

Transistor Amplifiers

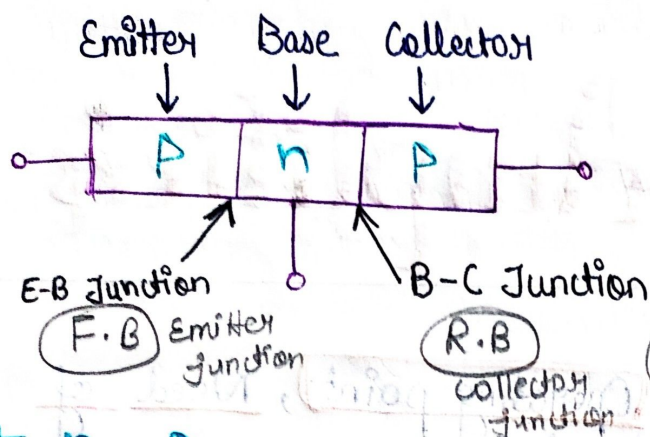
Topics

1. Introduction, DC load line, Operating point, Need of biasing, Stabilization, Stability factor.
2. Types of biasing - voltage divider bias for BJT.
3. Classification of Amplifiers - based on use, frequency, coupling methods & mode of operations (advantages, disadvantages).

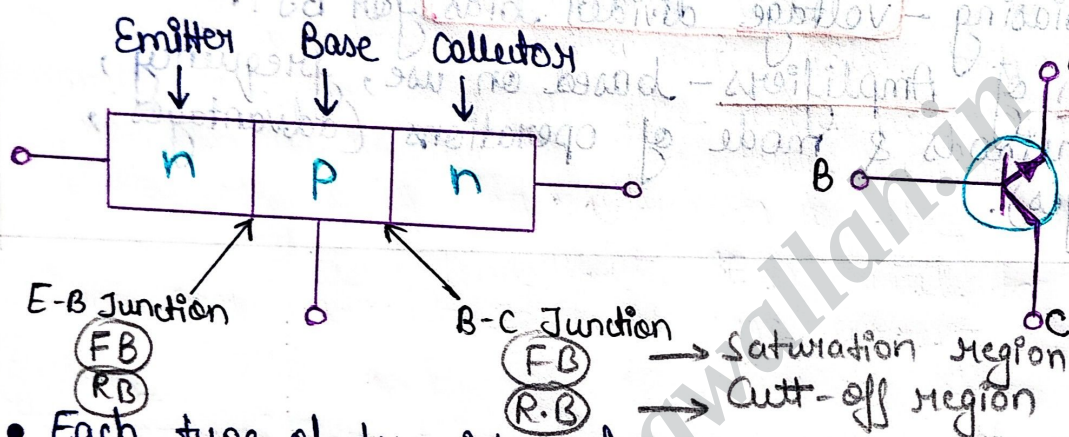
Transistor...

- The transistor is a solid state device, whose operation depends upon the flow of electric charge carriers within the solid.
- Transistor is capable of amplification and in most respect it is analogous to a vacuum triode. The main difference between the two is that the transistor is a current controlled device whereas vacuum triode is a voltage controlled device.
- A transistor (BJT) is a 3-layer semiconductor device consisting of either two n- and one p-type layer of material or two p-type and one n-type material. The former is called n-p-n transistor while the latter is called p-n-p transistor.

P-n-P



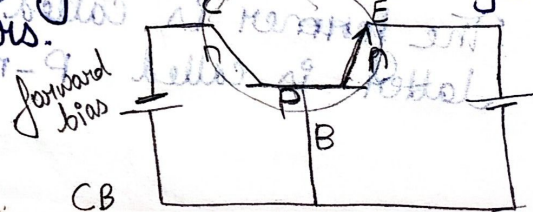
n-P-n



- Each type of transistor has two PN Junctions - one junction between the emitter and base called emitter-base junction or simply emitter junction and the other junction between the base and collector, called the collector-base junction or simply the collector junction. The three parts of a transistor are known as emitter, base & collector.

Emitter....

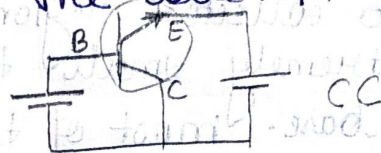
It is left section of the transistor and its main function is to supply majority charge carriers (electron in case of n-p-n and hole in case of p-n-p). It is always forward-bias with respect to base. The emitter is heavily doped so that it may be able to inject a large number of charge carriers.



Base....

51

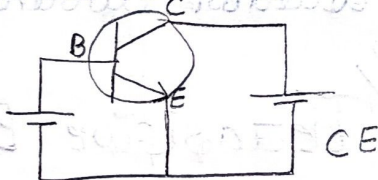
It is the middle section of the transistor and is very lightly doped and is very thin (often order of μm) in comparison to either emitter or collector so that it may pass most of the charge carrier to the collector.



Collector....

It is right hand section of the transistor and its main function is to collect majority charge carrier. Collector is always reverse biased so as to remove the charge carriers away from its junction with the base.

It is moderately doped. The forward biased emitter-base junction offers low resistance to the emitter current whereas the collector-base junction, which is reverse biased offers high resistance to the collector current.

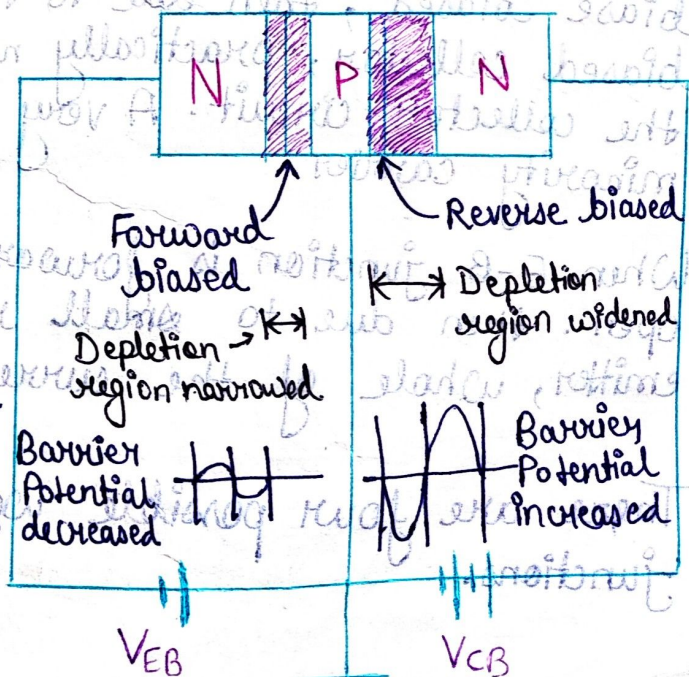


* Operation of Transistor....

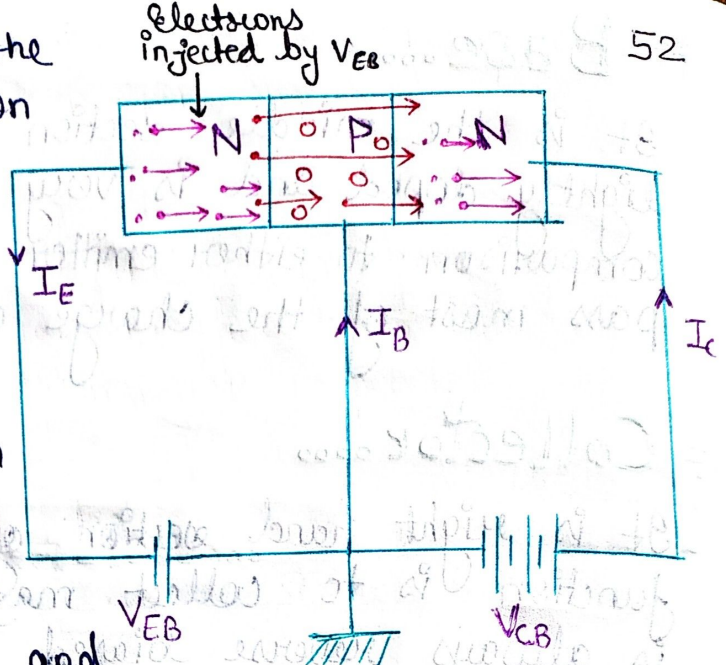
- For normal operation of transistor, the emitter-base junction is always forward biased while the collector-base junction is reverse biased.

- The forward bias at the emitter-base junction reduces the barrier potential and narrows the depletion region.

Due to which the injected electrons to the emitter enter the very thin lightly doped base region only few of the injected electrons combines with the base holes.



- Injection of electrons wakes the electron combines very large on emitter junction and small on the collector junction. Injected electrons diffuse into collector region due to extremely small thickness of base. Most of the electron cross into the collector region.



- Collector is reverse biased and creates a strong electrostatic field between base & collector. To maintain the base neutrality base electrodes provides equal number of electrons which have combined with the holes and results in the base current. Thus the emitter current I_E is equal to the sum of collector current I_C and base current I_B .

Transistor Biasing ...

