Hands out on Multi Stage amplifier

A- Need of Multistage amplifiers:

⇨ Cascading two or more stages of amplifier makes a multistage amplifier.
⇨ Cascading is the process when output of preceding stage is used as input of succeeding stage as shown below:

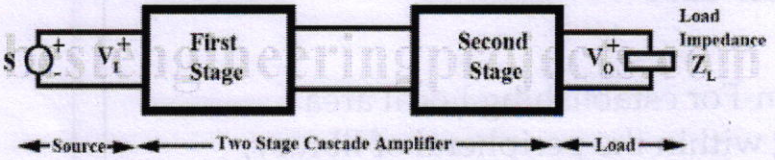


Figure 1:- Block Diagram of Two Stage Cascade Amplifiier

⇨ Use of Multistage amplifiers has the following **advantages** :

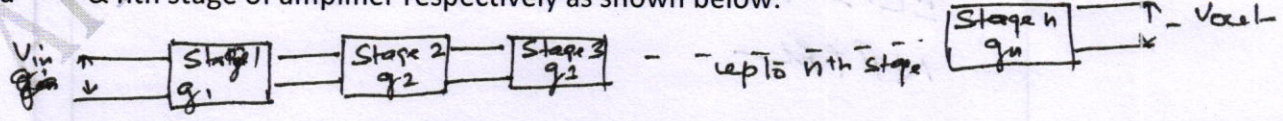
1- flexibility within input & output impedance
2- higher gain.

⇨ Multistage amplifier applications can be used to increase gain of extremely weak signals to optimum level as per the utilization.

⇨ The distortion occured due to this kind of application can be minimised by changing the signal levels within stages.

B- Gain of Multistage amplifiers:

⇨Gain is ratio of Output to input of an amplifier where input & output are similar qunatities having same units.
⇨ Since gain is a ratio, it has no unit. But after the name of Alexander graham Bell (Who discovered telephone) , gain got a logarithmic unit caleed bell. The Common logarithmic (log to the base 10) of Power gain is known as bel Power gain & Expressed as: $\log_{10} \frac{P_{out}}{P_{in}}$ bel
⇨ Since bell is a quite large unit for all practical purposes, therefore a smaller unit decibel is found to be more convenient. Decibel is defined as 1 bell= 10 decibel
⇨ Gain of a multistage amplifier can be calculated as below:
Let V_{in} be the input to first stage of amplifier & g1,g2,g3 ------gn be the gain of first, second, third ------ & nth stage of amplifier respectively as shown below:



Output of First stage= $g_1 \times V_{in}$
output of second stage= $g_2 \times g_1 \times V_{in}$
output of third stage= $g_3 \times (g_2 \times g_1 \times V_{in})$
output of nth stage= $V_{out} = g_n \times (g_1 \times g_2 \times g_3 \times \cdots \times V_{in})$

Overall gain of a multistage amplifier= $G = \frac{V_{out}}{V_{in}} = \frac{(g_1 \times g_2 \times g_3 \times \cdots g_n) V_{in}}{V_{in}}$

Overall gain of a multistage amplifier(in decibel)=

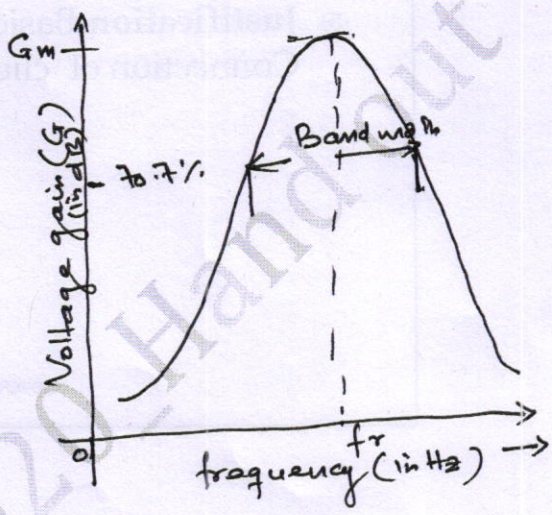
$$20\log_{10} G = 20\log_{10} g_1 + 20\log_{10} g_2 + 20\log_{10} g_3 + \cdots + 20\log_{10}$$

⇨ Thus we see that using multistage amplifier can increase gain of amplifier to a level which is suitable for a particular application.

