UNIT-II: SEMICONDUCTOR JUNCTION TRANSISTOR

Bipolar Junction Transistor (BJT): Construction and Operation of NPN and PNP transistors – CE, CB and CC configurations - Input and output characteristics of CE, CB and CC - Transistor biasing – Transistor as an Amplifier - Qualitative explanation of voltage gain, current gain, power gain, input impedance, output impedance, frequency response and bandwidth - Tuned amplifier – Introduction to power amplifier

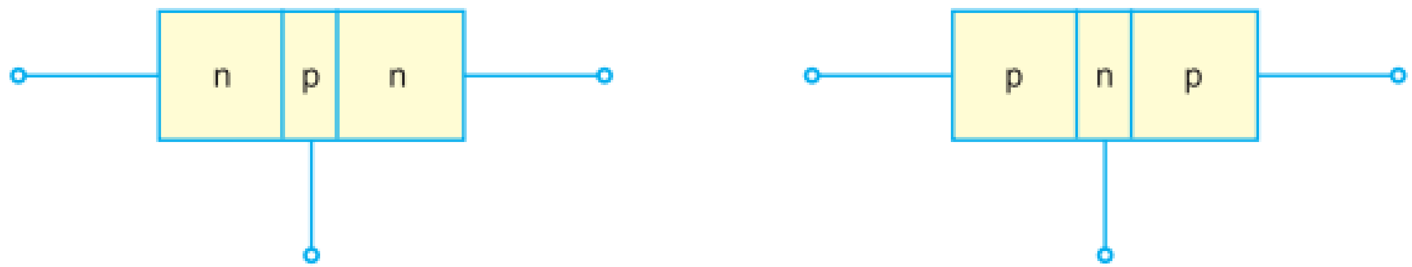
- **Bipolar Junction Transistors**

Bipolar Junction Transistors

- The transistor is a three-layer semiconductor device consisting of either two n- and one p- type layers of material or two p- and one n- type layers of material.
- The former is called an npn transistor, while the latter is called a pnp transistor
- So, there are two types of BJT-

  i) pnp transistor   ii) npn transistor

Bipolar Junction Transistors

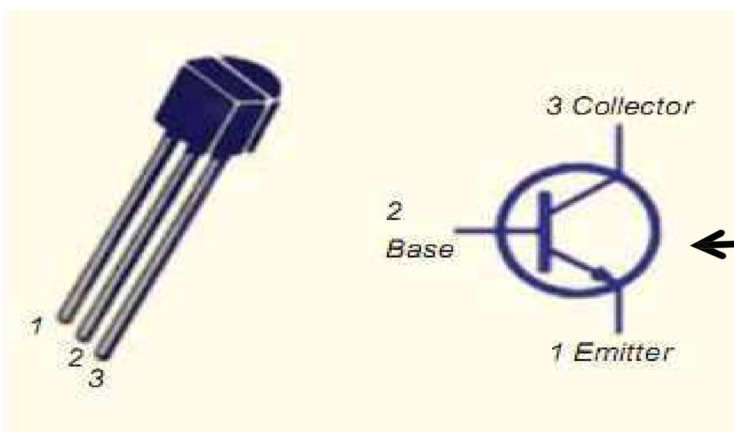


In each transistor following points to be noted-

i) There are two junction, so transistor can be considered as two diode connected back to back.
ii) There are three terminals.
iii) The middle section is thin than other.

Naming of Transistor Terminals

- Transistor has three section of doped semiconductor.
- The section one side is called “emitter” and the opposite side is called “collector”.
- The middle section is called “base”.



Transistor symbol

Naming of Transistor Terminals

1) ***Emitter:***

→ The section of one side that supplies carriers is called emitter.

→ Emitter is always forward biased wr to base so it can supply carrier.

→ For “npn transistor” emitter supply holes to its junction.

→ For “pnp transistor” emitter supply electrons to its junction.

Naming of Transistor Terminals

2) Collector:

→The section on the other side that collects carrier is called collector.

→ The collector is always reversed biased wr to base.

→For “npn transistor” collector receives holes to its junction.

→ For “pnp transistor” collector receives electrons to its junction.

Naming of Transistor Terminals

3) Base:

→The middle section which forms two pn junction between emitter and collector is called Base.

Some important factors to be remembered-

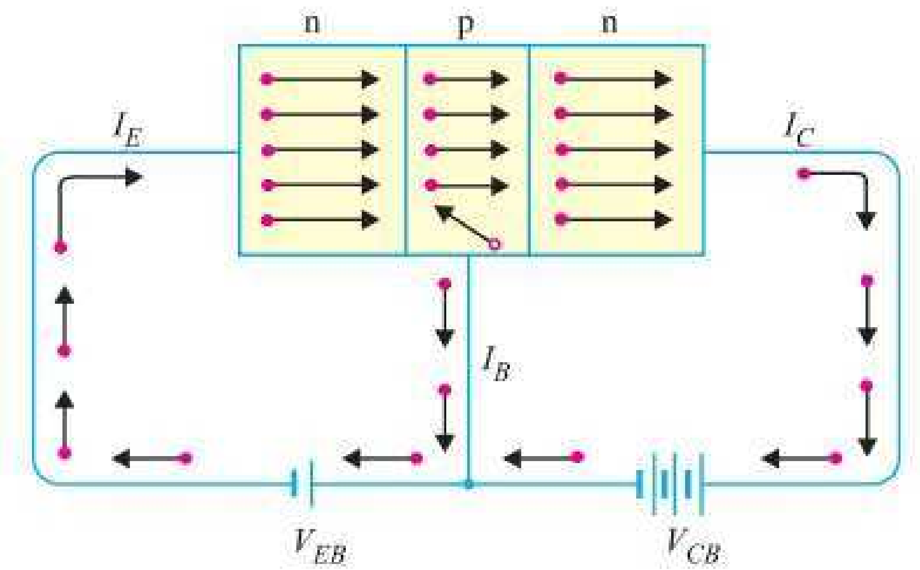
- The transistor has three region named emitter, base and collector.
- The Base is much thinner than other region.
- Emitter is heavily doped so it can inject large amount of carriers into the base.
- Base is lightly doped so it can pass most of the carrier to the collector.
- Collector is moderately doped.

Some important factors to be remembered-

- The junction between emitter and base is called emitter-base junction(emitter diode) and junction between base and collector is called collector-base junction(collector diode).
- The emitter diode is always forward biased and collector diode is reverse biased.
- The resistance of emitter diode is very small(forward) and resistance of collector diode is high(reverse).

Transistor Operation

1) Working of npn transistor:



✓Forward bias Is applied to emitter-base junction and reverse bias is applied to collector-base junction.

✓The forward bias in the emitter-base junction causes electrons to move toward base. This constitute emitter current, I_E

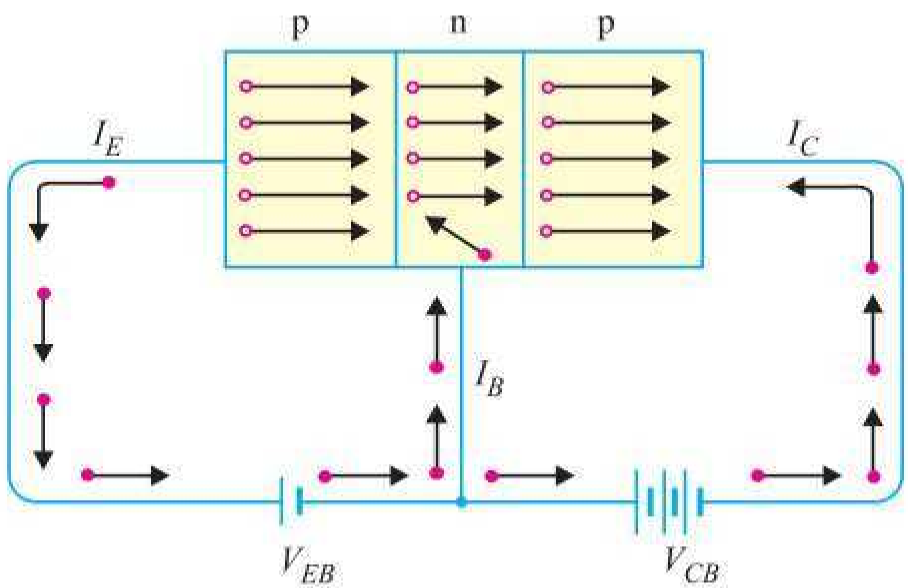
Transistor Operation

1) Working of npn transistor:

- ✓ As this electrons flow toward p-type base, they try to recombine with holes. As base is lightly doped only few electrons recombine with holes within the base.
- ✓ These recombined electrons constitute small base current.
- ✓ The remainder electrons crosses base and constitute collector current. $I_E = I_B + I_C$

Transistor Operation

2) Working of pnp transistor:



✓Forward bias is applied to emitter-base junction and reverse bias is applied to collector-base junction.

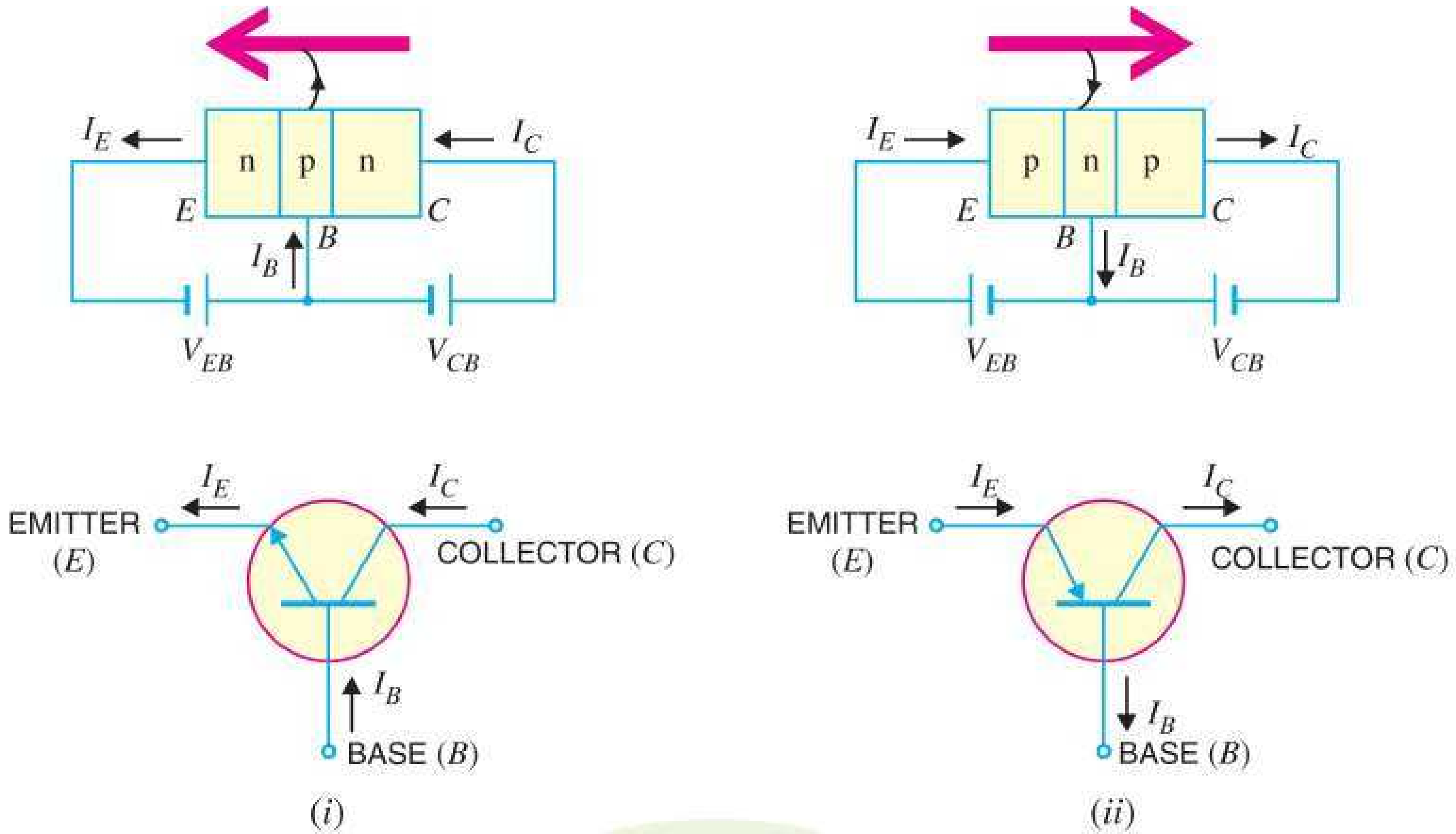
✓The forward bias in the emitter-base junction causes holes to move toward base. This constitute emitter current, I_E

Transistor Operation

2) Working of pnp transistor:

- ✓ As this holes flow toward n-type base, they try to recombine with electrons. As base is lightly doped only few holes recombine with electrons within the base.
- ✓ These recombined holes constitute small base current.
- ✓ The remainder holes crosses base and constitute collector current.

Transistor Symbol



Transistor Operating Modes

amplifier   Ex:- Switch ⇒ Sat, cut off
ON   1   0
OFF

- Active Mode

  → Base- Emitter junction is forward and Base- Collector junction is reverse biased.
- Saturation Mode

  → Base- Emitter junction is forward and Base- Collector junction is forward biased.
- Cut-off Mode

  → Both junctions are reverse biased.

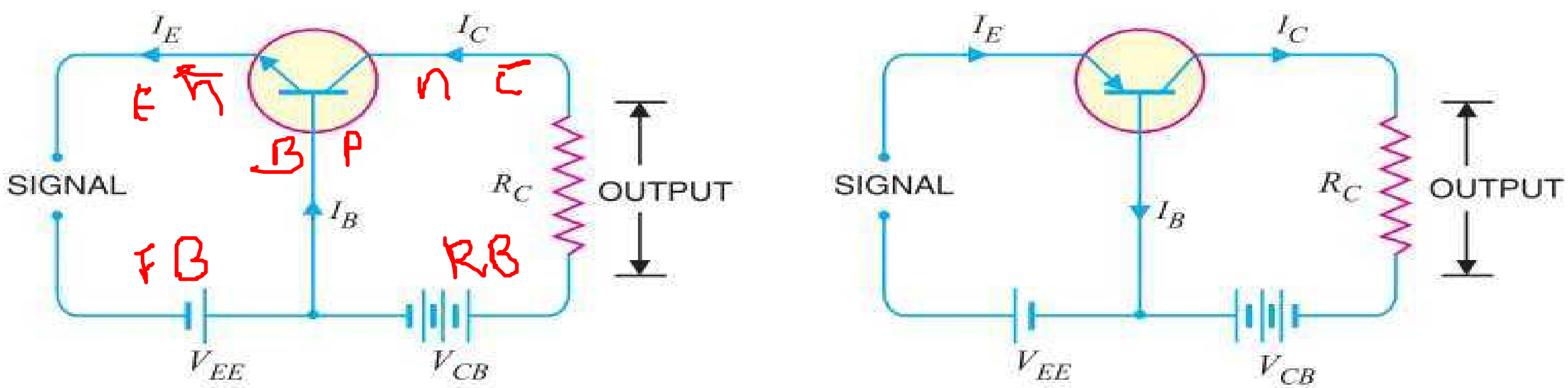
Transistor Connection

- Transistor can be connected in a circuit in following three ways-

1) Common Base
2) Common Emitter
3) Common Collector

Common Base Connection

- The common-base terminology is derived from the fact that the base is common to both the input and output sides of the configuration.



- First Figure shows common base npn configuration and second figure shows common base pnp configuration.