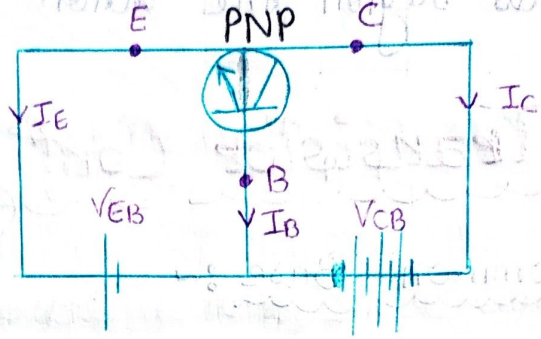
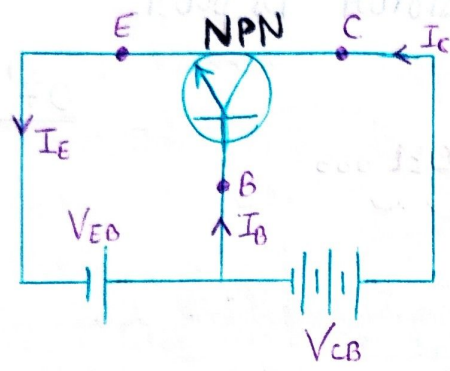
The process of applying dc voltages across the different terminals of a transistor is called biasing.

- When E-B junction is open and B-C junction is reverse biased, then due to the high resistance of reverse biased collector, practically no current would flow in the collector circuit. A very small current flows due to minority carrier.
- When E-B junction is forward biased and C-B junction open, then due to small resistance of forward biased emitter, whole of the current flows through the base.

There are four possible ways of biasing these two junctions.

(i) Forward - Reverse Biased....

For normal operation of a transistor E-B junction is always forward biased and C-B junction is always reverse biased. This type of biasing is known as F-R (forward reverse) biasing.

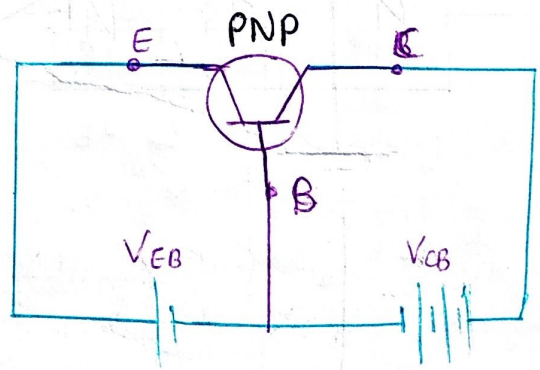
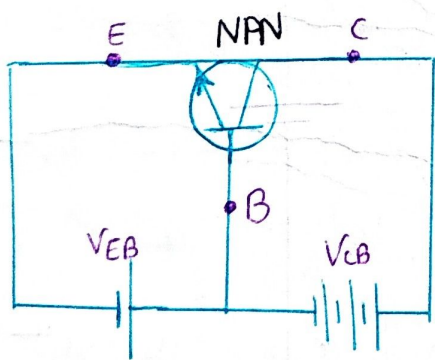


Saturation Region

In F-R biasing the transistor is in active region and the collector current I_C , depends upon the emitter current I_E . Generally transistor is operated in this region for amplification.

(ii) Forward - Forward Biasing....

In this biasing both collector & emitter are forward biased. The transistor operates in saturation region, the collector current becomes independent of the current. Thus the transistor acts like a close switch.



(iii) Reverse - Reverse Biasing....

In this biasing both the junctions are reverse biased. In this biasing, the transistor has practically zero current because the emitter does not inject charge carriers into the

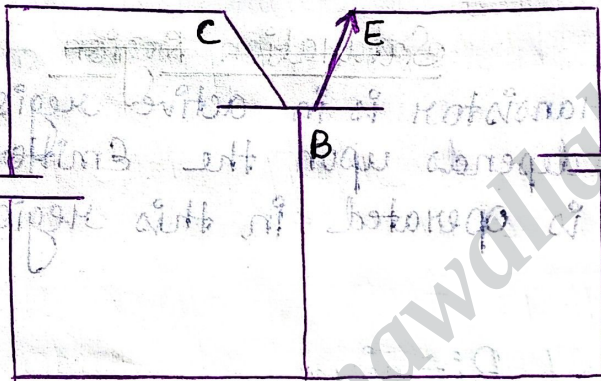
base and no charge carriers are collected by the collector.⁵⁴
Thus the transistor acts like an open switch.

(iv) Reverse - Forward Biasing.....
In this biasing the emitter junction is reverse biased while the collector junction is forward biased. In this region the action of transistor is poor.

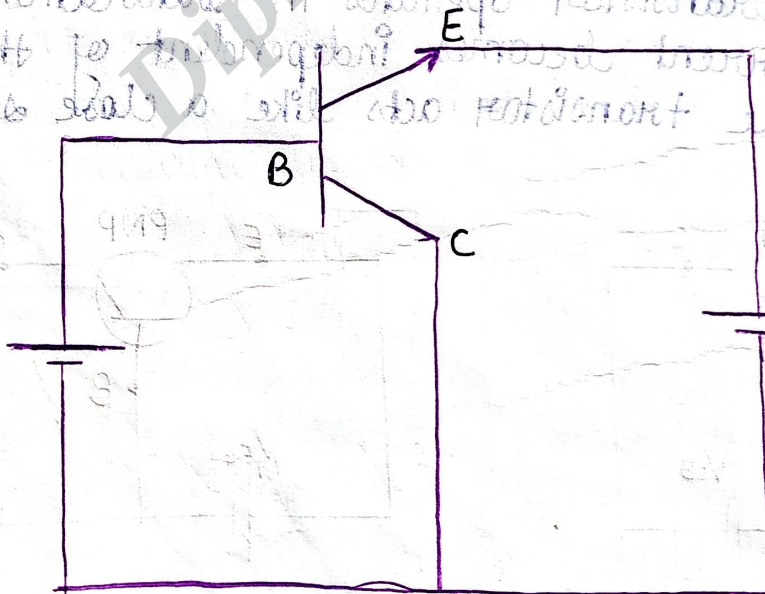
07/01/25

Transistor Configuration...

① Common Base :-

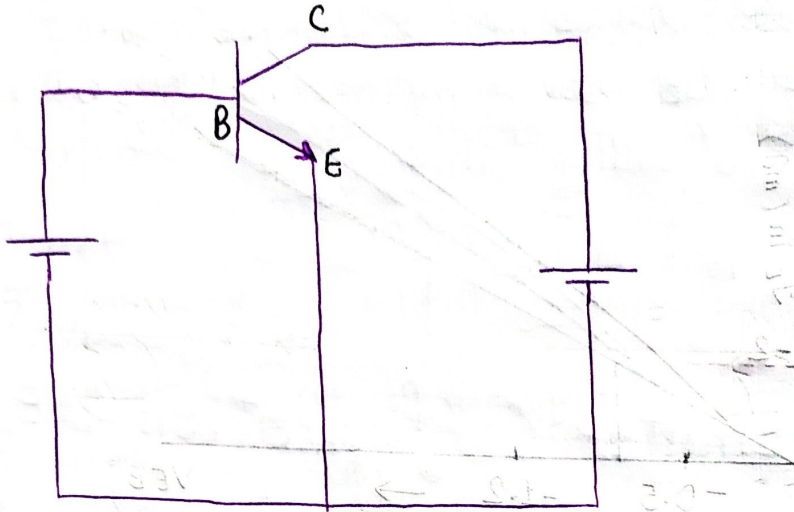


② Common Collector :-



④ Common Emitter :-

55



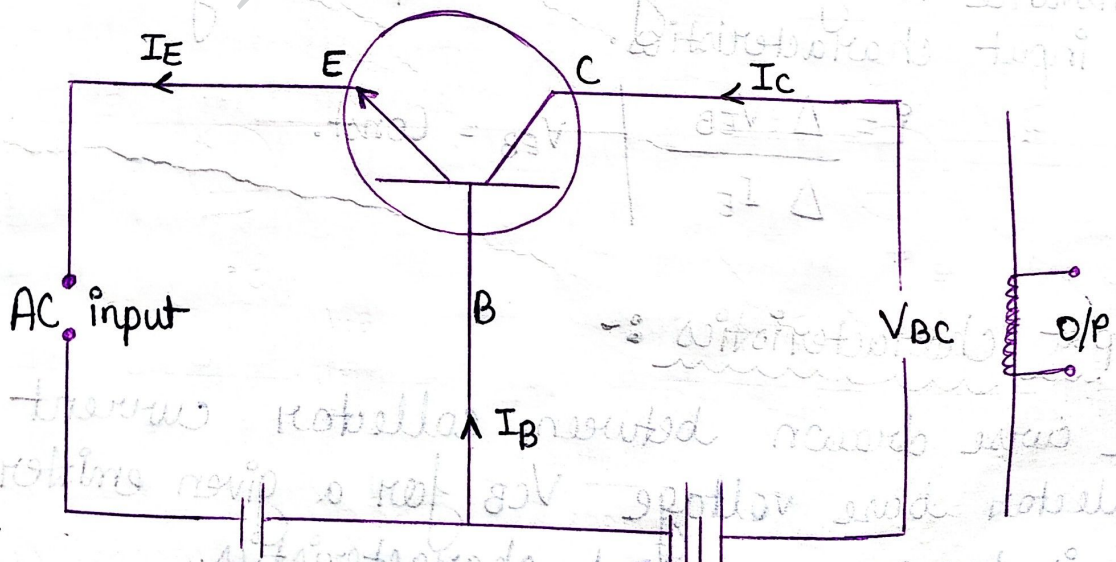
Common Base Configuration (CB) :-

In CB configuration input is connected between emitter and base and output between base and collector. The ratio of I_C to the I_E is called current amplification factor α for this configuration.