C- Frequency response & Bandwidth Of Amplifier :

⇨ It is defined as effect on the gain of an amplifier with respect to changes in frequency of input signal .

⇨ Frequency response is usually represented by a curve drawn between voltage gain(On Y - Axis) & Signal frequeny (on X-Axis) as shown below:



⇨ The voltage gain of an amplifier tends to change with change in signal frequency because the reactance of capacitance connected in amplifier circuit changes with frequency.

⇨ The gain becomes maximun when signal frequency is at resonant frequency level.

⇨ Any further change in signal frequency leads to decrease of gain as shown in diagram

⇨ The range of frequency overwhich the gain of amplifier is equal to or greater than 70.7% of maximun gain, is known as " **Band Width**"

D- Different type of Coupling used in multistage amplifiers:

For casading of amplifiers a suitable coupling network is used in between output of one stage & input of second stage. This is also called as interstage coupling. Depending upon the requirement & application various coupling used for multistage amplifier are as follows:

1- Direct Coupling : in which output of stage 1 is directly fed to input of Stage 2 of amplifier circuit.

2- RC Coupling : Here a Resistance capacitance combination is used to feed output of stage 1 to input of stage 2 of Amplifier Circuit.

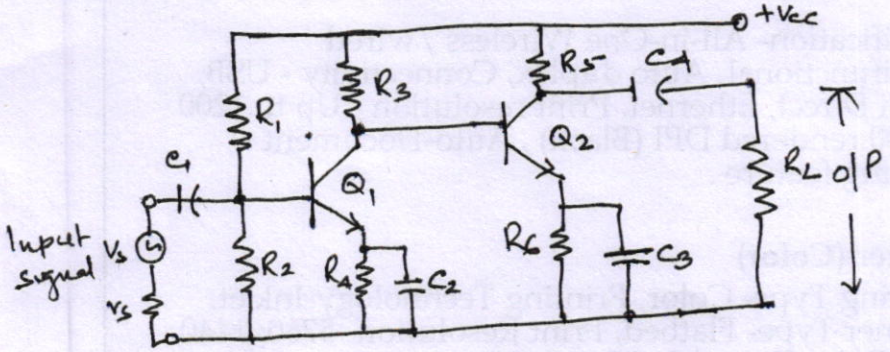
3- Transformer Coupling : In Thois type of coupling output of stage 1 is fed to primary of transformer & output of secondary winding is connected to input of stage 2 of Amplifier Circuit.

E- Direct Coupled Multistage amplifier:

⇨ Output of first stage of amplifier is directly cascaded to input of next stage

⇨ Generally used for amplification of DC or Low frequency signals

⇨ Schematic block diagram of two stage direct coupled amplifier is shown below:



⇨ As shown in the diagram, in direct coupled amplifier, base of Transistor Q2 is connected to collector of Trnsistor Q1

⇨ Since frequency response of such amplifier is very similar to a Low Pass filter, That's why sometimes this amplifier is also known as **"Low Pass Amplifier"**

⇨ Merits/Advantages :

a- Simple Circuit arrangement that involves minimum number of components

b- Low Cost

c-Used for low or zero frequency signals

⇨ Demerits/Disadvantages:

a- Unwanted change in output without change in Input is Observed

b- Output drifts with aging & Change in supply voltage

c- Due to high gain, any noise or stray signal at input increases abruptly at output.