Common Base Connection

- <u>Current amplification factor (α) :</u>

The ratio of change in collector current to the change in emitter current at constant V_{CB} is known as current amplification factor, α.

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

$\alpha < 1$

→ Practical value of α is less than unity, but in the range of 0.9 to 0.99

Expression for Collector Current

→Total emitter current does not reach the collector terminal, because a small portion of it constitute base current. So,

KCL

$$I_E = I_C + I_B$$

→Also, collector diode is reverse biased, so very few minority carrier passes the collector-base junction which actually constitute leakage current, I_{CBO}.

→ So, collector current constitute of portion of emitter current αI_E and leakage current I_{CBO}.

$$I_C = \alpha I_E + I_{CB0}$$

Expression for Collector Current

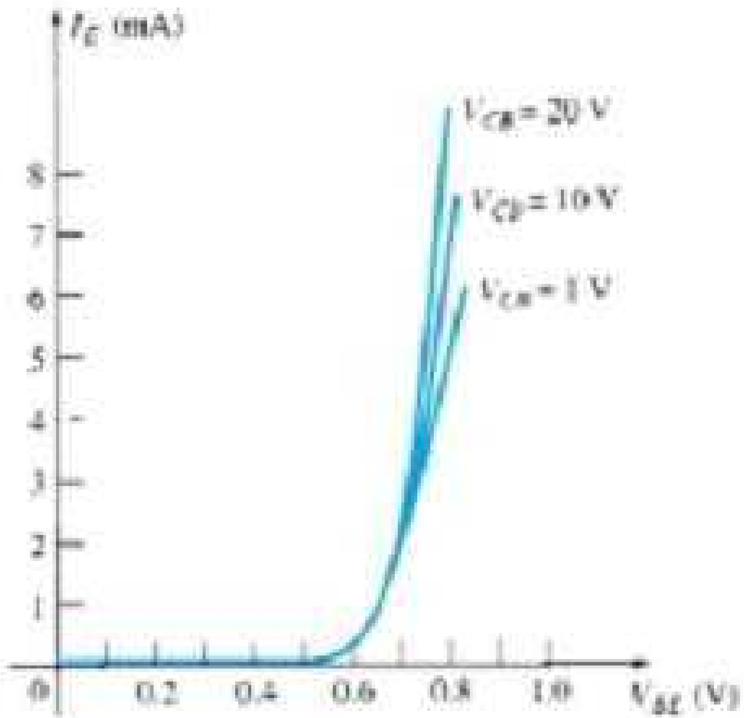
$$I_C = \alpha\,(I_C + I_B) + I_{CBO}$$

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

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

Characteristics of common base configuration

- <u>Input Characteristics:</u>



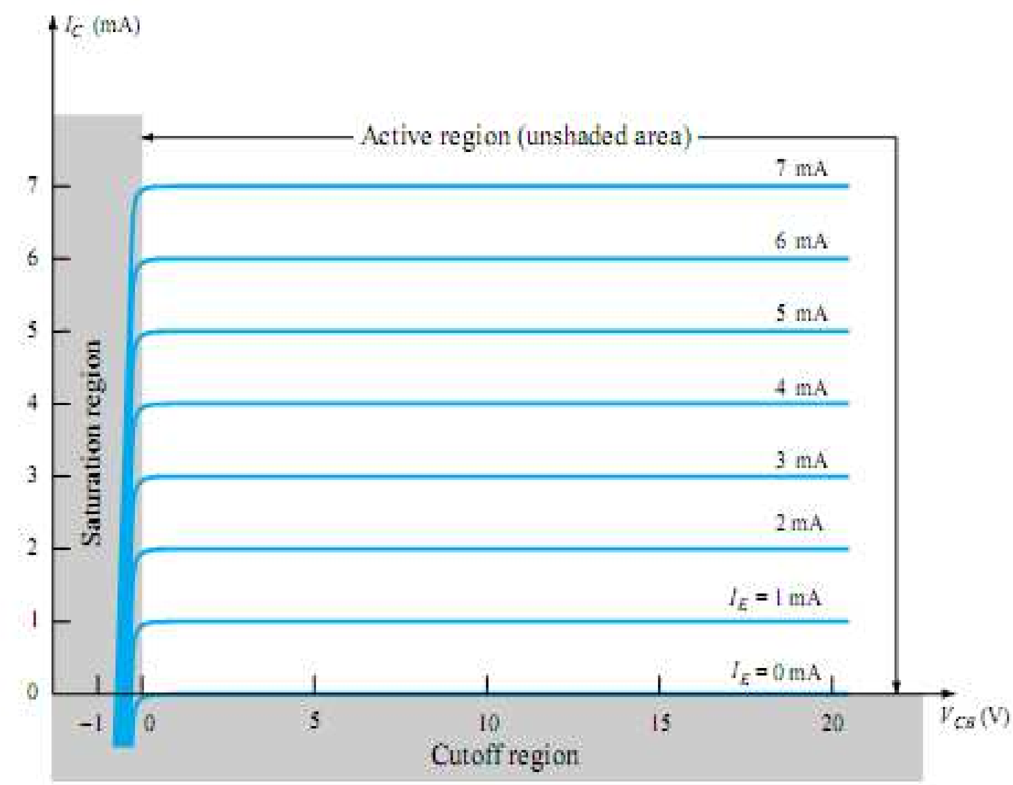
→V_{BE} vs I_E characteristics is called input characteristics.

→ I_E increases rapidly with V_{BE}. It means input resistance is very small.

→ I_E almost independent of V_{CB}.

Characteristics of common base configuration

<u>Output Characteristics:</u>



- → V_{Bc} vs I_c characteristics is called output characteristics.
- → I_C varies linearly with V_{Bc} ,only when V_{Bc} is very small.
- → As, V_{Bc} increases, I_C becomes constant.

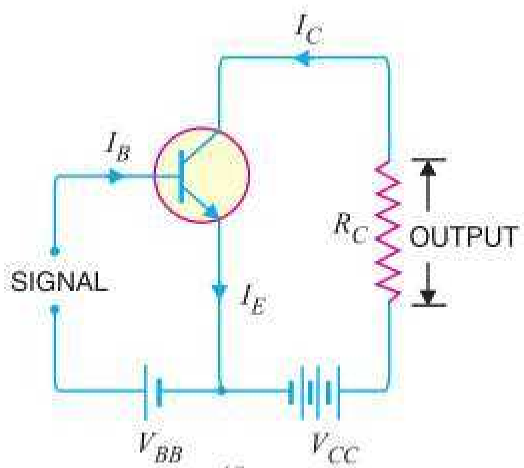
Input and Output Resistance of common base conf.

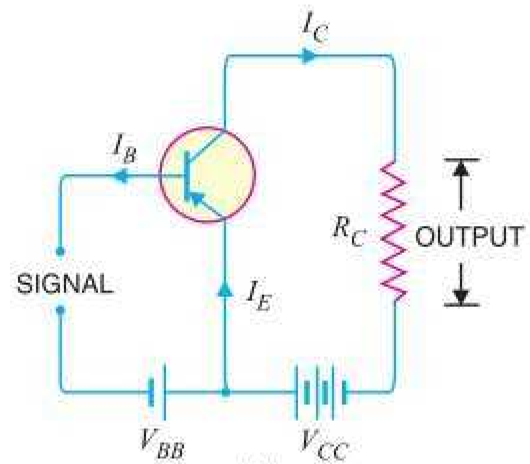
- <u>Input Resistance:</u> The ratio of change in emitter-base voltage to the change in emitter current is called Input Resistance. $$r_i = \frac{\Delta V_{BE}}{\Delta I_E}$$
- <u>Output Resistance:</u> The ratio of change in collector-base voltage to the change in collector current is called Output Resistance.

$$r_0 = \frac{\Delta V_{BC}}{\Delta I_C}$$

Common Emitter Connection

- The common-emitter terminology is derived from the fact that the emitter is common to both the input and output sides of the config





- First Figure shows common emitter npn configuration and second figure shows common emitter pnp configuration.

Common Emitter Connection

- <u>Base Current amplification factor (β)</u> :
- In common emitter connection input current is base current and output current is collector current.
- The ratio of change in collector current to the change in base current is known as base current amplification factor, β.

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

- Normally only 5% of emitter current flows to base, so amplification factor is greater than 20. Usually this range varies from 20 to 500.

Relation Between β and α

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

$$\alpha = \frac{\Delta I_C}{\Delta I_E}$$

$$I_E = I_B + I_C$$

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

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

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

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

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

Expression for Collector Current

(output)

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

$$I_E = I_B + I_C \quad \text{---} \quad (2)$$

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

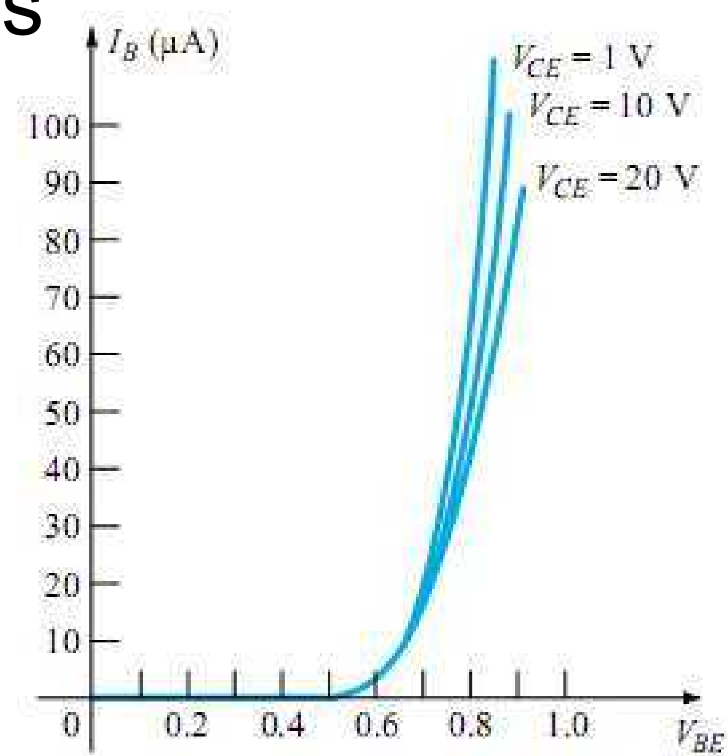
$$I_C (1-\alpha) = \alpha I_B + I_{CBO}$$

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

$$\boxed{I_C = \beta I_B + I_{CEO}}$$

Characteristics of common emitter configuration

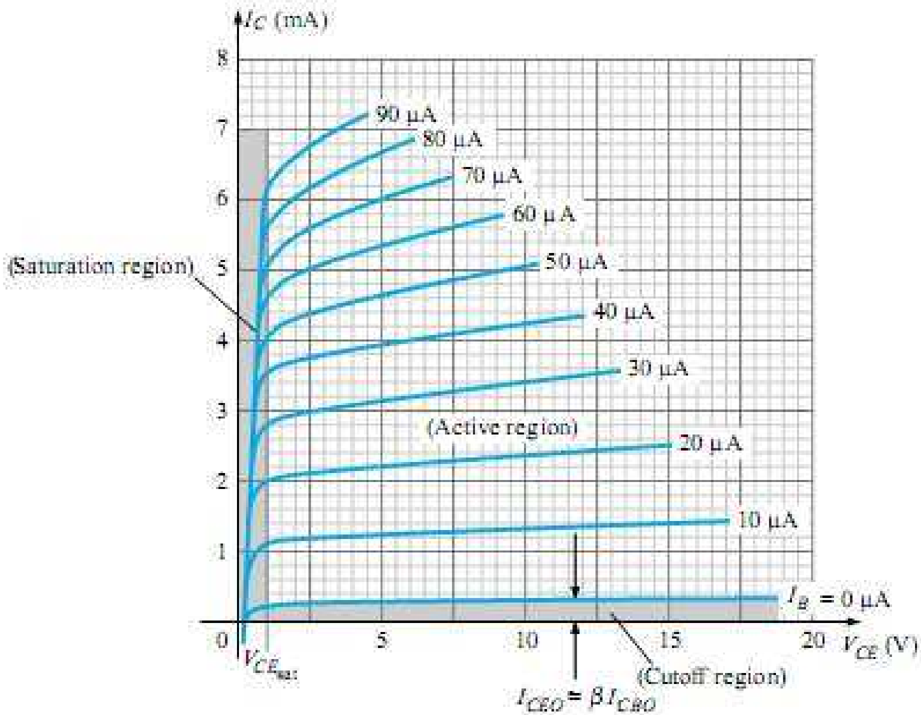
- Input Characteristics: → V_{BE} vs I_B characteristics is



called input characteristics.
→ I_B increases rapidly with V_{BE} . It means input resistance is very small.
→ I_E almost independent of $V_{CE.}$
→I_B is of the range of micro amps

Characteristics of common emitter configuration

- <u>Output Characteristics:</u>



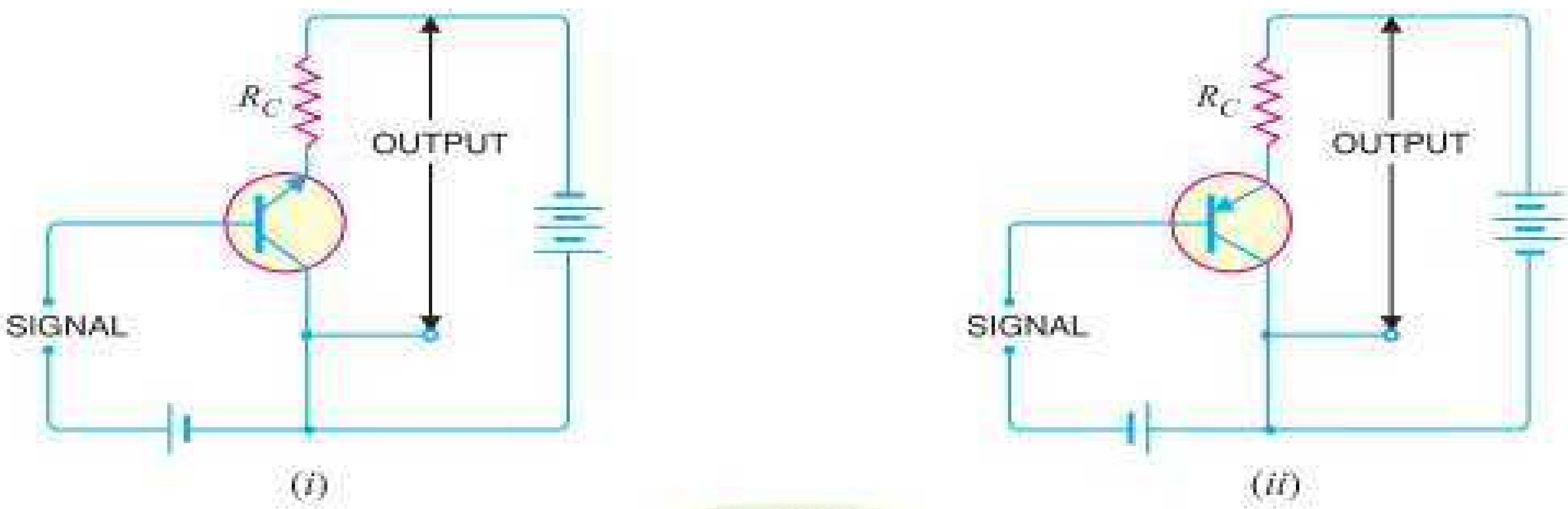
- → V_{CE} vs I_c characteristics is called output characteristics.
- → I_C varies linearly with V_{CE} ,only when V_{CE} is very small.
- → As, V_{CE} increases, I_C becomes constant.

Input and Output Resistance of common emitter conf.

