3. Feed Back Amplifiers

Feed back principle and concept, types of feed back, feed back topologies, characteristics of -ve feed back amplifiers, classification of amplifiers, generalized analysis of feed back amplifier, performance comparision of feed back amplifiers, Method of analysis of feed back amplifiers.

*The Concept of Feed back (Need of Feed back in amplifiers)

The practical amplifier has a gain of nearly 1 million i.e., its output is 1 million times of the input and consequently even small disturbance is added at the i/p of the amplifier, it will appears as amplified form at the o/p of the amplifier. There is a strong possibility in amplifiers to introduce noise due to sudden changes in temperature, electric and magnetic fields. Therefore, every high gain amplifier tends to give noise along with original signal at its o/p. This amplified noise at the o/p of an amplifier is undesirable and must be kept as small as possible.
The noise level in amplifiers can be reduced by the use of -ve feed back.

*Feed back :-

The process of injecting a fraction (or) some of the o/p energy of an amplifier (either voltage/current) back to the i/p is called as feed back. (principle)
An amplifier which uses the concept of feed back is called feed back amplifier.

Types of feed back :-

Depending upon either the feedback signal adds with (or) opposes with the i/p signal there are 2 types of feed back techniques.

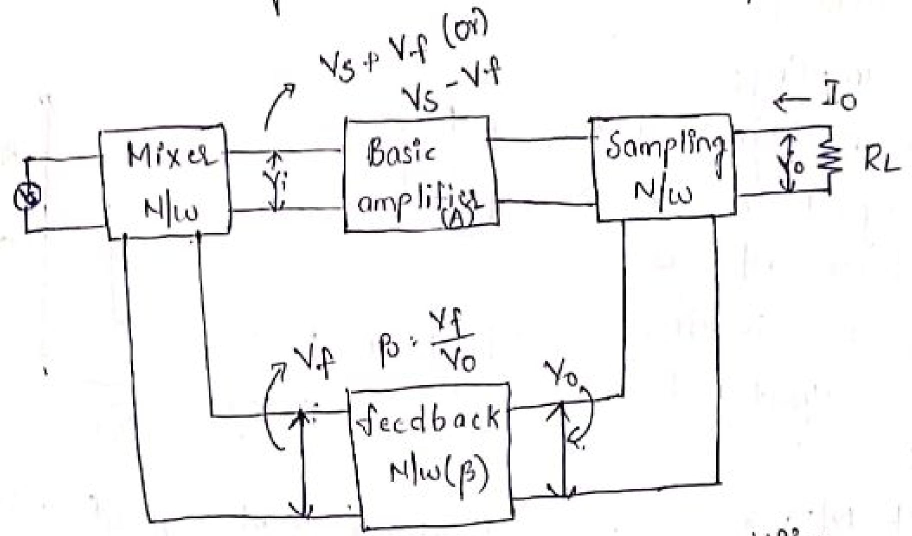
i) +ve feed back amplifier

ii) -ve feed back "

If the feed back signal adds with the i/p signal (when both are same inphase) is called +ve feed back

If the feed back signal opposes with the i/p signal (when both are in out of phase) is called -ve feed back.

* General Block diagram of feed back amplifier:



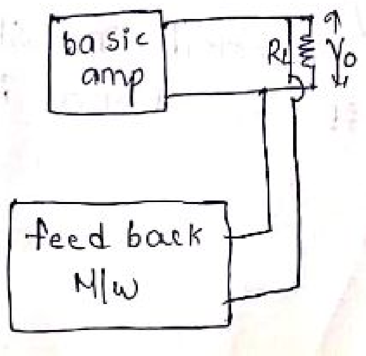
Block diagram of feed back amplifier

The above diagram shows the general block diagram for feed back amplifier. As shown in figure, the basic amplifier provides amplification. The sampleing N/w is used to take the part of the amplified o/p signal and it is back to the i/p through a feed back N/w. Again at the i/p of an amplifier the feed back signal is mixed with the original i/p signal by the mixer N/w. and it provides summation signal ($V_s + V_f$) (or) difference signal ($V_s - V_f$)

Basic amplifier:-
Generally, CE amplifier is used for providing amplification. and also it introduces 180° phase shift b/w i/p and o/p.

Sampling N/w:-
There are 2 methods of sampling the o/p signal.
1. voltage sampling
2. Current sampling

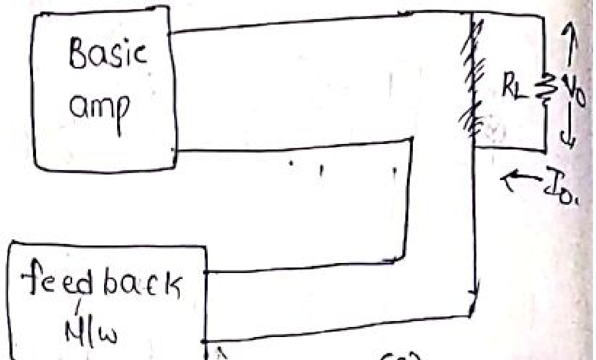
Voltage sampling:-



As shown in fig (b) if the sampling signal is voltage the feed back N/w is connected in shunt with the output terminals.

Current Sampling:-

As shown in fig.(c) if the sampling signal is current, the feed back N/w is connected in series with the output terminals.



(c)

Feed back N/w :-

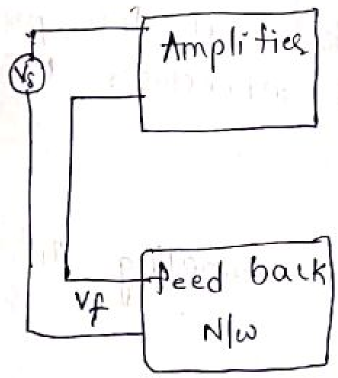
It is a two port N/w and it is made up of with resistors, capacitors and inductors. But most advantages method, it is made up of with only resistors. It is designed to provide either 0° phase shift (or) 180° phase shift.

Mixer Network :-

There are 2 methods for mixing the feed back signal with the i/p signal.

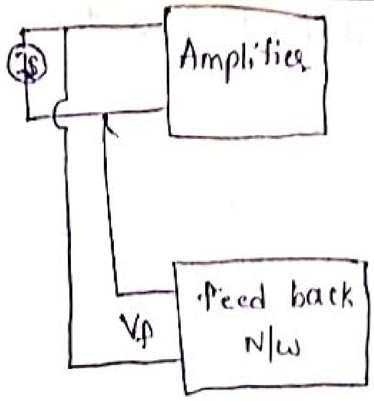
Series Mixing :-

If the i/p signal is voltage source the feed back N/w is connected in series with the i/p terminals and it is shown in below fig.

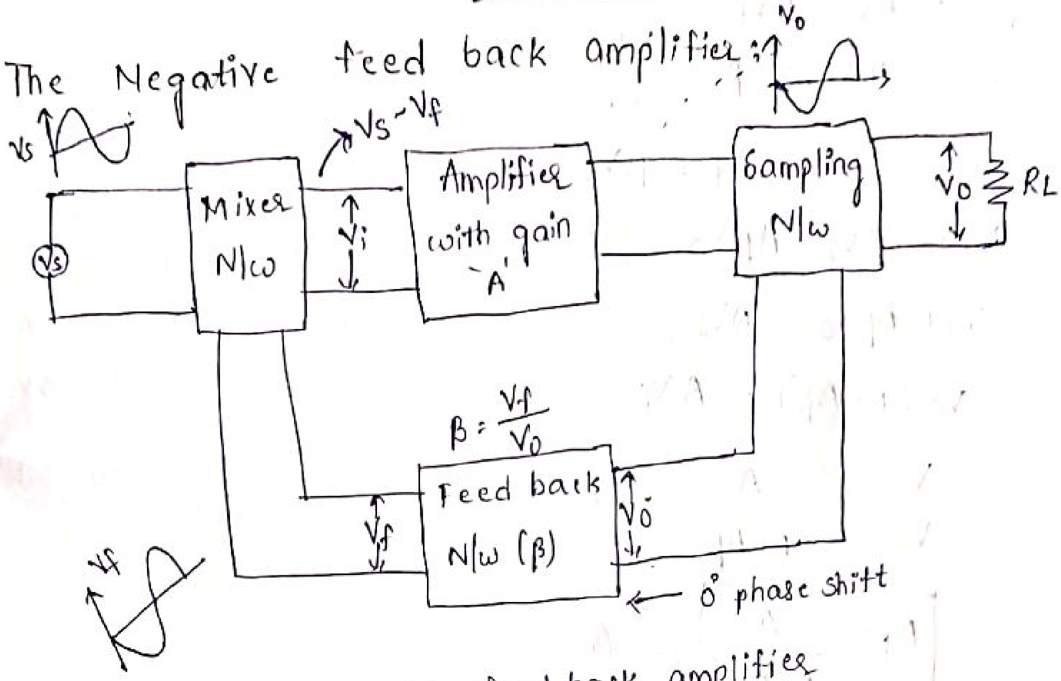


Shunt Mixing :-

If the i/p signal is current source the feed back N/w is connected in shunt with the i/p terminals and it is shown in the figure



The Negative feed back amplifier:-



B.D of -Ve feed back amplifier

The above fig. shows the block diagram of -Ve feed back amplifier. It consists of amplifier with gain 'A', sampling N/w, the feed back N/w and the mixer N/w.

