Feedback & Feedback amplifier

The process of combining a part or a fraction of output of an amplifier to back to the input is known as feedback.
There are following two types of feedback
i> Negative feed back
ii> Positive feedback

i> <u>Negative feedback</u>:- When the net effect of feedback is to reduce the input signal i.e in otherword, if feedback part is in oppos phase to the input signal then the feedback takes place is known as negative, inverse or Degenerative feedback.

ii> Positive feedback :- When then net effect of feedback is to increase the magnitude of input signal or in otherword that if the feedback amount is in with the phase of input signal then it is called positive or direct or Regenerative feedback

Advantages of negative feedback.

i> Stabilization of gain

ii> Reduction in distortion

iii> Reduction in noise.

iv> Increase in input impedance.

v> Decrease in output impedance

vi> Increase in bandwidth or increase the range of uniform amplification.

Feedback amplifiers are classified as below —

i> Voltage feedback amplifier

ii> Current feedback amplifier.

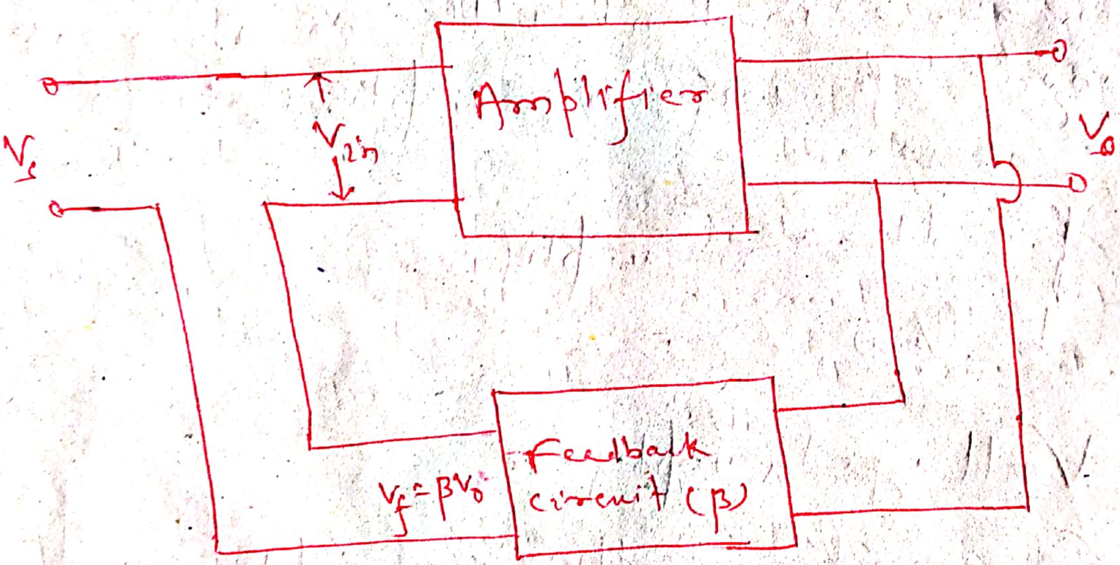
i> Voltage feedback :- The feedback amplifier in which the voltage fed back to the input is proportional to the output voltage is known as voltage feedback

ii> Current feedback :- The feedback in which the voltage fed back to the input is proportion to the Current through the load is known as Current feedback

Scanned with CamScanner

Basic theory of feedback OR Principle of feedback.

To understand the basic theory of feed, we consider the block diagram as shown in figure consist of an amplifier with gain A and a feed ckt of feedback ratio β.



Let,

V_s = Reference input to amplifier

V_{in} = ~~Actual~~ input " "

V_0 = Output of amplifier

V_f = Feedback voltage = βV_0.

