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Amplifiers.

An amplifier is a circuit, which can be used to increase the amplitude of the input voltage or current at the output. Amplifiers are used in music equipment, electronic devices such as television and radio receivers, audio equipment etc.

* Types of amplifier.

Many different types of amplifier are found in electronic circuits.

- a.c. coupled amplifiers.

  In a.c. coupled amplifiers, different stages are coupled together in such a way that d.c. levels are isolated and only the a.c. components of a signal are transferred from stage to stage.

- d.c. coupled amplifiers.

  In d.c. coupled (or direct coupled) amplifiers, stages are coupled together in such a way that stages are not isolated to d.c. voltages. Both a.c. and d.c. signal components are transferred from stage to stage.

- Large-signal amplifiers.

  Large-signal amplifiers are designed to amplify voltage levels 1V to 100V.

- Small-signal amplifiers.

  Small-signal amplifiers are designed to amplify low-level signals normally less than 1V and often much smaller.

- Audio frequency amplifiers.

Audio frequency amplifiers operate in the band of frequencies that is normally associated with audio signals. i.e. 20 Hz to 20 KHz.

- Wideband amplifiers

Wideband amplifiers are capable of amplifying a very wide range of frequencies, typically from a few tens of hertz (Hz) to several megahertz (MHz)

- Radio frequency amplifiers

Radio frequency amplifiers operates in the band of frequencies that is normally associated with radio signals. i,e 100 KHz to over 1 GHz.

- Low-noise amplifiers

Low-noise amplifiers are designed so that they contribute negligible noise to signal being amplified. These amplifiers are designed to amplify voltage levels less than 1 mV.

* Gain

One of the most important parameters of an amplifier is the amount of amplification or gain that it provides. Gain is simply the ratio of output electrical quantity to input electrical quantity. Accordingly, we have.

Voltage gain, $A_V = \frac{V_o}{V_i}$

Current gain, $A_I = \frac{I_o}{I_i}$

Power gain, $A_p = \frac{P_o}{P_i}$

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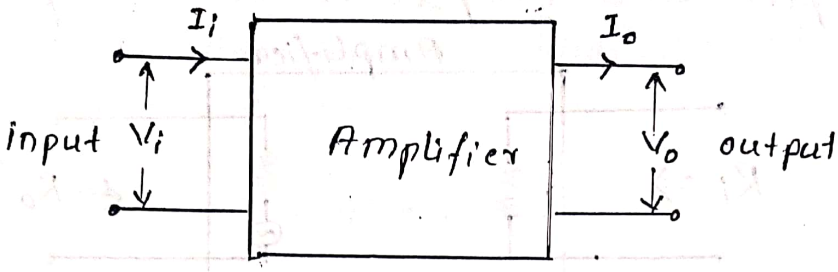


Fig. Block diagram of an amplifier.

Since power is the product of voltage and current

$$A_p = \frac{P_o}{P_i} = \frac{V_o \times I_o}{V_i \times I_i} = A_V \times A_I$$

Ex: An amplifier produces an output voltage of 2V for an input of 50mV. If the input and output currents in this condition are, respectively 4 mA and 200 mA. Determine:

a) Voltage gain, A_V

b) Current gain, A_I

c) Power gain, A_P

Soln: a) The voltage gain is calculated from

$$A_V = \frac{V_o}{V_i} = \frac{2}{50 \times 10^{-3}} = 40$$

b) Similarly current gain

$$A_I = \frac{I_o}{I_i} = \frac{200 \times 10^{-3}}{4 \times 10^{-3}} = 50$$

c) Power gain

$$A_P = \frac{V_o \times I_o}{V_i \times I_i} = \frac{2 \times 200 \times 10^{-3}}{50 \times 10^{-3} \times 4 \times 10^{-3}} = 2000$$

or

$$A_P = A_V \times A_I = 40 \times 50 = 2000.$$

* Input and output resistance of an Amplifier

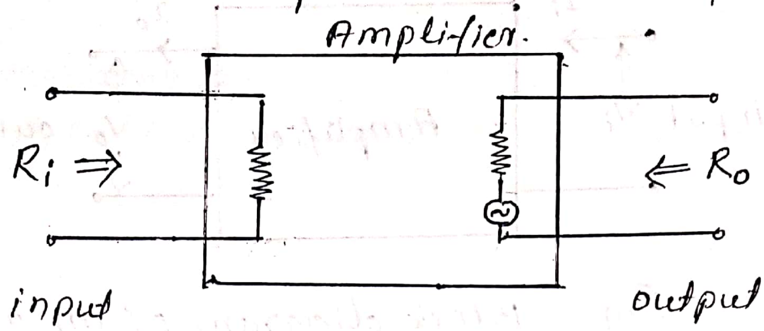


Fig: Input and output resistances seen looking in to the input and output terminals.