The basic amplifier amplifies the weak i/p signal and it introduces 180° phase shift b/w o/p & i/p. The amplified o/p is sampled by using sampling N/w and it is fed back to the mixer N/w through a feedback N/w.

The feed back N/w is so designed to introduce 0° phase shift. Now, the feed back signal is out of phase with the i/p signal. The mixer N/w produces, the difference signal $V_s - V_f$ and it is properly given to the i/p of basic amplifier.

Expression for gain with -Ve feed back (A_f)

The gain of an amplifier without feed back is given by $A = \frac{V_o}{V_s}$ —— (1)

By introducing, -ve feed back into the circuit, V_s changes to $V_s - V_f$.

$\therefore \quad A = \frac{V_o}{V_s - V_f}$

$$V_o = A(V_s - V_f)$$

$$V_o = AV_s - AV_f$$

we know that, $\beta = \frac{V_f}{V_o}$

$$V_f = \beta V_o$$

$$V_o = AV_s - A\beta V_o$$

$$V_o + A\beta V_o = AV_s$$

$$V_o(1 + A\beta) = AV_s$$

$$\frac{V_o}{V_s} = \frac{A}{1+A\beta} \quad \text{—(2)}$$

$$\boxed{A_f = \frac{A}{1+A\beta}} \quad \text{—(3)}$$

From eq (3), we can say that, without feedback the gain of an amplifier is 'A' and by providing -ve feed back the gain of an amplifier 'A' is decreased by the factor of $1+A\beta$.

Advantages:

1. Stability of Gain is increased.
2. Reduction in distortion
3. Reduction in Noise
4. i/p impedance is increased.
5. o/p impedance is decreased
6. Band width increases

→ The only disadvantage is the gain of the amplifier is decreased

Applications :-

1. This concept used in allmost all electronic amplifiers.
2. This concept used in regulated Power Supplies.
3. Used in amplifiers are having large band width.

*The characteristics of negative feed back amplifier

1. The stabilization of gain is improved.
2. The frequency response (or) band width of an amplifier is increased.
3. The distortion and noise of an amplifier decreased.
4. input impedance is increased.
5. Output impedance is decreased.

Stabilization of gain is improved :-

As we know that, the gain of an amplifier with -ve feed back is given by $A_f = \frac{A}{1+A\beta}$ —(1)

The eq (1) is differentiated w.r.to 'A'

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

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

The eq (2) is multiplied and divided with 'A'.

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

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

$$\cancel{\frac{dA_f}{dA}} \quad \boxed{\frac{dA_f}{A_f} = \frac{dA}{A} \cdot \frac{1}{(1+A\beta)}} \quad \text{—(3)}$$

In eq (3), $\frac{dA_f}{A_f}$ is fractional change in voltage gain with -ve feedback.

$\frac{dA}{A}$ is fractional change in voltage gain without feed back.

Now from eq(3), we conclude that the fractional change in voltage gain with -ve feed back is given by the fractional change in gain without feedback is decreased by a factor of $(1+A\beta)$.

Thus, the stability of gain is improved.

1. An amplifier has a open loop gain of 1000 with feed back ratio of 0.04. If the open loop gain changes by 10% due to temp. find the % change of gain of an amplifier with feed back.

Given, $A = 1000$

$\beta = 0.04$

$\frac{dA}{A} = 10\% = 0.1$

$\frac{dA_f}{A_f} = ?$

we know that,

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

$$= \frac{0.1}{1+1000(0.04)}$$

$$= 0.00243$$

$$\frac{dA_f}{A_f} = 0.24\%$$

2. An amplifier has a gain with feed back is 100. If the gain of an amplifier without feed back changes by 20% and with feedback changes by 2% then determine the values of open loop gain and feed back ratio.

Given, $A_f = 100$ $\qquad A = ?$

$\frac{dA}{A} = 20\%$ $\qquad \beta = ?$

$\frac{dA_f}{A_f} = 2\%$

we know that,

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

$$\Rightarrow 0.02 = \frac{0.2}{1+A\beta}$$

$$0.1 = \frac{1}{1+A\beta}$$

$$1+A\beta = 10$$

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

$100 = \frac{A}{10}$

$\boxed{A = 1000}$

$A\beta = 9 \Rightarrow \beta = \frac{9}{1000}$

$\boxed{\beta = 0.009}$

Frequency Response (or) Band width is increased :-

The band width of an amplifier is the difference b/w upper cutoff frequency and lower cut off frequency. without feed back, it is given by $B.W = f_2 - f_1$ —① By providing -Ve feedback, it is given by

$BW_f = f_{2f} - f_{1f}$ —②

The gain and band width

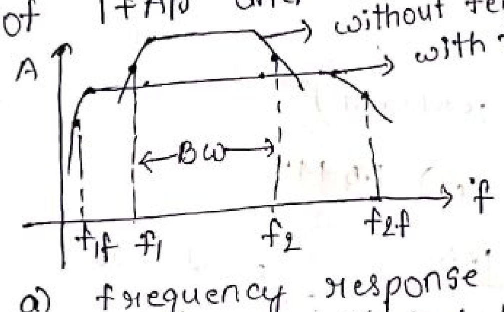
→ The product of with and without feedback remains the same. and it is given by

$B.W_f \times A_f = BW \times A$

$BW_f \times \frac{A}{1+A\beta} = BW \times A$

$\boxed{BW_f = BW(1+A\beta)}$ —③

From eq ③, we can say that without feed back. the band width of an amplifier is BW. By providing -Ve feed back, the band width is increased by a factor of $1+A\beta$ and it is shown in below fig.



a) frequency response of an amplifer with and without feed back

Distortion and Noise of an amplifier is decreased

Without feed back, the distortion in amplifier is denoted as 'D' and with negative feed back the distortion 'D' is decreased by a factor of $(1+A\beta)$. It is given by $\boxed{D_f = \frac{D}{1+A\beta}}$

Similarly, $\boxed{N_f = \frac{N}{1+A\beta}}$

Input Impedance increases:
Without feed back, the input impedance of an amplifier is 'R_i' and by providing -ve feedback it is increased by a factor of $(1+A\beta)$ and it is given by $R_{if} = R_i(1+A\beta)$

Output Impedance decreases:
without feedback, the output impedance of an amplifier is 'R_o' and by providing -ve feed back it is decreased by a factor of $(1+A\beta)$ and it is given by $\boxed{R_{of} = \frac{R_o}{1+A\beta}}$

. An amplifier has a mid band gain without feedback is 125 and band width without feed back is 250KHz. i) If 4% of -ve feedback is introduced in the ckt find the new band width and gain.
ii) If bandwidth is restricted to 1MHz, findout the feedback ratio and gain of the amplifier with feed back.

Given,

$A = 125$

$BW = 250KHz$

i) $\beta = 4\% = 0.04$

$BW_f = ?$

$BW_f = BW(1+A\beta)$

$= 250\times10^3(1+125(0.04))$

$BW_f = 1500KHz.$ (or) 1.5 MHz

$A_f = \frac{A}{1+A\beta} = \frac{125}{1+125.(0.04)} = 20.833$

ii) $BW_f = 1MHz.$

$\beta = ?$; $A_f = ?$

WKT $BW_f = BW(1+A\beta)$

$1\times10^6 = 250\times10^3.(1+125\beta)$

$\Rightarrow \quad 125\beta = 3$

$$\beta = \frac{3}{125} = 0.024$$

$$A_f = \frac{A}{1+A\beta} = \frac{125}{1+125(0.024)} = 31.25$$

Classification of -ve feed back amplifiers:-

Based on method of sampling the output signal and method of mixing the feed back signal with the input signal, there are 4 types of -ve feed back amplifiers.

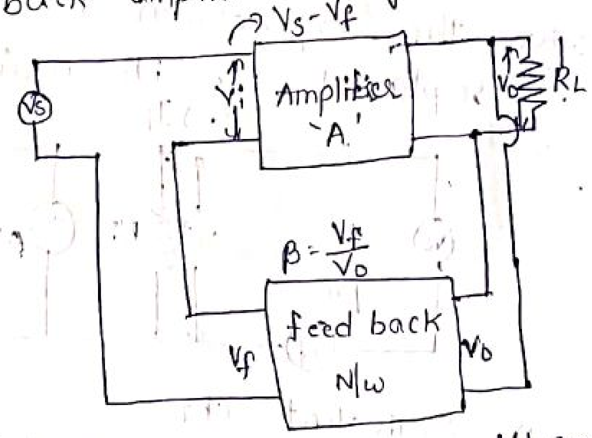
1. Voltage - Series feed back amplifier
2. Voltage - shunt feed back amplifier
3. Current - Series feed back amplifier
4. Current - Shunt feed back amplifier

Each type of feed back amplifier is a combination of 2 words, first word refers to sampling and second word is for mixing.

Voltage Series Feed back amplifier (Voltage amplifier):-

Fig (a) shows the block diagram of voltage series feed back amplifier.

