Feedback in Amplifiers

The term feedback implies transfer of energy from the output of a system to its input. The process of combining a fraction of the output energy (i.e, voltage or current) back to the input is called the feedback. The amplifiers which use the feedback principle, are known as feedback amplifiers.

A feedback amplifier mainly consists of two parts :- an amplifier circuit and feed back circuit. Amplifier circuit amplifies the i/p signal and the function of feed back n/w is to return a fraction of o/p energy to the i/p of the amplifier. A feed back n/w may be consist of either passive elements like resistors, inductors or capacitors or active elements like transistors.

Classification of Feedback.

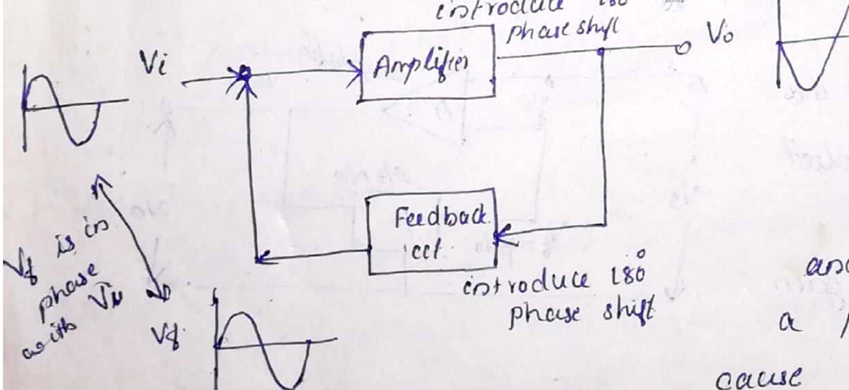
Depending upon whether the feedback signal increases or decreases the input signal, the feed back may be classified into two types

(1) Positive feedback

(2) Negative feed back.

Positive feedback

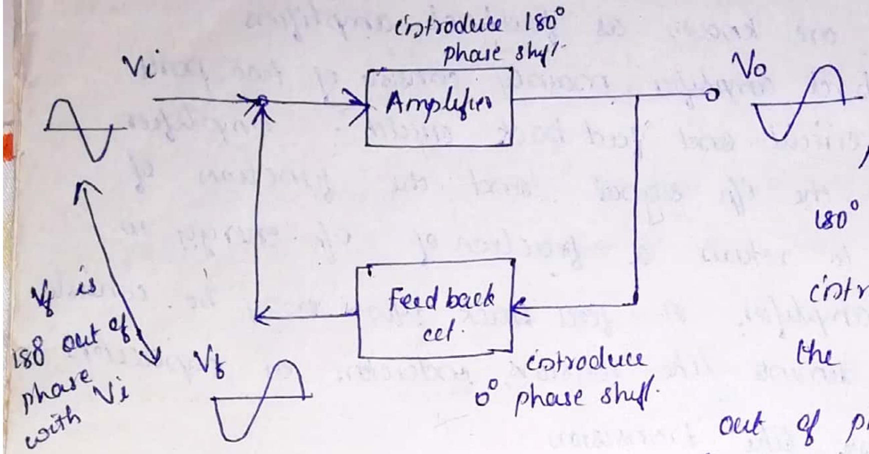
If the feedback signal applied is in phase with the i/p signal and thus increases it, then it is called a $+^{ve}$ feedback. It is also known as regenerative feedback or direct feed back



Here both the amplifier and feed back n/w introduce a phase shift of 180°. This cause a 360° phase shift around the loop and thus feedback signal is in phase with the input signal. $+^{ve}$ f/b causes excessive distortion and instability ∴ it is seldom used in amplifiers. Because of its capability of increasing the power of the original signal, it is used in oscillator circuit.

Negative feedback-

If the feedback signal is out of phase with the i/p signal and thus decreases it, then it is called -ve feed back. It is also known as degenerative feedback or inverse feedback.



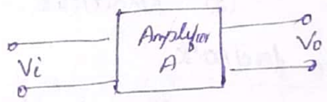
Here amplifier introduce 180° and feedback n/w introduce 0° phase shift. Thus the feed back signal is out of phase with the i/p signal.

-ve feedback reduces the amplifier gain but it has some advantages such as gain stability, reduction in non-linear distortion, reduction in noise, increase in band width etc. ∴ -ve feedback is most widely used in amplifier circuit.