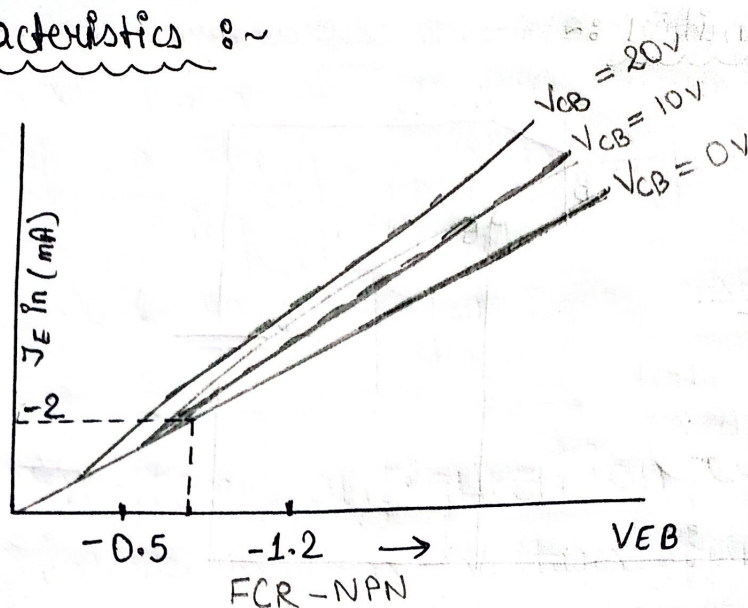
$$I_C = \alpha I_E + I_{CBO}$$

$$\alpha_{ac} = \frac{I_C}{I_E}$$

$$\alpha_{ac} = \frac{\Delta I_C}{\Delta I_E} \quad / \quad V_{CB} \text{ Constant.}$$



★ Input Characteristics :-



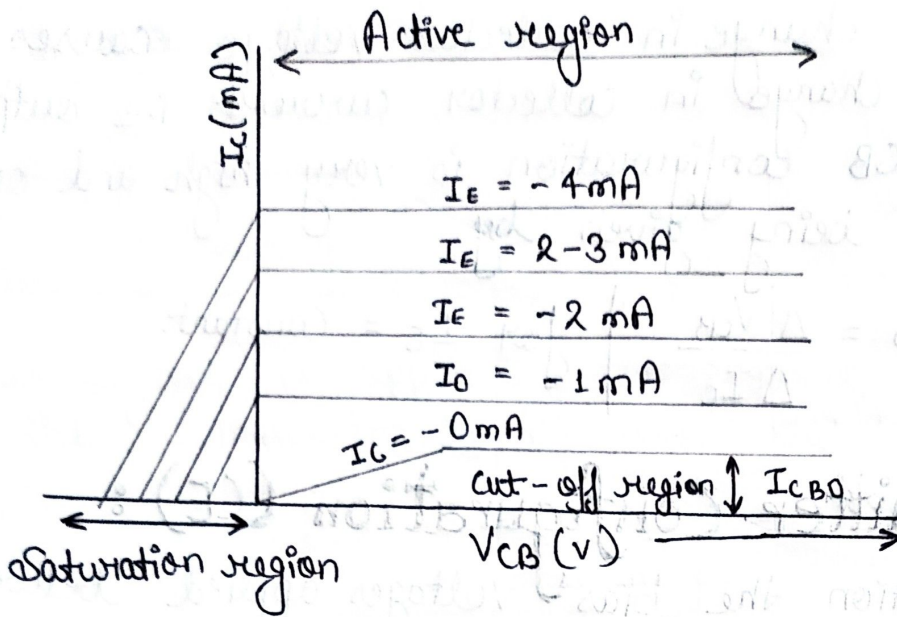
→ The curve drawn between I_E and emitter base voltage V_{EB} for a given value of collector-base voltage V_{CB} is known as input characteristics. This characteristics may be used to determine input resistance of the transistor from figure it is seen that with the increase in V_{CB} , it conducts better.

- There exists a cut in offset or threshold voltage V_{EB} below which the emitter current is very small.
- The emitter current I_E increases rapidly with small increase in emitter-base voltage V_{EB} . This shows that the input resistance is very small and the input resistance is given by the reciprocal of the slope of its input characteristics.

$$r_i = \frac{\Delta V_{EB}}{\Delta I_E} \quad \bigg| \quad V_{CB} = \text{Const.}$$

★ Output Characteristics :-

The curve drawn between collector current I_C and collector base voltage V_{CB} for a given emitter current I_E is known as output characteristics.



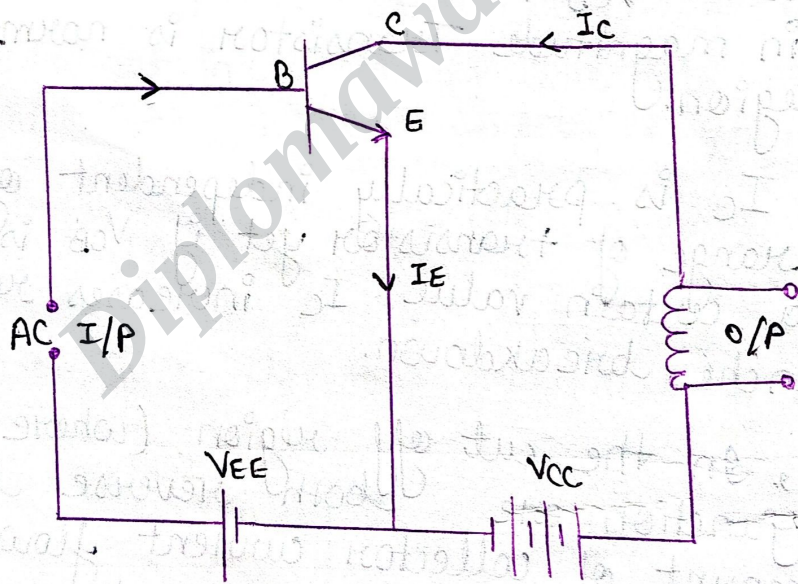
- i) The collector current I_C varies with V_{CB} only for very low voltage () but transistor is never operated in this region.
- ii) In active region I_C is almost equal to I_E and remain constant when V_{CB} is increased. I_C is slightly lesser than I_E in magnitude. Transistor is normally operated in this region.
- iii) Although I_C is practically independent of V_{CB} over the working range of transistor yet if V_{CB} is increased beyond a certain value, I_C increases rapidly due to avalanche breakdown.
- iv) Although, in the cut off region (where emitter and collector junction are both reverse biased), a small amount of collector current flows even when emitter current $I_E = 0$. This is the collector leakage current I_{CBO} .
- v) In the saturation region (when both emitter and collector junctions are forward biased) the collector current I_C flows even when $V_{CB} \approx 0$.

vi) A very large change in collector voltage causes a very small change in collector current i.e. output resistance of CB configuration is very high and output resistance r_o being given by.

$$r_o = \frac{\Delta V_{CB}}{\Delta I_C} \quad \text{for } I_E = \text{constant.}$$

Common Emitter Configuration (CE) :

In this configuration the bias voltages applied between collector and emitter and base and emitter. I_{EB} is forward bias and I_{CE} is reverse bias, common emitter is commonly used because its current voltage and power gains are quite high and output to input impedance ratio is moderate.



★ Base Current amplification factor (β) :-

When no signal is applied then the ratio of collector current to the I_B is called β_{dc} of a transistor.

$$\boxed{\beta_{dc} = \beta = \frac{I_C}{I_B}} = \frac{I_C}{I_E - I_C}$$

$$= \frac{I_C / I_B}{1 - I_C / I_B}$$

$$B = \frac{\alpha}{1 - \alpha}$$

When signal is applied, the ratio of change in I_C to the change in I_B is called B_a .

$$B_{ac} = B = \frac{\Delta I_C}{\Delta I_B}$$

In common emitter configuration, a small current flows even when base current is zero (i.e. base is open). This is the collector cut-off current and denoted by I_{CEO} .

I_{CEO} must be larger than I_C .

The current equations are :-

$$I_E = I_B + I_C$$

and $I_C = \alpha I_E + I_{CBO}$

$$= \alpha (I_B + I_C) + I_{CBO}$$

$$I_C (1 - \alpha) = \alpha I_B + I_{CBO}$$

$$I_C = \frac{\alpha}{1 - \alpha} I_B + \frac{I_{CBO}}{1 - \alpha} \quad \text{--- (1)}$$

and total collector current.

$$I_C = B I_B + I_{CEO} \quad \text{--- (11)}$$

→ Comparing eq (1) and (11) we have

$$B = \frac{\alpha}{1-\alpha} \text{ and } I_{CEO} = \frac{1}{1-\alpha} I_{CBO}$$

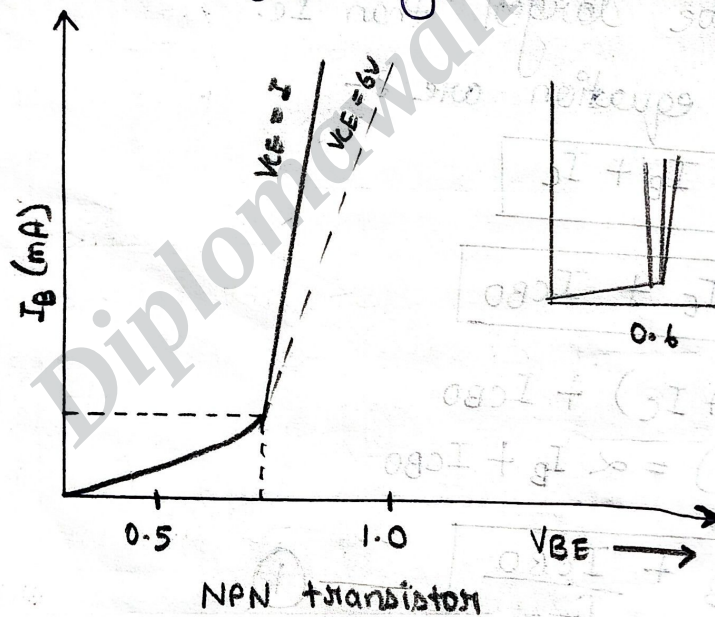
Substituting the value of I_{CEO} in eqn (11).

$$I_C = B I_B + \frac{1}{1-\alpha} I_{CBO}$$

$$I_C = B I_B + (B+1) I_{CBO}$$

★ Input characteristics :-

The curve drawn between base current I_B and base-emitter voltage V_{BE} for a given value of collector-emitter voltage V_{CE} is known as the input characteristics. The following points are noted :-



- (i) In this case, I_B increases less rapidly with V_{BE} as compared to CB configuration. This shows that the input resistance of CE circuit is higher than that of CB configuration. This shows that the input resistance of CE circuit is higher than that of CB circuit.