Now, after feedback ——

The actual input to amplifier —

$$V_{in} = V_s \pm V_f = V_s \pm \beta V_0$$

Since, $A = \frac{V_o}{V_{in}}$ or, $V_o = AV_{in}$

or, $V_o = A(V_s \pm \beta V_o) = AV_s \pm A\beta V_o$

or, $V_o(1 \mp A\beta) = AV_s$

$\Rightarrow \frac{V_o}{V_s} = \frac{A}{1 \mp A\beta}$

$\Rightarrow A_f = \frac{V_o}{V_s} = \text{Overall gain} = \frac{A}{1 \mp A\beta}$

$\Rightarrow A_f = \frac{A}{1 + A\beta}$ [for -ve feedback]

$A_f = \frac{A}{1 - A\beta}$ [for +ve feedback]

Here, A_f is called overall gain or gain with feedback. $(1 \pm A\beta)$ is known as loop gain and "$A\beta$" is called feedback fraction.

Note:- i) $A_f < A$ for -ve feedback

ii) $A_f > A$ " +ve "

iii) In case of +ve feedback $A_f = \frac{A}{1 - A\beta}$

if $A\beta = 1$, then $A_f = \infty$, this is possible when $V_s = 0$. And in this case amp. operates as an oscillator.

i) Negative feedback stabilizes the gain :-

For -ve feedback —

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

if $A >> \beta$ and $A\beta >> 1$ then

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

Clearly, overall gain depends only upon "β" and independent from open loop gain. Since feedback ratio β of feedback circuit depends upon passive elements like resistors because basically, a feedback circuit consist of passive element, hence the overall gain stabilizes.

Let us consider a certain change in temp which causes the change in amplifier gain, then we can analysis of % change of overall gain with the % change in amp. gain as below —

Since,

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

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

Scanned with CamScanner

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

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

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

$$\Rightarrow \frac{dA_f}{A_f} = \frac{1}{(1+A\beta)} \cdot \frac{dA}{A}$$

Obviously % change in overall gain decrease by a factor $\frac{1}{(1+A\beta)}$ of amplifier gain

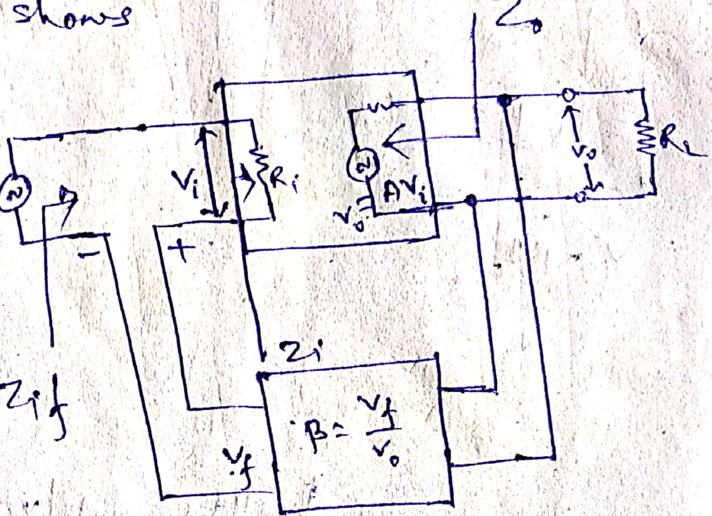
i.e, $$\frac{dA_f}{A_f} < \frac{dA}{A}$$

Here, $\frac{1}{(1+A\beta)}$ is known as sensitivity.

Scanned with CamScanner

Input impedance with -ve feedback for voltage series feedback amp.

The adjecent fig. shows voltage-series -ve feedback amplifier where V_s



V_s = Applied source voltage Z_{if}

V_i = Actual input voltage to the amp.

Z_i = Input imp. without feedback

Z_{if} = " " with feedback

$\beta = \frac{V_f}{V_o}$ = Feedback ratio.