- <u>Input Resistance:</u> The ratio of change in emitter-base voltage to the change in base current is called Input Resistance. $r_i = \frac{\Delta V_{BE}}{\Delta I_B}$
- <u>Output Resistance:</u> The ratio of change in collector-emitter voltage to the change in collector current is called Output Resistance. $r_0 = \frac{\Delta V_{CE}}{\Delta I_C}$

Common Collector Configuration

- The common-collector terminology is derived from the fact that the collector is common to both the input and output sides of the configuration.



- First Figure shows common collector npn configuration and second figure shows common collector pnp configuration.

Common Collector Configuration

- Current amplification factor (γ) :
- In common emitter connection input current is base current and output current is emitter current.
- The ratio of change in emitter current to the change in base current is known as current amplification

factor in common collector configuration.

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

- This circuit provides same gain as CE configuration as

$$\underline{\Delta I_E \approx \Delta I_C}$$

,

$$I_E = I_B + I_C$$

Relation Between γ and α

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

$$\alpha = \frac{\Delta I_C}{\Delta I_E}$$

$$I_E = I_B + I_C$$

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

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

$$\gamma = \frac{\Delta I_E}{\Delta I_E - \Delta I_C}$$

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

Expression for ~~Collector Current~~ o/p

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

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

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

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

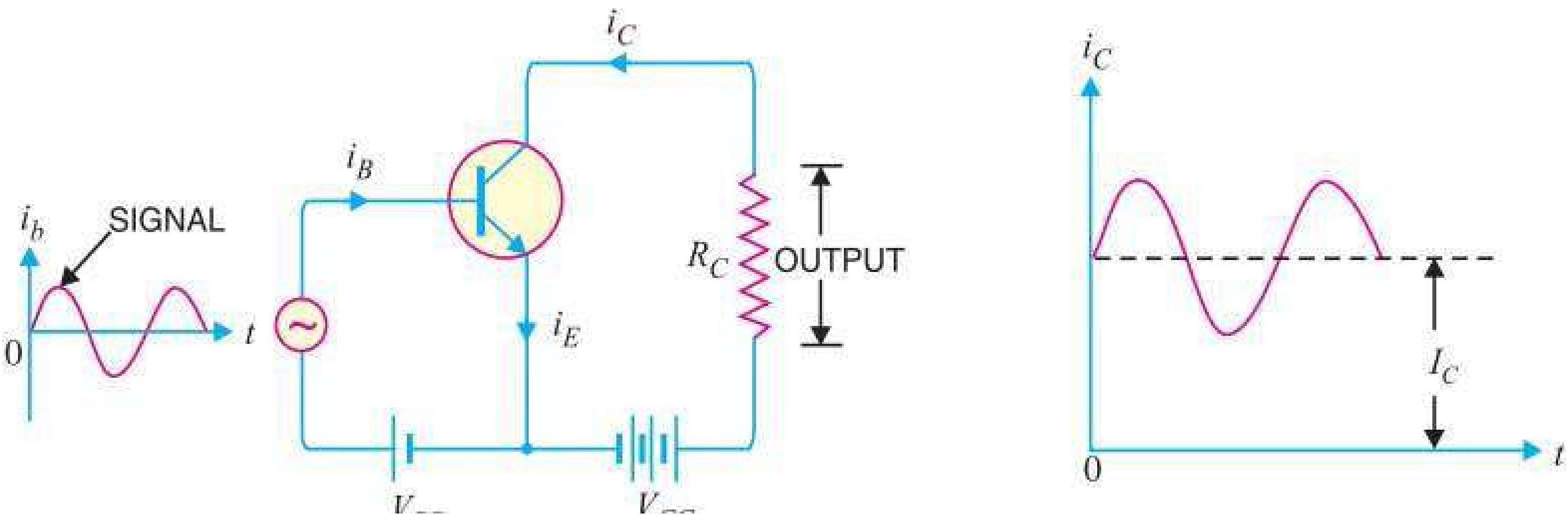
$$\cancel{I_C}\ ; \quad I_E = *(\beta+1)\, I_B + (\beta+1)\, I_{CBO}$$

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

Comparison of Transistor Connection

S. No.	Characteristic	Common base	Common emitter	Common collector
1.	Input resistance	Low (about 100 Ω)	Low (about 750 Ω)	Very high (about 750 kΩ)
2.	Output resistance	Very high (about 450 kΩ)	High (about 45 kΩ)	Low (about 50 Ω)
3.	Voltage gain	about 150	about 500	less than 1
4.	Applications	For high frequency applications	For audio frequency applications	For impedance matching
5.	Current gain	No (less than 1)	High (β)	Appreciable

Transistor as an amplifier in CE conf.



- Figure shows CE amplifier for npn transistor.
- Battery V_{BB} is connected with base in-order to make base forward biased, regardless of input ac polarity.
- Output is taken across Load R

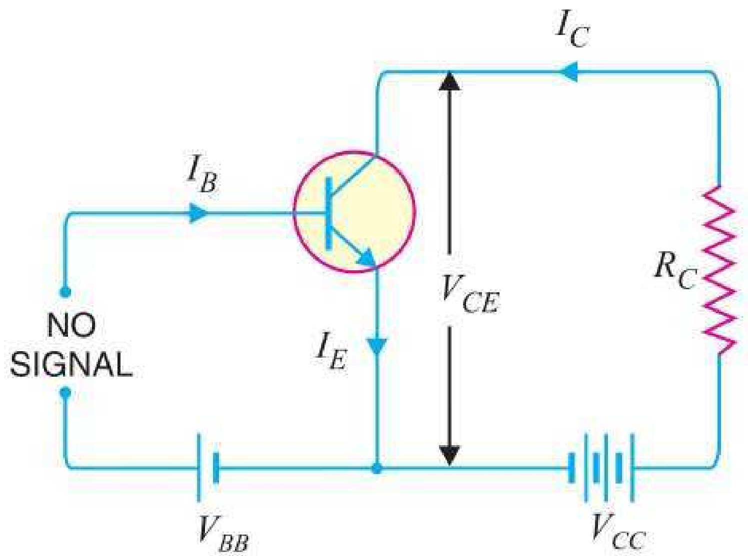
Transistor as an amplifier in CE conf.

- During positive half cycle input ac will keep the emitter- base junction more forward biased. So, more carrier will be emitted by emitter, this huge current will flow through load and we will find output amplified signal.
- During negative half cycle input ac will keep the emitter-base junction less forward biased. So, less carrier will be emitted by emitter. Hence collector current decreases.
- This results in decreased output voltage (In opposite direction).

Transistor Load line analysis

- In transistor circuit analysis it is necessary to determine collector current for various V_{CE} voltage.
- One method is we can determine the collector current at any desired V_{CE} voltage, from the output characteristics.
- More conveniently we can use load line analysis to determine operating point.

Transistor Load line analysis



→Consider common emitter npn transistor ckt shown in figure.
→There is no input signal.
→ Apply KVL in the output ckt-

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

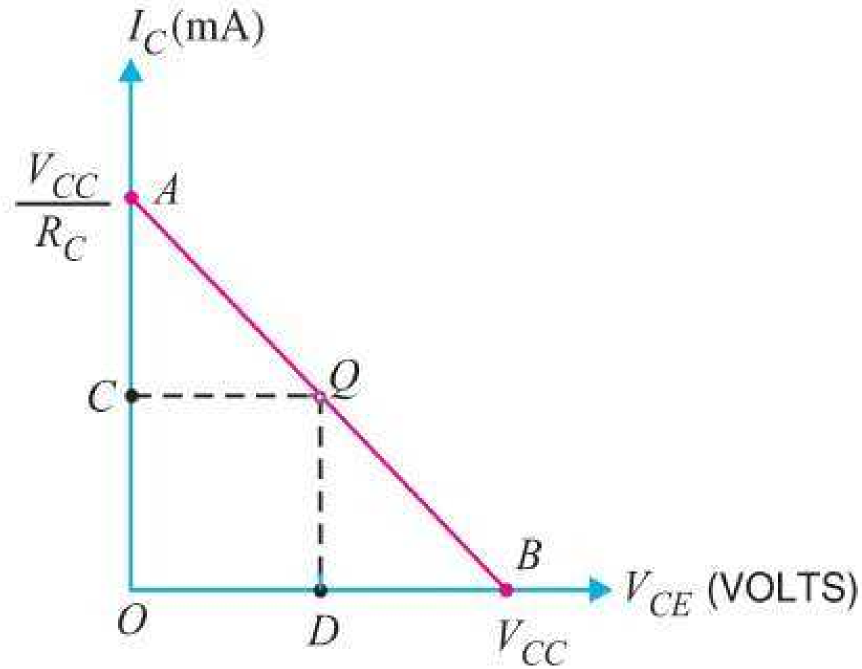
(*i*) When the collector current $I_C = 0$, then collector-emitter voltage is maximum and is equal to V_{CC} *i.e.*

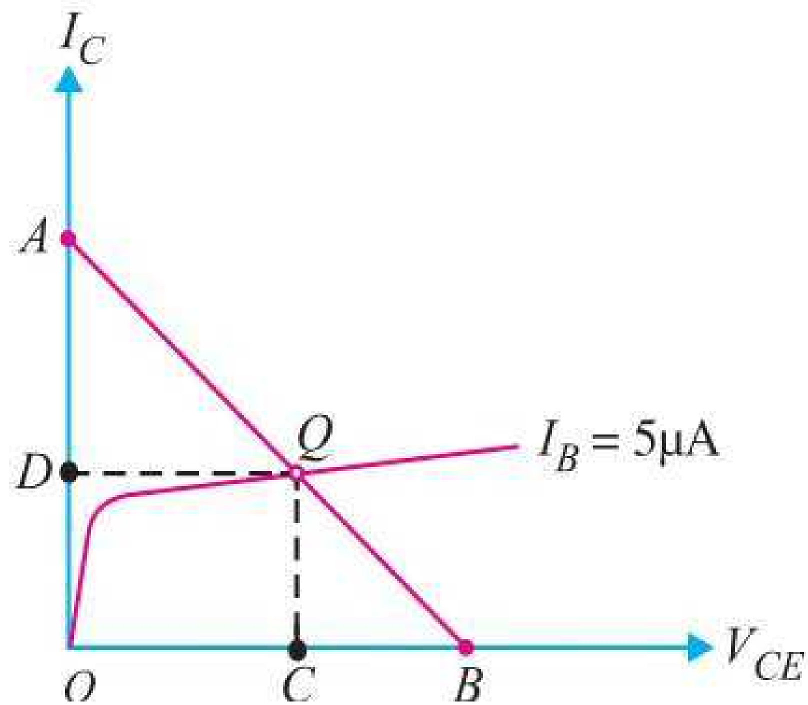
$$\text{Max. } V_{CE} = V_{CC} - I_C R_C$$
$$= V_{CC} \qquad (\because I_C = 0)$$

When collector-emitter voltage $V_{CE} = 0$,

$$V_{CE} = V_{CC} - I_C R_C$$
$$0 = V_{CC} - I_C R_C$$
$$\text{Max. } I_C = V_{CC}/R_C$$

Transistor Load line analysis



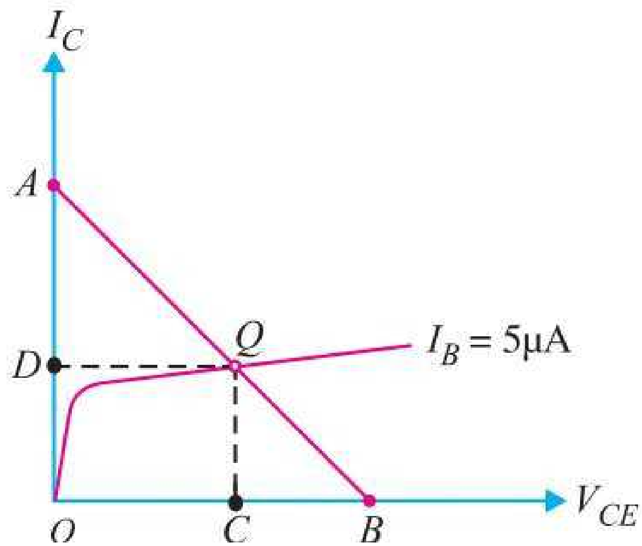


Operating Point

The zero signal values of I_C and V_{CE} are known as the **operating point.**

→It is called operating point because variation of I_C takes place about this point.

→ It is also called quiescent point or Q-point.



Frequency response and B.W

- Topic to be covered:

  - ❖Basic concepts
  - ❖Low-frequency amplifier response
  - ❖High-frequency amplifier response
  - ❖Total amplifier frequency response

The Decibel

- The **decibel** is a common unit of measurement of voltage gain and frequency response. It is a logarithmic measurement of the ratio of one power to another or one voltage to another.
- The formulas below are used for calculation of decibels for power gain and voltage gain.