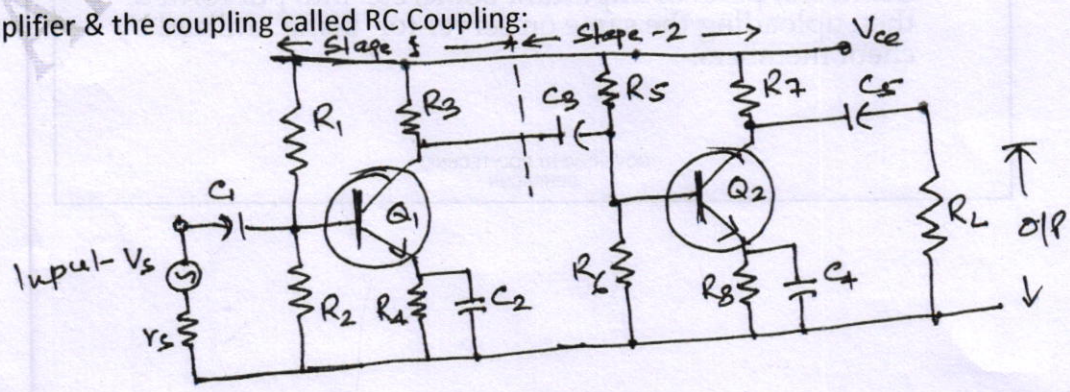
⇨ Applications:

1- Used as basic circuit for differential & Operational amplifiers

2- Widely used in computers & regulator circuits

F- RC Coupled Amplifier:

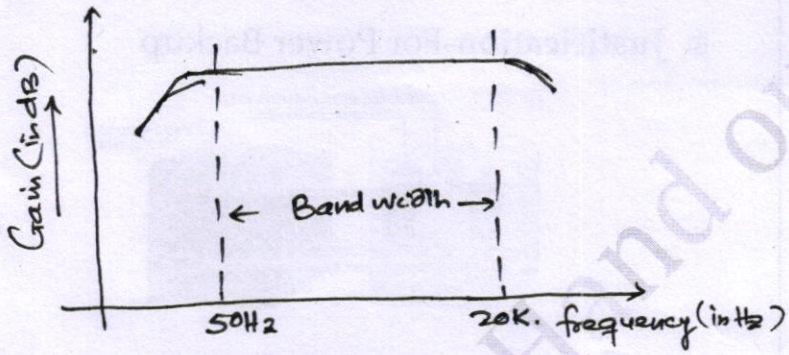
⇨When output of stage 1 is coupled to input of stage 2 of an amplifier through a combination of capacitor & resistor as shown in the diagram, this is called Rc Coupled amplifier & the coupling called RC Coupling:



⇨ Here the signal is applied to input of stage 1 & the load is coupled to output of stage 2.
⇨ The signal is amplified by stage 1 & the output of stage 1 is amplified by stage 2, so that the overall voltage gain is much greater than the gain of a single stage.
⇨ Overall gain of Two stage rc coupled amplifier:

Overall voltage gain G= gain of stage 1 (g_1)x gain of stage 2(g_2)

⇨ **Frequency response:** Since gain of such amplifier is constant over a wide range of frequency,therefore they have a large bandwidth. The frequency response curve of such amplifier is shown in the diagram:



⇨ **Merits/Advantages :**
a- Involves low cost components, hence is less expensive.
b- Large bandwidth
c-Good fidelity over audio range
d- Amplitude distortion is low

⇨ **Demerits/Disadvantages:**
a- Low Voltage & Poer gain
b- With aging, the amplifier is less immune to noise.
c- Impedance matching is poor.

⇨ **Applications:**
1- Widely used as pre amplifiers
2- In Optical fibre communication.

G- Comparison of different couplings :

Characteristic	Direct Coupled	RC Coupled	Transformer Coupled
Frequency Response	Good	Excellent	Poor
Cost	Least	Less	Costly
Impedance matching	Satisfactory	Poor	Excellent
Application	DC or Low Freq. Signal amplification	Voltage amplification	Power Amplification