Now,

$I_i = \frac{V_i}{Z_i}$, $Z_{if} = \frac{V_s}{I_i}$

$\because V_i = V_s - V_f$

$\therefore I_i = \frac{V_s - V_f}{Z_i} = \frac{V_s - \beta V_o}{Z_i}$

or, $I_i Z_i = V_s - \beta V_o$ or, $V_s = I_i Z_i + \beta V_o$

$\therefore Z_{if} = \frac{V_s}{I_i} = \frac{I_i Z_i + \beta V_o}{I_i}$

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

$\therefore Z_{if} = \frac{Z_i I_i + \beta A V_i}{I_i} = Z_i + A\beta \cdot \frac{V_i}{I_i} = Z_i + Z_i A\beta$

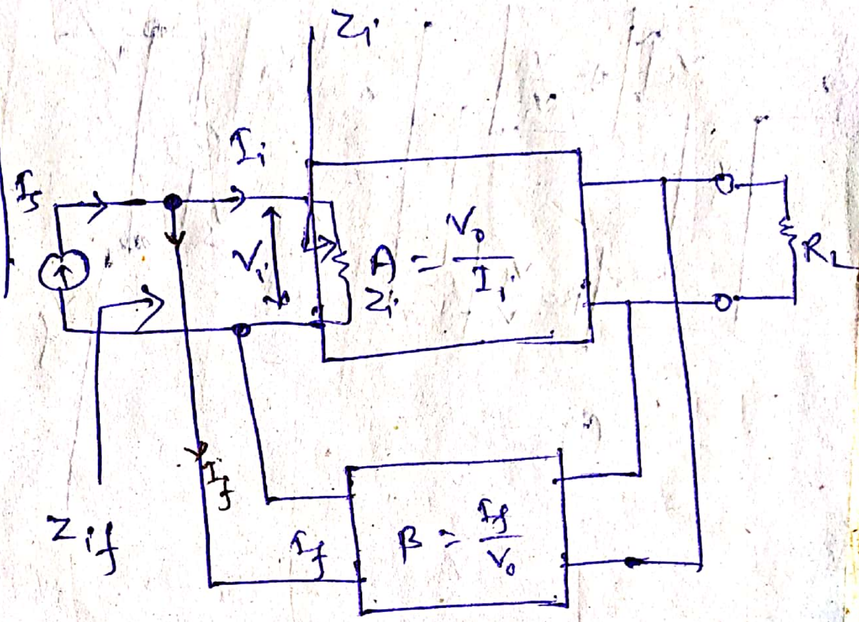
$\boxed{Z_{if} = Z_i(1+A\beta)}$

Scanned with CamScanner

Input impedance of voltage-shunt

$I_s = I_i + I_f$

$Z_{if} = \frac{V_i}{I_s}$, $Z_i = \frac{V_i}{I_i}$



$\because$ $I_f = \beta V_o$

& $A = \frac{V_o}{I_i} \Rightarrow V_o = AI_i$

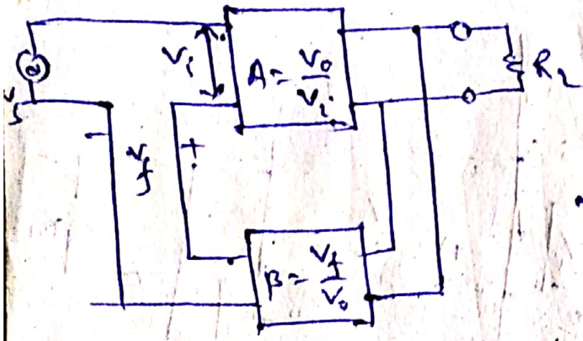
$\therefore$ $Z_{if} = \frac{V_i}{I_i + I_f}$

or, $Z_{if} = \frac{V_i}{I_i + \beta V_o} = \frac{V_i}{I_i + \beta A I_i} = \frac{V_i}{I_i(1+A\beta)}$