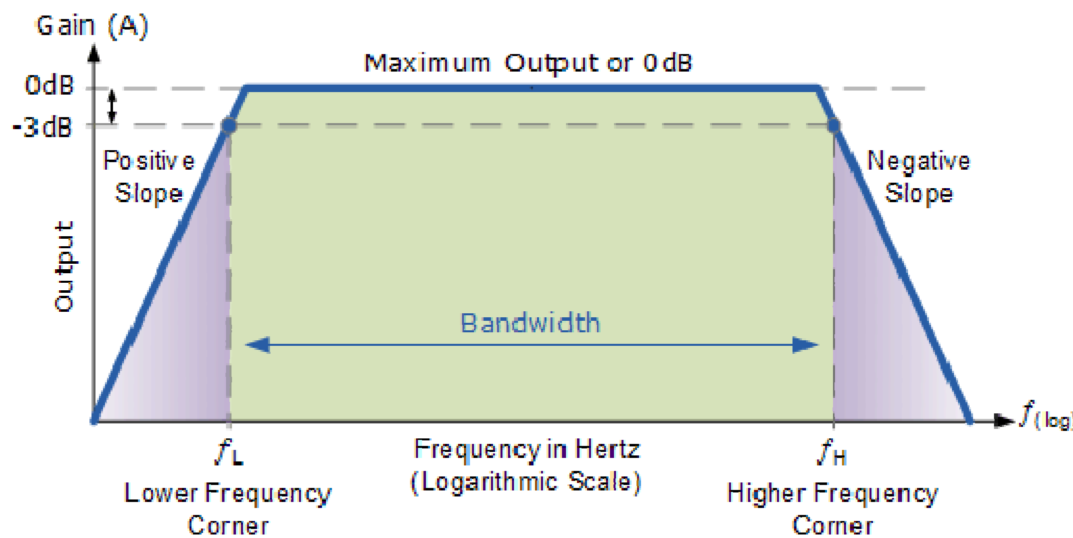
$$\boldsymbol{A_p(db) = 10 \log A_p}$$

$$\boldsymbol{A_v(db) = 20 \log A_v}$$

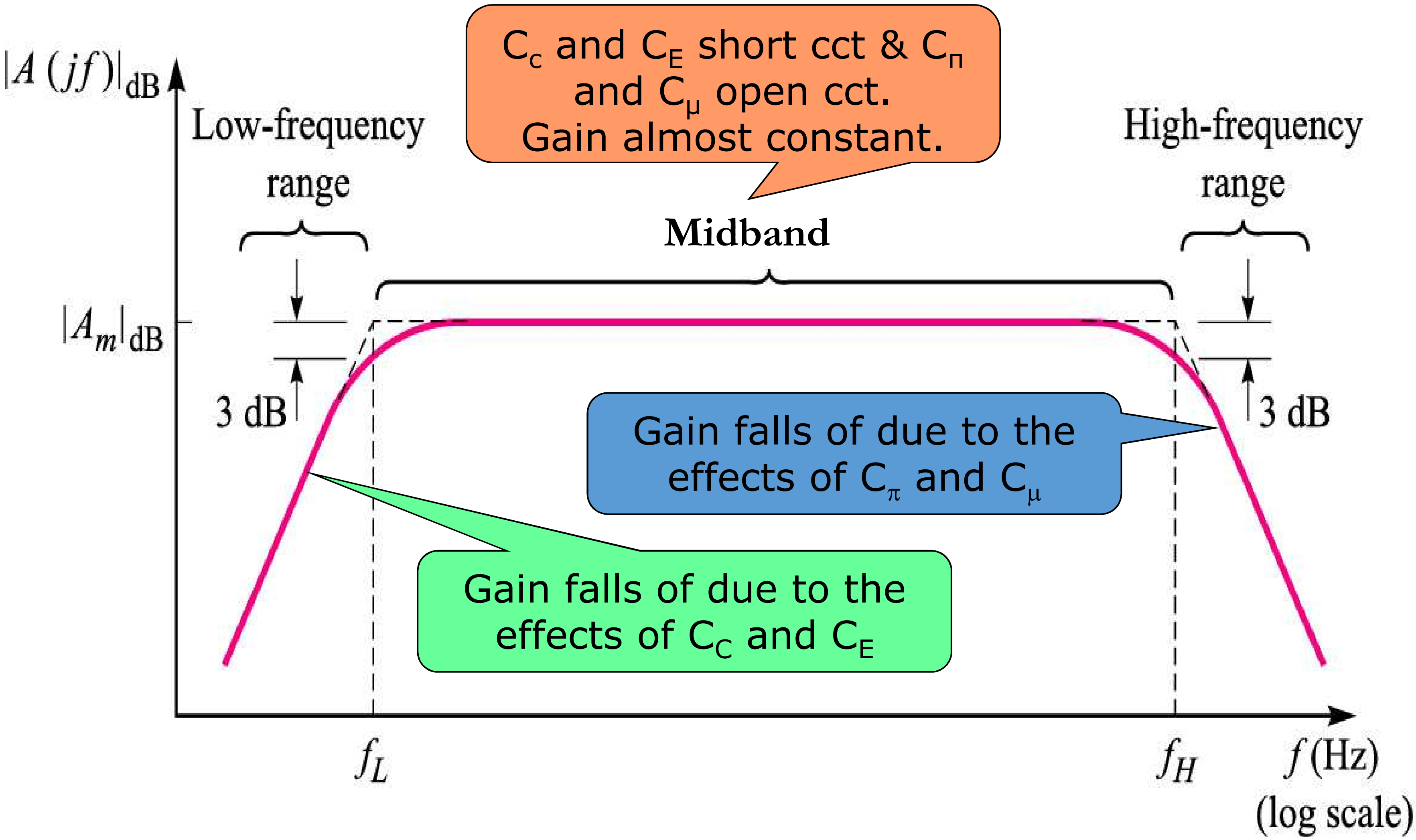
- If Av is > 1, dB gain is +ve. If Av is < 1, dB gain is –ve and usually called attenuation.

Bandwidth:

- **Bandwidth** is the range of frequencies that a circuit operates at in between its upper and lower cut-off **frequency** points. These cut-off or corner **frequency** points indicate the frequencies at which the power associated with the output falls to half its maximum value.



Basic concepts cont..
-Amplifier gain vs frequency-



-Amplifier gain vs frequency-

- **LOW FREQUENCY RANGE**

→gain decreases as the frequency decreases due to **coupling** and **bypass capacitor** effects.

- **HIGH FREQUENCY RANGE**

→gain decreases as the frequency increases due to **stray capacitance** and **transistor capacitance** effects.

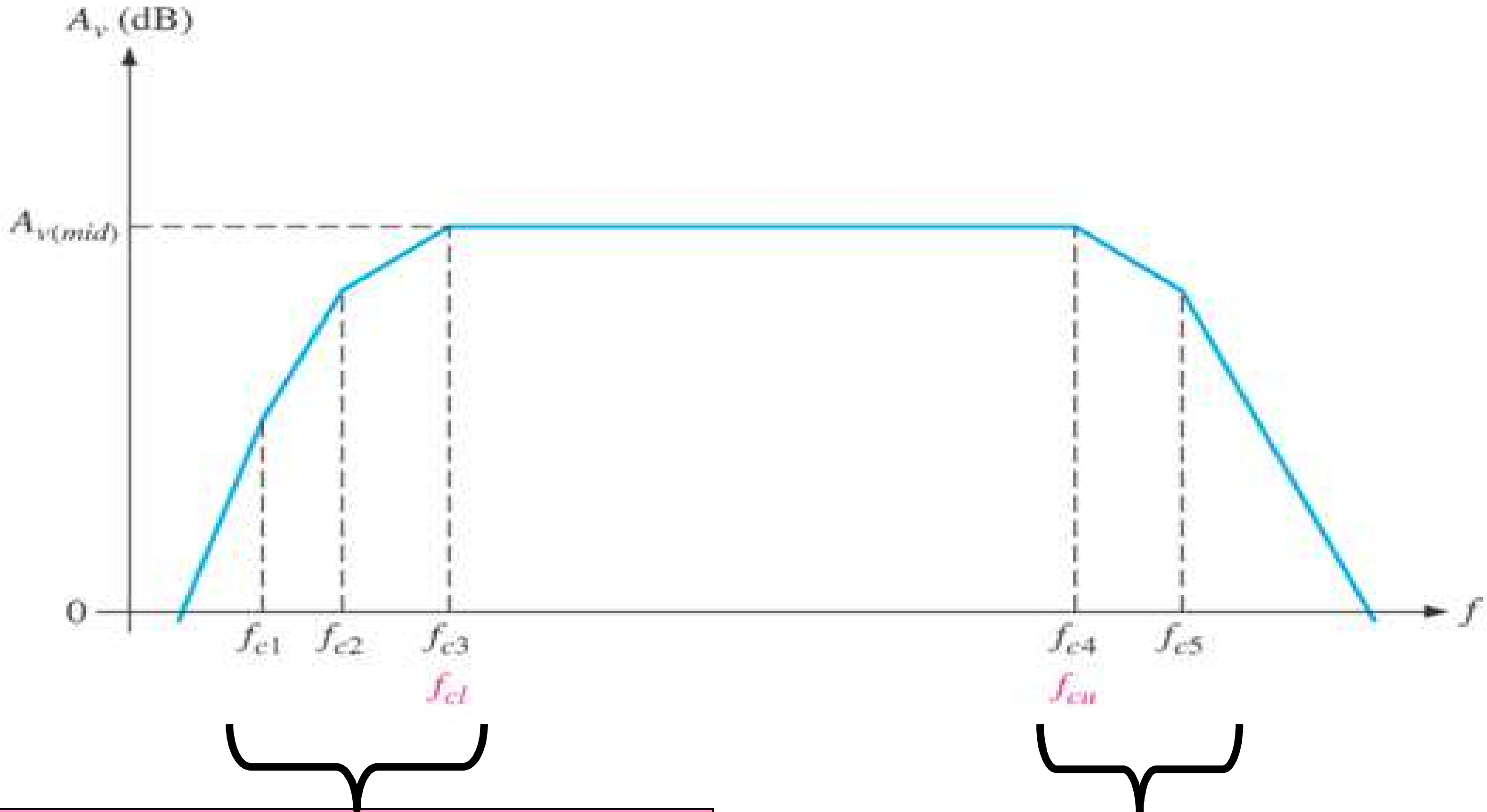
- **MIDBAND RANGE**

→ gain is almost constant – coupling and bypass capacitors act as **short circuits** and stray and transistor capacitances act as **open circuits**.

Definitions

- Frequency response of an amplifier is the graph of its *gain versus the frequency*.
- *Cutoff frequencies* : the frequencies at which the voltage gain equals 0.707 of its maximum value.
- *Midband* : the band of frequencies between $10f_1$ and $0.1f_2$. The voltage gain is maximum.
- *Bandwidth* : the band between upper and lower cutoff frequencies

Total Amplifier Frequency Response



-3 break points at lower critical frequencies (fc1,fc2 and fc3) produced by 3 low-frequency RC circuits formed by Cc and C_E

-2 break points at upper frequencies fc4 and fc5 produced by 2 high-frequency RC circuits formed by transistor's internal capacitance

Tuned Amplifiers:

DEFINITION:-

An amplifier circuit in which the load circuit is a tank circuit such that it can be tuned to pass or amplify selection of a desired frequency or a narrow band of frequencies, is known as Tuned Circuit Amplifier.

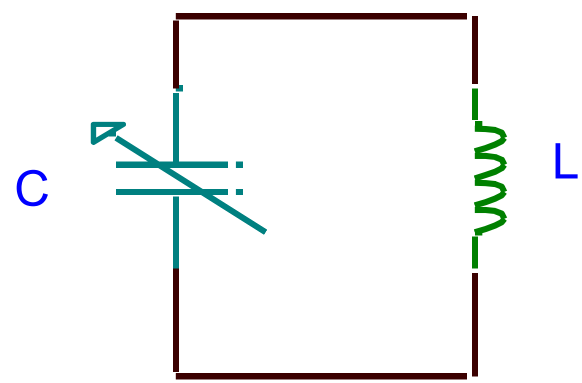
CHARACTERISTICS OF TUNED AMPLIFIER:

- Tuned amplifier selects and amplifies a single frequency from a mixture of frequencies in any frequency range.

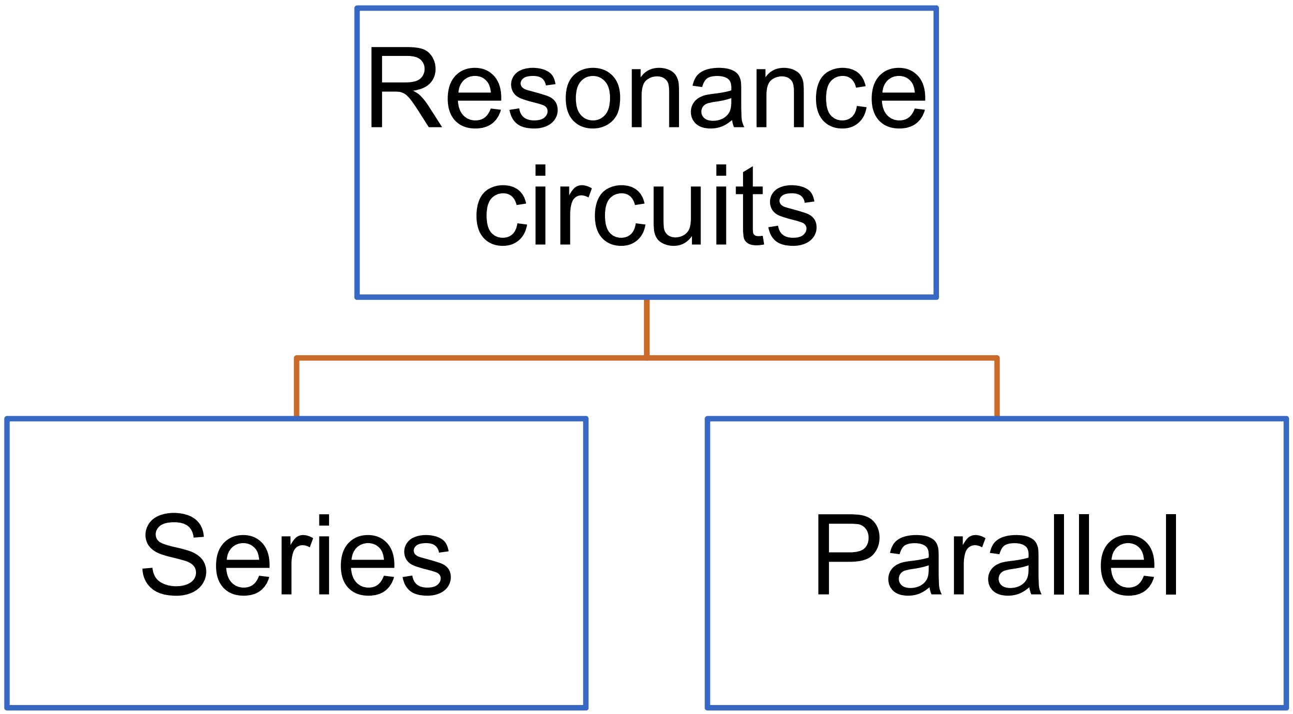
- A Tuned amplifier employs a tuned circuit.
- It uses the phenomena of resonance, the tank circuit which is capable of selecting a particular or relative narrow band of frequencies.
- The centre of this frequency band is the resonant frequency of the tuned circuit .
- Both types consist of an inductance L and capacitance C with two element connected in series and parallel.

RESONANCE CIRCUITS:

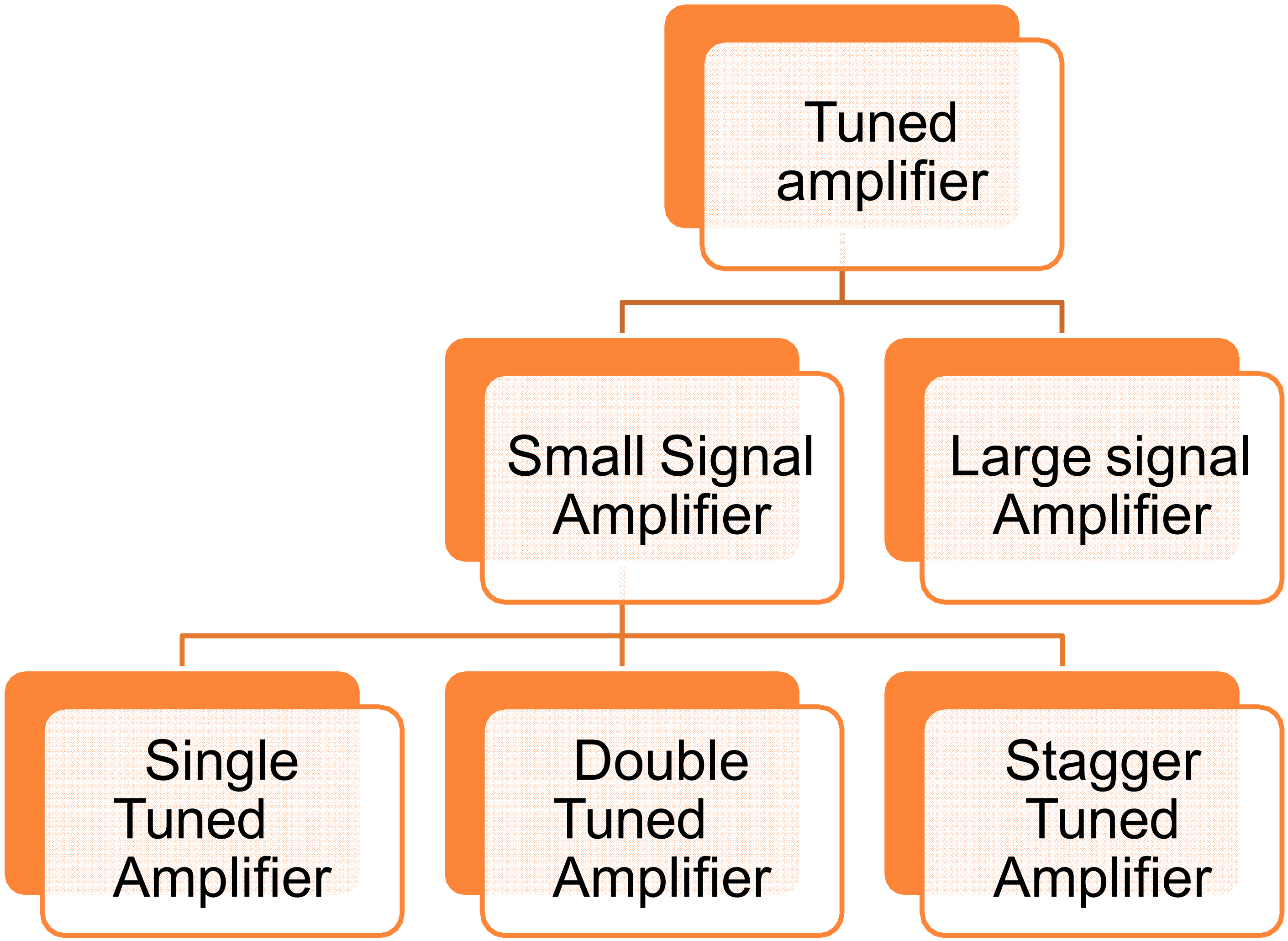
When at particular frequency the inductive reactance became equal to capacitive reactance and the circuit then behaves as purely resistive circuit. This phenomenon is called the resonance and the corresponding frequency is called the resonant frequency.