- (ii) The input characteristics of CE transistors are quite similar to those of a forward biased diode because the emitter-base region of the transistor is a diode and it is forward biased.

The input resistance of at a given V_{CE} is given as:-

$$V_i = \frac{\Delta V_{BE}}{\Delta I_B} \quad \Bigg| \quad V_{CE} = \text{Constant}$$

★ Output characteristics :-

Output characteristics for a CE transistor is the curve drawn between collector current I_C and V_{CE} for a given value of I_B .

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

The transistor are always operated above 1V.

- ii) Output characteristics in CE configuration has some slope which CB configuration has almost horizontal characteristics. This indicates that output resistance in case CE configuration is less than in CB configuration.

- iii) In active region (collector junction reverse biased and emitter junction forward biased) for small value of I_B the effect of collector voltage V_C over I_C is small for large values of I_B this effect increases.

- iv) With low values (initially zero) of V_{CE} the transistor is said to be operated in saturation region and in this region I_B does not cause a corresponding change in I_C .

52

(v) With much higher V_{CE} , the collector base junction completely breakdown and because of this avalanche breakdown collector current I_C increases rapidly and the transistor gets damaged.

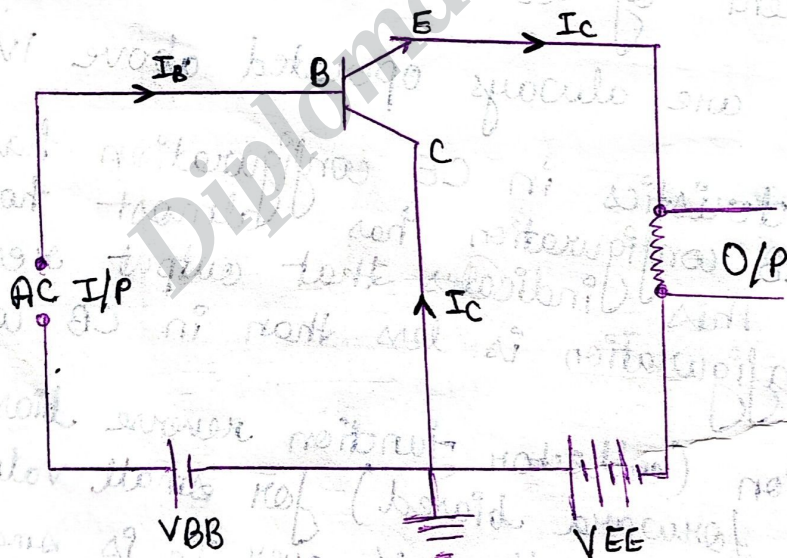
(vi) In cut-off region, small amount of current I_C flows even when base current $I_B = 0$. This is called I_{CEO} . Since main current I_C is zero so the transistor is said to be cut-off.

Output resistance of the output circuit is given by.

$$r_o = \frac{\Delta V_{CE}}{\Delta I_C} \Big|_{I_B = \text{const.}}$$

Common Collector Configuration (CC) :-

In common collector configuration, input is applied between base and collector while the output is taken across emitter and collector.



Current equation are :-

$$I_C = \alpha I_E + I_{CBO}$$

$$\text{and } I_E = I_B + I_C$$

$$= I_B + \alpha I_E + I_{CBO}$$

$$I_E (1 - \alpha) = I_B + I_{CBO}$$

$$I_E = \frac{I_B}{1-\alpha} + \frac{I_{CBO}}{1-\alpha}$$

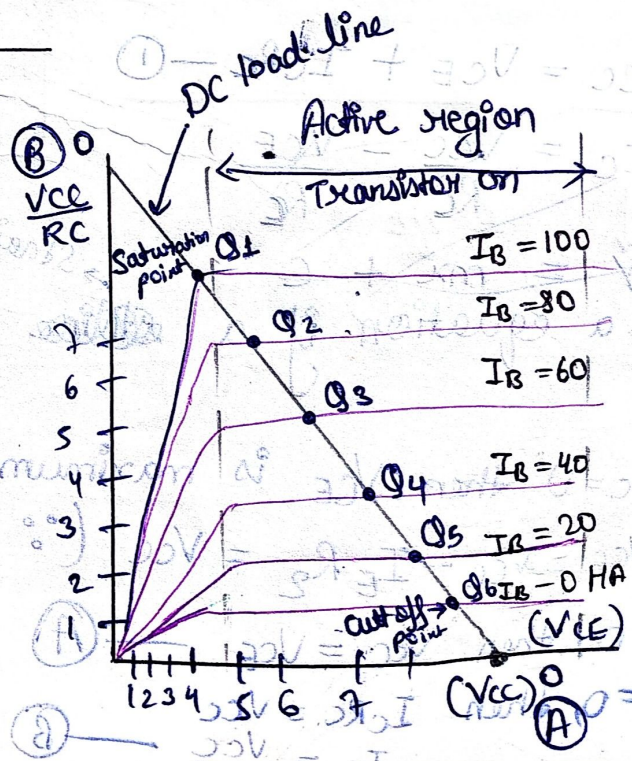
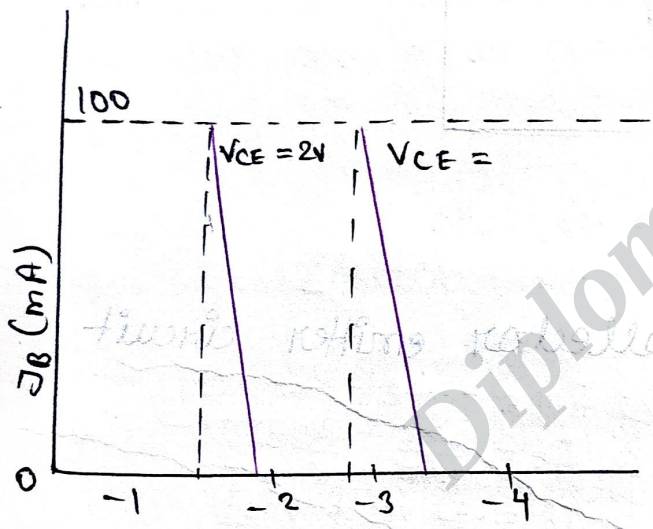
$$I_E = (B+1) I_B + (B+1) I_{CBO}$$

Current gain,

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

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

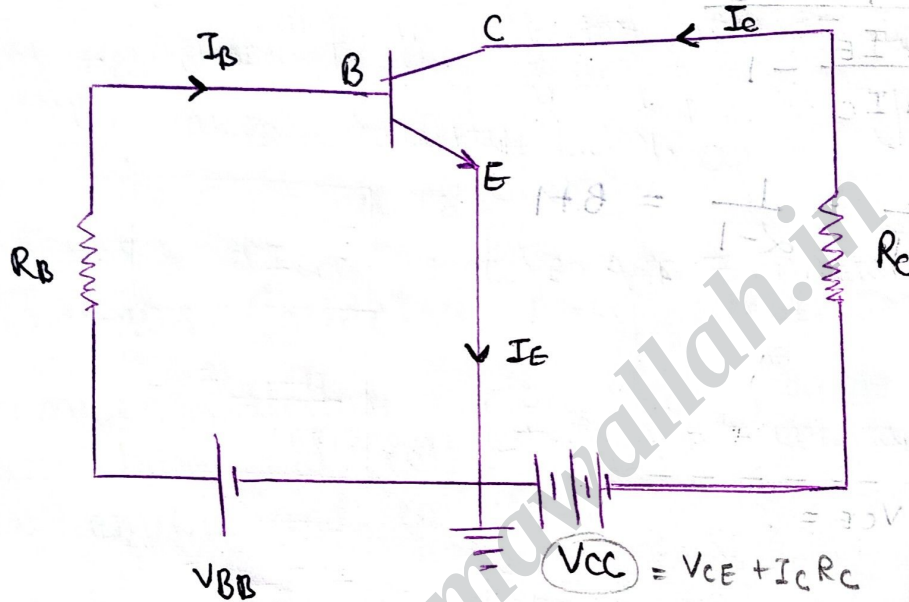
$$= \frac{I/\alpha}{1-\alpha-1} = \frac{1}{\alpha-1} = B+1$$



DC Load line :-

For finding the value of I_C for various collector-emitter voltages, dc load line method is applied. For drawing dc load line of a transistor, we require only its cut-off and saturation points. Then the line joining these two points is known as dc load line.