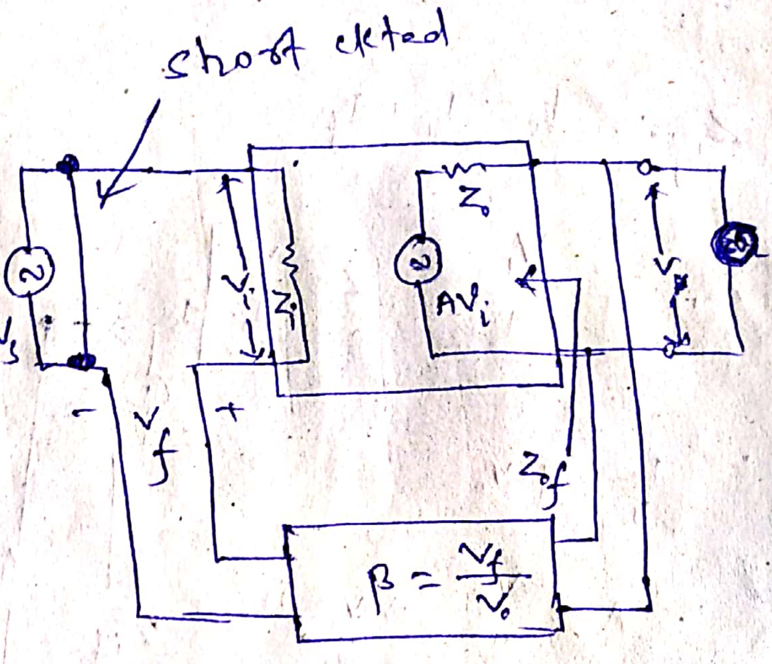
or $Z_{if} = \frac{V_i/I_i}{1+A\beta} = \frac{Z_i}{1+A\beta}$

$$\boxed{Z_{if} = \frac{Z_i}{1+A\beta}}$$

Output impedance of voltage series feedback



(1)



(2)

Fig-1 shows topology for voltage series feedback amp. To find out the output impedance, we replace load and connect a voltage source V and input signal voltage is short ckted which is shown in fig-2.

Hence

$$Z_{of} = \text{o/p imp. after feedback} = \frac{V}{I}$$

Here $V_i = -V_f$

Applying KVL in o/p side ——

$$V = IZ_o + AV_i = IZ_o - A\beta V$$

or $V(1+A\beta) = IZ_o$ or $\frac{V}{I} = \frac{Z_o}{1+A\beta}$

$$\therefore Z_{of} = \left(\frac{Z_o}{1+A\beta}\right)$$

i.e. After feedback, output impedance is reduced by a factor (1+Aβ)