As shown in figure, for sampling the output voltage the feed back network is connected in shunt



a) B.d of voltage series fd amplifier

with the output terminals. and the feed back signal is connected in series with the input terminals. It is also called shunt - Series feed back amplifier

Expression for gain with feed back (A_f)

The gain of an amplifier without feed back $A = \frac{V_o}{V_i}$

$$A = \frac{V_o}{V_i} \text{ (or) } \frac{V_o}{V_s} \quad \text{—(1)}$$

By introducing -ve feed back into the circuit, V_s changes to $V_s - V_f$.

$$A = \frac{V_o}{V_s - V_f}$$

$$\Rightarrow \quad A(V_s - V_f) = V_o$$

$$AV_s - AV_f = V_o$$

wkt $$\beta = \frac{V_f}{V_o}$$

$$V_f = \beta V_o$$

$$AV_s - A\beta V_o = V_o$$

$$AV_s = V_o(1 + A\beta)$$

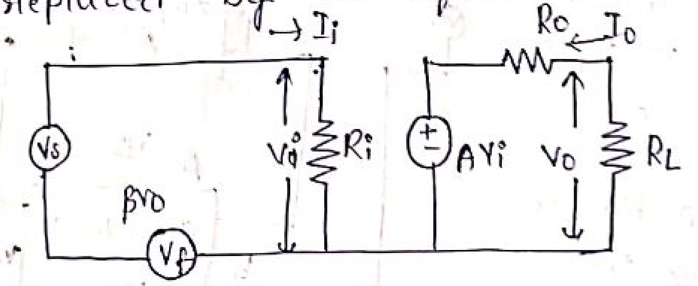
$$\frac{V_o}{V_s} = \frac{A}{1+A\beta} \quad \text{—(2)}$$

where $\frac{V_o}{V_s}$ is gain with -ve fb.

$$\boxed{A_f = \frac{A}{1+A\beta}} \quad \text{—(3)}$$

Input resistance with feed back (R_{if}) :-

To derive the expression for input resistance, Fig(a) is replaced by its equivalent circuit



b) Equivalent ckt

Without feed back, input resistance of an amplifier is $R_i = \frac{V_i}{I_i}$ —(4)

By introducing -ve fb, V_i changes to $V_s - V_f$

$$R_i = \frac{V_s - V_f}{I_i}$$

$$= \frac{V_s - \beta V_o}{I_i}$$

$$R_i = \frac{V_s - \beta A V_i}{I_i}$$

$$R_i I_i = V_s - \beta A V_i \qquad \because V_i = I_i R_i$$

$$R_i I_i = V_s - \beta A I_i R_i$$

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$R_i I_i + A\beta R_i I_i = V_s$

$R_i I_i (1+A\beta) = V_s$

$$\boxed{\frac{V_s}{I_i} = R_i(1+A\beta)} \quad (5)$$

$$\boxed{R_{if} = R_i(1+A\beta)} \quad (6)$$

With series mixing, the input resistance is increased by a factor of $(1+A\beta)$

Output Resistance with feedback (R_{of}):-

To measure the output resistance $V_s = 0$ & $R_L = \infty$. with these two assumptions fig (b) is modified as shown in fig(c)

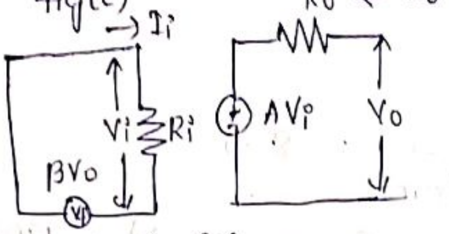


fig (c)

Apply KVL to the output loop.

$V_o = I_o R_o + AV_i$

$= I_o R_o + A(V_s - V_f)$

$= I_o R_o + A(0 - V_f)$

$V_o = I_o R_o - AV_f$

$V_o = I_o R_o - A\beta V_o$

$V_o + A\beta V_o = I_o R_o$

$V_o(1+A\beta) = I_o R_o$

$$\boxed{\frac{V_o}{I_o} = \frac{R_o}{1+A\beta}} \quad (7)$$

$$\boxed{R_{of} = \frac{R_o}{1+A\beta}} \quad (8)$$

with series mixing, the output resistance is decreased by a factor of $(1+A\beta)$

1) A Voltage Series -Ve feed back amplifier has a voltage gain without feed back is 500, input resistance is 3kΩ, output resistance is 20kΩ and feed back ratio is 0.01. Calculate the voltage gain, input resistance and output resistance with feed back.

Given,

$A = 500$

$R_i = 3k\Omega = 3000\Omega$

$R_o = 20k\Omega = 20000\Omega$

$\beta = 0.01$

$A_f = ?$

$R_{if} = ?$

$R_{of} = ?$

$$A_f = \frac{A}{1+A\beta} = \frac{500}{1+500(0.01)} = 83.3$$

$$R_{if} = R_i(1+A\beta) = 3000\left(1+500(0.01)\right) = 18000\ \Omega$$

$$R_{of} = \frac{R_o}{1+A\beta} = \frac{20000}{6} = 3.3\times10^3\ \Omega$$

2) An amplifier has a voltage gain is 4000, i/p resistance is 2kΩ and o/p resistance is 16kΩ. Calculate the voltage gain, i/p resistance and o/p resistance of the circuit when 5% of feedback is fed in the form of series.

$A = 4000$

$R_i = 2k\Omega$

$R_o = 16k\Omega$

$\beta = 5\% = \frac{5}{100} = 0.05$

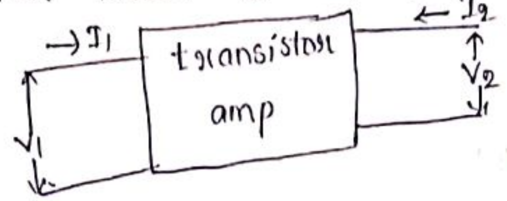
$$A_f = \frac{A}{1+A\beta} = \frac{4000}{1+4000(0.05)} = 19.9$$

$$R_{if} = R_i(1+A\beta) = 2\cancel{16}\times10^3\left(1+4000(0.05)\right) = \cancel{3200\times10^3\ \Omega}\ 402\ k\Omega$$

$$R_{of} = \frac{R_o}{1+A\beta} = \frac{16\times10^3}{1+200} = 0.07\ k\Omega$$

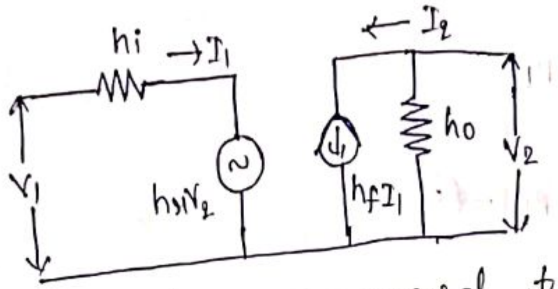
A practical ckt diagram of voltage series feed back amplifier

h-parameter model of a transistor amplifier :-

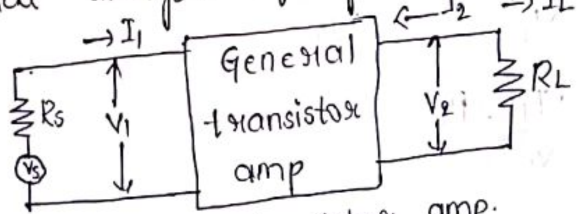


$V_1 = h_{11} I_1 + h_{12} V_2$

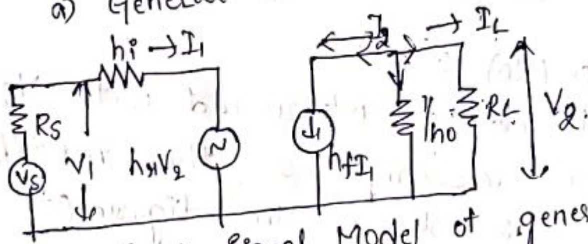
$I_2 = h_{21} I_1 + h_{22} V_2$



Small Signal analysis of general transistor amplifier:-



a) General transistor amp.



b) Small Signal Model of general transistor amp.

1) $A_I = \frac{I_L}{I_1} = \frac{-I_2}{I_1}$ — (1)

$I_2 = h_f I_1 + h_o V_2$

$= h_f I_1 + h_o I_L R_L$

$I_2 = h_f I_1 + h_o(-I_2) R_L$

$I_2 + h_o I_2 R_L = h_f I_1$

$I_2 (1 + h_o R_L) = h_f I_1$

$$\frac{I_2}{I_1} = \frac{h_f}{1 + h_o R_L}$$

$A_I = \frac{-h_f}{1 + h_o R_L}$ — (2)

2) $R_I = \frac{V_1}{I_1}$

$= \frac{h_i I_1 + h_r V_2}{I_1}$

$= \frac{h_i I_1 + h_r(-I_2 R_L)}{I_1}$

$= h_i - \frac{h_r I_2 R_L}{I_1}$

$R_I = h_i + h_r A_I R_L$ — (3)

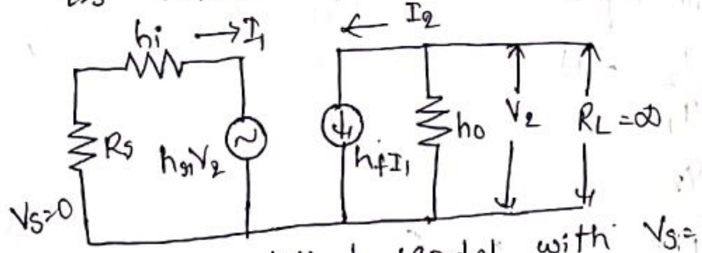
3) $A_V = \frac{V_2}{V_1} = \frac{I_L R_L}{V_1} = \frac{-I_2 R_L}{V_1}$

$A_V = \frac{-I_2}{I_1} \cdot \frac{I_1}{V_1} \cdot R_L$

$A_V = \frac{A_I R_L}{R_i}$ — (4)

4) Output Resistance (R_o) :

The output admittance is measured with $V_S = 0$ and $R_L = \infty$, with these assumptions the modified model is drawn as shown in figure (c)



(c) Modified Model with $V_S = 0$ & $R_L = \infty$.