- Input resistance is the ratio of input voltage to input current and it is expressed in ohms. In some cases reactance of the input may become appreciable. In such cases we call it as input impedance rather than input resistance.
- Output resistance is the ratio of open-circuit output voltage to short-circuit output current and is measured in ohms. If reactance of the output is appreciable, then we call it as output impedance.

* Frequency response

The frequency response of an amplifier refers to the band of frequencies or frequency range that amplifier was designed to amplify.

The frequency response characteristics for various types of amplifier are shown in fig. . Note that frequency is almost invariably plotted on a logarithmic scale.

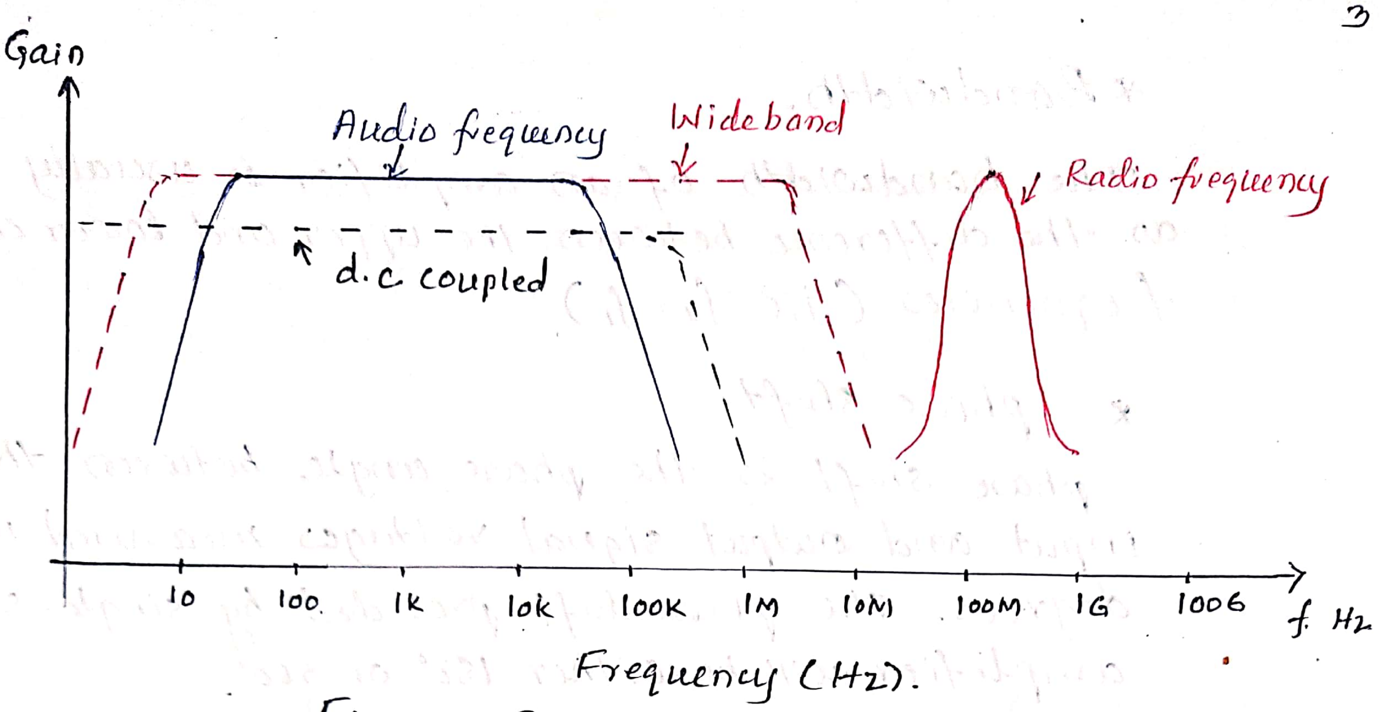


Fig. . Frequency response and Bandwidth.