Tuned circuit


Resonance circuits
Series
Parallel

Classification of Tuned Amplifier



CLASSIFICATION OF TUNED AMPLIFIERS

- **Small Signal Tuned Amplifiers** :- They are used to amplify the RF signals of small magnitude.

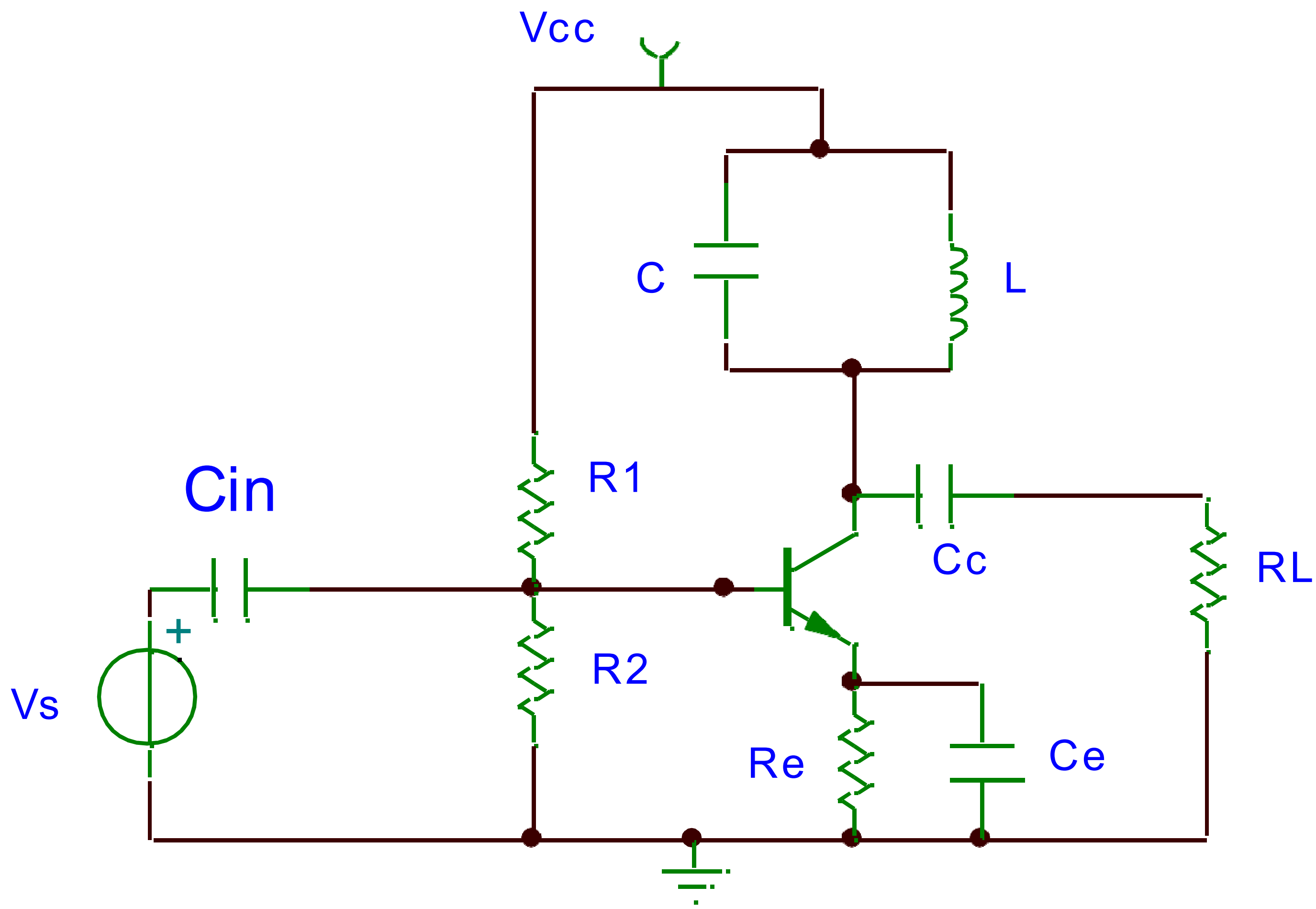
  They are further classified as:

  (a)**Single Tuned Amplifiers**:- In this we use one parallel tuned circuit in each stage.

  (b)**Double Tuned Amplifiers**:- In this we use two mutually coupled tuned circuits for every stage both of tuned circuits are tuned at same freq.

  (c)**Stagger Tuned Amplifiers**:- It is a multistage amplifier which has one parallel tuned circuit for every stage but tuned frequency for all stages are slightly different from each other.

SINGLE TUNED AMPLIFIER



SINGLE TUNED AMPLIFIER

- O/P of this amplifier may be taken either with the help of Capacitive.
- A parallel tuned circuits is connected in the collector circuit.
- Tuned voltage amplifier are usually employed in RF stage of wireless communication circuits are assigned the work of where such selecting the desired carrier frequency and of amplifying the permitted pass-band around the selected carrier frequency

SINGLE TUNED AMPLIFIER

- Tuned amplifier are required to be

R_1, R_2, & R_e = For biasing & stabilization circuit.

C_e = By pass capacitor

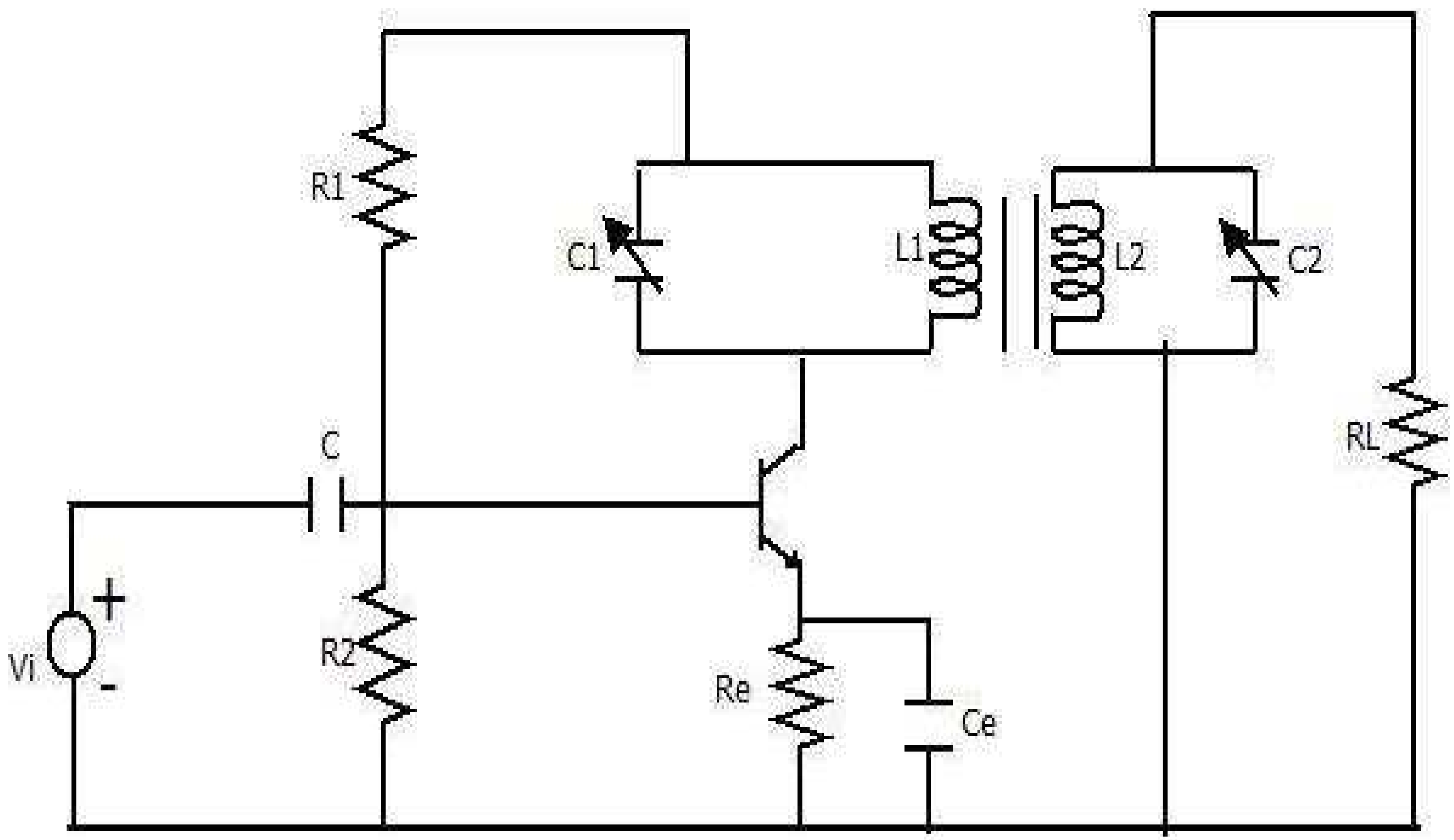
L-C = Tuned circuit connected in collector, the impedance of which depend upon frequency, act as a collector load.

If i/p signal has same frequency as resonant frequency of L-C circuit . Large amplification will be obtain because of high impedance of L-C ckt.

LIMITATION

- This tuned amplifier are required to be highly selective. But high selectivity required a tuned circuit with a high Q-factor .
- A high Q- factor circuit will give a high A_v but at the same time , it will give much reduced band with because bandwidth is inversely proportional to the Q- factor .
- It means that tuned amplifier with reduce bandwidth may not be able to amplify equally the complete band of signals & result is poor reproduction . This is called potential instability in tuned amplifier.

Double Tuned Amplifier



DOUBLE TUNED CIRCUIT

- The problem of potential instability with a single tuned amplifiers overcome in a double tuned amplifier which consists of independently coupled two tuned circuit :

  (1) L_1C_1 in collector circuit

  (2) L_2C_2 in output circuit

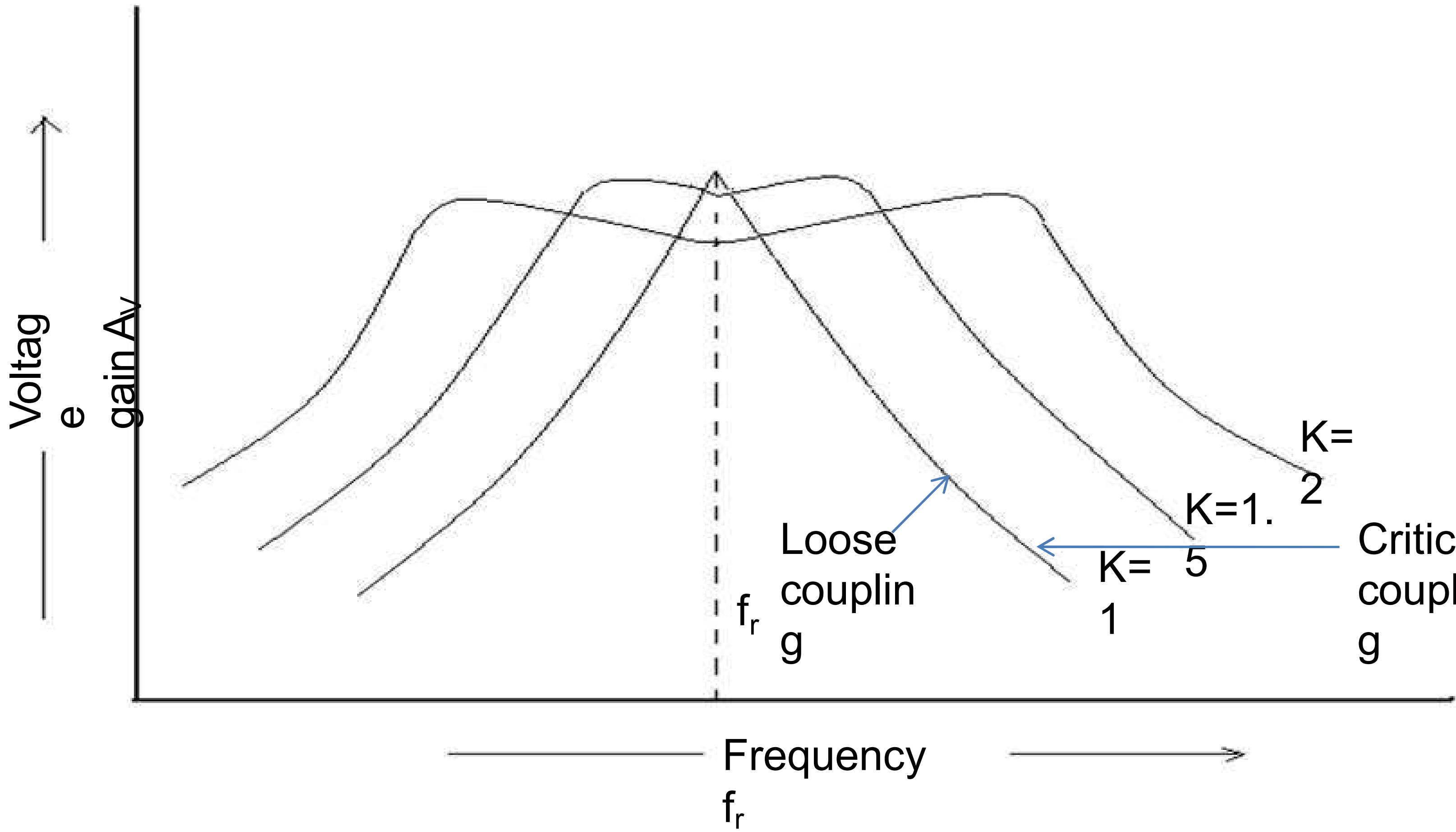
  A change in the coupling of two tuned circuit results in change in the shape of frequency response . By proper adjustment of coupling between two coils of two tuned circuits, the required results are :

- High selectivity
- High voltage gain
- Required bandwidth

CIRCUIT OPERATION

- The resonant freq. of tuned circuit connected in collector circuit is made equal to signal freq. by varying the value of C_1.
- Tuned circuit (L_1C_1) Offer very high impedance to signal frequency & this large o/p is developed across it.
- The o/p of (L_1C_1) is transferred to (L_2C_2) through mutual inductance.
- Thus the freq. response of double tuned circuit depends upon magnetic coupling of L_1 & L_2.
- Most suitable curve is when optimum coefficient of coupling exists between two tuned circuit .The circuit is then highly selective & also provides sufficient amount of gain for a particular band of frequency.

Resonance curve of Parallel Resonant circuit:



STAGGER TUNED AMPLIFIERS

- It is a multistage amplifier which has one parallel resonant circuit for every stage, while resonant frequency of every stage

  is slightly different from previous stages.

