UNIT - 1

MULTISTAGE AMPLIFIERS

In practical applications, the output of a single state amplifier is usually insufficient, though it is a voltage or power amplifier. Hence they are replaced by Multi - stage transistor amplifiers.

[∵ An Amplifier is a device that increases the amplitude of input signal]

In Multi-stage amplifiers, the output of first stage is coupled to the input of next stage using a coupling device

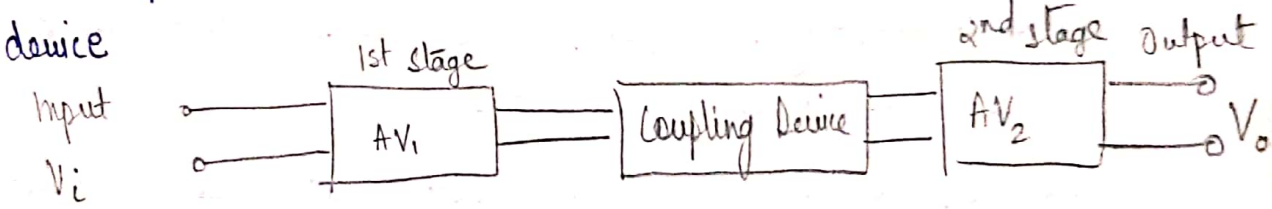


Fig 1 Two stage Amplifier connected in cascade

The overall gain is the product of voltage gain of individual stages

$$A_V = A_{V_1} \times A_{V_2}$$

$$= \frac{V_2}{V_1} \times \frac{V_o}{V_2} = \frac{V_o}{V_1}$$

A_V = Overall gain

A_{V_1} = Voltage gain of 1st stage

A_{V_2} = Voltage gain of 2nd stage

Purpose of coupling device

1. To transfer the AC from the output of 1st stage to input of next stage
2. To block DC to pass from the output of one stage to input of next stage, Isolate the dc condn.

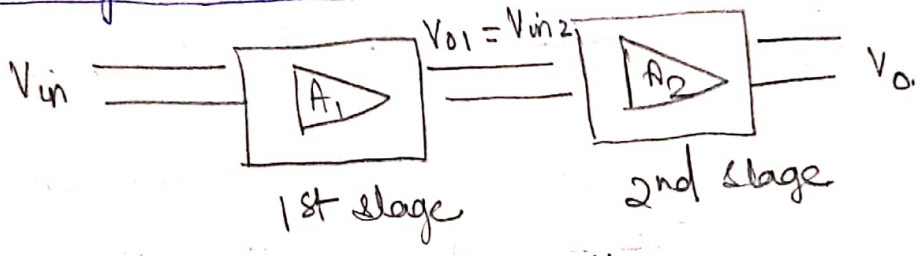
Types of coupling

1) R-C coupling : Mostly used method of coupling formed using simple R-C combination.
2) Impedance coupling : Coupling N/w uses inductance & capacitance as coupling elements
3) Transformer Coupling : Coupling method that uses a transformer as a coupling device. There is no capacitor used in this method of coupling because the transformer itself convey AC component directly to base of second stage.
4) Direct coupling : If previous amplifier stage is connected to the next amplifier stage directly, i.e two stages are combined without DC Isolation.

Need of Multistage Amplifier

1. To raise the strength of weak signal to several volts signal, any desirable gain can be obtained by selecting gain of each stage of amplifier. The overall gain is the product of gain of each stage.
2. It also improve Input impedance & output impedance in a ckt.