Principle of Feedback in Amplifiers

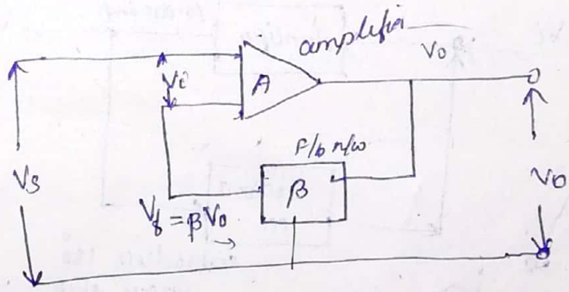
Consider an ordinary amplifier

Voltage gain, $A = \frac{\text{o/p voltage}}{\text{i/p voltage}} = \frac{V_o}{V_i}$



$A = \frac{V_o}{V_i}$ ⟶ open loop gain.

Consider a feedback amplifier



Let a fraction β of the o/p voltage Vo be supplied back to i/p and let A be the open-loop gain

$A = \frac{V_o}{V_i}$

i/p voltage $V_i = V_s + V_f$

For +ve f/b $V_i = V_s + \beta V_o$

For -ve f/b $V_i = V_s - V_f = V_s - \beta V_o$.

ie $V_i = V_s \pm \beta V_o$

& we consider the $-^{ve}$ feedback case

$$V_i = V_s - \beta V_o$$

here o/p voltage is equal to the i/p voltage $(V_s - \beta V_o)$ multiplied by the amplifier open loop gain, A.

$$\therefore V_o = A(V_s - \beta V_o)$$

or $(1+\beta A) V_o = A V_s$

$$\frac{V_o}{V_s} = \frac{A}{1+\beta A}$$

This is known as the voltage gain of the amplifier with feedback A_f. This is also known as the closed loop gain.

Hence voltage gain with $-^{ve}$ feedback will be

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

$||^{rly}$ voltage gain with $+^{ve}$ feedback

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

$\beta A \longrightarrow$ feedback factor

$(1 \pm \beta A) \longrightarrow$ loop gain

$A \rightarrow$ gain without feedback.

$A_f \rightarrow$ gain with feedback.

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

a) If no feedback ie $\beta = 0$

then $A_f = A$

A & $\beta \rightarrow$ phasor quantities having mag as well as phase.

b) if $1+A\beta > 1$, then $-^{ve}$ f/b

ie $A_f < A$

c) if $1+A\beta < 1$, then $+^{ve}$ f/b

$A_f > A$

d) if $1+A\beta = 0$

ie $A_f = \infty$ it acts as an oscillator

The feedback may also be classified as voltage feedback and current feedback. Both the voltage and current can be feedback to the i/p either in series or in $||^{l}$ which results in 4 basic feedback connections

Comparison of $+^{ve}$ f/b and $-^{ve}$ f/b.

$+^{ve}$ feed back.

Advantages:

gain of amplifier increases.

disadvantages:

- gain is unstable
- produce distortion of the o/p signal.

$-_{ve}$ feedback.

disadvantages

— gain of amplifier decreases.

advantages:

* improves stability of gain
* Reduction of non-linear distortion.
  - non linear distortion is reduced by a factor of $(1+A\beta)$.
* Reduction of noise
  - reducted by a factor of $(1+A\beta)$
* increase in bandwidth (improved frequency response).
* increased in i/p impedance — ↑ by a factor of $(1+A\beta)$
* reduction in o/p impedance — ↓ by a factor of $(1+A\beta)$

$(1-\beta A)$ is a complex quantity.

1) If $(1-\beta A)$ is less than unity, then A_f exceeds A. This condi: corr. to +ve f/b because voltage feedback adds to i/p sgl voltage & ↑es Vin: +ve f/b, though ↑es gain but it reduces the stability & ↑es the distortion & so avoided

2) If $(1-\beta A)=0$, gain A_f becomes infinite. This is possible when e/p is zero. Thus the amp is then capable of giving o/p voltage even with zero sgl. operates as an amplifier

3) If $(1-\beta A) >$ unity then $A_f < A$. This means f/b voltage Vin becomes smaller than Vin. This corr: to -ve f/b. Though -ve f/b reduces the gain of the amp: but improves its performance

Q) A single stage tr amp has a voltage gain of 600 without f/b & 50 with f/b. Calcu: % of o/p which is fed back to e/p

$A = 600, \quad A_f = 50$

$A_f = \dfrac{A}{1+A\beta} = \quad$ or $\beta = 0.01833$

$\dfrac{V_f}{V_o} \times 100 = \beta \times 100 = 0.01833 \times 100 = 1.833\%$