  From circuit diagram it is clear that first stage of this amplifiers has a resonant circuit formed by L_1 & C_1 that

  $$\boxed{f_1 = 1 / (2\Pi \sqrt{L_1 C_1})}$$

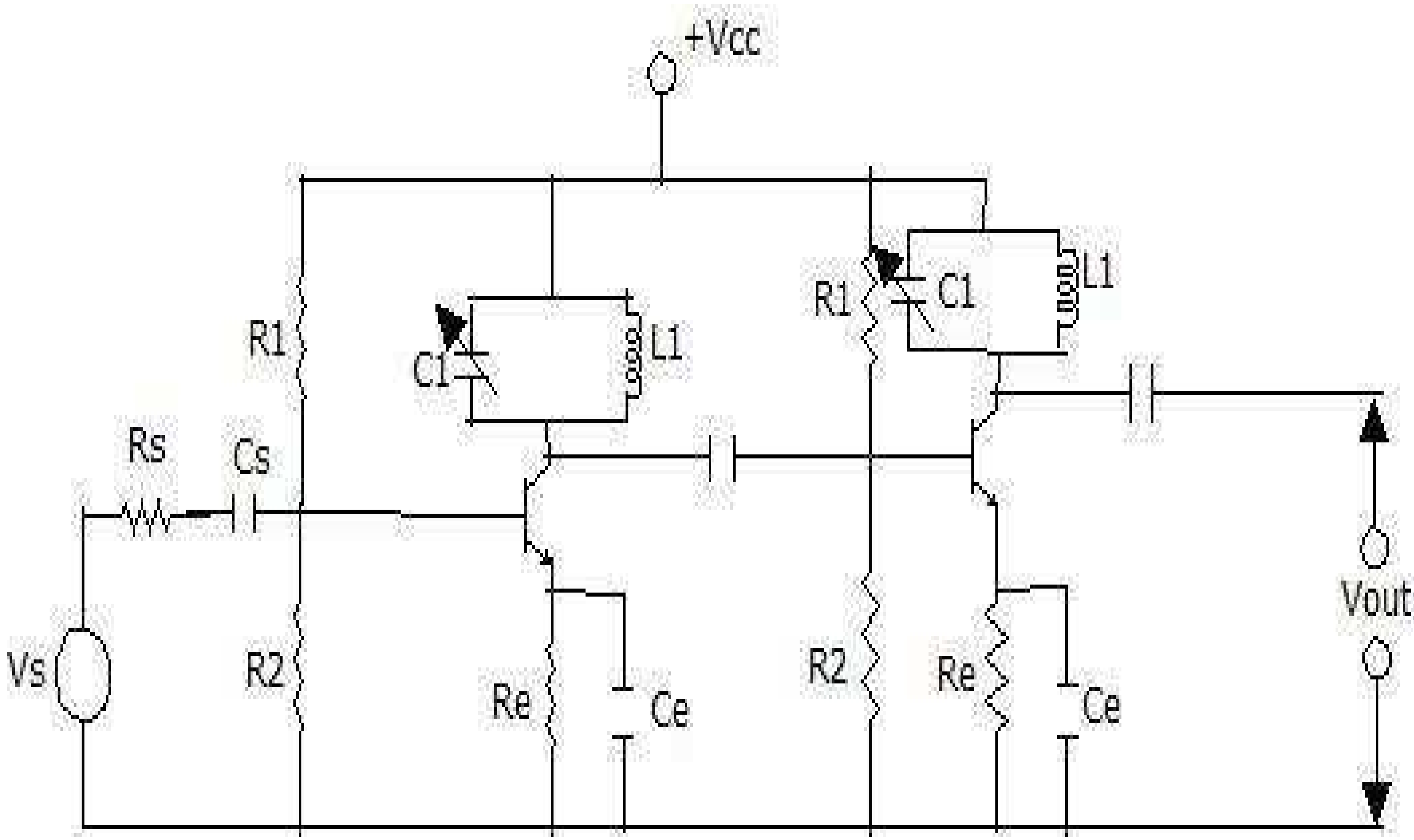
  The o/p of stage is applied to second stage which is tuned to slightly higher frequency.

  $$\boxed{f_2 = 1 / (2\Pi \sqrt{L_2 C_2})}$$

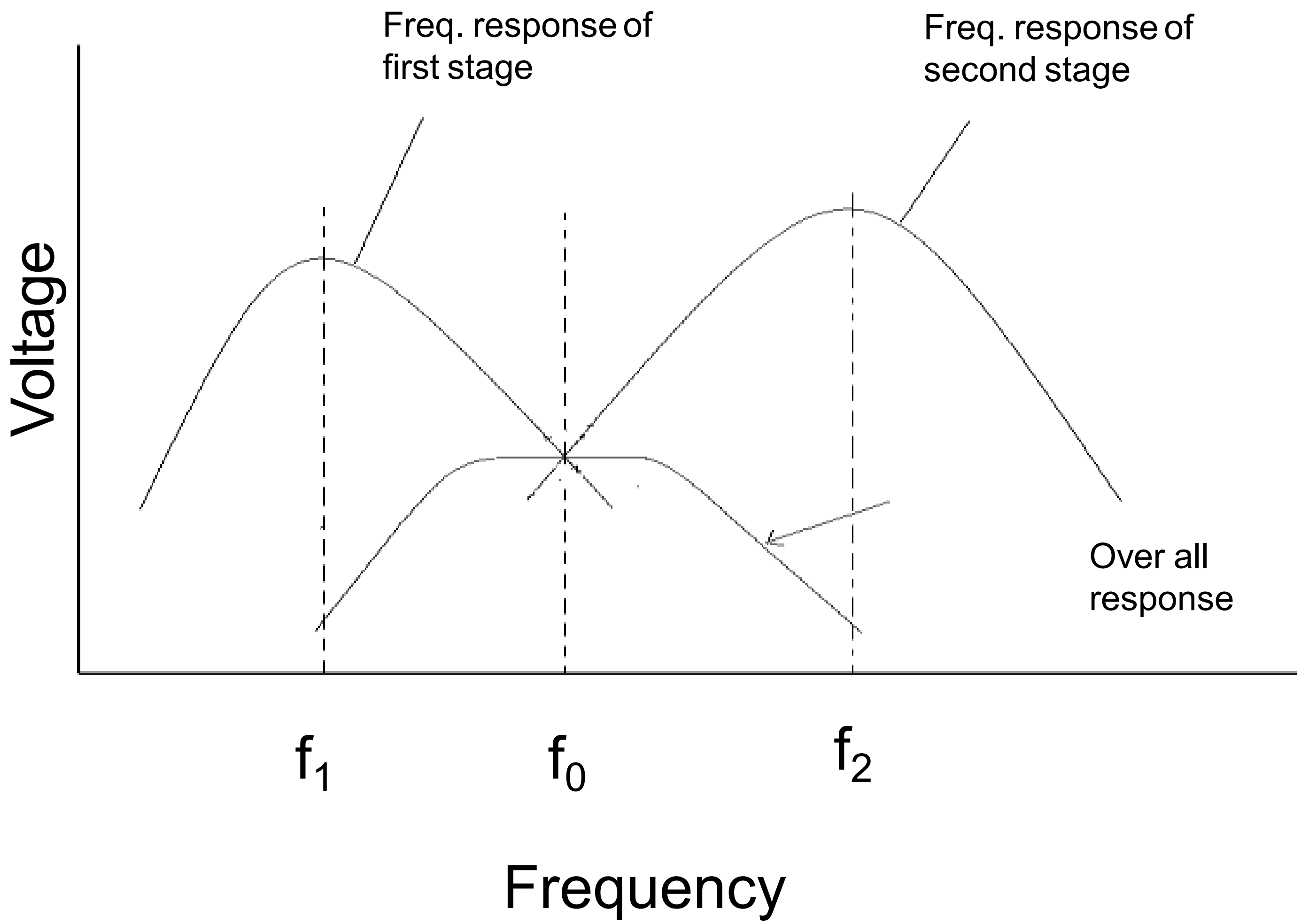
- Second stage amplifiers the signals of frequency f_2 by maximum amplitude while other frequency signal are amplified by less quantity . Thus frequency response

- Curve of second stage has a peak of f_2 which is slightly higher than f_1.

STAGGER TUNED AMPLIFIERS :



STAGGER TUNED AMPLIFIER



STAGGER TUNED AMPLIFIERS

Over all response of these two stage is obtained by combining individual response & it exhibits a maximum flatness around the center frequency f_0. Thus overall bandwidth is better than individual stage.

Since two stages are in parallel (shunt) & overall bandwidth is increased thus, it behaves like shunt circuits for the increased bandwidth.

APPLICATIONS OF TUNED AMPLIFIER

Tuned amplifiers serve the best for two purposes:

a)Selection of desired frequency.

b)Amplifying the signal to a desired level.

USED IN:

- Communication transmitters and receivers.
- In filter design :--Band Pass, low pass, High pass and band reject filter design.

ADVANTAGES

- It provides high selectivity.
- It has small collector voltage.
- Power loss is also less.
- Signal to noise ratio of O/P is good.
- They are well suited for radio transmitters and receivers .

DISADVANTAGES

- They are not suitable to amplify audio frequencies.
- If the band of frequency is increase then design becomes complex.
- Since they use inductors and capacitors as tuning elements, the circuit is bulky and costly.

POWER AMPLIFIER

Amplifier Basics

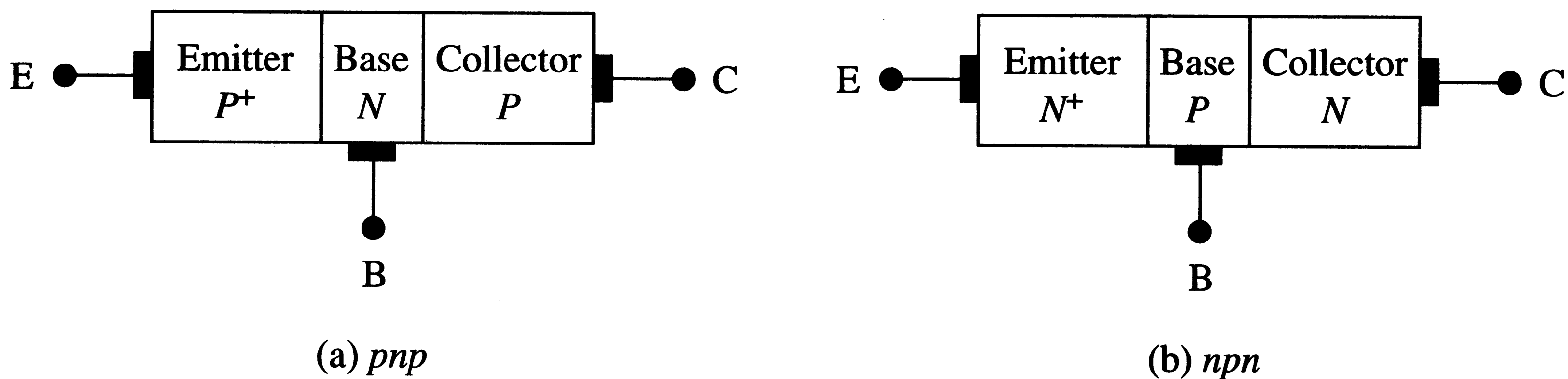
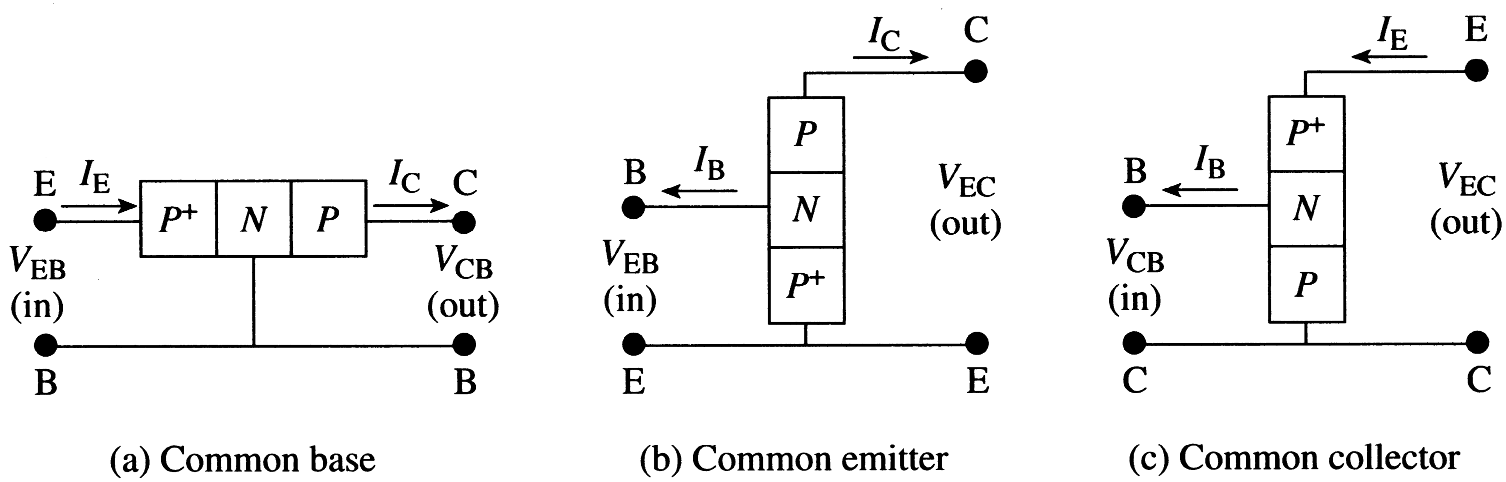


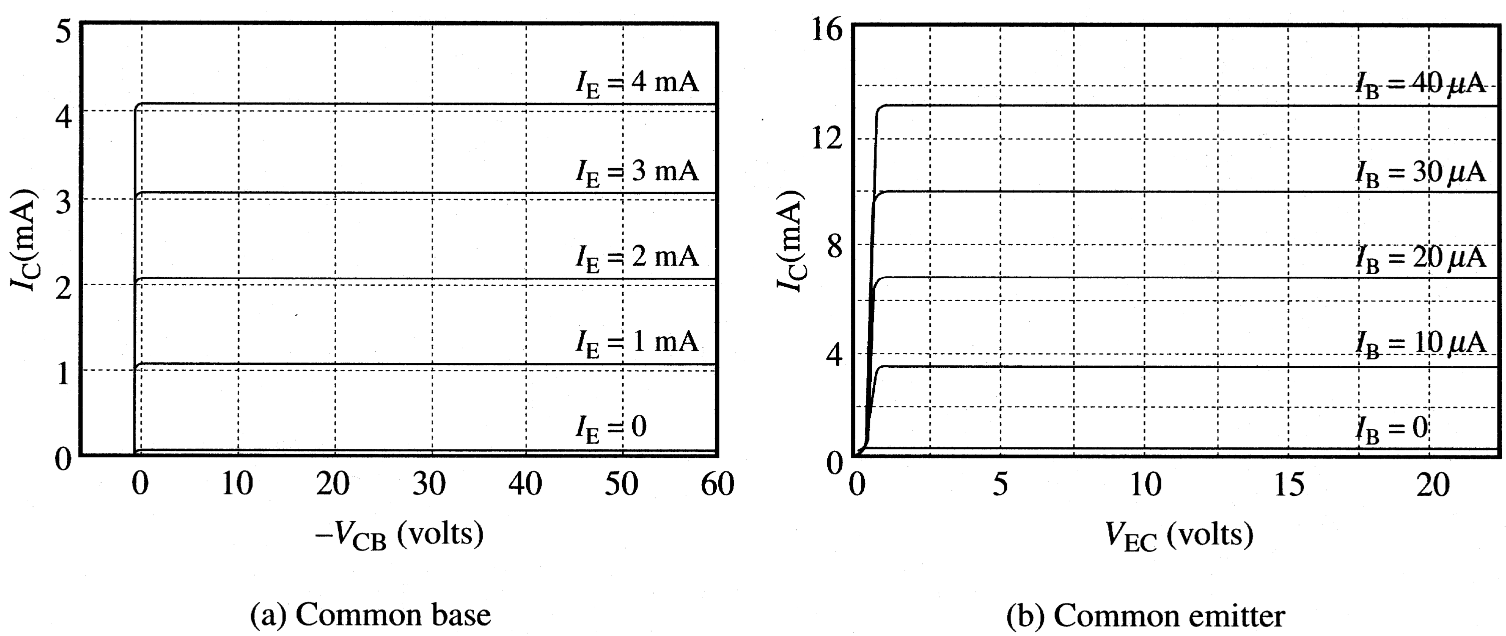
Figure 10.1

Emitter is heavily doped compared to collector. So, emitter and collector are not interchangeable.

