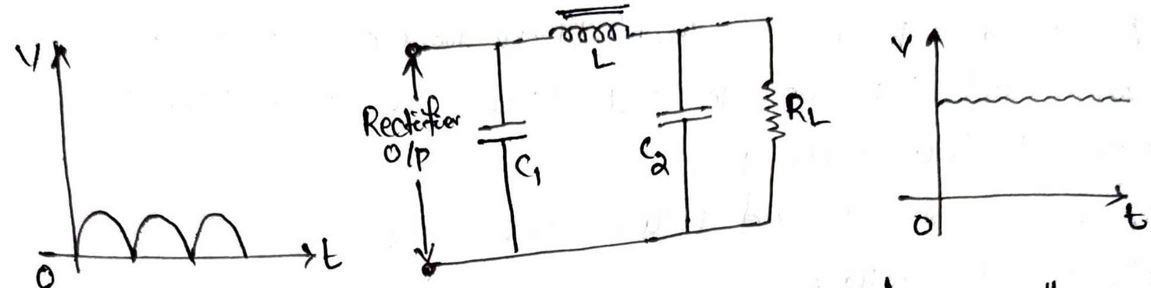
blocked by the capacitor to reach the load.

→ The dc output obtained at the load is more improved than the capacitor filter.

Capacitor input filter or π- filter



→ It consists of a filter capacitor C_1 connected across the rectifier output, a choke L in series and another filter capacitor C_2 connected across the load.

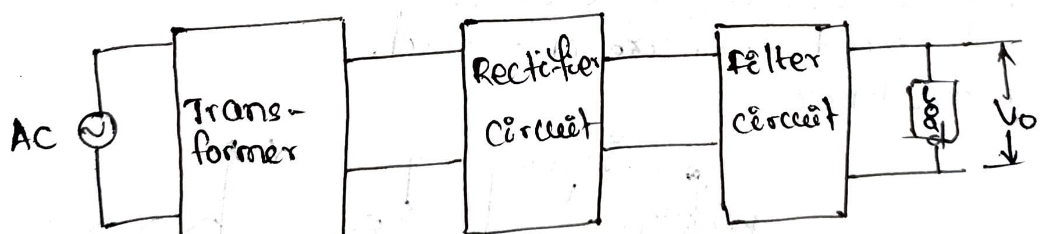
→ The capacitor C_1 passes the ac components and blocks the dc component and dc components continues its journey to choke L.

→ The choke L passes the dc component and blocks the ac component

→ The dc component again passes through the capacitor C_2. capacitor blocks the dc and only passes the ac components which the choke has failed to block.

→ Therefore only dc component appears across the load and that is what we desire.

DC power supply system (unregulated)



Transformer :- It converts an AC input source to AC required output without changing frequency. Step down transformer reduces amplitude of ac voltage to required level.

Rectifier :- Rectifier is an electronic circuit consisting of diodes which carries rectification process. It converts alternating voltages or current into corresponding dc quantity. Here the output is pulsating dc.

Filter circuit : The output of rectifier is pulsating dc which is having very high ripple. so to eliminate the ripples from the pulsating dc filter circuit is used. Normally π filter is used and the pure dc is given to the load.

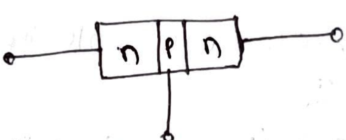
Transistor

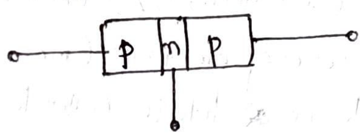
Transistor is an electronic or semiconductor device which transfers a signal from low resistance to high resistance.

→ A transistor consists of two pn junctions formed by sandwiching either p-type or n-type semiconductor between a pair of opposite types. Accordingly there are two types of transistors namely
(i) n-p-n transistor (ii) p-n-p transistor.

→ An n-p-n transistor is composed of two n-type semiconductors separated by a thin section of p-type.