$Y_o = \frac{I_2}{V_2}$

$= \frac{h_f I_1 + h_o V_2}{V_2}$

$\boxed{Y_o = h_f \frac{I_1}{V_2} + h_o}$ — (5)

The relation b/w I_1 & V_2 is obtained by applying KVL to the i/p node.

$(R_S + h_i) I_1 + h_r V_2 = 0$

$(R_S + h_i) I_1 = -h_r V_2$

$\frac{I_1}{V_2} = \frac{-h_r}{R_S + h_i}$ — (6)

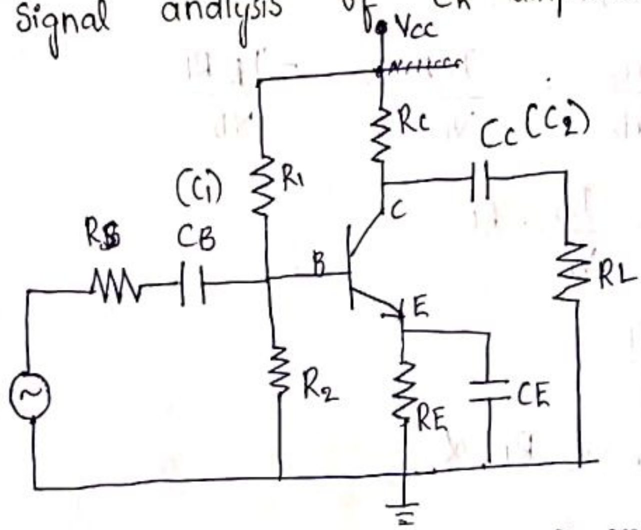
Sub. eq. 6 in eq 5

$$Y_0 = h_f\left(\frac{-h_r}{R_s+h_i}\right) + h_o$$

$$Y_0 = \frac{-h_f h_r}{R_s+h_i} + h_o \quad — (7)$$

$$\boxed{R_0 = \frac{1}{Y_0} = \frac{1}{h_o - \frac{h_f h_r}{R_s+h_i}}} \quad — (8)$$

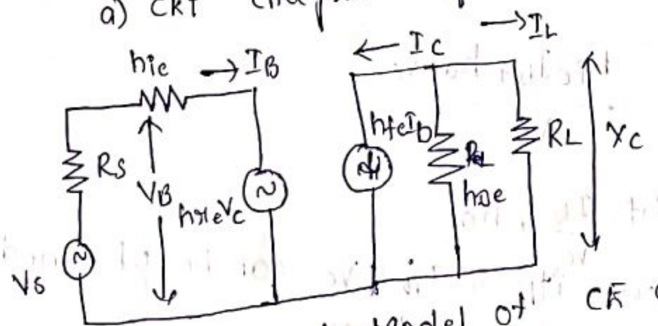
Small Signal analysis of CE amplifier (Exact analysis) :-



C_1, C_2 - Coupling capacitors

C_E - Bypass capacitor

a) ckt diagram of CE amplifier



b) Small Signal Model of CE amp

1) $A_I = \frac{I_L}{I_1} = \frac{-I_c}{I_b}$

$I_c = h_{fe}I_b + h_{oe}V_c$

$I_c = h_{fe}I_b + h_{oe}I_L R_L.$

$I_c = h_{fe}I_b + h_{oe}(-I_c)R_L$

$I_c + h_{oe}I_c R_L = h_{fe}I_b$

$(1 + h_{oe}R_L)I_c = h_{fe}I_b$

$$\frac{I_c}{I_b} = \frac{h_{fe}}{1+h_{oe}R_L}$$

$$A_I = \frac{-I_c}{I_b} = \frac{-h_{fe}}{1+h_{oe}R_L}$$

2) $R_I = \frac{V_1}{I_1} = \frac{V_b}{I_b}$

$$= \frac{h_{ie} I_b + h_{re} V_c}{I_b}$$

$$= \frac{h_{ie} I_b + h_{re}(-I_c R_L)}{I_b}$$

$$= h_{ie} - h_{re} R_L \frac{I_c}{I_b}$$

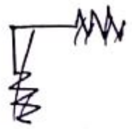
$$R_I = h_{ie} + h_{re} A_I R_L$$

3) $A_V = \frac{V_2}{V_1} = \frac{V_c}{V_b} = \frac{I_L R_L}{V_b} = \frac{-I_c R_L}{V_b}$

$$A_V = \frac{-I_c}{I_b} \cdot \frac{I_b}{V_b} \cdot R_L$$

$$A_V = \frac{A_I R_L}{R_i}$$

4) $R_O = \frac{1}{Y_O}$, $V_S = 0$, $R_L = \infty$.



$$Y_O = \frac{I_c}{V_c} = \frac{h_{fe} I_b + h_{oe} V_c}{V_c}$$

$$Y_O = h_{fe} \frac{I_b}{V_c} + h_{oe}$$

The relation b/w i/p & I_b & V_c can be obtained by applying KVL at input loop.

$$(R_s + h_{ie}) I_b + h_{re} V_c = 0$$

$$(R_s + h_{ie}) I_b = -h_r V_c$$

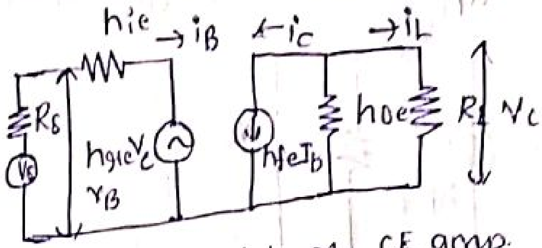
$$\frac{I_b}{V_c} = \frac{-h_r}{R_s + h_{ie}}$$

$$Y_O = h_{fe}\left(\frac{-h_r}{R_s + h_{ie}}\right) + h_{oe}$$

$$Y_O = \frac{-h_{fe} h_r}{R_s + h_{ie}} + h_{oe}$$

$$R_O = \frac{1}{Y_O} = \frac{1}{h_{oe} - \frac{h_{fe} h_r}{R_s + h_{ie}}}$$

Approximate analysis of CE amplifier :-
To draw the approximate model, first we consider exact model and it is shown in fig (a)



a) Exact Model of CE amp.

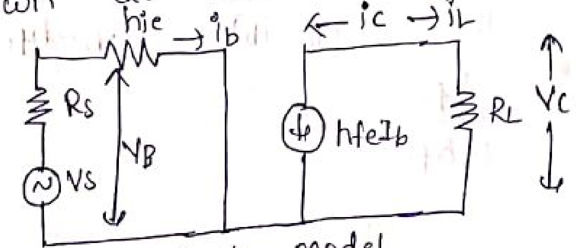
step1: As $\frac{1}{h_{oe}} >> R_L$, h_{oe} is neglected from the o/p circuit

$\boxed{i_c = h_{fe}I_b}$

step2: $h_{re}V_c = h_{re}(i_L R_L) = h_{re}(-i_c R_L) = -h_{re}(h_{fe}I_b)R_L$

$h_{re}V_c = -h_{re}h_{fe}I_bR_L$

where the product of $h_{re}h_{fe} \cong 0.01$ and then voltage source $h_{re}V_c$ is neglected from input equivalent circuit with these two conditions, the remaining circuit is drawn as shown in fig (b).



b) approximate model

Analysis :-

1. Current gain $(A_I) = \frac{I_2}{I_1} = \frac{i_L}{i_b} = \frac{-i_c}{i_b} = \frac{-h_{fe}\cancel{i_b}}{\cancel{i_b}} = -h_{fe}$

$A_I = -h_{fe}$

2. $R_I = \frac{V_1}{I_1} = \frac{V_B}{I_b} = \frac{h_{ie}\cancel{i_b}}{\cancel{i_b}} = h_{ie}$

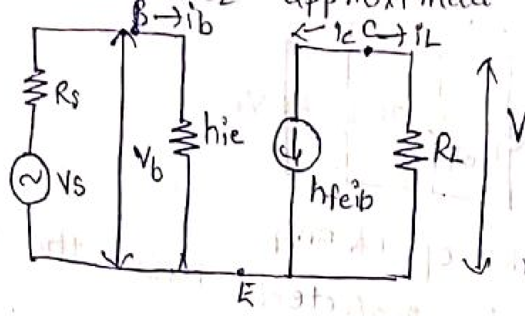
3. $A_V = \frac{V_2}{V_1} = \frac{V_c}{V_b} = \frac{i_L R_L}{V_b} = \frac{-i_c R_L}{V_b} = \frac{-h_{fe}\cancel{I_b}R_L}{h_{ie}\cancel{i_b}}$

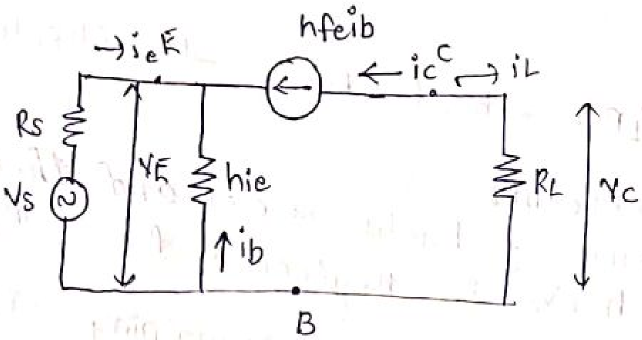
$A_V = \frac{-h_{fe}R_L}{h_{ie}}$

4. $R_o = \infty$

Approximate analysis of CB amplifier:-

To draw the approximate model of CB amplifier, first we consider approximate model of CE amplifier





a) app. model of CB amp.