Fig. a) and Fig. b) respectively show how the bandwidth can be expressed in terms of either power or voltage (the cut-off frequencies, f_1 and f_2 and bandwidth are identical).

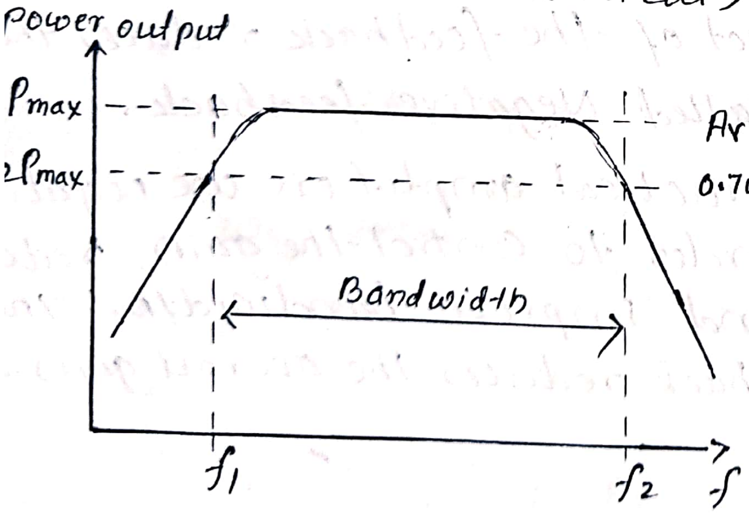


Fig. a)

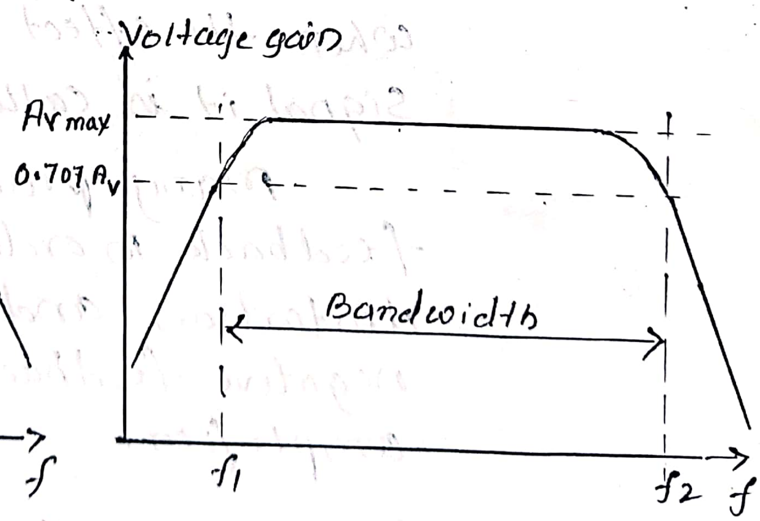


Fig. b)

In above fig.

$$\text{Bandwidth} = (f_2 - f_1)\ Hz.$$

* Bandwidth.

The bandwidth of an amplifier is usually taken as the difference between the upper and lower cutoff frequencies (i.e $f_2 - f_1$)

* phase shift

phase shift is the phase angle between the input and output signal voltages measured in degrees. The phaseshift provided by single-stage amplifier will be either 180° or 360°.

* Negative feedBack.

Feedback is the process of taking a portion of an amplifier's output signal and feeding it back in to the input. when feedback is used to increase the input signal, it is called Positive feedback and when the effect of the feedback reduces the input signal it is called Negative feedback.

many practical amplifiers use negative feedback in order to control the gain, reduce distortion and improve bandwidth. The negative feedback reduces the overall gain of the amplifier.