→ A p-n-p transistor is formed by two p-sections separated by a thin section of n-type.



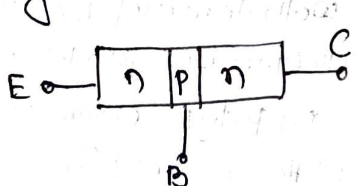


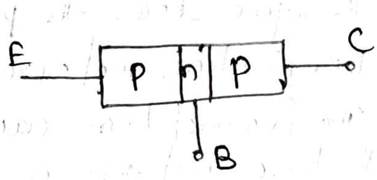
→ In a transistor, there are two pn junctions, three terminals named as Emitter, Base and collector.

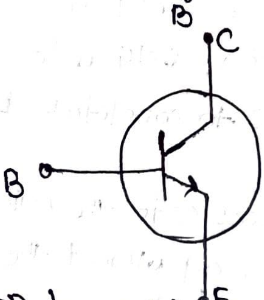
Emitter :- The section that supplies or emits the charge carriers (electrons or holes) is called the emitter. The emitter is highly doped and medium in size.

Base :- The middle section which forms two pn junctions between the emitter and collector is called the base. It is lightly doped and ~~than~~ narrow in size.

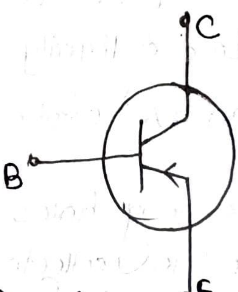
Collector :- The section that collects the charges (electrons ~~and~~ or holes) is called the collector. The collector is always reverse biased. It is moderately doped and ~~med~~ larger in size.





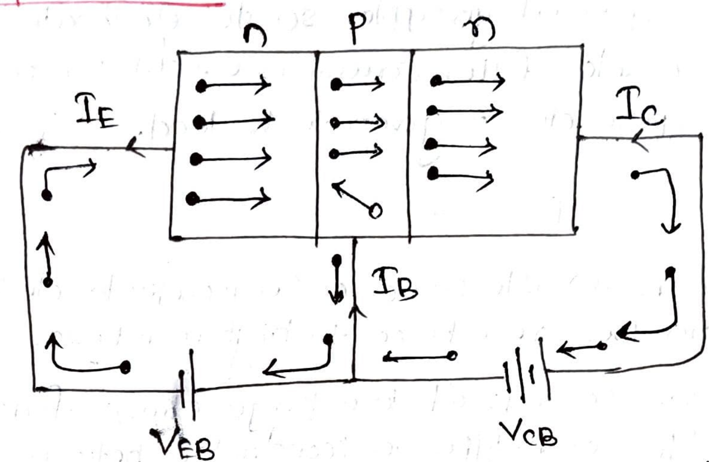


(n-p-n transistor)



(p-n-p transistor)

Working of npn transistor



→ The figure shows the npn transistor with forward bias to emitter-base junction and reverse bias to collector-base junction.

→ The forward bias causes the electrons in the n-type emitter to flow towards the base. This constitutes the emitter current I_E.

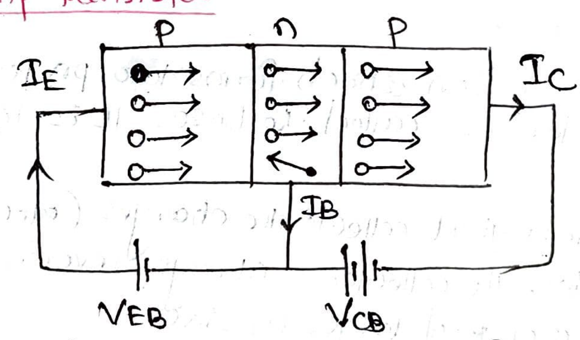
→ As these electrons flow through the p-type base, they tend to recombine with holes. As the base is lightly doped and very thin only few electrons (less than 5%) combine with holes to constitute base current I_B.