This discussed below.



The voltage equation of the collector emitter circuit is.

$$\textcircled{1} V_{CC} = V_{CE} + I_C R_C \quad \text{--- (1)}$$

$$\textcircled{2} I_C = \frac{V_{CC} - V_{CE}}{R_C}$$

$$\textcircled{2} I_C R_C = V_{CC} - V_{CE}$$

$$\textcircled{3} I_C = \frac{V_{CC}}{R_C} - \frac{V_{CE}}{R_C}$$

$$I_C = -\frac{1}{R_C} V_{CE} + \frac{V_{CC}}{R_C}$$

$$Y = mX + C$$

→ straight line

This is a equation of a ~~line~~ of slope $m = -\frac{1}{R_C}$

(i) When $I_C = 0$ then V_{CE} is maximum and is equal to V_{CC} .
i.e. $V_{CE} = V_{CC} - I_C R_C = V_{CC}$ ($\because I_C = 0$)

$$\text{if } I_C = 0, \text{ then } V_{CC} = V_{CE} \quad \text{--- (A)}$$

$$\text{if } V_{CE} = 0, \text{ then } I_C R_C = V_{CC} \quad \text{--- (B)}$$

$$I_C = \frac{V_{CC}}{R_C}$$

This gives the cut off point B.

65

(ii) When collector emitter voltage $V_{CE} = 0$, then I_C is maximum and is equal to V_{CC} / R_C i.e.

$$V_{CE} = V_{CC} - I_C R_C$$

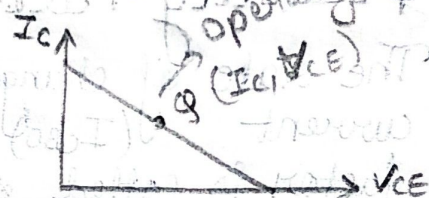
$$0 = V_{CC} - I_C R_C$$

So, $I_C = \frac{V_{CC}}{R_C}$ (B)

① Q point $\rightarrow$ stop

② Saturation point

③ Cut-off point



(iii) Operating point :- This is a point on dc load line which represents the values of I_C and V_{CE} that exist in a transistor circuit. When AC signal is applied. This is also known as operating point or working point.

>> Need For Stabilization

Stabilization

The process of making operating point independent of temperature changes and variation in transistor parameters is known as stabilization.

* Transistor Biasing

The basic function of a transistor is its amplification. For faithful amplification (amplified magnitude of signal without any changes in shape),

- The following three conditions must be satisfied.
- (i) The emitter base junction should be forward biased.
 - (ii) The collector base junction should be reversed biased.

(iii) There should be proper I_C signal collector current.

The proper flow of I_C signal collector current (proper operating point of a transistor) and the maintenance of proper collector emitter voltage during the passage of signal is known as transistor biasing.

* Stability Factor

The rate of change in collector current I_C w.r.t. leakage current (I_{CBO}) at constant input voltage and amplification factor is called stability factor.

$$S = \frac{dI_C}{dI_{CBO}}$$

[V_{BE} & $\beta = \text{Constant}$]

$$S' = \frac{dI_C}{dV_{BE}}$$

[I_{CBO} & $\beta = \text{Constant}$]

$$S'' = \frac{dI_C}{d\beta}$$

[V_{BE} & $I_{CBO} = \text{Constant}$]

Here, I_C = Collector current

I_{CBO} = leakage current

V_{BE} =

β =

* Note :- lower the value of S , (stability factor) the system will more stable.

** Need for Biasing Circuit :-

1. Selection of operating point :-
Middle of load line.

- 2.) Stabilization against temperature variation of I_C . 67
- 3.) Free from transistor parameter variations.

* Expression for Stability factor:-

When a transistor is biased in the active region.

$$I_C = \beta I_B + (1 + \beta) I_{CBO} \quad \text{--- (1)}$$

differentiate (1) w.r.t I_C , considering β is the constant.

$$\frac{dI_C}{dI_C} = \beta \frac{dI_B}{dI_C} + (1 + \beta) \frac{dI_{CBO}}{dI_C}$$

$$\Rightarrow 1 = \beta \frac{dI_B}{dI_C} + (1 + \beta) \frac{1}{S} \left[\frac{dI_{CBO}}{dI_C} = \frac{1}{S} \right]$$

$$\Rightarrow 1 - \beta \frac{dI_B}{dI_C} = (1 + \beta) \frac{1}{S}$$

$$\Rightarrow \boxed{S = \frac{1 + \beta}{1 - \beta \frac{dI_B}{dI_C}}}$$

* Expression for stability factor (S'') :-

$$I_C = \beta I_B + (\beta + 1) I_{CBO} \quad \text{--- (1)}$$

$\therefore$ differentiate eqⁿ (1) w.r.t I_C , keeping I_{CBO} is to be constant.

$$\frac{dI_C}{dI_C} = \frac{d(\beta I_B)}{dI_C} + I_{CBO} \cdot \frac{d(\beta + 1)}{dI_C}$$

$$\frac{dI_C}{dI_C} = \beta \cdot \frac{dI_B}{dI_C} + I_B \cdot \frac{d\beta}{dI_C} + I_{CBO} \frac{d\beta}{dI_C}$$

$$1 = \beta \frac{dI_B}{dI_C} + I_B \frac{d\beta}{dI_C} + I_{CBO} \times \frac{1}{S''} \left[S'' = \frac{dI_C}{d\beta} \right]$$

$$1 = \beta \cdot \frac{dI_B}{dI_C} + I_B \cdot \frac{1}{S''} + I_{CBO} \times \frac{1}{S''}$$

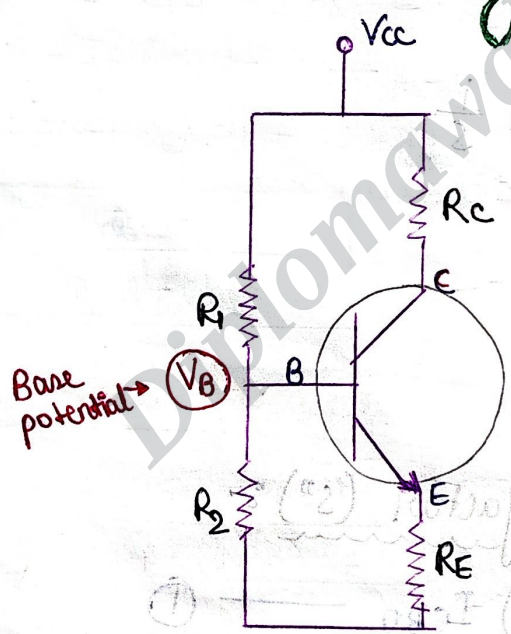
$$1 - \beta \frac{dI_B}{dI_C} = \frac{1}{S''} (I_B + I_{CBO})$$

$$S'' = \frac{I_B + I_{CBO}}{1 - \beta \frac{dI_B}{dI_C}}$$

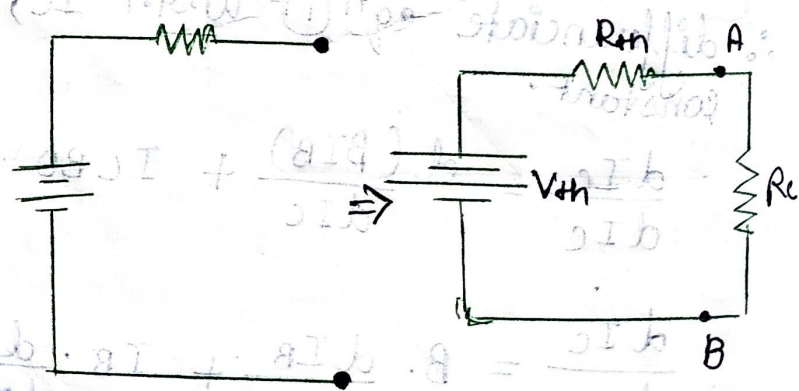
**** V.V.I** [June-2019, 7 marks]