Output Impedance of voltage-shunt feedback

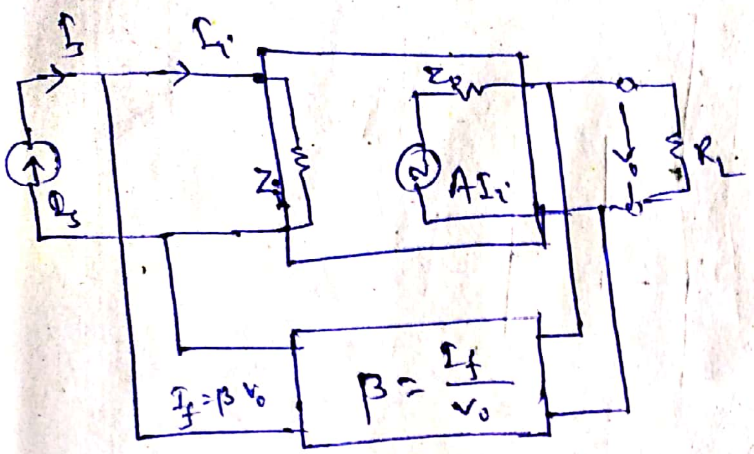


Fig-1

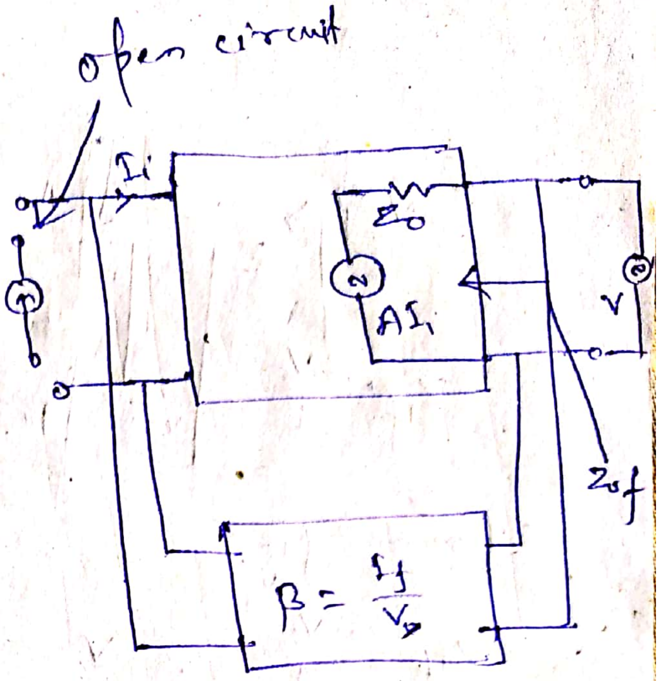


Fig-2.

The above fig.-1. represent a topology for voltage shunt feed back amp. It is a trans-resistence amp. For finding output impedence we replace load by a voltage source V and open the input current source as shown in fig-2.

Here $I_i = -I_f = -\beta V$

And, $Z_{of} = \frac{V}{I}$

By Applying KVL in o/p ckt ——

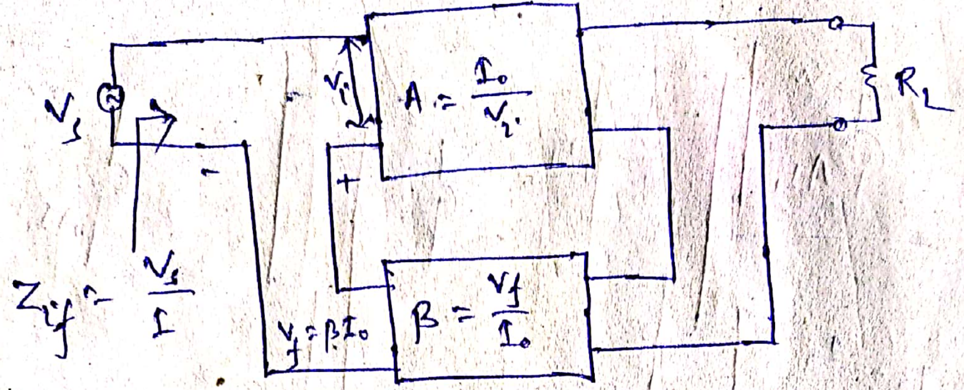
$V = IZ_o + AI_i = IZ_o - A\beta V$

$\Rightarrow V(1+A\beta) = IZ_o \quad \Rightarrow \frac{V}{I} = \left(\frac{Z_o}{1+A\beta}\right)$.

$Z_{of} = \left(\frac{Z_o}{1+A\beta}\right)$

i.e o/p impedance reduces by $(1+A\beta)$ A

Input impedance of current-series.



from fig.

$Z_{if} = \frac{V_s}{I}$, V_s = Source voltage , $A = \frac{I_o}{V_i}$

$\beta = \frac{V_f}{I_o} \Rightarrow V_f = \beta I_o$, $Z_i = \frac{V_i}{I}$

Now, $V_s - V_f = V_i \Rightarrow V_s = V_i + V_f = V_i + \beta I_o$

or, $V_s = V_i + \beta A V_i = V_i(1 + A\beta)$

$\therefore Z_{if} = \frac{V_s}{I} = \frac{V_i(1+A\beta)}{I} = Z_i(1+A\beta)$.

i.e. Input impedance increase by $(1+A\beta)$ factor.