The base width is small compared to the minority carrier diffusion length.

BJT circuit configurations and output characteristics





BJT biasing modes

Table 10.1 Biasing Modes.

Biasing Mode	*Biasing Polarity E–B Junction*	*Biasing Polarity C–B Junction*
Saturation	Forward	Forward
Active	**Forward**	**Reverse**
Inverted	Reverse	Forward
Cutoff	Reverse	Reverse

POWER AMPLIFIERS

- An amplifier typically receives signal from input source and provides a larger version of the signal to output device or to another amplifier stage

- The input signal is generally very small and needs to be amplified sufficiently to operate an output device.

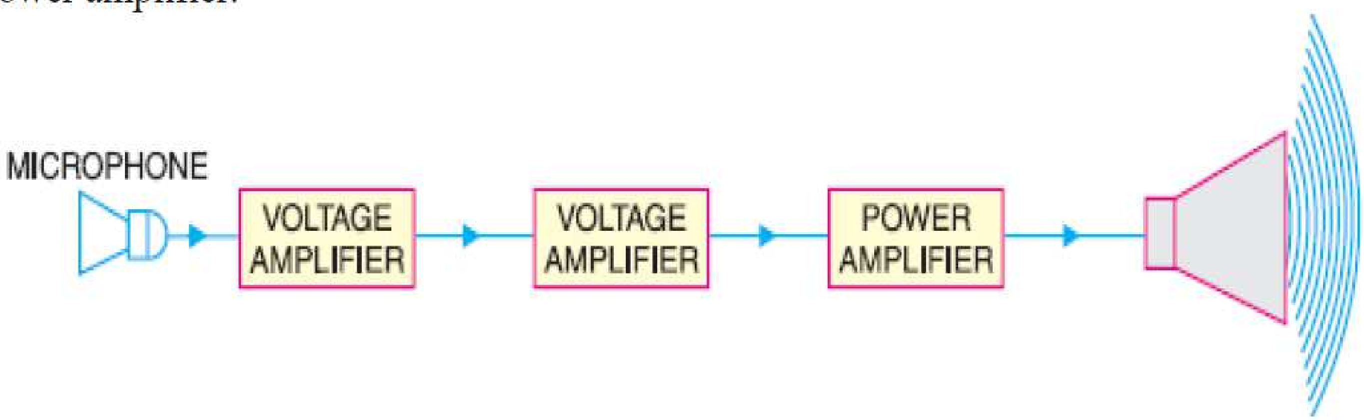
- For the small signal amplifiers the main factors are usually amplification linearity and magnitude of gain.

- Since voltage and current are small in a small – signal amplifier the amount of power – handling capacity and power efficiency are of **concern**

- A voltage amplifier provides voltage amplification primary to increase the voltage of the input signal, on the other hand, large – signal or **Power Amplifiers** primarily provide sufficient power to an output load to drive a speaker or other power devices

INTRODUCTION

A practical amplifier always consists of a number of stages that amplify a weak signal until sufficient power is available to operate a loudspeaker or other output device. The first few stages in this multistage amplifier have the function of only voltage amplification. However, the last stage is designed to provide maximum power. This final stage is known as *power stage*.
The term audio means the range of frequencies which our ears can hear. The range of human hearing extends from 20 Hz to 20 kHz. Therefore, audio amplifiers amplify electrical signals that have a frequency range corresponding to the range of human hearing *i.e.* 20 Hz to 20 kHz. Fig. 12.1 shows the block diagram of an audio amplifier. The early stages build up the voltage level of the signal while the last stage builds up power to a level sufficient to operate the loudspeaker. In this chapter, we shall talk about the final stage in a multistage amplifier—the power amplifier.



2. Power amplifier. A power amplifier is required to deliver a large amount of power and as such it has to handle large current. In order to achieve high power amplification, the following features are incorporated in such amplifiers :

(*i*) The size of power transistor is made considerably larger in order to dissipate the heat produced in the transistor during operation.

(*ii*) The base is made thicker to handle large currents. In other words, transistors with comparatively smaller □ □ are used.

(*iii*) Transformer coupling is used for impedance matching.

The comparison between voltage and power amplifiers is given below in the tabular form :

S. No.	Particular	Voltage amplifier	Power amplifier
1.	β	High (> 100)	low (5 to 20)
2.	R_C	High (4 – 10 kΩ)	low (5 to 20 Ω)
3.	*Coupling*	usually $R-C$ coupling	Invariably transformer coupling
4.	*Input voltage*	low (a few mV)	High (2 – 4 V)
5.	*Collector current*	low (≃ 1 mA)	High (> 100 mA)
6.	*Power output*	low	high
7.	*Output impedance*	High (≃ 12 kΩ)	low (200 Ω)

Features of Power Amplifier

- Circuit’s Power Efficiency
- Maximum amount of power circuit is capable of handling
- Impedance matching to the output device

Categories / Types of Power Amplifier

- CLASS A
- CLASS B, Push – Pull Amplifier
- CLASS AB
- CLASS C
- CLASS D

Classification of Power Amplifiers

Transistor power amplifiers handle large signals. Many of them are driven so hard by the input large signal that collector current is either cut-off or is in the saturation region during a large portion of the input cycle. Therefore, such amplifiers are generally classified according to their mode of operation *i.e.* the portion of the input cycle during which the collector current is expected to flow. On this basis, they are classified as :

Amplifier circuits may be classified in terms of the portion of the cycle for which the active device conducts.

Class A: It is one, in which the active device conducts for the full 360°.

Class B: Conduction for 1800

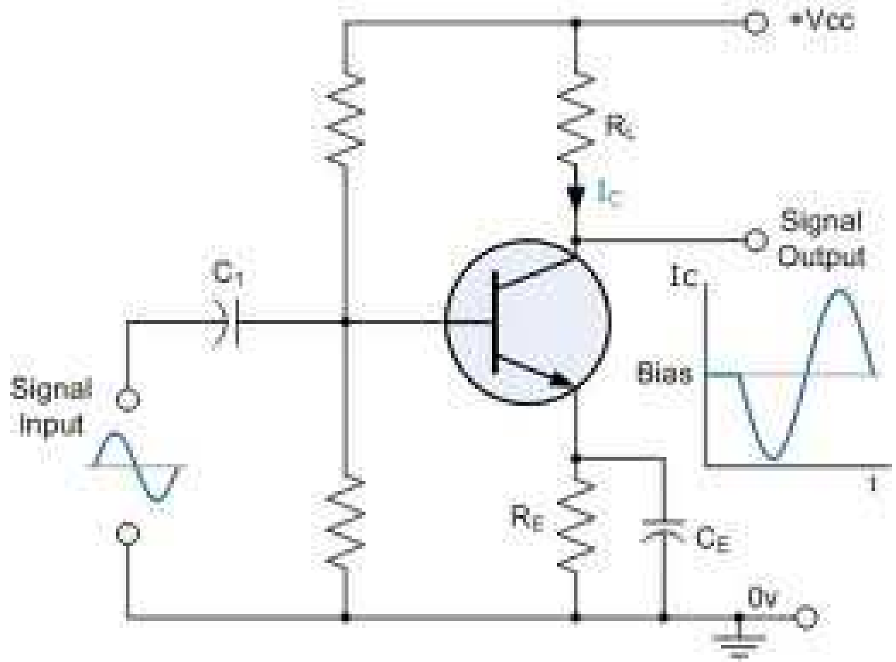
Class C: Conduction for < 1800

Class AB :Conduction angle is between 1800 and 3600

(*i*) class *A* power amplifier (*ii*) class *B* power amplifier (*iii*) class *C* power amplifier

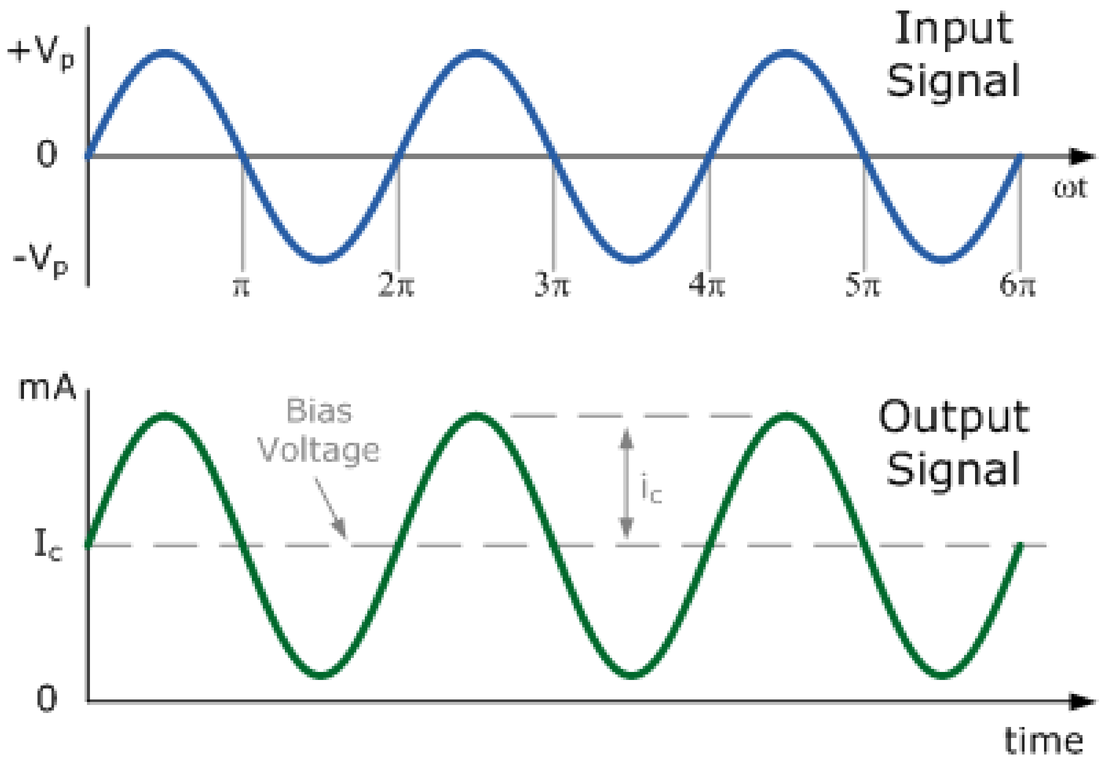
iv) CLASS C
v) CLASS D

Class A Amplifier configuration



The output signal varies for a full 360 of the cycle.
Max Efficiency: 25 %

Class A Output



Class B Amplifier

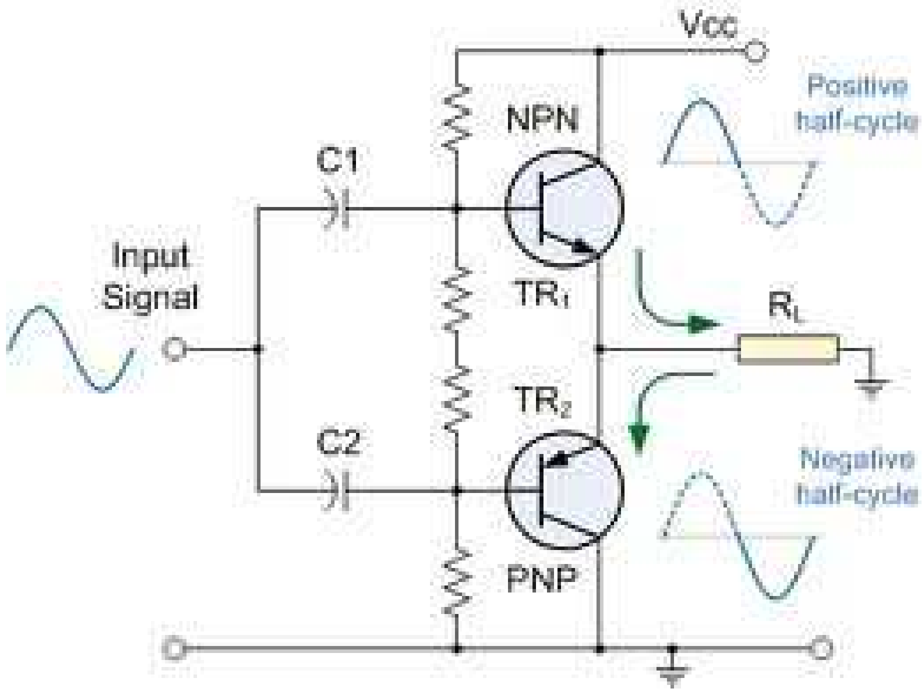
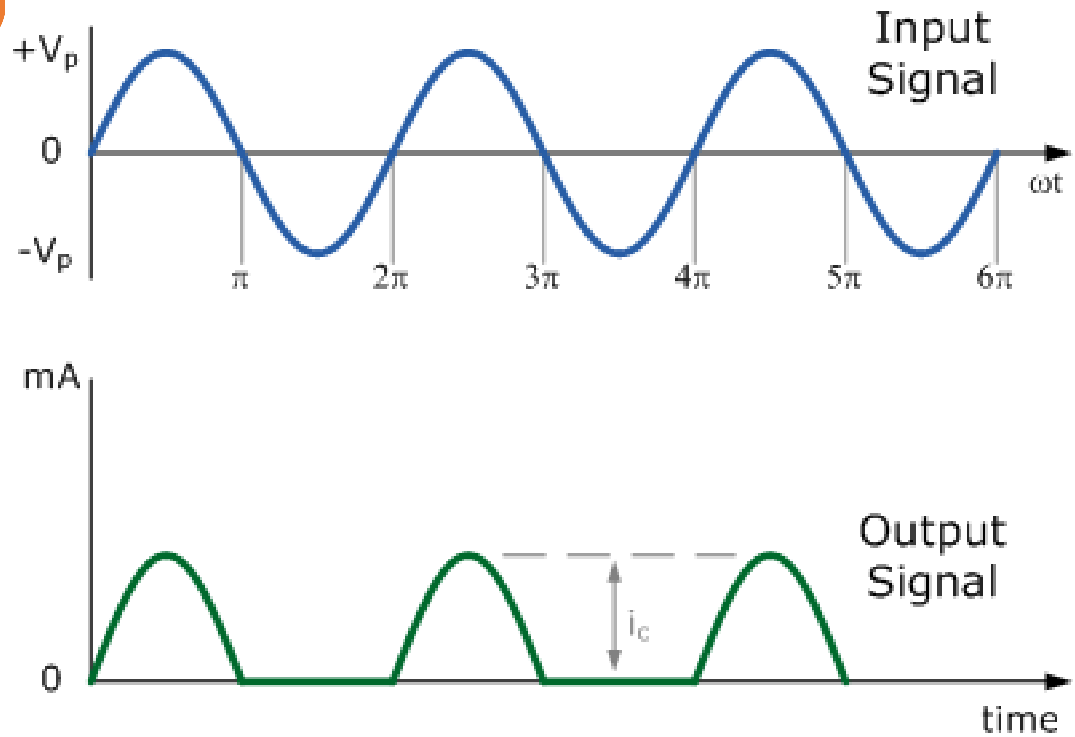