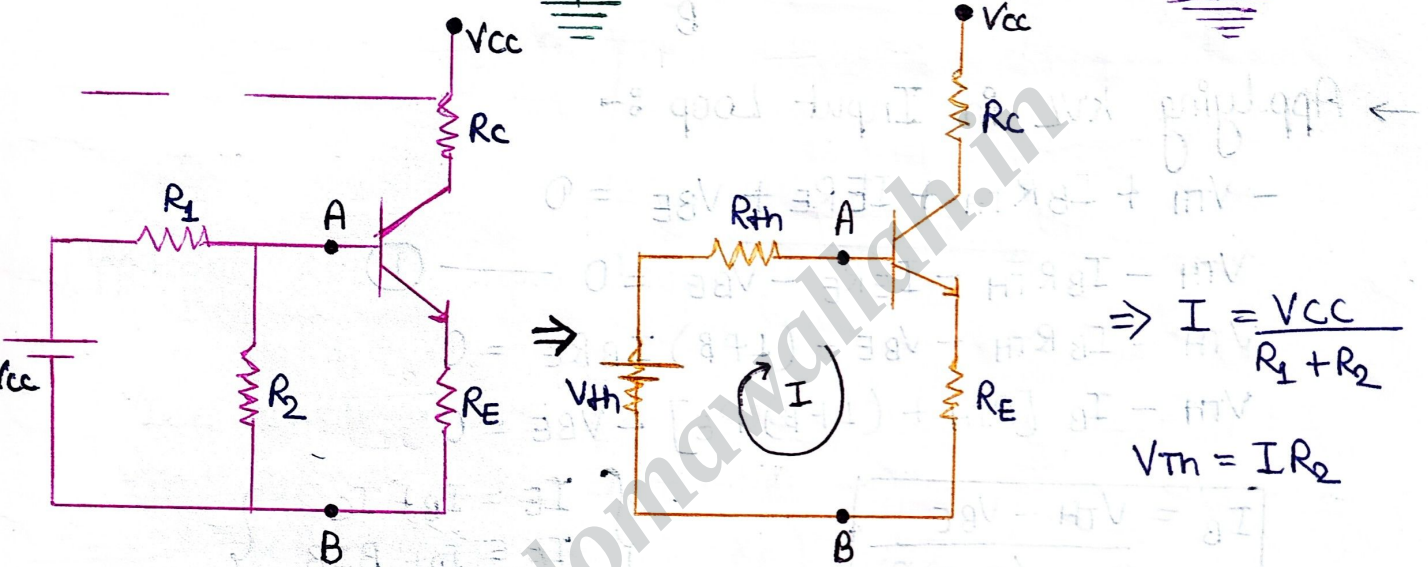
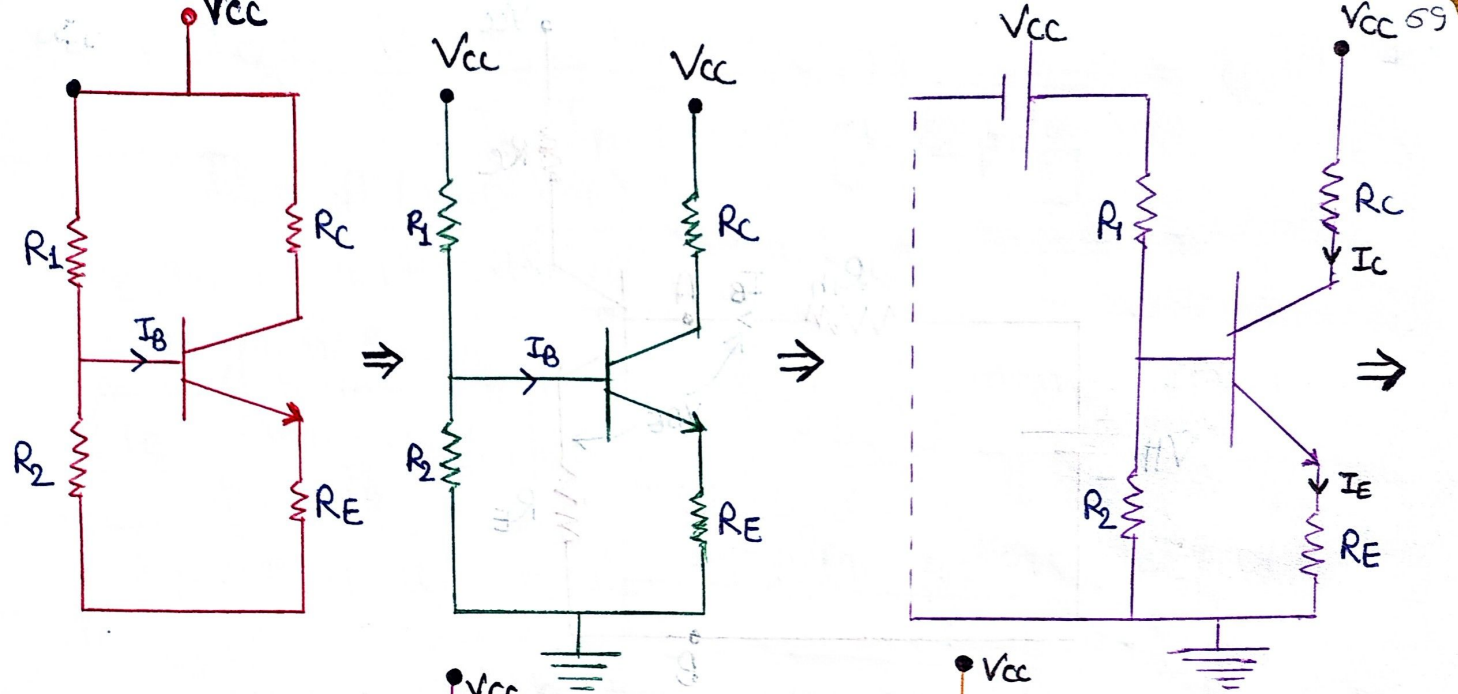
16/01/25

2. Voltage Divider Biasing Circuit



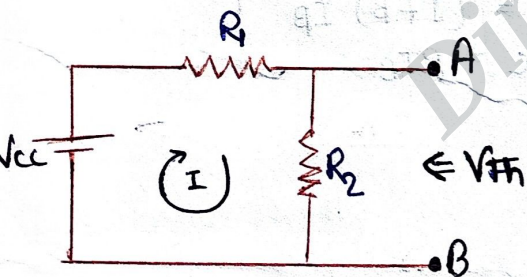
Complicated Network containing Resistors and voltage





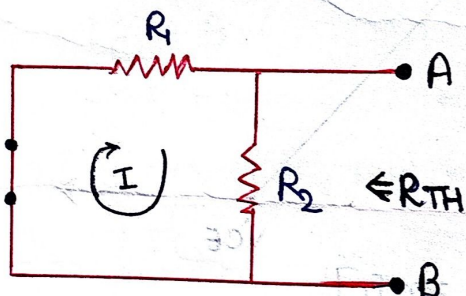
$$I = \frac{V_{CC}}{R_1 + R_2}$$

$$V_{TH} = IR_2$$



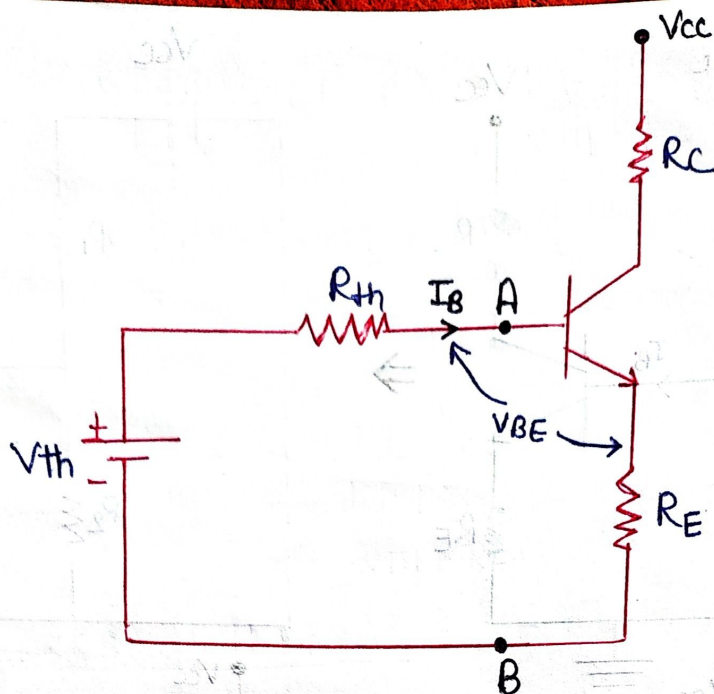
Acc. to thevenin's theorem:-

$$V_{TH} = \frac{V_{CC}}{R_1 + R_2} \times R_2$$



$$R_{TH} = \frac{R_1 R_2}{R_1 + R_2}$$

$$R_{TH} = R_1 \parallel R_2$$



→ Applying KVL in Input Loop :-

$$-V_{TH} + I_B R_{TH} + I_E R_E + V_{BE} = 0$$

$$V_{TH} - I_B R_{TH} - I_E R_E - V_{BE} = 0 \quad \text{--- (1)}$$

$$V_{TH} - I_B R_{TH} - V_{BE} - (1+\beta) I_B R_E = 0$$

$$V_{TH} - I_B [R_{TH} + (1+\beta) R_E] - V_{BE} = 0$$

$$I_B = \frac{V_{TH} - V_{BE}}{R_{TH} + (1+\beta) R_E}$$

$$\left\{ \begin{array}{l} I_E = I_B + I_C \\ I_E = I_B + \beta I_B \\ I_E = (1+\beta) I_B \\ I_C = \beta I_B \end{array} \right.$$

* $I_C = \beta I_B$

$$I_C = \frac{\beta (V_{TH} - V_{BE})}{R_{TH} + (1+\beta) R_E}$$

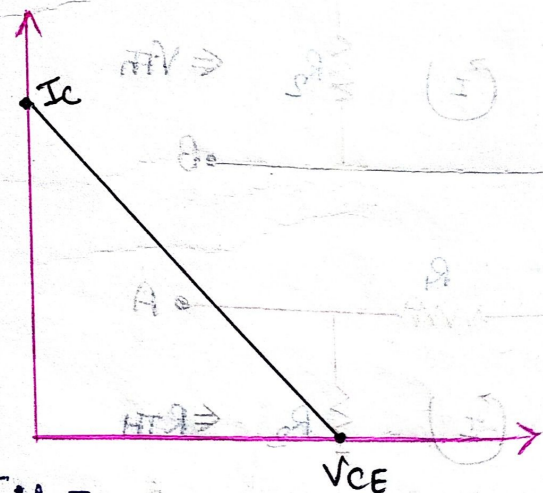
→ Applying KVL in Output Loop :-

$$V_{CC} - R_C I_C - V_{CE} - I_E R_E = 0$$

$$V_{CC} - I_C R_C - V_{CE} - I_C R_E = 0$$

$$V_{CC} - I_C (R_C + R_E) - V_{CE} = 0$$

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



[$\because I_E \approx I_C$]

