscillations are simultaneously amplified by amplifier. The amplified output at collector develops across $L_1$. $L_1$-$L_2$ acts as a voltage divider. The voltage developed across L2 is the feedback voltage. The oscillator output is collected across $L_1$ or $L_2$.

The voltage across $L_2$ is 180 degree out of phase with the voltage developed across $L_1$. Hence there is a !80 degree phase shift produced by $L_1$-$L_2$ voltage divider. Another 180 degree phase

Shift is provided by the transistor. Hence the total phase shift is 360 degree. This implies Barkhausen criterion is satisfied. Hence oscillation is possible.

## PHASE SHIFT OSCILLATOR:

*Circuit diagram;




*Circuit details:

It is an RC oscillator used for generating very low frequencies.

It consists of an RC network which acts as tank circuit. This RC network consists of three identical RC sections, R1-C1, R2-C2, R3-C3.Each RC section provides a phase shift of 60 degrees & total phase shift is 180 degree. Basically, R1=R2=R3=R & C1=C2=C3=C.

The transistor Q acts as the amplifier. Resistor RB provides biasing in base resistor method.

RC is the collector load.

The frequency of oscillation depends upon the values of RC network & given by:

$f=1/2piRC\sqrt{6}$

*Circuit operation;

When the circuit is switched on, capacitors starts charging & discharging. This produces oscillations Vi. This oscillation is amplified by transistor Q. The amplified output Vo is feedback again to the RC network to recover the losses occurring in the circuit , so that undamped oscillation is produced.

Here 180 degree phase shift is provided by RC network. Another 180 degree phase shift is provided by transistor Q. Hence total phase shift is 360 degree. As a result Barkhausen criterion is satisfied & oscillation is possible.

**ADVANTAGES:**

1-It does not requires transformers or inductors.

2-It can provide very low frequency.

3-It provides good frequency stability.

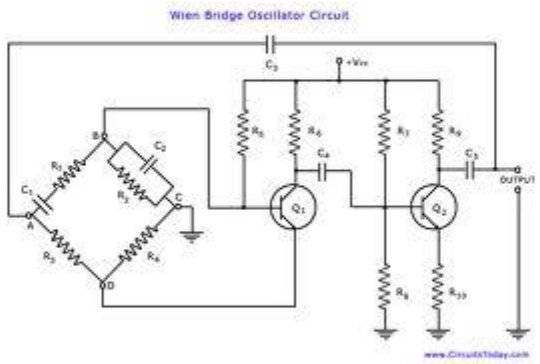
DISADVANTAGES:

1-It is difficult to produce oscillations , since the feedback is very small.

2-The circuit provides small output.

## WIEN BRIDGE OSCILLATOR:

*Circuit diagram:




*Circuit details:

It is an RC oscillator that can generate very low frequencies in the range of 10Hz to 1Mz.

It consists of a bridge network, two stage amplifier. R1-C1, R2-C2, R3, tungstain lamp Lp constitute the bridge. The branch R1-C1, R2-C2 produces oscillations. The resistance R3 & Lp are used to provide -ve feedback which stabilizes the amplitude of the output. The circuit uses both positive & negative feedback.

Positive feedback is provided through R1-C1, R2-C2 to transistor Q1. The negative feedback is through the voltage divider R3,Lp to input of transistor T2.Transistor T2 used to produce 180 degree phase shift for satisfying Barkhausen criterion.

*Operation:

When the circuit is switched on, due to charging & discharging of C1, C2 an oscillation produces by the bridge circuit. This oscillation is applied to the base of transistor T1 & it is amplified. The amplified output develops at the collector of T1 & it is further amplified by transistor T2. This output is again feedback to bridge circuit to recover the losses & undamped oscillation is possible.

The resistance of Lp increases with current.If the amplitude of output tends to increase, more current provides more negative feedback. As a result the output returns to original value. An opposite action occurs if the output decreases.

**ADVANTAGES:**

1-It provides constant output.

2-its speed of operation is high.

3-It provides mire gain.

**DISADVANTAGES:**

1-The circuit is complicated, since it requires more components.

2-It can not generates high frequencies.