Gain of Multistage Amplifier



$$A \text{ (Voltage gain)} = \frac{\text{O/P voltage}}{\text{I/P voltage}}$$

$$V_{01} = A_1 V_{in} \quad \text{---- i)}$$

$$V_{in2} = V_{01}$$

$$V_{02} = A_2 V_{01} = V_o$$

$$V_o = A_2 V_{01} \quad \text{---- put eq i)}$$

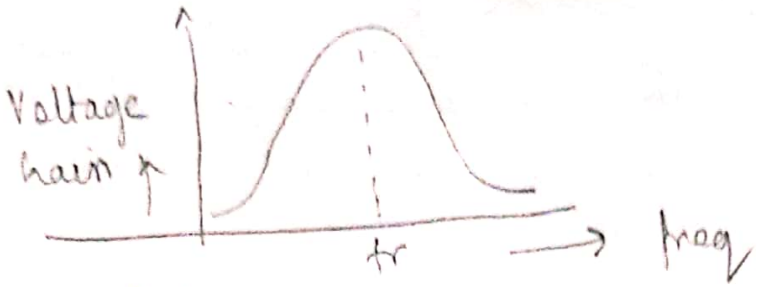
$$\boxed{V_o = A_2 A_1 V_{in}}$$

$$G_T \text{ (Voltage gain)} = \frac{V_o}{V_{in}} = A_1 A_2$$

$$G_T \text{ dB} = A_1 (\text{dB}) + A_2 (\text{dB})$$

Terms related to Multistage Amplifiers

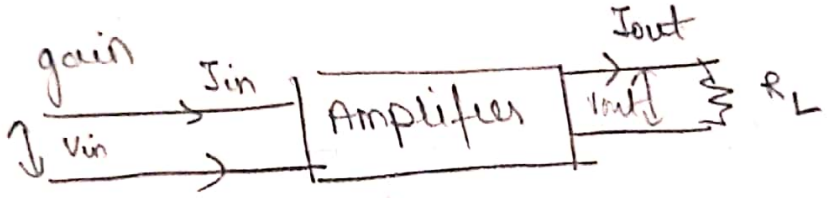
i)



Frequency Response
The curve b/w voltage gain & freq of an amplifier

The gain of amplifier increases with the freq from zero till it become max. at fr (called resonant freq) If freq of signal increases bayond fr, then gain start decreasing.

ii) Decibel gain



$$\text{Power gain} = \log_{10} \frac{P_o}{P_{in}} \text{ bel}$$

$$dB = 10 \times \text{No. of bel}$$

$$\boxed{\text{Power gain} = 10 \log_{10} \frac{P_o}{P_{in}} \text{ dB.}}$$

$$\text{Voltage gain} = 10 \log_{10} \frac{V_{out}^2/R}{V_{in}^2/R} = 10 \log_{10} \left(\frac{V_{out}}{V_{in}}\right)^2$$

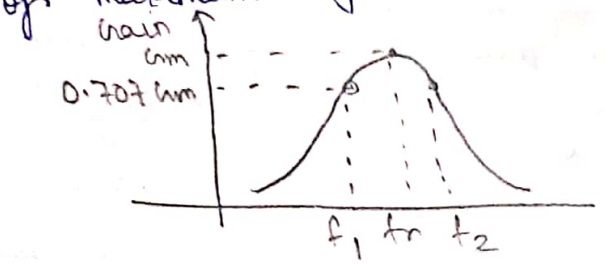
$$\boxed{\text{Voltage gain} = 20 \log_{10} \frac{V_{out}}{V_{in}} \text{ dB}}$$