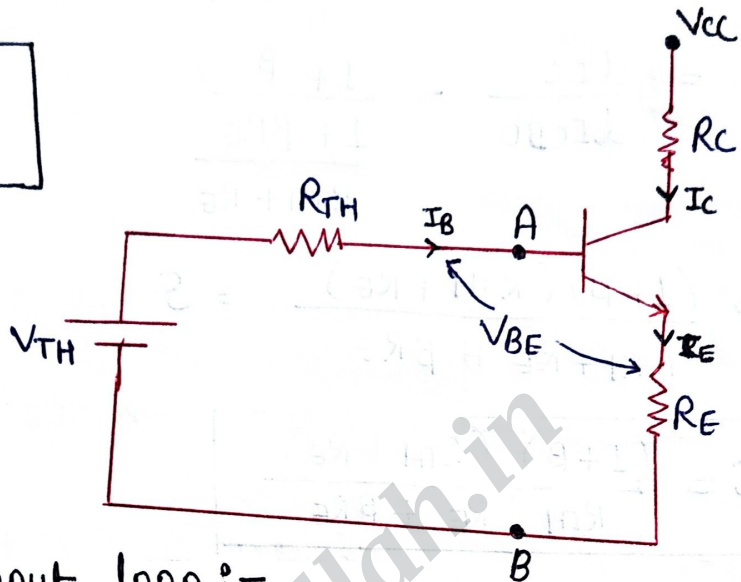
$$I_C = \frac{\beta (V_{TH} - V_{BE})}{R_{TH} + \beta R_E}$$

$$I_C = \frac{\cancel{\beta} (V_{TH} - V_{BE})}{0 + \cancel{\beta} R_E}$$

$$[R_{TH} < \beta R_E]$$

Free from β .

$$I_C = \frac{(V_{TH} - V_{BE})}{R_E}$$



→ Applying KVL in input loop :-

$$V_{TH} - I_B R_{TH} - V_{BE} - I_E R_E = 0$$

$$V_{TH} - I_B R_{TH} - V_{BE} - (I_B + I_C) R_E = 0 \quad [\because I_E = I_B + I_C]$$

$$V_{TH} - I_B R_{TH} - I_B R_E - I_C R_E - V_{BE} = 0$$

$$V_{TH} - I_C R_E - V_{BE} - I_B (R_{TH} + R_E) = 0$$

$$I_B = \frac{V_{TH} - I_C R_E - V_{BE}}{R_{TH} + R_E}$$

We know that,

$$I_C = \beta I_B + (\beta + 1) I_{CBO}$$

$$I_C = \beta \frac{(V_{TH} - I_C R_E - V_{BE})}{R_{TH} + R_E} + (\beta + 1) I_{CBO}$$

→ Differentiate w.r.t I_C :-

$$\begin{aligned} \frac{dI_C}{dI_C} &= \frac{\beta}{R_{TH} + R_E} [0 - R_E - 0] + (\beta + 1) \frac{dI_{CBO}}{dI_C} \\ &= \frac{dI_{CBO}}{dI_C} (1 + \beta) - \frac{\beta R_E}{R_{TH} + R_E} = 1 \end{aligned}$$

$$= \frac{dI_{CBO}}{dI_C} (1 + \beta) - \frac{1 + \beta R_E}{R_{TH} + R_E}$$

$$= \frac{dI_{CBO}}{dI_C} = \frac{1 + \frac{\beta R_E}{R_{TH} + R_E}}{1 + \beta}$$

$$= \frac{dI_C}{dI_{CBO}} = \frac{1 + \beta}{1 + \frac{\beta R_E}{R_{TH} + R_E}}$$

$$\Rightarrow \frac{(1 + \beta)(R_{TH} + R_E)}{R_{TH} + R_E + \beta R_E} = S$$

$$S = \frac{(1 + \beta)(R_{TH} + R_E)}{R_{TH} + R_E + \beta R_E}$$

3. Amplifiers... signal se strength ko increase karta he

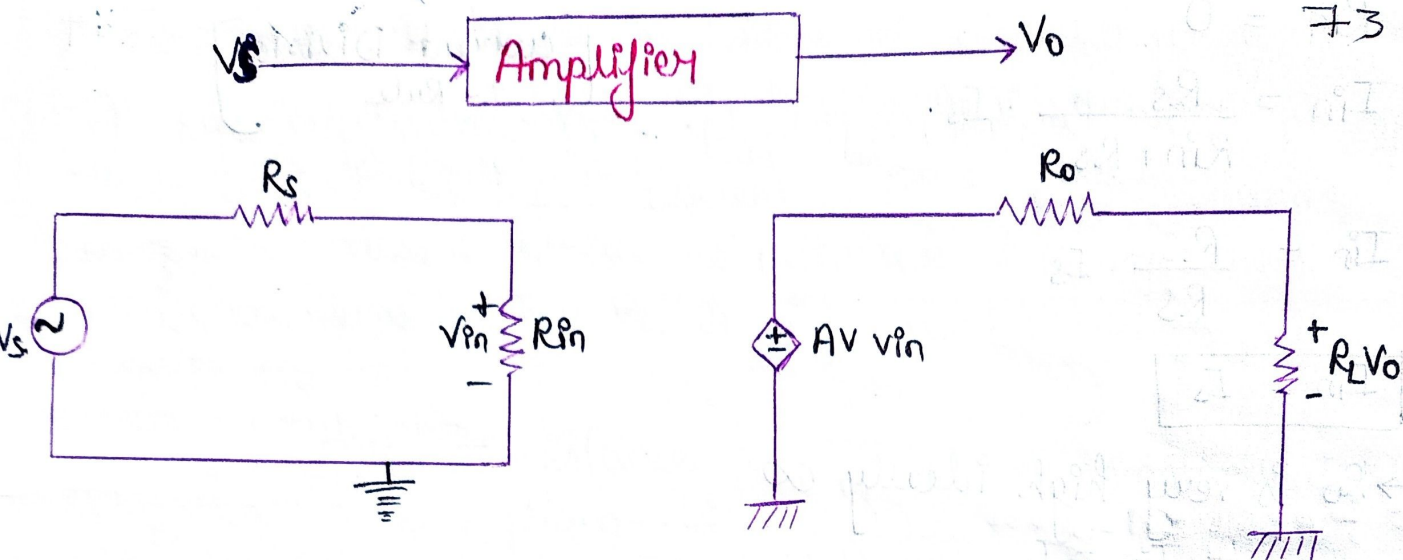
Amplifier is an electronic device that increase the strength of a signal typically audio or electrical making it stronger or more powerful without changing its content.

Types of Amplifier...

1. Voltage amplifier
2. Current amplifier
3. Transconductance amplifier
4. Transresistance amplifier

1. Voltage Amplifier...

Designed to increase the voltage level of an input signal commonly used in low-power application like audio equipment of instrumentation.



R_{in} is very high ideally infinity

$$V_{in} = \frac{R_{in}}{R_s + R_{in}} \times V_s \quad \left[\begin{array}{l} \text{voltage division} \\ \text{Rule} \end{array} \right]$$

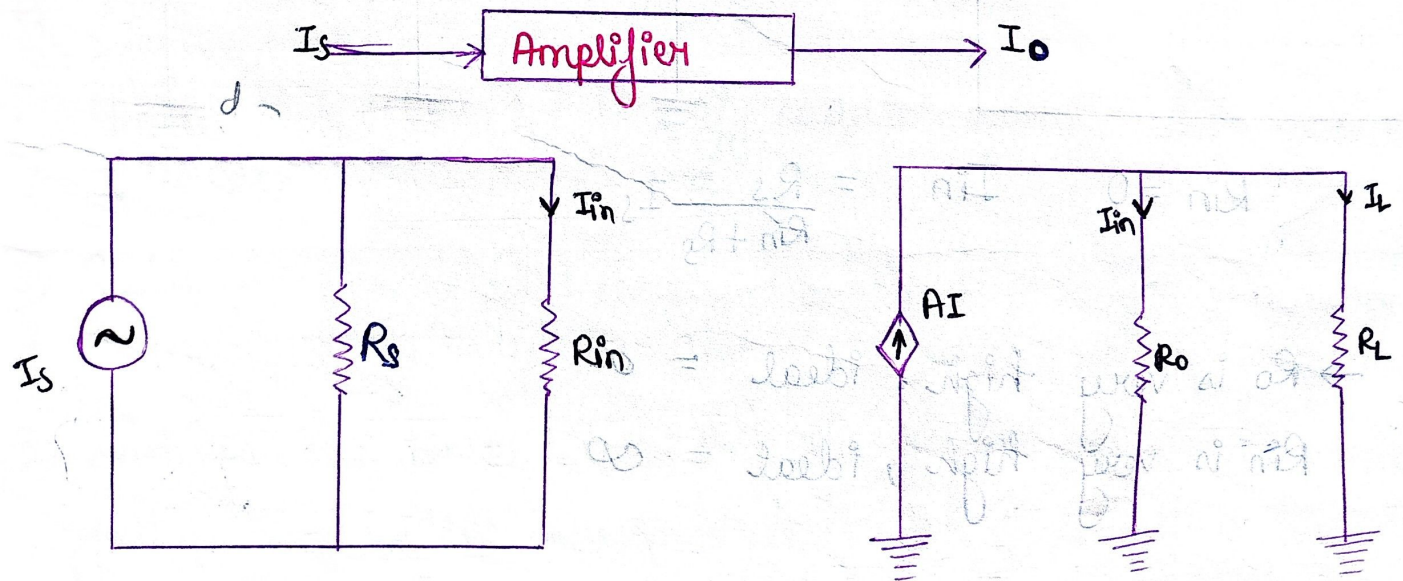
$$V_{in} \approx V_s$$

→ R_o is very less ideally 0.