→ The remaining electrons (more than 95%) cross over into the collector region to constitute collector current I_C.

→ In this way almost the entire current (I_E) flows in the collector circuit. The emitter current is the sum of collector and base current

$$I_E = I_B + I_C$$

Working of pnp transistor



→ The figure shows the pnp transistor with forward bias to emitter-base junction and reverse bias to collector-base junction.

→ The forward bias causes the holes in p-type emitter to flow towards the base and this constitutes the emitter current I_E.

→ As the base is lightly doped and very thin, only a few holes (less than 5%) combine with the electrons to constitute base current I_B.

→ The remaining holes (more than 95%) cross into the collector region to constitute collector current I_C. In this way almost the entire emitter current flows in the collector circuit.

The emitter current is the sum of collector and Base current

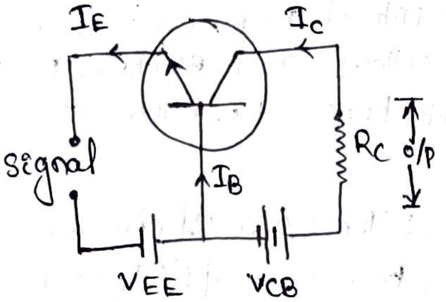
$$I_E = I_B + I_C.$$

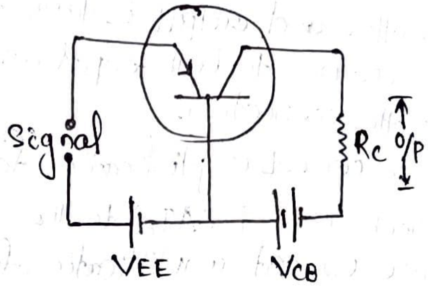
Transistor configuration

A transistor can be connected in a circuit in three ways.

(i) common Base (CB) connection
(ii) common Emitter (CE) connection
(iii) common collector (CC) connection

common Base connection





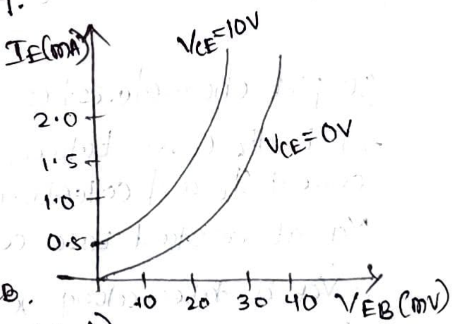
→ In this arrangement, input is applied between emitter and base and output is taken from collector and base. Here Base is common to both input and output circuits and hence the name is common Base connection.

current amplification factor (α):- The ratio of change in collector current to the change in emitter current at constant collector base voltage V_{CB} is known as current amplification factor (α).

$$\alpha = \frac{\Delta I_C}{\Delta I_E} \text{ at constant } V_{CB}$$

The value of α ranges from 0.9 to 0.99.

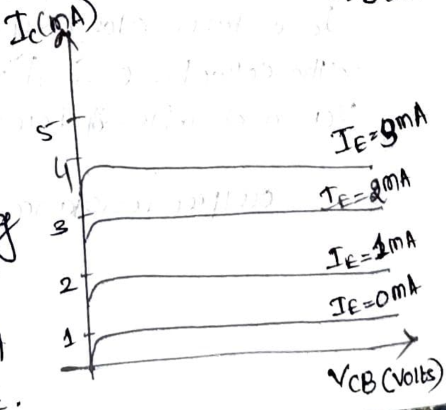
Input characteristics:



→ It is the curve between emitter current I_E and emitter base voltage V_{EB} at constant Collector-base voltage V_{CB}.