$$\text{Current gain} = 10 \log_{10} \frac{I_{out}^2 R}{I_{in}^2 R}$$

$$\boxed{\text{Current gain} = 20 \log_{10} \frac{I_{out}}{I_{in}}}$$

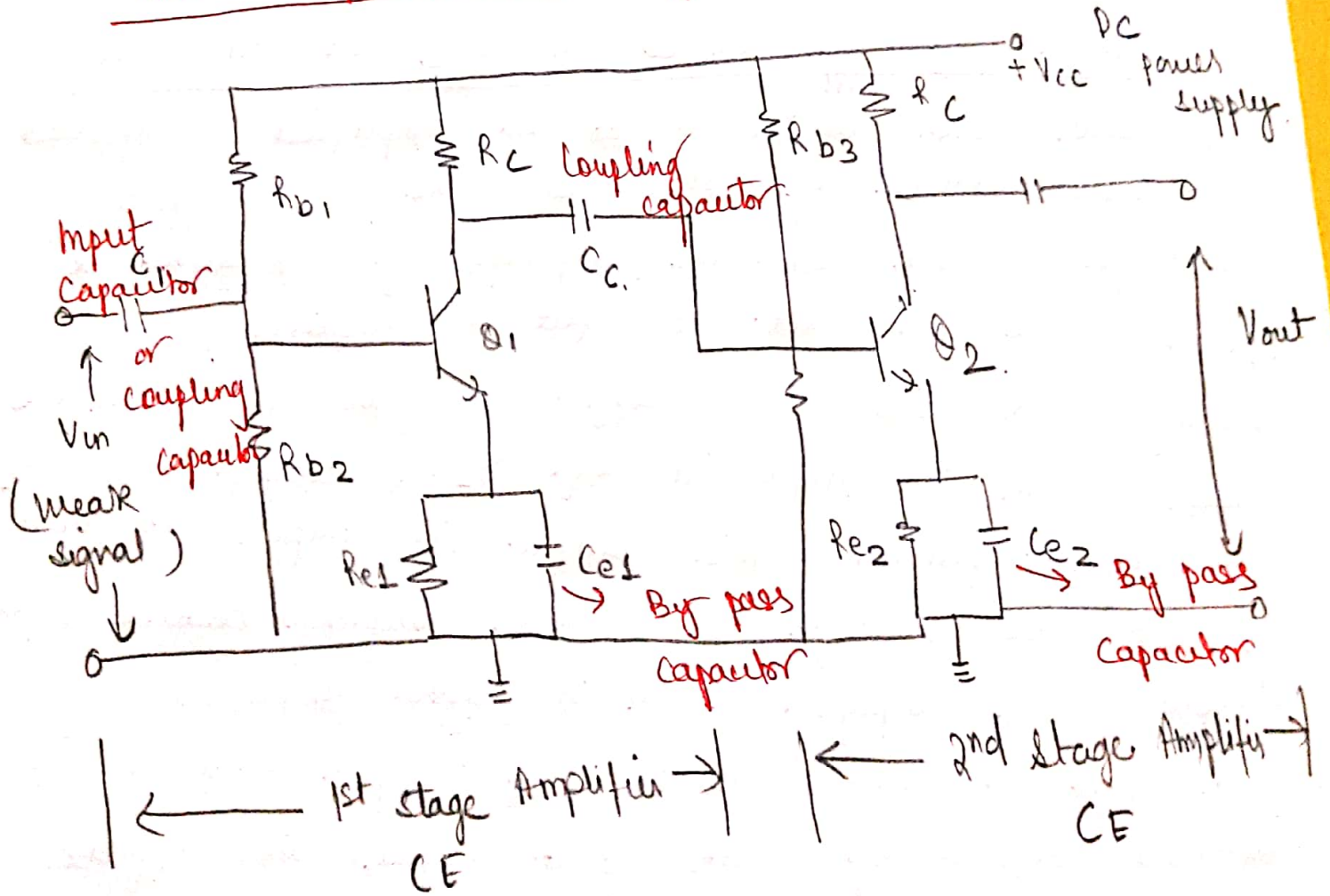
iii) Bandwidth (BW)

The range of freq over which the gain of an amplifier is equal to or greater than 70.7% of maximum gain is called BW



$$BW = f_2 - f_1$$

RC Coupled Multistage Amplifier



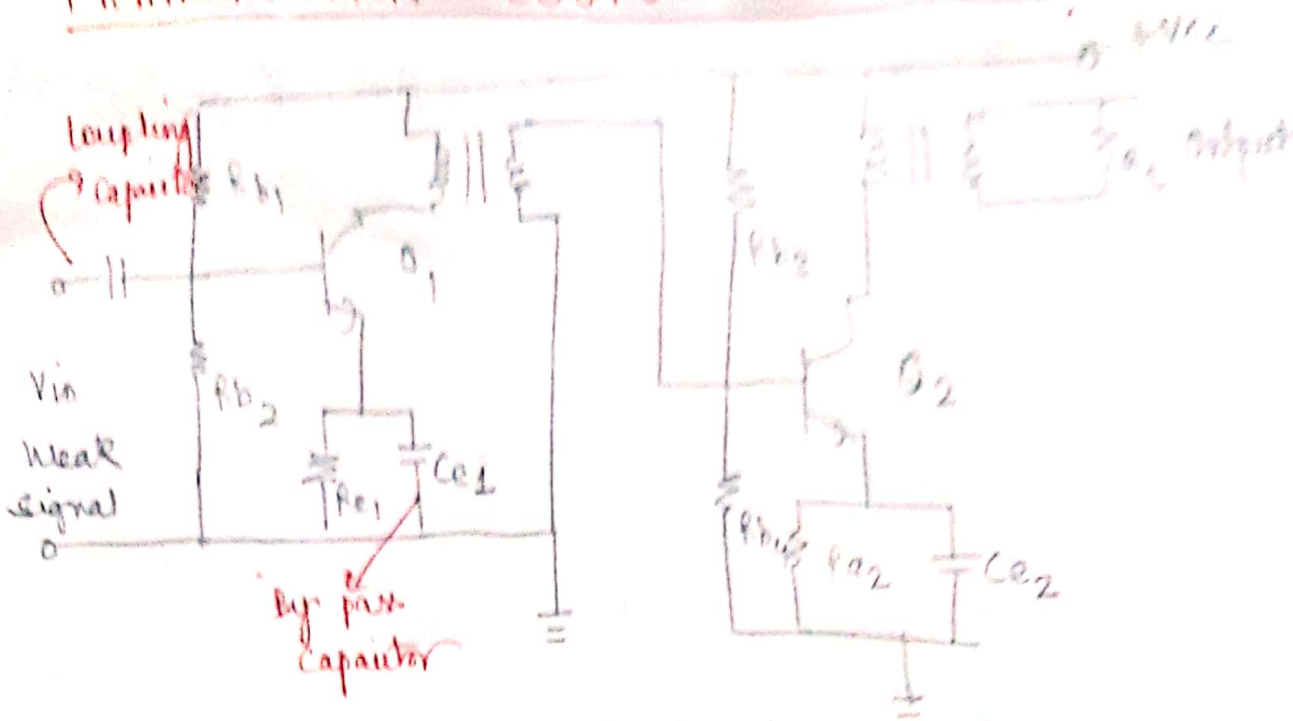
The most suitable Amplifier is CE, in comparison with CC, & CB amplifier