$$V_o = \frac{R_L}{R_o + R_L} \times A_v V_{in} \Rightarrow \boxed{V_o = A_v V_{in}}$$

2. Current Amplifier...

Amplify the current of an input signal typically used when driving low impedance loads or specific current based application.



$$R_{in} = 0$$

$$I_{in} = \frac{R_s}{R_{in} + R_s} \cdot I_s$$

$$I_{in} = \frac{R_s}{R_s} \cdot I_s$$

$$I_{in} = I_s$$

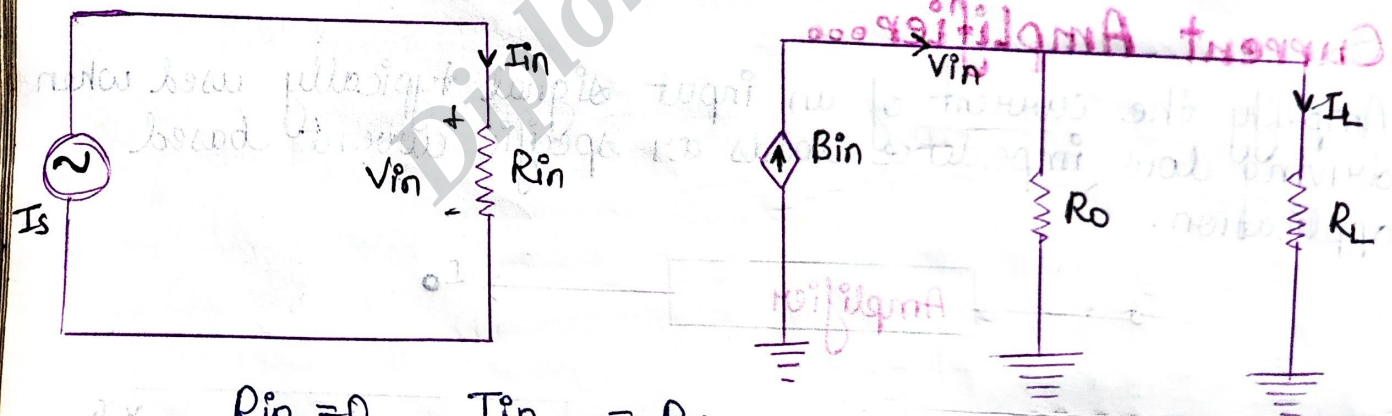
→ R_o is very high ideally ∞

d.c

$$A_i I_{in} = I_L$$

3. Transconductance Amplifier...

A transconductance amplifier is an amplifier that converts an input voltage into an output current. It is characterized by its ability to amplify the input voltage and produce a proportional output current with the ratio of output current to input voltage known as the transconductance.



$$R_{in} = 0$$

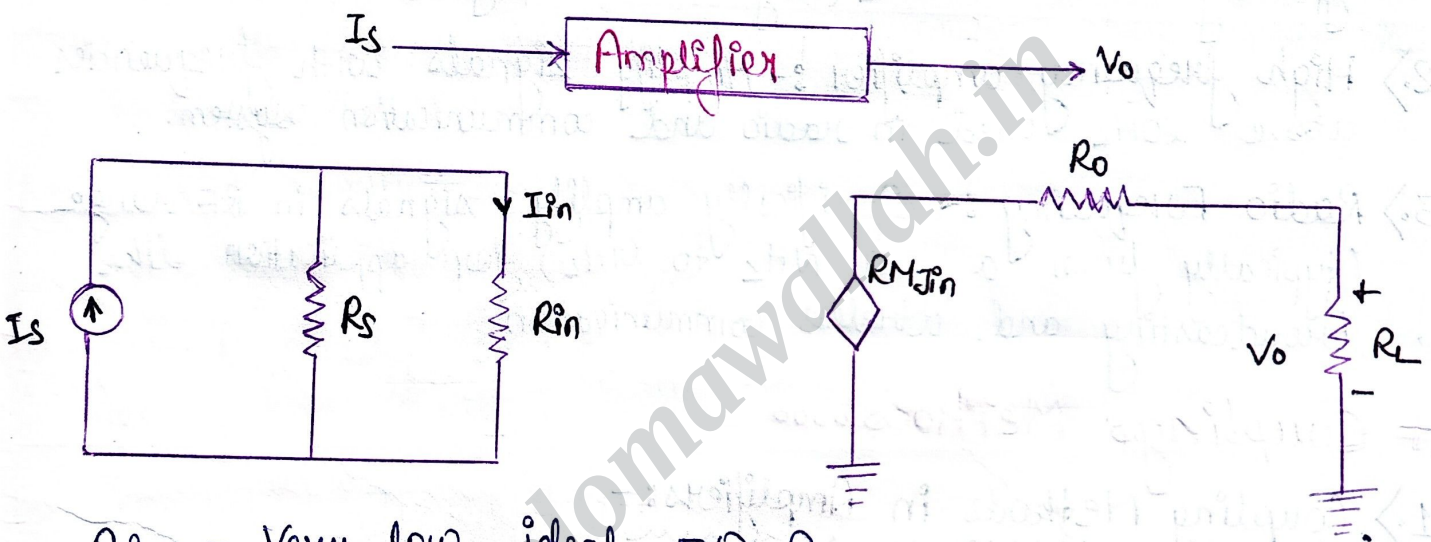
$$I_{in} = \frac{R_s}{R_{in} + R_s} I_s$$

→ R_o is very high, ideal = ∞
 R_{in} is very high, ideal = ∞

4. Transresistance Amplifier

A transresistance amplifier is an electronic amplifier that converts an input current into a proportional output voltage. It is characterized by its transresistance which is the ratio of output voltage to input current.

Transresistance amplifiers are commonly used in applications like photo detector circuit and signal processing where current signals need to be converted to voltage.



$$R_{in} = \text{Very low, ideal} = 0 \Omega$$

$$R_o = \text{very low, ideal} = 0 \Omega$$

Amplifier can be classified based on their use as:-

- ① Audio Amplifiers :- Amplify audio signals for speakers, musical instruments, and sound system.
- ② Radio frequency (RF) Amplifier :- Amplify high-frequency signals for radio, TV and communication system.
- ③ Instrumental Amplifier :- Amplify small differential signal for precise measurements and sensor applications.

- ④ Transconductance Amplifier :- Amplify convert input voltage into output current used in signal processing and audio.
- ⑤ Transresistance amplifier :- Convert input current into output voltage used in photodiode circuit and current of voltage conversion.

Frequency

1. Low Frequency amplifiers :- Amplify signals with frequencies typically below 20kHz (e.g audio amplifier).
2. High frequency amplifier :- Amplify signals with frequencies above 20Hz used in radio and communication system.
3. Radio Frequency :- Specifically amplify signals in RF range (typically from a few MHz to GHz) for application like broadcasting and wireless communication.

Couplings Methods

1. Coupling Methods in Amplifiers :-

→ Coupling refers to how signal transfer occurs between amplifier stages. The main types of coupling methods are-

(i) RC coupling (Resistor - Capacitor coupling).

→ Uses a capacitor to couple the signal between amplifier stages.

(ii) Transformer Coupling :-

→ Uses a transformer to transfer the signal between stages.

(iii) Direct coupling (DC coupling) :-

→ Directly connects amplifier stages without capacitor or transformers.

77
(iv) Optical Coupling (Optacoupling):-
→ Uses an optocoupler (LED) and (photo detector) to transfer signals.

Mode of Operation of Amplifier.....

i) Class A Amplifier :-

→ Conduction angle : 360° (always on)

ii) Class B Amplifier :-

→ Conduction angle : 180° (each transistor conducts for half of the cycle).

iii) Class AB Amplifier :- Conduction angle :- $180^\circ - 360^\circ$ (small bias current to reduce cross over distortion).

iv) Class C Amplifier :- Conduction angle :- Less than 180° (Used in RF applications).

v) Class D amplifier :- Uses pulse-width modulation (PWM) to operate transistors as switches.

Advantages and Disadvantages.....

1. Coupling Methods

Coupling Method	Advantages	Disadvantages
RC Coupling	Simple, inexpensive, good for audio applications.	Poor low frequency response, signal loss due to capacitor.
Transformer Coupling	Provides impedance matching, electrical isolation, good gain.	Bulky expensive, limited Band width.
Direct coupling (DC Coupling)	Excellent low frequency response, good for DC applications.	Prone to DC drift and thermal instability.

Optical
Coupling
(optocou-
pling)

Provides complete
electrical isolation
used in digital
circuits.

Slower response
time, limited to
low-power applic-
ations.

2. Modes of Operation

Amplifier Mode	Advantages	Disadvantages
Class A	Low distortion, high signal quality.	Least efficient (25-30%) high heat generation.
Class B	High efficiency (50-60%) less heat than class A.	Crossover distortion at zero crossing
Class AB	Good balance of efficiency and signal quality reduced cross-over distortion.	Slightly lower efficiency than class B.
Class C	High efficiency (70-80%) ideal for RF applications.	High distortion not suitable for audio signals.
Class D	Very high efficiency (90%) low power dissipation, ideal for audio.	Requires complex filtering to remove switching noise.