→ Input resistance $r_i = \frac{\Delta V_{BE}}{\Delta I_E}$ at constant V_{CB}.

output characteristics

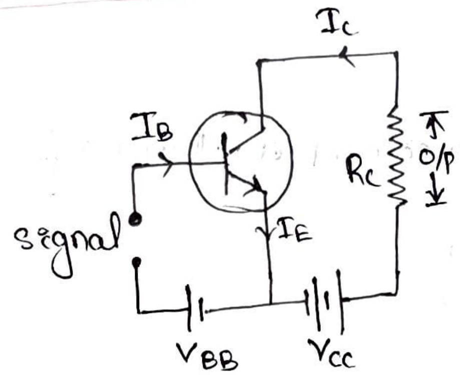


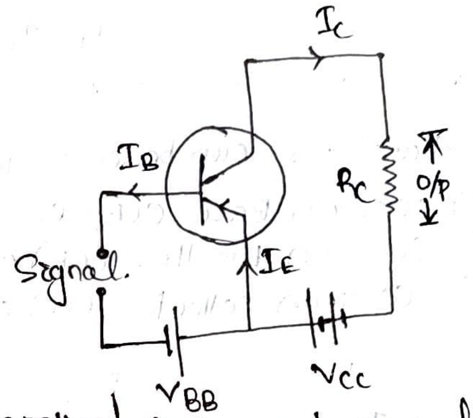
→ It is the curve between collector current I_C and collector base voltage V_{CB} at constant emitter current I_C.

→ The collector current I_C ~~varies~~ is taken along y-axis and V_{CB} is taken along x-axis.

→ output resistance $r_o = \frac{\Delta V_{CB}}{\Delta I_C}$ at constant I_E.

Common Emitter connection





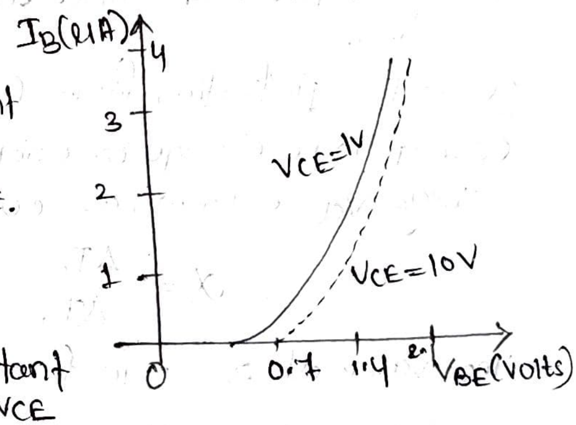
→ In this arrangement, Input is applied between base and emitter and output is taken from the collector and emitter. Emitter is common to both input and output hence it is known as common emitter connection.

Base current amplification factor (β): The ratio of change in collector current (ΔI_C) to the change in base current (ΔI_B) is known as base current amplification factor.

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

→ The value of β ranges from 20 to 500.

Input characteristics

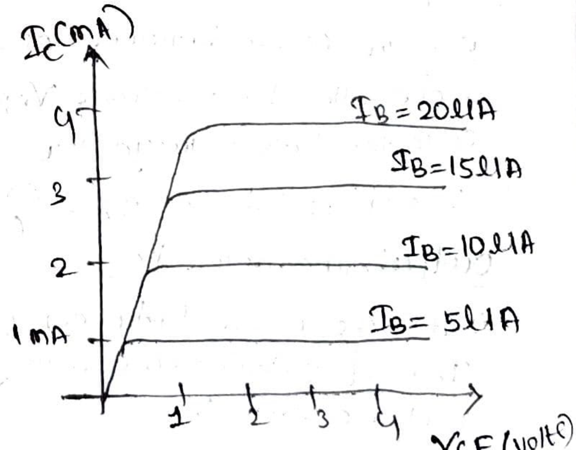


→ It is the curve between base current I_B and base emitter voltage V_{BE} at constant collector emitter voltage V_{CE}.

→ I_B is taken along y-axis and V_{BE} is taken along x-axis.