1) $A_I = \frac{i_L}{i_e} = \frac{h_{fe} i_b}{} \; \frac{-i_c}{i_e} = \frac{\cancel{+} h_{fe} i_b}{\cancel{+}(i_c + i_b)} = \frac{h_{fe} i_b}{i_b + h_{fe} i_b}$

$= \frac{h_{fe} i_b}{i_b(1 + h_{fe})} = \frac{h_{fe}}{1 + h_{fe}}$

$A_I = \frac{h_{fe}}{1 + h_{fe}}$

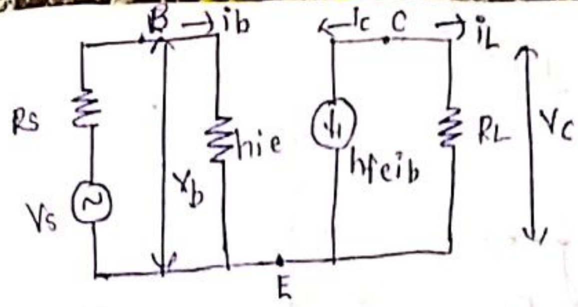
2) $R_I = \frac{V_E}{I_E} = \frac{\cancel{+} h_{ie} i_b}{\cancel{+}(i_b + i_c)} = \frac{h_{ie} i_b}{i_b + h_{fe} i_b} = \frac{h_{ie}}{1 + h_{fe}}$

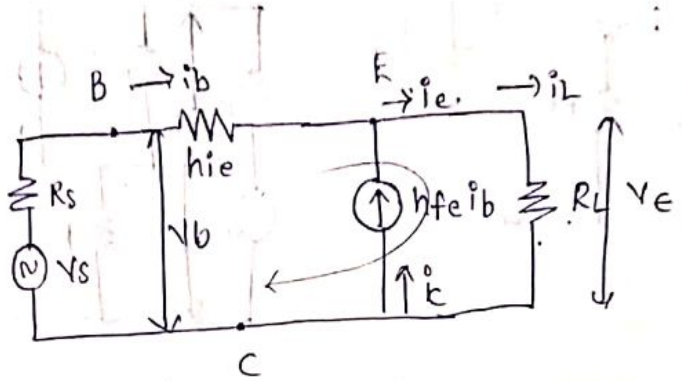
3) $A_V = \frac{V_C}{V_E} = \frac{i_L R_L}{V_E} = \frac{\cancel{+} i_c R_L}{\cancel{+} h_{ie} i_b} = \frac{h_{fe} \cancel{i_b} R_L}{h_{ie} \cancel{i_b}} = \frac{h_{fe} R_L}{h_{ie}}$

4) $R_O = \infty$..

Approximate analysis of CC amplifier:-

To draw the approximate analysis of CC amplifier, first we obtain approximate model of CE amplifier





1) $A_I = \dfrac{i_L}{i_b} = \cancel{\dfrac{h_{fe} i_b}{i_b}} = h_{fe}$

$= \dfrac{i_e}{i_b} = \dfrac{i_b + i_c}{i_b} = \dfrac{i_b + h_{fe} i_b}{i_b} = 1 + h_{fe}$

2) $R_I = \dfrac{V_B}{I_B} = \dfrac{h_{ie} i_b + h_{fe} i_b R_L}{i_b} = h_{ie} + h_{fe} R_L$

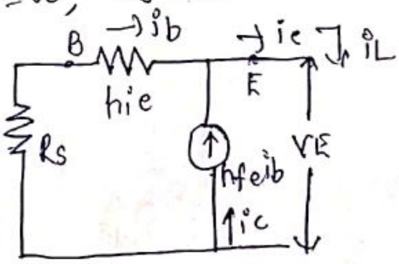
$= \dfrac{h_{ie} i_b + (i_b + h_{fe} i_b) R_L}{i_b} = h_{ie} + (1 + h_{fe}) R_L$

3) $A_V = \dfrac{V_E}{V_b} = \dfrac{(1 + h_{fe}) i_b R_L}{} = \dfrac{A_I R_L}{R_I}$

$A_V = \dfrac{(1 + h_{fe}) R_L}{h_{ie} + (1 + h_{fe}) R_L}$

4) $R_O = \dfrac{V_E}{I_E} =$

R_O :- Remove the load resistance, $R_L = \infty$, $V_s = 0$.

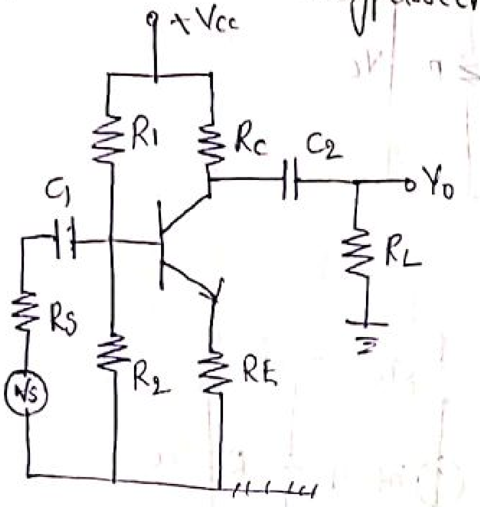


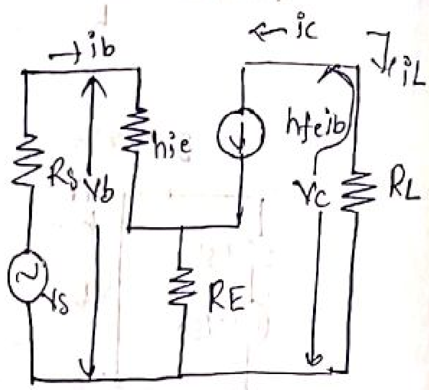
$R_O = \dfrac{V_E}{I_E} = \dfrac{h_{ie} i_b + R_s i_b}{i_b + i_c}$

$= \dfrac{(h_{ie} + R_s) i_b}{i_b + h_{fe} i_b}$

$R_O = \dfrac{h_{ie} + R_s}{1 + h_{fe}}$

CE amplifier with unbypassed R_E :-





i) $A_I = \frac{I_L}{I_b} = \frac{-I_c}{I_b} = \frac{-h_{fe} i_b}{i_b} = -h_{fe}$.

ii) $R_I = \frac{V_B}{I_b} = \frac{h_{ie} i_b + R_E(i_b + h_{fe} i_b)}{i_b}$

$= h_{ie} + (1+h_{fe})R_E$

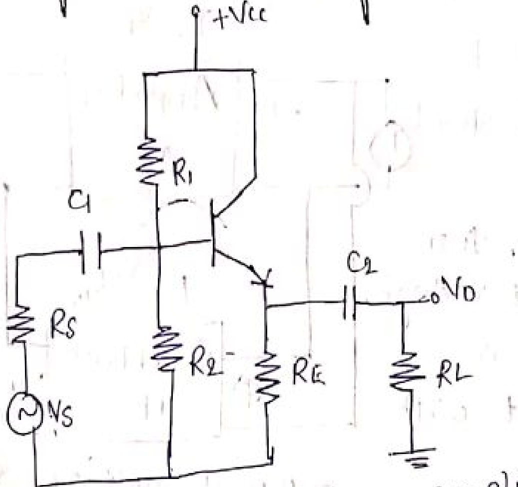
iii) $A_v = \frac{V_c}{V_b} = \frac{A_I R_L}{R_I} = \cancel{-h_{fe}(h_{ie}+(1+h_{fe})R_E}$

$= \frac{-h_{fe} R_L}{h_{ie} + (1+h_{fe})R_E}$

iv) $R_L = \infty$, $V_S = 0$.

Output resistance, $R_O = \infty$.

practical ckt diagram for Voltage series feed back amplifier:-

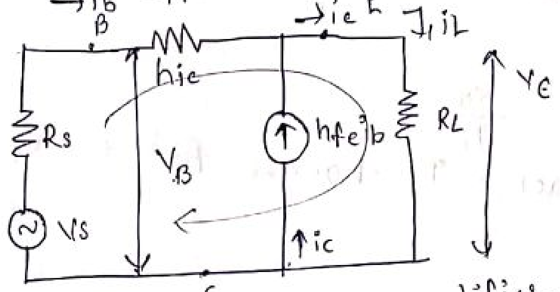


a) ckt diagram of cc amplifier

Fig (a) shows the ckt diagram of CC amplifier. The voltage which is developed across resistor R_E back to the i/p in series opposition. Thus, it is the best example of voltage series feed back amplifier.

Analysis:-

To derive the characteristics circuit diagram is replaced by its approximate model.