CE amplifier	CC amplifier	CB amplifier
1. Its voltage gain is greater than Unity	1. less than Unity	1. less than Unity
2. Voltage gain further increased by cascading	2. Not suitable for intermediate stages	2. Not suitable for cascading

Operation of RC Coupled Multistage CE amplifier

A weak signal which is to be amplified is applied at input terminal of 1st stage. The C_1 (coupling capacitor) block any dc component of I/P signal & passes entire ac part to input of amplifier; so biasing or Q point isn't shift; & gain isn't reduce weak signal is amplified by θ_1. & output is appears at collector junction, this output is coupled to input of next stage through C (the coupling device para - meter). The amplified signal is further amplified by next stage amplifier. Thereby, at output terminal, amplified version of weak input signal will appear.

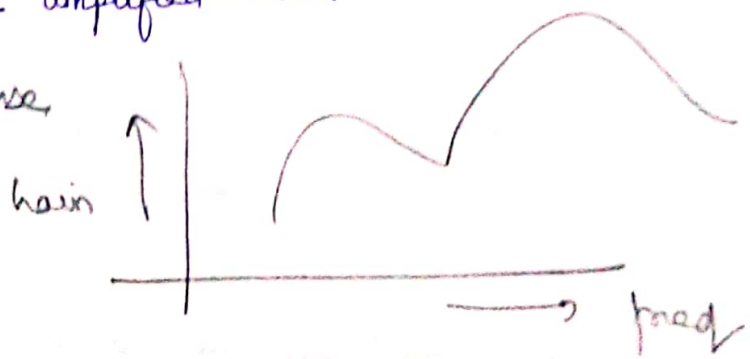
TRANSFORMER COUPLED AMPLIFIER



Here the coupling device is transformer

Operation: When an input ac signal Vin is applied to the base of first transistor, an amplified ac flows to the collector circuit of transistor & hence through primary coil of transformer. This amplified o/p is transfered to the secondary side of coupling transformer & is fed to the next (Q_2) transistor. This signal is further amplified now.

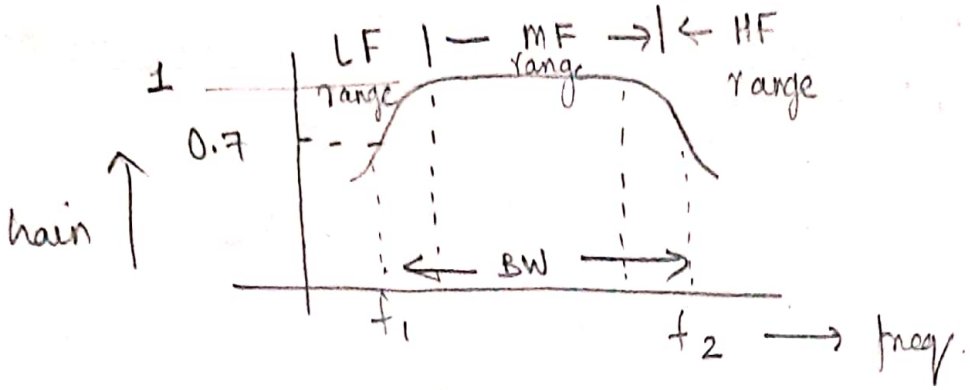
Freq Response



Gain isn't const as shown above from freq response curve.