→ Input resistance $r_i = \frac{\Delta V_{BE}}{\Delta I_B}$ at constant V_{CE}

Output characteristics



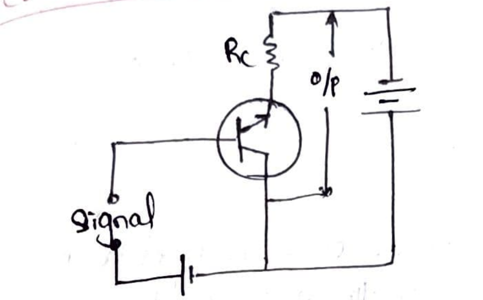
→ It is the curve between collector current I_C and collector-emitter voltage V_{CE} at constant base current I_B.

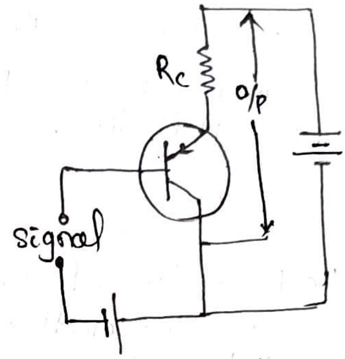
→ V_{CE} is taken along x-axis and I_C is taken along y-axis.

→ The collector current varies with V_{CE} and after it becomes constant

output resistance $r_o = \frac{\Delta V_{CE}}{\Delta I_C}$ at constant I_B.

Common collector connection





→ In this arrangement, input is applied between base and collector while output is taken between the emitter and collector. Here collector of transistor is common to both input and output hence it is known as common collector connection.

→ current amplification factor (γ): The ratio of change in emitter current (ΔI_E) to the change in base current (ΔI_B) is known as current amplification factor γ.

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

Relation between α and β

we know $\alpha = \frac{\Delta I_C}{\Delta I_E}$ and $\beta = \frac{\Delta I_C}{\Delta I_B}$, $I_E = I_B + I_C$

$$\alpha = \frac{\Delta I_C}{\Delta I_B + \Delta I_C}$$

Dividing ΔI_B in numerator and denominator, we get

$$\alpha = \frac{\Delta I_C / \Delta I_B}{(\Delta I_B + \Delta I_C)/\Delta I_B}.$$

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

$$\boxed{\alpha = \frac{\beta}{1+\beta}}$$

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

Dividing ΔI_E in numerator and denominator, we get

$$\beta = \frac{\Delta I_C/\Delta I_E}{(\Delta I_E - \Delta I_C)/\Delta I_E} = \frac{\Delta I_C/\Delta I_E}{\frac{\Delta I_E}{\Delta I_E} - \frac{\Delta I_C}{\Delta I_E}}$$

$$\Rightarrow \boxed{\beta = \frac{\alpha}{1-\alpha}}$$

Faithful amplification :- The process of raising the strength of a weak signal without any change in its general shape is known as faithful amplification.

Transistor Biasing :-

The proper flow of zero signal collector current and the maintenance of proper collector-emitter voltage during the passage of signal is known as transistor Biasing.

→ For faithful amplification, a transistor amplifier must satisfy three basic conditions namely

(i) Proper zero signal collector current
(ii) Proper Base-emitter voltage at any instant
(iii) Proper Collector-emitter voltage at any instant

Stabilisation

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

→ The collector current changes rapidly when

(i) the temperature changes
(ii) the transistor is replaced by another of the same type.

→ When the temp. changes or transistor is replaced, the operating point also changes. However for faithful amplification, it is essential that operating point remains fixed.

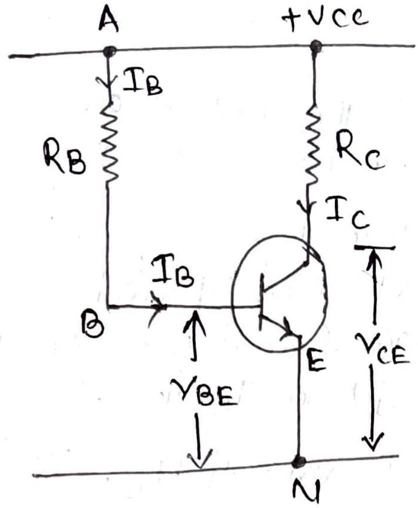
→ once stabilisation is done, i.e operating point is fixed. A good biasing circuit always ensures the stabilisation of operating point.