Fig. . shows the block diagram of an amplifier stage with negative feedback. (next page).
In this circuit, the portion of the output voltage fed back to the input is given by β and the overall voltage gain will be given by.

$$\text{Overall Gain, } G = A_F = \frac{V_{out}}{V_{in}}$$

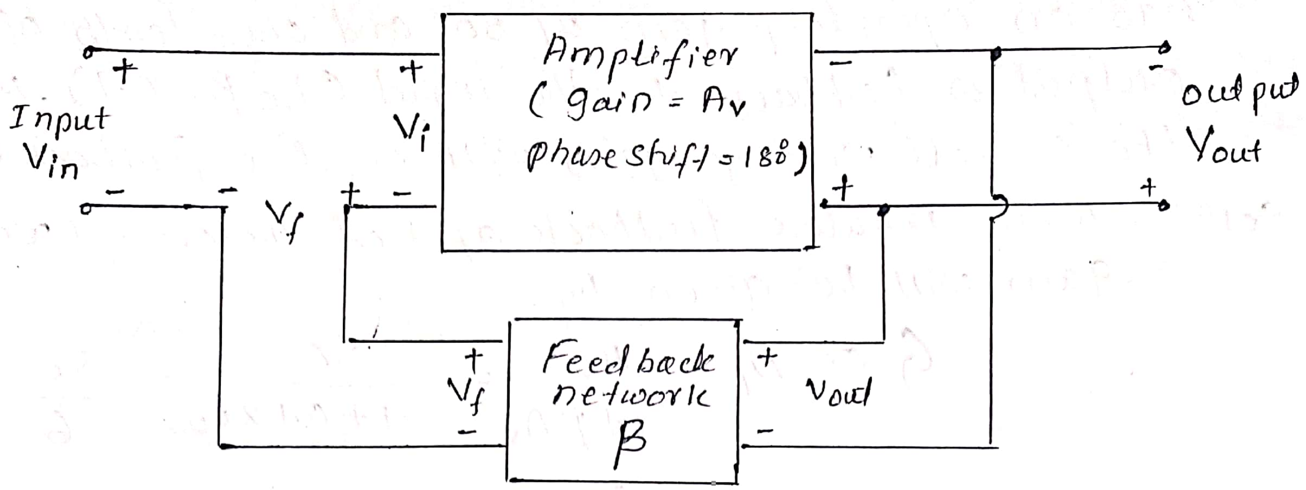


Fig. Amplifier with negative feed back.

From fig. voltage gain without feed back

$$A_v = \frac{V_{out}}{V_i}$$

Overall voltage gain, i.e voltage gain with feedback

$$A_F = \frac{V_{out}}{V_{in}}$$

feed back factor $\beta = \frac{V_f}{V_{out}}$

we have, $V_{out} = A_v . V_i$

but $V_i = V_{in} - V_f$

$\therefore \quad V_{out} = A_v (V_{in} - V_f) \qquad \because \; V_f = \beta V_{out}$

$= A_v (V_{in} - \beta V_{out})$

$V_{out} (1 + \beta A_v) = A_v V_{in}$

$\therefore$ over all gain, G or $A_F = \frac{V_{out}}{V_{in}} = \frac{A_v}{1 + \beta A_v}$

if $\beta A_v >> 1$,

then G or $A_F = \frac{1}{\beta}$

loop gain of the feed back amplifier is defined as the product of β and A_v.

i.e loop Gain = $\beta . A_v$.

Ex: An amplifier with negative feedback applied has an open loop gain of 50: and one-tenth of its output is feedback to the input (i.e $\beta = 0.1$). Dete the overall voltage gain with negative feedback app

Soln: with negative feedback applied the overall volta gain will be given by.

$$G \text{ or } A_F = \frac{A_V}{1+\beta A_V} = \frac{50}{1+0.1\times 50} = \frac{50}{6}$$

$$= 8.33$$

Ex: In above example, the amplifiers open-loop voltage gain increases by 20%, determine the percentage increment in overall voltage gain.

Soln: The new value of voltage gain is

$$A_V = A_V + 0.2A_V = (1+0.2)A_V = 1.2\times 50$$
$$= 60$$

The overall gain G or $A_F = \frac{A_V}{1+\beta A_V} = \frac{60}{1+0.1\times 60}$

$$= \frac{60}{7} = 8.57$$

The increase in overall voltage gain in percenta is given by.

$$\frac{8.57 - 8.33}{8.33} \times 100\% = 2.88\%$$

Ex: An integrated circuit that produces an open loop gain of 100 is to be used as an amplifier having precis voltage gain of 20. Determine the amount of feed back required.