(b) app. model of cc amplifier.

i) $A_I = \dfrac{I_L}{I_B} = \dfrac{i_e}{i_b} = \dfrac{i_b + i_c}{i_b} = \dfrac{i_b + h_{fe} i_b}{i_b} = 1 + h_{fe}$

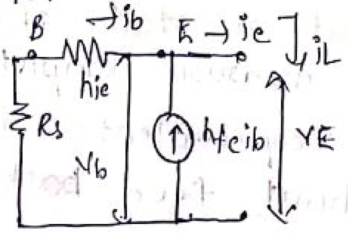
ii) $R_I = \dfrac{V_b}{i_b} = \dfrac{i_b h_{ie} + i_L R_L'}{i_b} = \dfrac{i_b h_{ie} + (i_b + h_{fe} i_b) R_L}{i_b}$

$= h_{ie} + (1 + h_{fe}) R_L$

iii) $A_V = \dfrac{V_E}{V_b} = \dfrac{A_I R_I}{R_I} = \dfrac{(1 + h_{fe}) R_L}{h_{ie} + (1 + h_{fe}) R_L}$

iv) $R_O = \dfrac{V_E}{(1 + h_{fe})\, i_b} = \dfrac{h_{ie} i_b + R_s i_b}{(1 + h_{fe}) i_b}$

$= \dfrac{h_{ie} + R_s}{1 + h_{fe}}$



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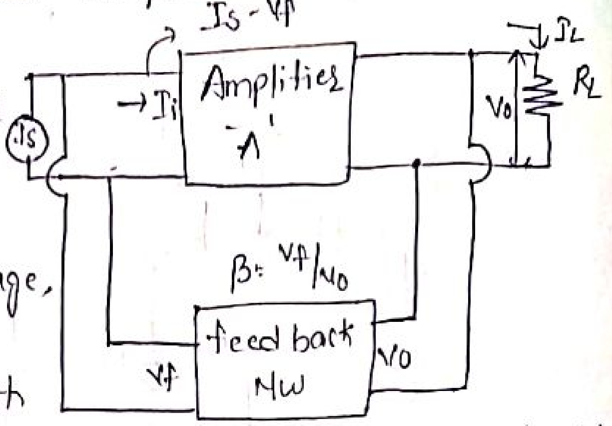
Voltage shunt feed back amplifier (Trans resistance amplifier)

Fig (a) shows the block diagram of voltage shunt feed back amplifier



(a) B.D of voltage shunt feed back amplifier

As shown in fig (a), for sampling the output voltage, the feed back N/w is connected in shunt with the o/p terminals.

~~This feed ba~~

This sampled signal back to the i/p in shunt opposition through a feed back network. The shunt sampling decreases its output resistance and the shunt mixing decreases its input resistance by a factor of $(1+A\beta)$.

Feed back gain with feed back (A_f) :-

Trans resistance gain of an amplifier is without feed back the gain of an amplifier is given by

$$A = \frac{V_0}{I_s} = \frac{V_0}{I_i}$$

By -ve feed back, I_i changes to $I_s - V_f$

$$A = \frac{V_0}{I_s - V_f}$$

$$AI_s - AV_f = V_0$$

$$AI_s - A\beta V_0 = V_0$$

$$AI_s = (1+A\beta) V_0$$

$$\frac{V_0}{I_s} = \frac{A}{1+A\beta}$$

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

Input resistance (R_{if}) :-

To measure input resistance, fig (a) is replaced by its equivalent circuit

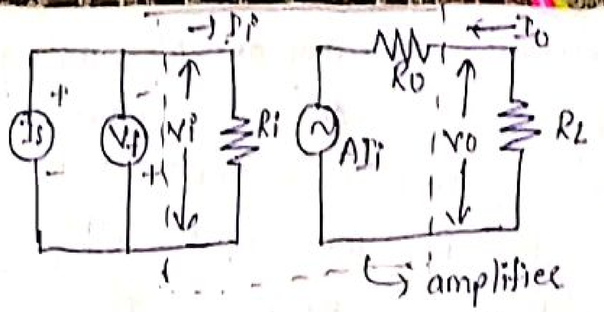
without feed back, input resistance is given as

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

with feed back,

$I_i \leftarrow I_s - V_f$

$$R_i = \frac{V_i}{I_s - V_f}$$



b) Equivalent circuit

$$R_i I_s - R_i V_f = V_i$$

$$R_i I_s - R_i \beta V_o = V_i$$

$$R_i I_s - R_i \beta A I_i = V_i$$

$$R_i I_s - R_i \beta A \left(\frac{V_i}{R_i}\right) = V_i$$

$$R_i I_s - A\beta V_i = V_i$$

$$R_i I_s = (1+A\beta) V_i$$

$$\frac{V_i}{I_s} = \frac{R_i}{1+A\beta}$$

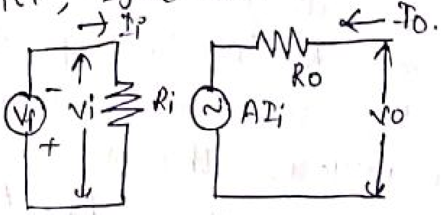
$$\boxed{R_{if} = \frac{R_i}{1+A\beta}}$$

Output Resistance (R_{of}):-

To measure the o/p resistance, $I_s = 0$ and $R_L = \infty$.

with these assumptions,

Apply KVL to o/p loop



$$V_o = R_o I_o + A I_i$$

$$V_o = R_o I_o + A(I_s - V_f)$$

$$V_o = R_o I_o + A(-V_f)$$

$$V_o + A V_f = R_o I_o$$

$$V_o + A\beta V_o = R_o I_o$$

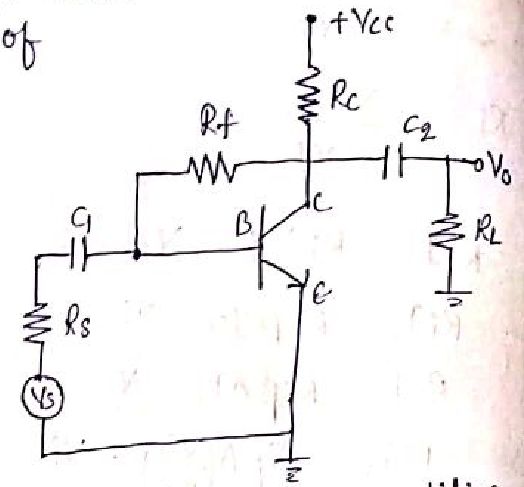
$$(1 + A\beta) V_o = R_o I_o$$

$$\frac{V_o}{R_o} = \frac{I_o}{}$$

$$\frac{V_o}{I_o} = \frac{R_o}{1+A\beta}$$

$$\boxed{R_{of} = \frac{R_o}{1+A\beta}}$$

Practical ckt diagram of voltage shunt feed back amplifier:

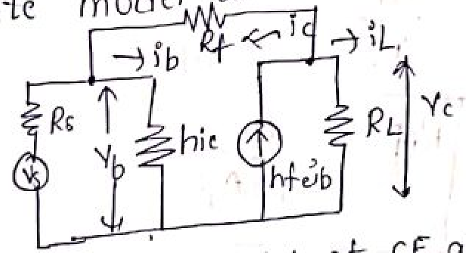


a) ckt diagram of CE amplifier with feed back resistor R_f.

Fig (a) shows the ckt diagram of CE amplifier with feed back resistor R_f. The output voltage which is developed across resistor R_L, back to the input through a feed back resistor R_f in shunt opposition.
Thus, it is the best example for voltage shunt feed back amplifier.

Analysis:-

To determine the characteristics, the circuit diagram is replaced by its approximate model as shown in fig (b).

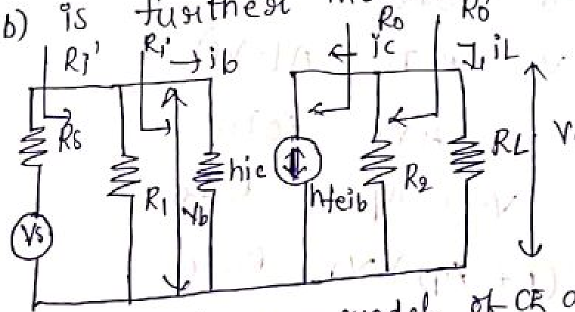


b) app. model of CE amplifier with resistor 'R_f'.

when an amplifier with feed back resistor 'R_f', it is difficult to do analysis.
Thus, by using Miller's theorem R_f can be seperated into two resistances R_1 and R_2.
From Miller's theorem,

$$R_1 = \frac{R_f}{1-A}, \quad R_2 = R_f \cdot \frac{A}{-(1-A)} = \frac{R_f A}{A-1}$$

with these two values, fig(b) is further modified as shown in fig(c).



c) modified app. model of CE amp. with 'R_f'.

1) $A_I = \frac{i_L}{i_b} = \frac{-i_c}{i_b}$

$= \frac{-h_{fe} i_b}{i_b}$

$A_I = -h_{fe}$

2) $R_I = \frac{V_b}{i_b} = \frac{h_{ie} i_b}{i_b} = h_{ie}$

$R_i' = R_i \| R_1$

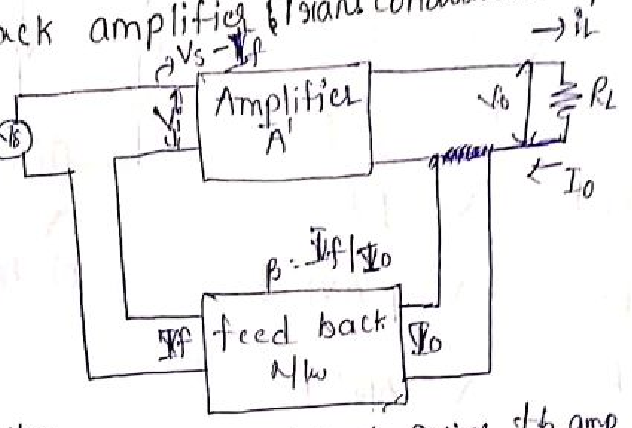
3) $A_V = \frac{A_I R_L}{R_I} = \frac{-h_{fe} R_L}{h_{ie}}$

4) $R_0 = \infty$

5) $R_0' = R_0 \| R_L = R_L$

Current series feed back amplifier (Trans conductance amplifier)

Fig (a) shows the block diagram of current series feed back amplifier.



a) B.d of Current Series f/b amp.