Methods of transistor Biasing:

The following are the most commonly used methods of obtaining transistor biasing.

(i) Base Resistor method
(ii) Emitter Bias method
(iii) Biasing with collector-feedback resistor
(iv) Voltage-divider bias.

Base Resistor Method:



→ In this method, a high resistance R_B is connected between the base and +ve end of supply for npn transistor.

→ The required zero signal base current is provided by Vcc and it flows through R_B.

$$R_B = \frac{V_{CC} - V_{BE}}{I_B}$$

Since V_{BE} is very small as compared to V_{CC},

$$R_B = \frac{V_{CC}}{I_B}$$

→ R_B can always be found directly. This method is sometimes called fixed bias method.

Advantages:-

→ circuit is very simple as only one resistance R_B is required.

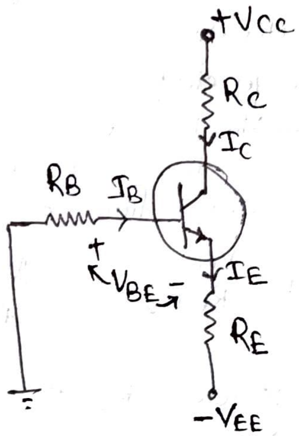
→ Biasing condition can easily be set.

Disadvantage:-

→ This method provides poor stabilisation.

→ The stability factor is very high. Therefore, there are strong chances of thermal runaway.

Emitter Bias circuit:-



→ In this method, it uses two separate dc voltage sources; one positive (+Vcc) and other negative (−VEE). Normally the two supply voltages will be equal.

→ There is a resistor R_E in the emitter circuit.

→ The expression of collector current is

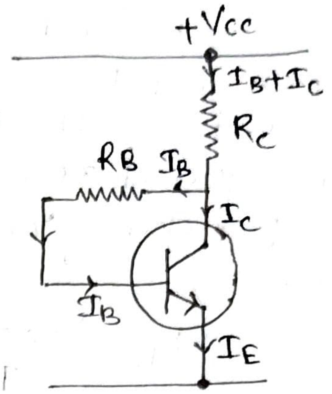
$$I_C = \frac{V_{EE} - V_{BE}}{R_E + R_B/\beta}$$

if $R_E >> R_B/\beta$, $I_C = \frac{V_{EE} - V_{BE}}{R_E}$ This condition makes I_C independent of β.

if $V_{EE} >> V_{BE}$, $I_C = \frac{V_{EE}}{R_E}$, This condition makes I_C independent of V_{BE}.

→ If I_C is independent of V_{BE} and β, the Q point is not affected. Thus emitter bias can provide stable Q point if properly designed.

Biasing with Collector feedback Resistor



→ In this method, one end of R_B is connected to the base and the other end to the collector.

→ Here the zero signal base current is determined by collector base voltage V_{CB}.

→ V_{CB} forward biases the base-emitter junction and hence I_B flows through R_B.

The value of $R_B = \frac{V_{CC} - V_{BE} - I_C R_C}{I_B}$

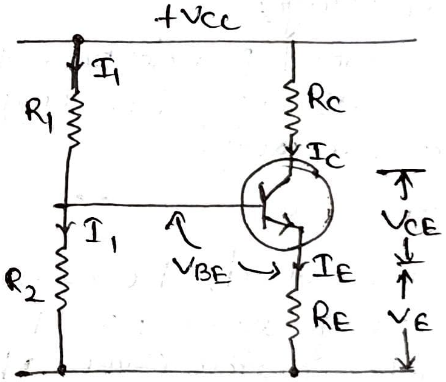
or $R_B = \frac{V_{CE} - V_{BE}}{I_B}$

→ In this method some stabilisation occurs as compared to base resistor method.