Soln: Rearranging formula.

$$G = \frac{A_V}{1+\beta A_V} \Rightarrow \beta = \frac{1}{G} - \frac{1}{A_V}$$

Thus, $\beta = \frac{1}{20} - \frac{1}{100} = 0.05 - 0.01 = 0.04$ ← Ans

* Multi-stage amplifiers.

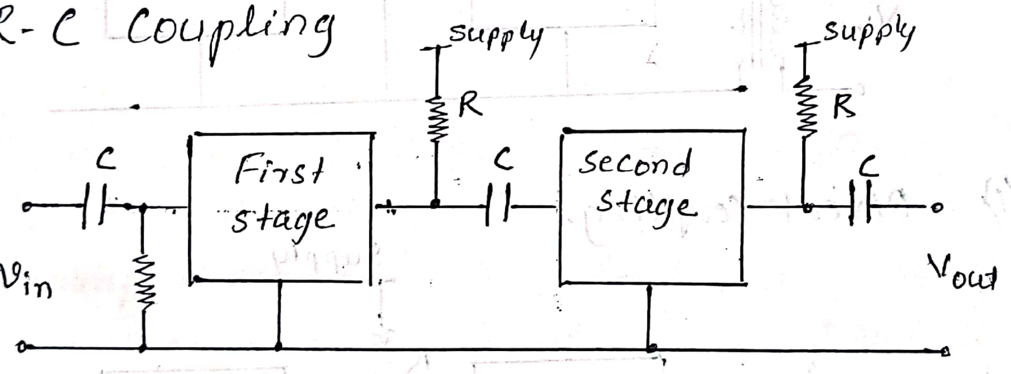
In order to provide sufficiently large values of gain, it is necessary to use a number of interconnected stage within an amplifier. This is called multi-stage amplifier. The overall gain of multistage amplifier with several stages is simply the product of the individual voltage gains.

i.e $A_V = A_{V_1} \times A_{V_2} \times A_{V_3}$ etc.

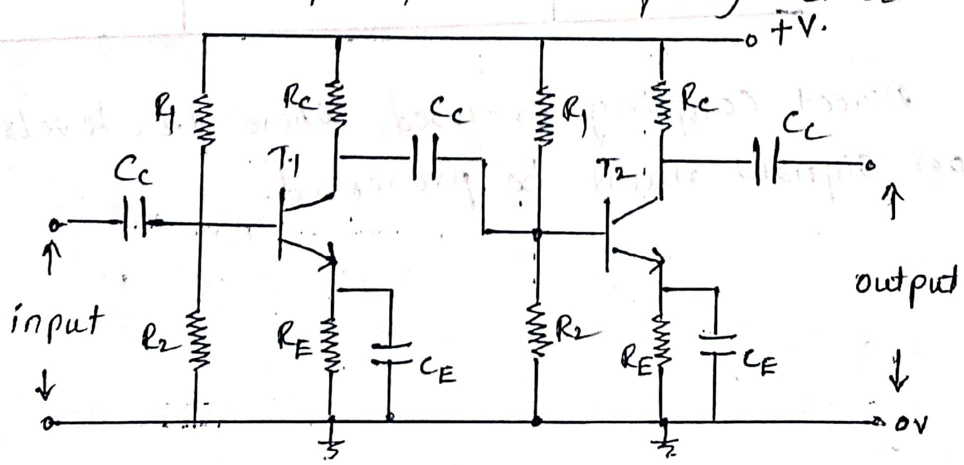
However, the bandwidth of multistage amplifier is less than Bandwidth of each individual stage.

Signals can be coupled between the individual stages of a multi-stage amplifier using one of the coupling methods as follows.