As shown in fig (a), for sampling the o/p current, the feed back N/w is connected in series with the output terminals.

This feed back signal back to the input in series opposition.

By series sampling, the output resistance increases by a and by series mixing, the input resistance increases by a factor of $(1+A\beta)$.

Trans conductance gain with feed back (Af):

without feed back, the gain of an amplifier is

$$A = \frac{I_o}{V_s} = \frac{I_o}{V_i}$$

with feed back, V_i changes to $V_s - I_f$

$$A = \frac{I_o}{V_s - I_f} \qquad \beta = \frac{I_f}{I_o}$$

$$AV_s - AI_f = I_o$$

$$AV_s - A\beta I_o = I_o$$

$$AV_s = (1+A\beta) I_o$$

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

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

Input resistance (Rif):

To measure the input resistance, fig (a) is replaced by its equivalent ckt

without feed back, the input resistance is given by

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

with feed back,

$V_i \longleftrightarrow V_s - I_f$

$R_i = \dfrac{V_s - I_f}{I_i}$

$R_i I_i = V_s - \beta I_o$

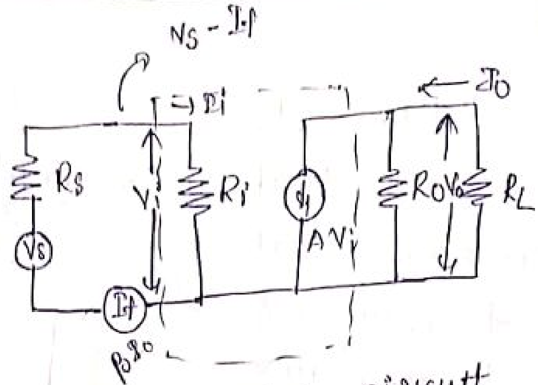
$R_i I_i = V_s - \beta A V_i$

$R_i I_i = V_s - A\beta I_i R_i$

$I_i R_i (1 + A\beta) = V_s.$

$\dfrac{V_s}{I_i} = R_i(1 + A\beta)$

$\boxed{R_{if} = R_i(1 + A\beta)}$

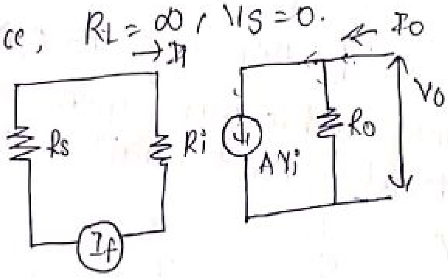


b) Equivalent circuit

Output resistance (R_{of}):-

To measure the o/p resistance, $R_L = \infty$, $V_s = 0$.

Apply KCL to o/p loop.



$I_o = AV_i + \dfrac{V_o}{R_o}$

$I_o = A(V_s - I_f) + \dfrac{V_o}{R_o}$

$I_o = -AI_f + \dfrac{V_o}{R_o}$

$I_o = -A\beta I_o + \dfrac{V_o}{R_o}$

$I_o(1 + A\beta) = \dfrac{V_o}{R_o}$

$\dfrac{V_o}{I_o} = R_o(1 + A\beta)$

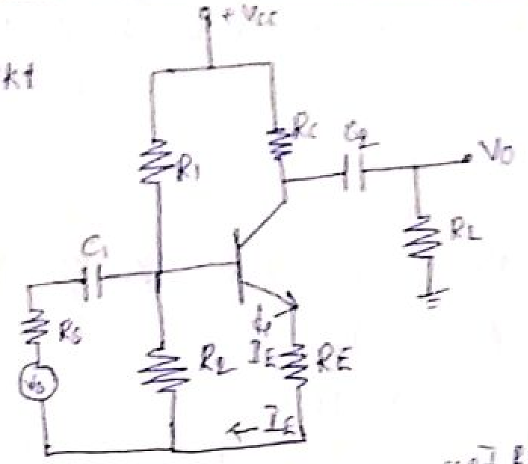
$\boxed{R_{of} = R_o(1 + A\beta)}$

Practical ckt diagram for current series feed back amplifier:

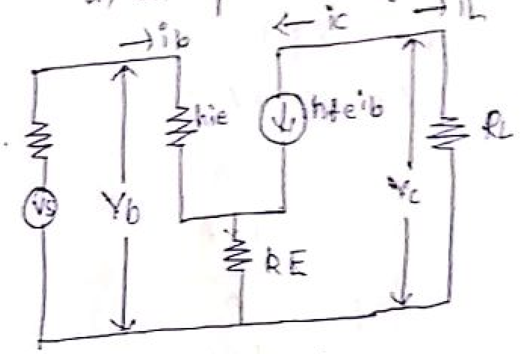
Fig(a) shows the ckt diagram of CE amplifier with unbypassed 'R_E'. The current flowing through R_E back to the i/p in series opposition. Thus, it is the best example for current series feed back amplifier

Analysis :

To determine the characteristics, ckt diagram is replaced by its approximate model in fig (b).



a) CE amp with unbypassed RE.



b) app. model.

$$A_I = \frac{i_L}{i_b} = \frac{-i_c}{i_b} = \frac{-h_{fe} i_b}{i_b}$$

$$A_I = -h_{fe}$$

$$R_I = \frac{V_b}{i_b}$$

$$= \frac{h_{ie} i_b + R_e(i_b + i_c)}{i_b}$$

$$= \frac{h_{ie} i_b + R_e(i_b + h_{fe} i_b)}{i_b}$$

$$R_I = h_{ie} + R_e(1 + h_{fe})$$

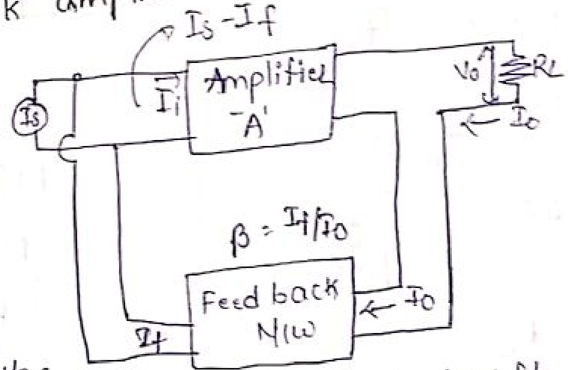
$$A_V = \frac{A_I R_L}{R_I} = \frac{-h_{fe} R_L}{-h_{ie} + R_e(1+h_{fe})}$$

R_o $V_s = 0$, $R_L = \infty$.

$R_o = \infty$.

Current shunt feed back amplifier (current amplification) :

Fig (a) shows the block diagram of current shunt feed back amplifier



a) B.d of current shunt fb amp.

As shown in fig (a), for sampling the o/p current the feed back N/w is connected in series with the o/p terminals.

This feed back signal is connected in shunt in the input terminals.

By series ~~mixing~~ sampling, the output resistance increases and by shunt mixing, the input resistance decreases.

Gain with feed back (A) :-

The gain of an amplifier without feedback is given by

$$A = \frac{I_0}{I_i}$$

with feed back, $I_i \longleftrightarrow I_s - I_f$

$$A = \frac{I_0}{I_s - I_f}$$

$\beta = I_f / I_0$

$$AI_s - AI_f = I_0$$

$$AI_s - A\beta I_0 = I_0.$$

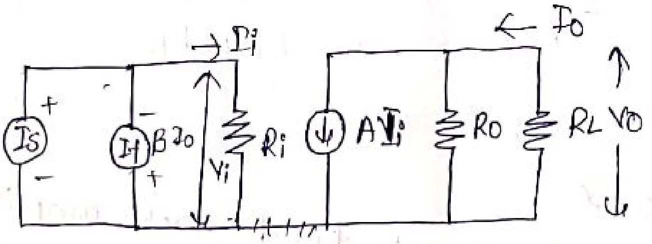
$$AI_s = (1 + A\beta) I_0$$

$$\frac{I_0}{I_s} = \frac{A}{1 + A\beta}$$

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

Input resistance (R_{if}) :-

To measure the i/p resistance, fig (a) is replaced by its equivalent ckt.



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

$I_i \longleftrightarrow I_s - I_f$

$$R_i = \frac{V_i}{I_s - I_f}$$

$$R_i = \frac{V_i}{I_s - \beta I_0.}$$

$$R_i = \frac{V_i}{I_s - \beta A I_i}$$

$\cancel{R_i I_s - R_i A\beta I_i} = V_i$

$R_i I_s - \cancel{R_i A\beta I_i} = R_i I_i$

$R_i I_s = \cancel{(1 + A\beta)} R_i$

$\Rightarrow$ $R_i I_s - R_i I_f = V_i$

$R_i I_s - R_i \beta I_0 = V_i$

$R_i I_s - R_i \beta A I_i = V_i$

$R_i I_s - \cancel{R_i} A\beta \left(\frac{V_i}{\cancel{R_i}}\right) = V_i$

$R_i I_s = (1 + A\beta) V_i$

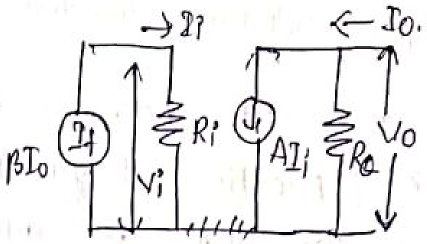
$$\frac{V_i}{I_s} = \frac{R_i}{1 + A\beta}$$

$$\boxed{R_{if} = \frac{R_i}{1 + A\beta}}$$

Output Resistance (R_{of}) :-

To measure the o/p resistance, $V_s \cdot I_s = 0$, $R_L = \infty$.