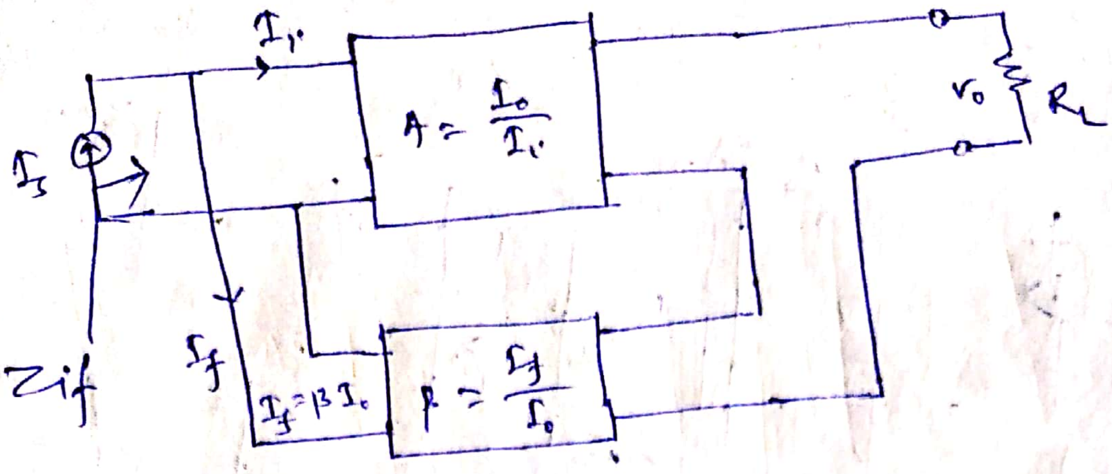
Input impedance of current-shunt.

from fig —

$Z_{if} = \frac{V_i}{I_s}$, $A = \frac{I_o}{I_i}$, $\beta = \frac{I_f}{I_o}$

$Z_i = \frac{V_i}{I_i}$

or $I_s = I_f + I_i = I_i + \beta I_o = I_i + \beta A I_i = I_i(1+A\beta)$

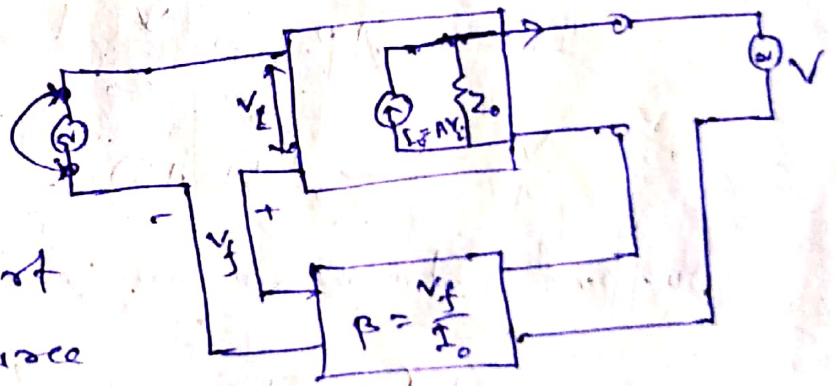


$$\therefore \; Z_{if} = \frac{V_i}{I_s} = \frac{V_i}{I_i(1+A\beta)} = \frac{Z_i}{1+A\beta}.$$

Input impedance decrease by a factor $(1+A\beta)$.

Output impedance of current series feedback

To obtain the output impedance, we replace load by a voltage source and we make short circuited the source input as shown in adjacent fig.



Then, $Z_{of} = \frac{V}{I}$

Here $\beta = \frac{V_f}{I}$, $A = \frac{I_o}{V_i}$

from input side —

$$V_i = -V_f = -\beta I$$

from o/p side

$$I = AV_i + \frac{V}{Z_o}$$

$$= A(-\beta I) + \frac{V}{Z_o}$$

or $I(1+A\beta) = \frac{V}{Z_o}$

$$\therefore \frac{V}{I} = Z_o(1+A\beta)$$

o/p impedance increases by $(1+A\beta)$ factor.

Scanned with CamScanner