1.3 EFFECTS OF FEEDBACK

Stabilization of Gain:

- The gain of the amplifier may change due to the changes in the parameters of the transistor or the supply voltage variation.
- The gain A of the feedback amplifier is independent of internal gain A and depends only on feedback fraction.

  W.K.T,

$$A_f = \frac{A}{1+\beta A}$$

Diff.w.r.t A

$$dA_f = \frac{dA}{(1+\beta A)^2}$$

Dividing both sides by A_f we get

$$\frac{dA_f}{A_f} = \frac{dA}{(1+\beta A)^2} \, X \, \frac{1}{A_f}$$

$$\left|\frac{dA_f}{A_f}\right| = \left|\frac{dA}{A}\right| \frac{1}{|(1+\beta A)|}$$

Where $\left|\frac{dA_f}{A_f}\right|$= fractional change in gain with the feedback

$\left|\frac{dA}{A}\right|$= fractional change in gain without the feedback.

- The sensitivity of transfer gain of the feedback amplifier A_f with respect to the variations in the internal amplifier gain A is defined as the ratio of the fractional change in gain with the feedback to the fractional change in gain without the feedback.
- The sensitivity is $\frac{1}{|(1+\beta A)|}$
- The inverse or reciprocal of sensitivity is called De-Sensitivity.

$$D = 1+\beta A$$

- The stability of the amplifier increases with increase in desensitivity

Reduction in distortion:

- The negative feedback reduces the non-linear distortion inthe output signal.
- Nonlinear distortion occurs when an active device in the amplifier has nonlinear transfer characteristics.
- The negative feedback reduces the nonlinear distortion by the factor

$$D = 1 + \beta A$$

Increase in Bandwidth:

- The negative feedback decreases the lower cut off frequency f while increases the upper cut off frequency f i.e. it increases the bandwidth of the amplifier.
- This implies that if the band width of the gain A has certain values (say 1MHz), by applying negative feedback, it can be increased.
- The increase, happens by sacrificing the value of the gain A.
- It implies a mid-band gain of A_{Mf} and a high frequency band width of A_{Hf}.

  Lower Cutoff frequency

$$f_{Lf} = \frac{f_L}{1 + A_{mid}\,\beta}$$

  Upper cutoff frequency

$$f_{Hf} = (1 + A_{mid}\,\beta)\, f_H$$

- It can be clearly seen that the new mid-band gain is (1+A β) times smaller than the mid-band gain without feedback, but the high frequency band width is (1+Aβ) times larger than the band width without feedback.
- Thus an extension of band width by the factor (1+Aβ) has been achieved.
- Band width =Upper cut-off Frequency – Lower cut-off Frequency

$$BW = (1 + A_{mid}\,\beta)\, f_H \; - \; \frac{f_L}{1 + A_{mid}\,\beta}$$

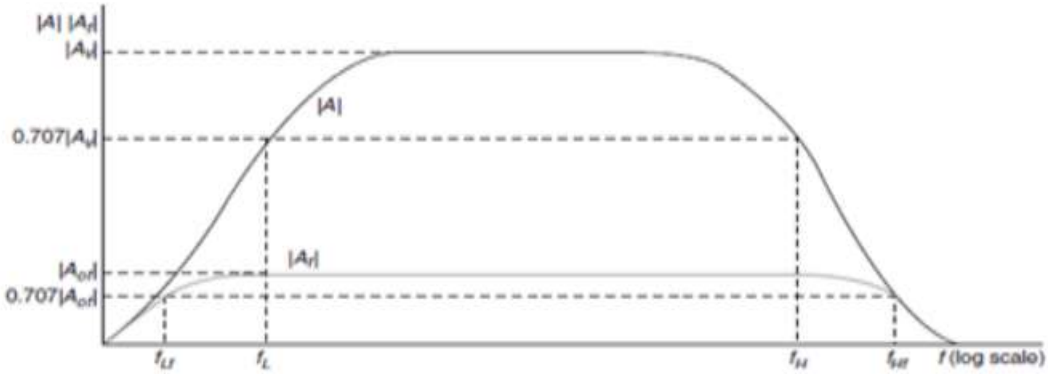

Fig.1.3.1 effect of negative feedback on gain and bandwidth

(Source: Microelectronics byJ. Millman and A. Grabel, , 2nd ed., Page-212)

- Bandwidth with negative feedback increases by factor (1+Aβ) and gain decreases by same factor, the gain bandwidth product of an amplifier does not altered, when negative feedback is introduced

Reduction in Noise:

- Almost all amplifier circuit produces noise due to presence of active and passive components in it.
- The negative feedback can be used to reduce the noise in amplifiers.
- It is possible to improve signal to noise ration of an amplifier under certain conditions.

- A noisy amplifier is modified by a noiseless amplifier in series with noise source V_n.
- The output voltage of this noisy amplifier is given by,

$$V_0 = A(V_s + V_n)$$

- The signal to noise ratio is given by

$$\frac{S}{N} = \frac{V_s}{V_n}$$

- It is possible to improve S/N ratio of this noisy amplifier by preceding a noise free preamplifier
- The signal to noise ratio at the output is given by

$$S/N = \frac{V_s A_p}{V_n}$$

- We can improve SNR of a noisy amplifier by factor of A_p if a noise-free preamplifier with a voltage gain A_p precedes a noisy amplifier.

Input impedance:

- If the feedback signal is added to the input in series with the applied voltage it increases the input resistance.
- Hence, the input resistance with feedback $R_{if} = \frac{V_s}{I_i}$ is greater than the input resistance without feedback.
- Feedback signal is added to the input in shunt with applied voltage, it decreases the input resistance.
- Hence, the input resistance with feedback $R_{if} = \frac{V_i}{I_s}$ is decreased.

Output impedance:

- Negative Feedback which samples the output voltage, it decreases output resistance.
- Negative Feedback which samples the output Current, it Increases output resistance