Frequency Response of RC coupled Amplifier

the amplitude of Input & Output signal measured for different range of frequencies.



1. At low freq, ($< 50 Hz$) reactance of coupling capacitor cannot be ignored thereby it attenuate the signal to some extend.
2. Capacitor act as S.C, gain is constt (50 to 20 KHz)
3. Due to inter electrode capacitance of terminal of transistor Gain (> 20 kHz) decreases.

Advantages

1. Good freq Response
2. lowers cost
3. Ckt is very compact

Disadvantages

1. Has low Voltage & power gain
2. Tendency to become very noise with age.
3. Impedance Matching is poor

Applications :

Employed as Audio amplifier as they have an excellent audio fidelity over a wide range of frequency.

T/F coupled Amplifier

Advantages

1. No signal power is lost in base resistor
2. Easy to fabricate the ckt
3. Higher gain can easily be achieved at high freq.

Disadvantage

1. Poor freq response
2. Transformer bulky & expensive
3. how freq signal are less amplified.

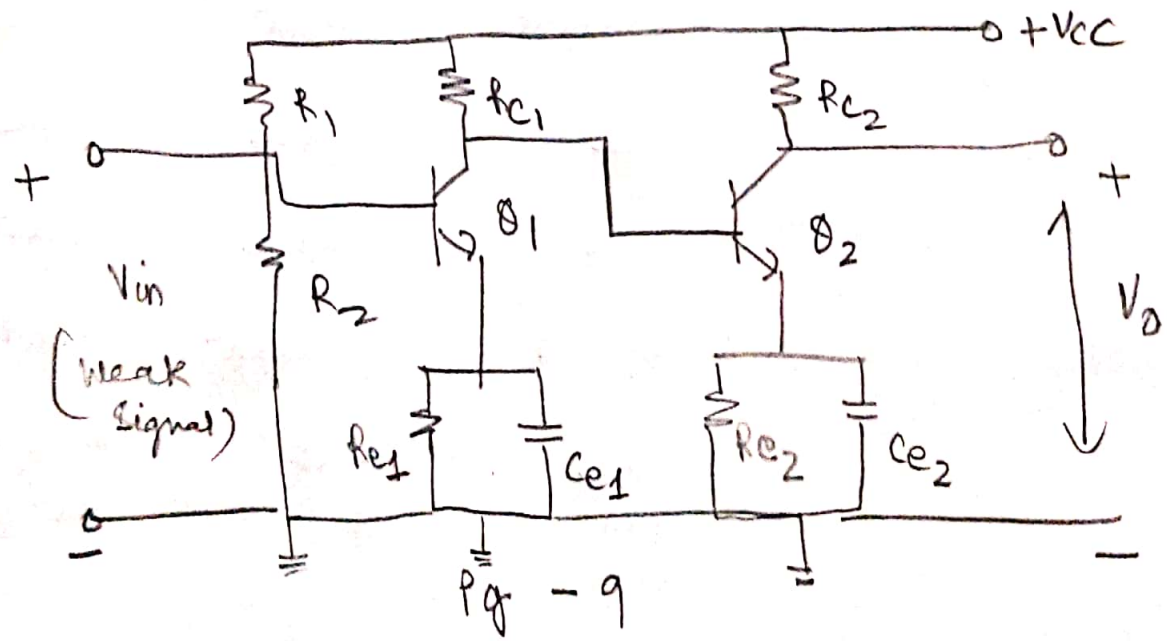
Applications

Used in loudspeakers in radio & T.V receivers as these device operate on single frequency.

DIRECT COUPLING AMPLIFIERS

the amplifier used for amplification of slowly varying signal make use of direct coupling

No coupling or by pass capacitor is used



Operation

A weak signal of low freq is applied to base of Q_1, due to transistor action, an amplified signal is obtained at RC_1. this is further fed to the base of Q_2. This is how it raises the strength of weak signal

Advantages

1. Simple ckt
2. low cost ckt

Disadvantages

1. Can't be use for amplifying high freq
2. Operating point shifted due to temp. variation

Applications

Use in thermo couple & photosensor

Comparision

		RC coupling	Transformer coupling	Direct coupling
1.	Freq Response	~~Excellent~~	Poor	Poor
2.	Cost	less	More	least
3.	Space & Weight	less	More	least
4.	Impedance matching	Not good	Excellent	Good
5.	Uses	Voltage amplification	Power amplification	Amplifying low freq