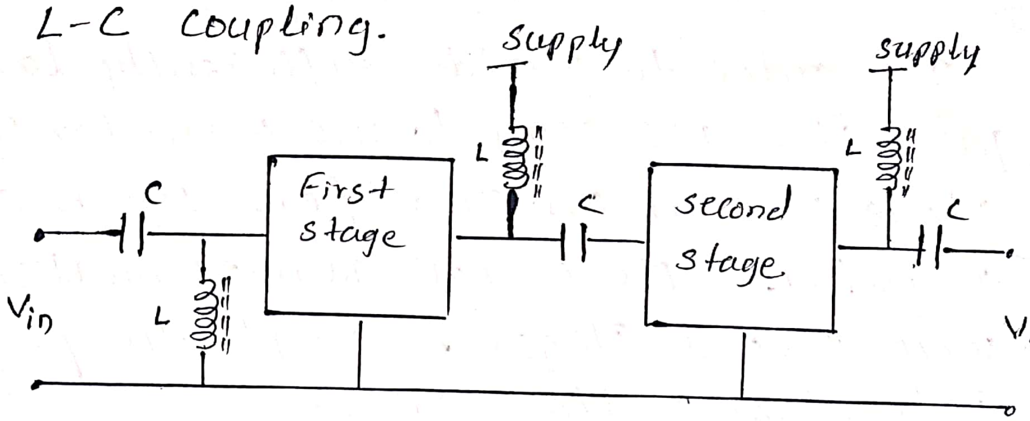
1) R-C Coupling



In this coupling method, the stages are coupled together using capacitors and resistors. Below fig shows a practical example of this coupling method.

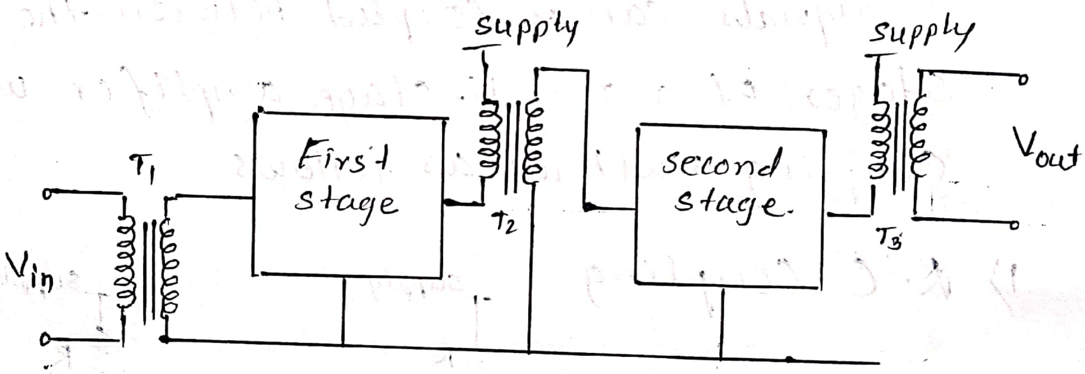


2) L-C Coupling.

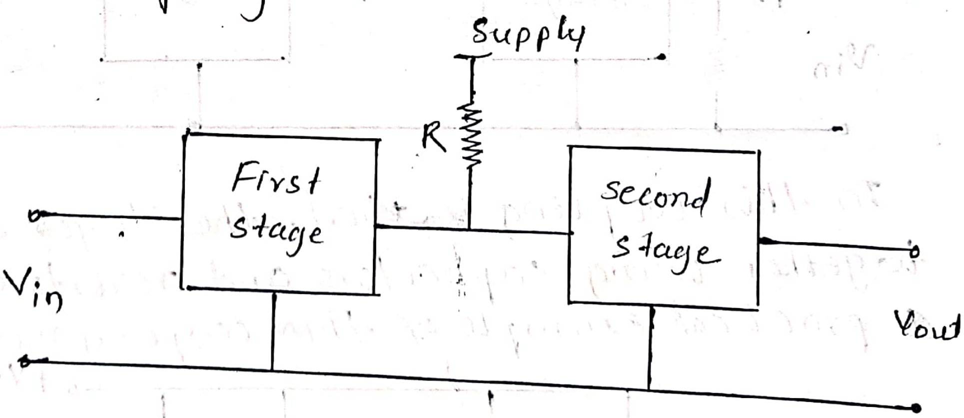


In this method inductors and capacitors are used for Coupling. from one Stage to other. This type of Coupling is generally only used in RF and high-frequency amplifier

3) Transformer Coupling.



4) Direct Coupling.



Direct Coupling is used where d.c. levels present on signals must be preserved.