→ Here stability factor is also high therefore operating point may change.

→ This method provides a negative feedback which reduces the gain of the amplifier.

Voltage Divider Bias



→ In this method, two resistances R_1 and R_2 are connected across the supply voltage Vcc and provide biasing.

→ The emitter resistance R_E provides stabilisation.

→ The voltage drop across R_2 forward biases the base emitter junction. This causes the base current and hence collector current flow in the zero signal condition.

→ $I_1 = \frac{V_{CC}}{R_1 + R_2}$ (As base current is very small, it can be assumed that current flowing through R_2 is I_1)

→ Voltage across R_2 is $V_2 = \left(\frac{V_{CC}}{R_1 + R_2}\right) R_2$

The expression of $I_C = \frac{V_2 - V_{BE}}{R_E}$ $(I_E \simeq I_C)$

Practically $V_2 >> V_{BE}$

so $I_C = \frac{V_2}{R_E}$

so I_C is independent of V_{BE} and β.

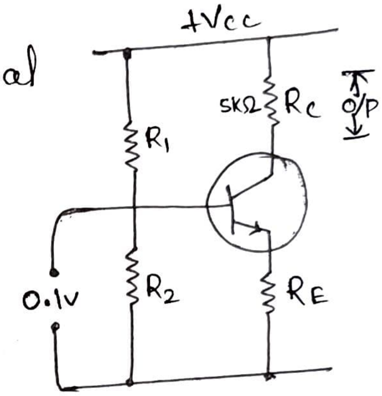
$V_2 = V_{BE} + I_C R_E$ $(I_E \simeq I_C)$

if I_C increases due to temperature the voltage drop across R_E i.e $I_C R_E$ increases. But V_2 is fixed so V_{BE} decreases and it causes I_B to decrease. The reduce in I_B also changes I_C to decrease to its original value

→ Here excellent stabilisation is provided by R_E.

→ Stability factor is very small (≈1) so it provides maximum thermal stability

Single stage transistor Amplifiers



→ When only one transistor with associated circuitry is used for amplifying a weak signal the circuit is known as single stage transistor amplifier.

→ When a weak ac signal is given to the base of transistor, a small base current starts flowing.

→ Due to transistor action high value of collector current ($I_C = \beta I_B$) flows through the load.

→ As the value of R_C is quite high, therefore, a large voltage appears across the R_C.

→ Thus a weak signal applied in the base circuit appears in amplified form in the collector circuit. In this way transistor acts as an amplifier.

Sinusoidal oscillators:-

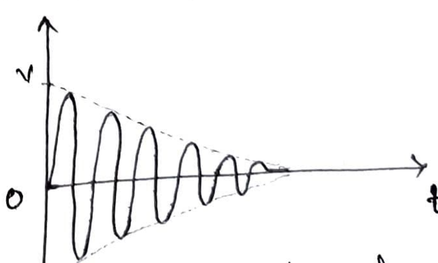
An electronic device that generates sinusoidal oscillations of desired frequency is known as a "sinusoidal oscillator".

→ Oscillator can produce sinusoidal or non-sinusoidal (square) waves.

Types of sinusoidal oscillations

It can be of two types (i) Damped oscillations
(ii) undamped oscillations.

(i) Damped oscillations

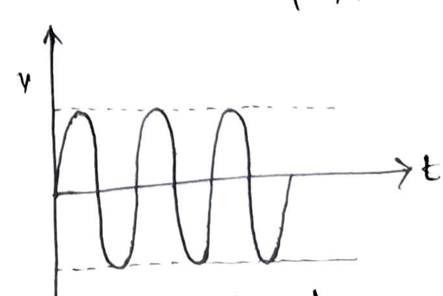


(damped)

→ The electrical oscillation whose amplitude goes on decreasing with time are called damped oscillations.

→ some energy is lost during each oscillations.

(ii) Undamped oscillations



(undamped)

→ The electrical oscillations whose amplitude remains constant with time are called undamped oscillations.