Illustration of Push – Pull Configuration

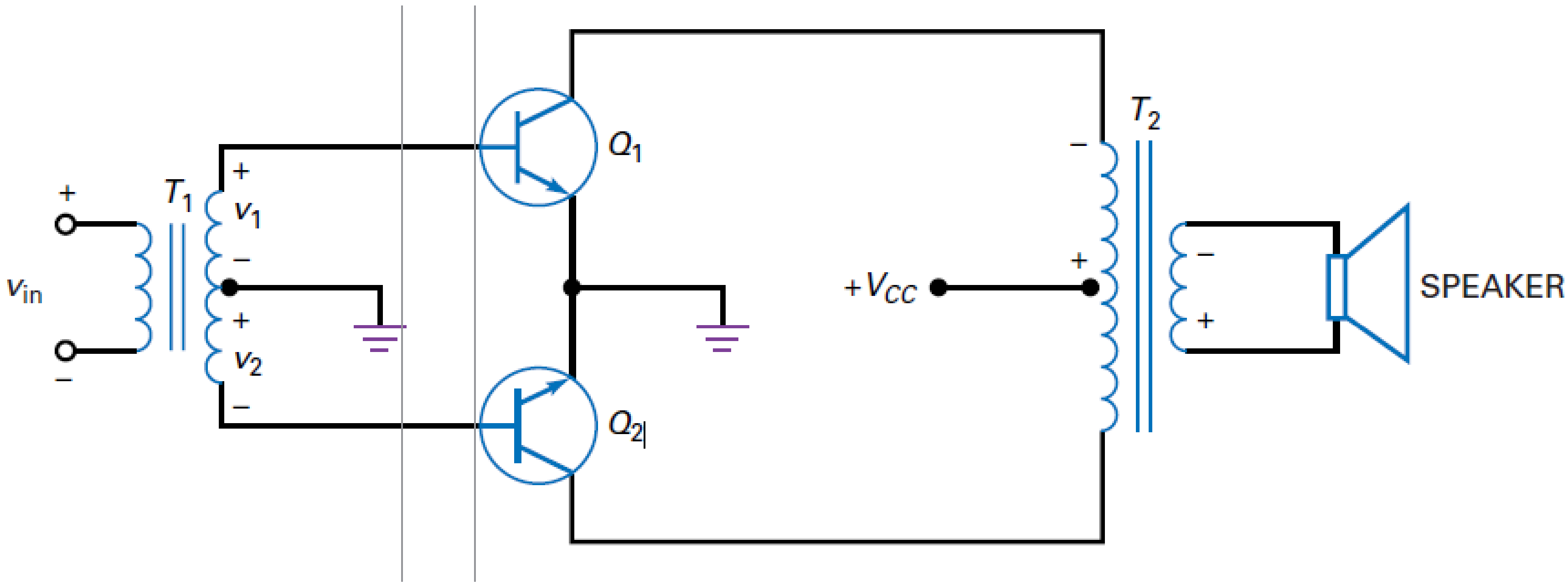
Class B Output (w/o Push Pull Mode)



Output signal varying over one-half of the input signal cycle / 180^0 operation.

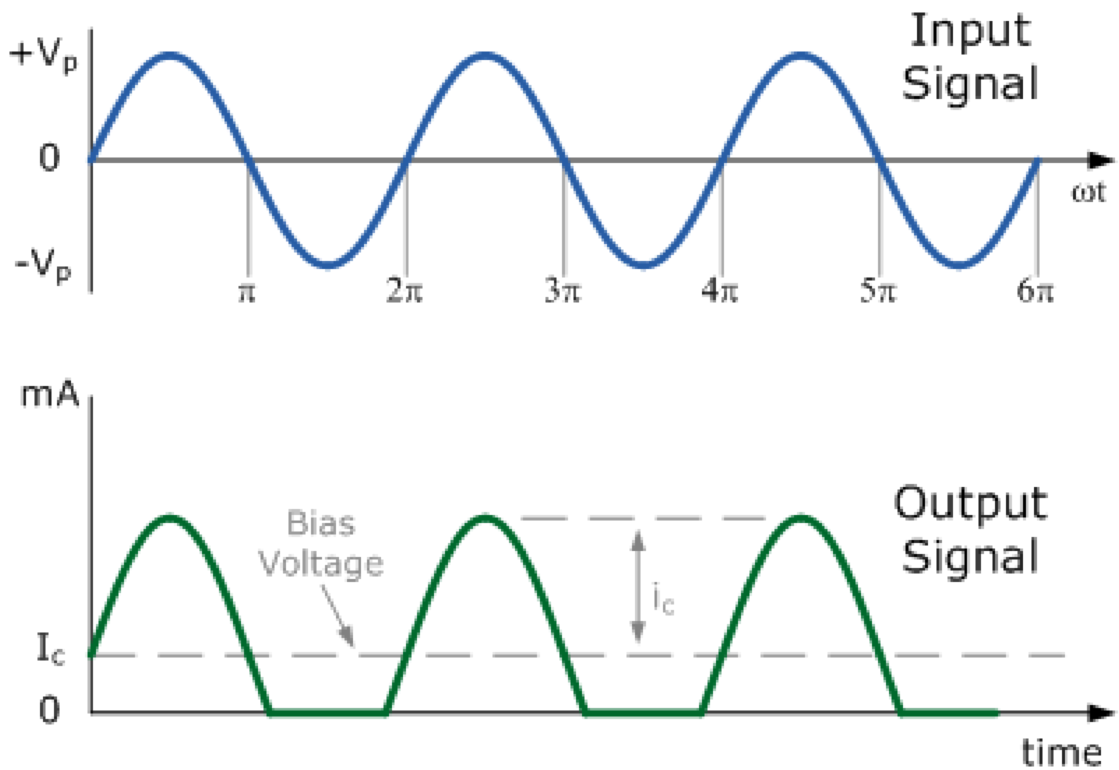
Maximum efficiency: 78.5% (Push Pull Configuration)

Real time Circuit of Push Pull Amplifier



The main disadvantage of the amplifier shown in Figure is the use of transformers.

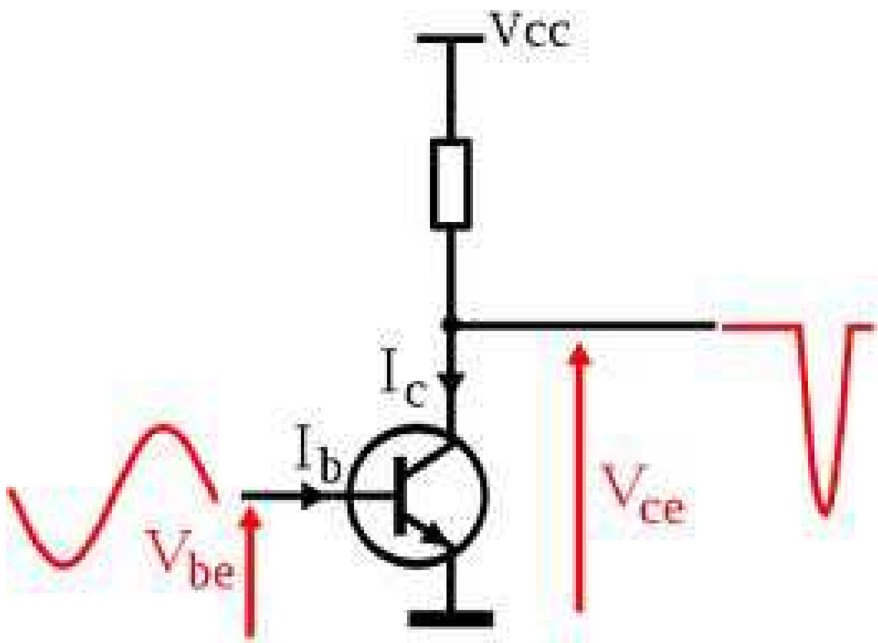
Class AB



More than 180^0 input cycle operation:

Maximum Efficiency: 25.00% - 78%

Class C Amplifier



Amplification for less than 180^0 of input cycle.

Maximum Efficiency: 80%

Applicable to Tuned Circuit at Amplification of Resonant Frequencies

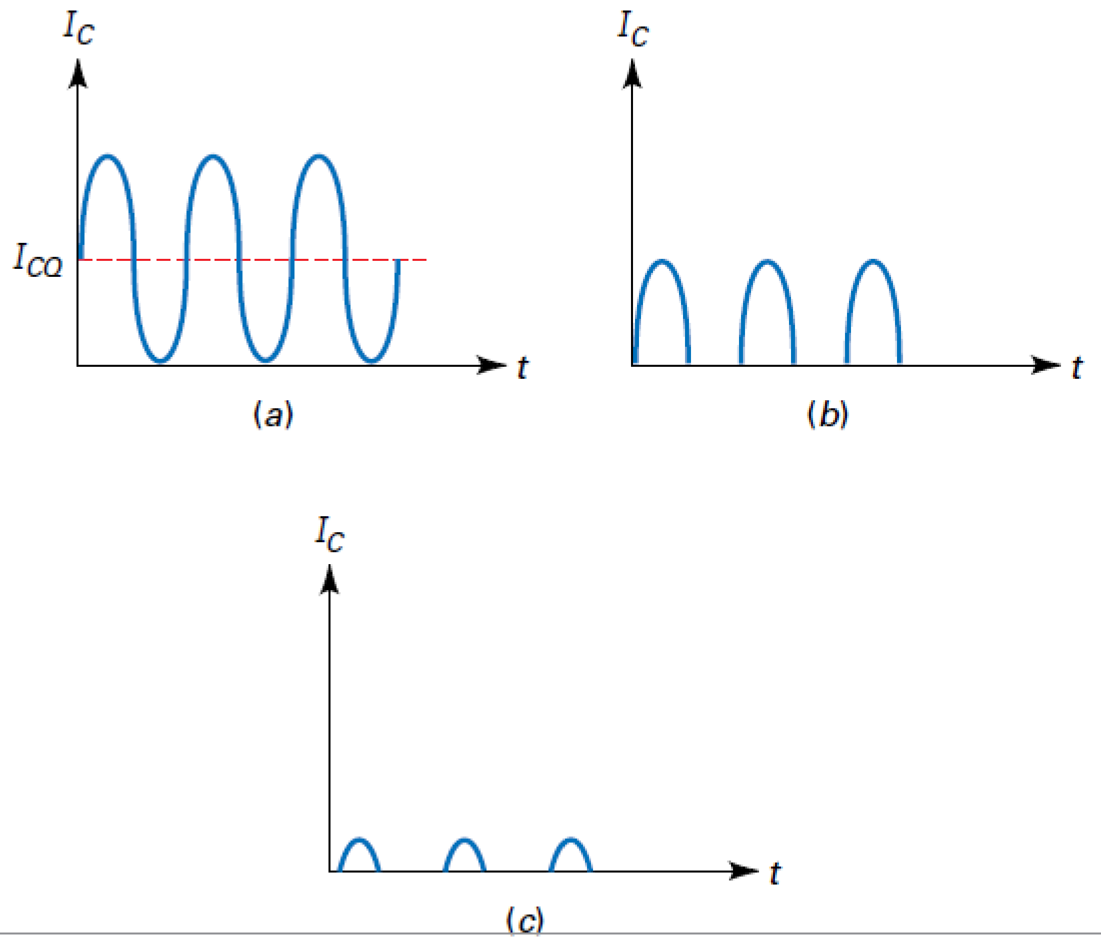
Class D Amplifier

- This operating class is a form of amplifier operation using pulse (digital) signals, which are on for a short interval and off for a longer interval..

- Using digital techniques makes it possible to obtain a signal that varies over the full cycle (using sample-and-hold circuitry) to recreate the output from many pieces of input signal.

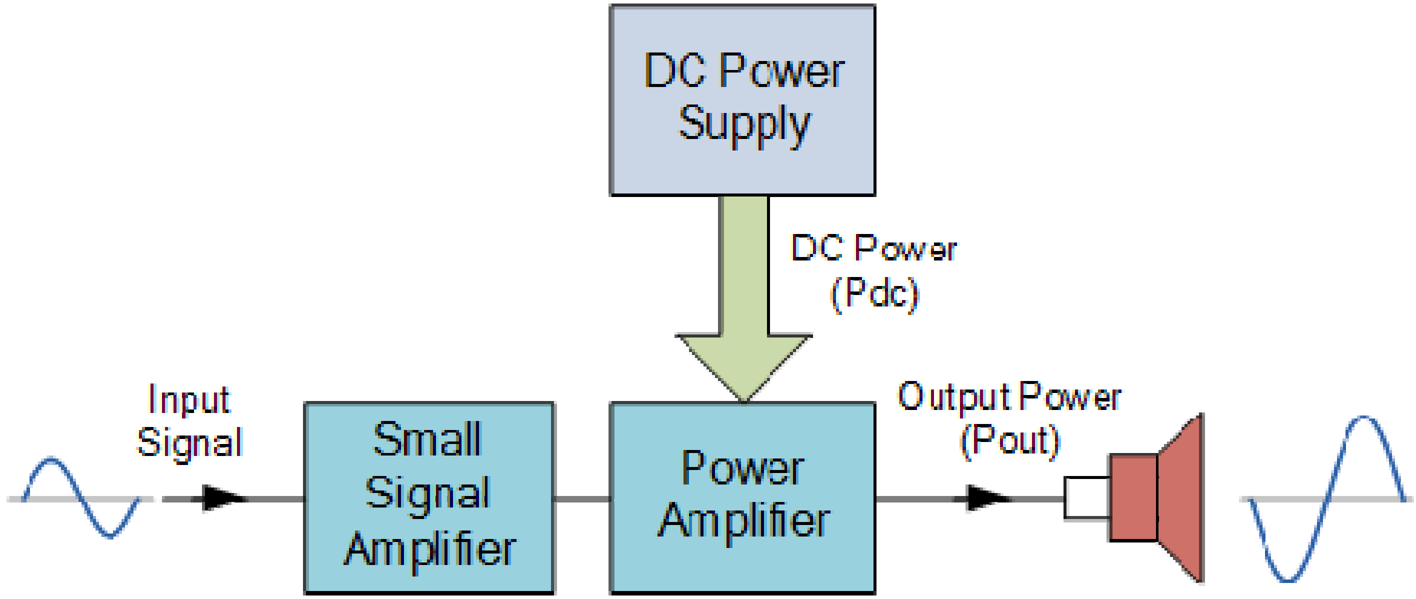
- The major advantage of class D operation is that the amplifier is on (using power) only for **short intervals** and the **overall efficiency** can practically be **very high(90%)**

Collector Current of different amplifier configuration



Can you identify these yourself now!!!?

Conversion Efficiency



$$\eta\% = \frac{P_{OUT}}{P_{DC}} \times 100$$

η% - is the efficiency of the amplifier.

Pout - is the amplifiers output power delivered to the load.

Pdc - is the DC power taken from the supply.

Comparison of Amplifiers

Class	A	B	C	AB
Conduction Angle	360^o	180^o	Less than 90^o	180 to 360^o
Position of the Q-point	Centre Point of the Load Line	Exactly on the X-axis	Below the X-axis	In between the X-axis and the Centre Load Line
Overall Efficiency	Poor, 25 to 30%	Better, 70 to 80%	Higher than 80%	Better than A but less than B 50 to 70%
Signal Distortion	None if Correctly Biased	At the X-axis Crossover Point	Large Amounts	Small Amounts