Apply KCL to the o/p loop.



$$\cancel{AI_i = I_o + \frac{V_o}{R_L}}$$

$$AI_i \quad I_o = AI_i + \frac{V_o}{R_o}$$

$$I_o = A(I_s - I_f) + \frac{V_o}{R_o}$$

$$I_o = -AI_f + \frac{V_o}{R_o}.$$

$$I_o = -A\beta I_o + \frac{V_o}{R_o}.$$

$$(1 + A\beta) I_o = \frac{V_o}{R_o}.$$

$$\frac{V_o}{I_o} = R_o(1 + A\beta)$$

$$\boxed{R_{of} = R_o(1 + A\beta)}$$

Performance comparision of -Ve feed back amplifiers:-

Parameter	Type of feed back amplifier			
	Voltage-Series	Voltage-Shunt	Current-Series	Current-Shunt
(1) Gain	Decreases	Decreases	Decreases	Decreases
2) Band width	increases	increases	increases	increases
3) distortion & noise	decreases	decreases	decreases	decreases
4) input resistance	increases	decreases	increases	decreases
5) output resistance	decreases	decreases	increases	increases

1) what is effect of -Ve feed back on amplifier gain?

2) Derive the expression for o/p resistance of a voltage-sampled circuit

3) Analyse CE amplifier with resistor RE using feed back concept?

4) S.T the band width improved with -ve feed back?

5) S.T i/p resistance increases with series mixing? (Voltage series)

6) Draw the ckt diagram of current series feed back amplifier?, (Practical diagram) , Rif, Rof, Af.

7) Explain the steps in analysis of -ve feed back amplifier? (feed back topology)

8) Explain the concept of feed back with block diagram and also advantages and disadvantages of -ve f.b.

9) what is fb and its types?

10) with a neat sketch obtain -ve fb amplifier and derive expression for closed loop gain?

11) How does -ve fb reduce distortion of an amplifier?

12) Compare -ve fb and +ve fb amplifiers.

13) Difference b/w amplifier and oscillator?

14) An amplifier with gain 200 is provided with -ve feed back of fb ratio 0.005, find new gain?

Given, $A = 200$

$\beta = 0.005$

$$A_f = \frac{A}{1+A\beta} = \frac{200}{1+200(0.005)} = 100$$

15) An amplifier with 2.5kΩ i/p resistance and 50kΩ o/p resistance has a voltage gain of 100. The amplifier is now modified to provide 5% of -ve feed back. in series with the i/p. Calculate the voltage gain, with fb. i/p resistance, and the o/p resistance

Given, $R_i = 2.5k\Omega$

$R_o = 50k\Omega$

$A = 100$

$\beta = 5\% = 0.05$

$$A_f = \frac{A}{1+A\beta} = \frac{100}{1+100(0.05)} = 16.66$$

$$R_{if} = R_i(1+A\beta) = 2.5\times10^3\,(\cancel{100}\ 1+100(0.05)) = 15\,k\Omega$$

$$R_{of} = R_o(1+A\beta) = 50\times10^3(6) = 300\times10^3 = 300k\Omega$$

16) Feed back factor ~~0.0~~ 0.1 is introduced into an amplifier with a gain of 20 and band width of 0.6 MHz, obtain the resultant band width of the fb amplifier.

Given, $\beta = 0.1$

$A = 20$

$BW = 0.6 \times 10^6$ Hz

$BW_f = BW(1+A\beta)$

$= 0.6 \times 10^6 (1 + 20(0.1))$

$BW_f = 1.8$ MHz.

**

17) An amplifier has a gain of 50 with -Ve fb. For a specified o/p voltage, if the i/p required is 0.1V without fb and 0.8V with fb, compute β and openloop gain?

Given, $A_f = 50$

$\beta = ?$

$A = ?$

$V_i = 0.1V$

$V_{if} = 0.8V$

$A = \frac{V_0}{V_i} = \frac{V_0}{0.1}$ — 1

$A_f = \frac{V_0}{V_i} = \frac{V_0}{0.8}$ — 2

$V_0 = A(0.1)$ $\quad V_0 = A_f(0.8)$

$A(0.1) = A_f(0.8)$

$A(0.1) = 50 \times 0.8$

$A = \frac{50 \times 0.8}{0.1} = 400.$

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

$\cancel{50} = \frac{\cancel{400}}{1+400\beta}$

$1+400\beta = 8$

$400\beta = 7$

$\beta = 0.0175$

Draw the topologies of -Ve feed back

feed back connection - topology

Feed back topology :-

The type of feed back connection in -Ve feed back amplifiers is called feed back topology.

There are 4 basic ways of connecting the feedback signal.

Both voltage and current fedback can be ~~at the~~ into the input either in series or parallel.

There are 4 types of feedback topologies.

(Draw the ckt diagrams)

Voltage - series ; Current - Series

voltage - shunt ; Current - shunt

Explain the method of identifying the feedback topology?

Identify topology :-

1) To find the type of sampling network.

i) By shortening the output terminals, if feed-back signal becomes zero then it is called voltage sampling.

ii) By opening the output loop, if feedback signal becomes zero then it is called current sampling.

2) To find the type of mixing network.

i) If the feedback signal is subtracted from the externaly applied as a voltage in the input loop, it is called series mixing.

ii) If the feedback signal is subtracted from the externaly applied signal as a current in the input loop, it is called shunt mixing.

Thus by finding the type of sampling network and mixing network, type of feed back amplifier can be determined

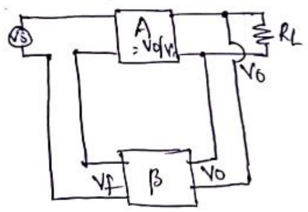
For example : If an amplifier uses a voltage sampling and series mixing, then it is called a voltage - Series feedback amplifier

Type of topology

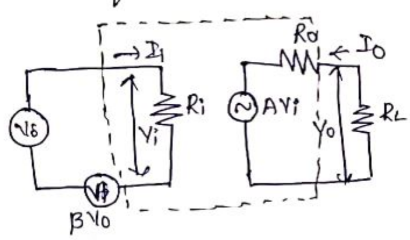
Block diagram

Equivalent Circuit

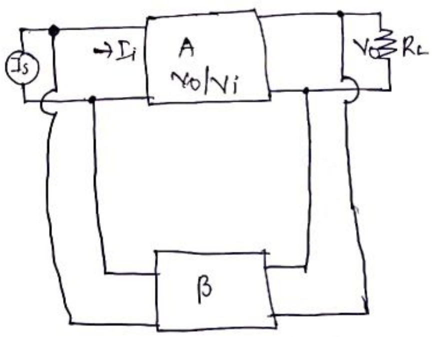
Voltage - series feedback amplifier (Voltage amplifier)



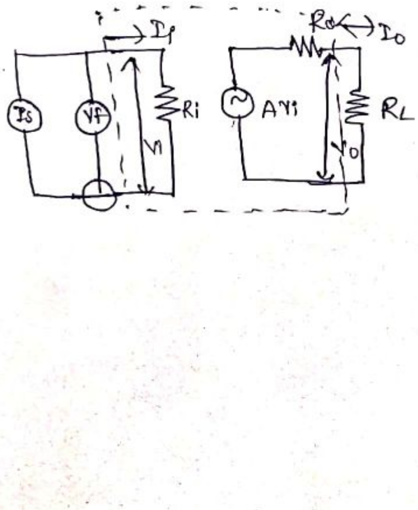
$\beta = V_f / V_o$



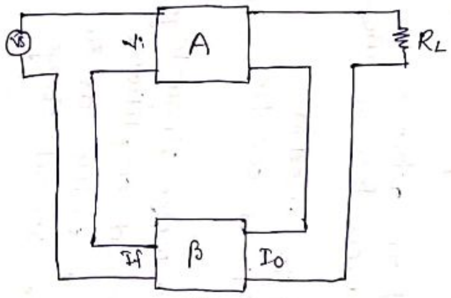
Voltage - shunt feedback amplifier (Trans resistance amplifier)



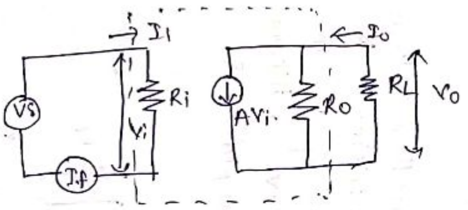
$A = \frac{V_o}{I_s} = \frac{V_o}{I_i}$



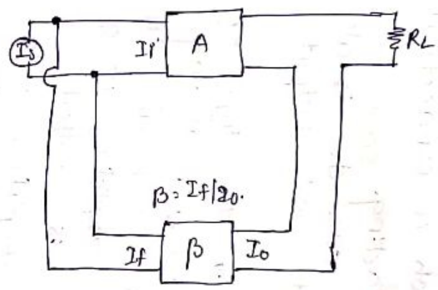
Current - series feed back amplifier (Trans conductance amplifier)



$\beta = I_f / I_o \quad A = \frac{I_o}{V_i}$



Current - shunt feed back amplifier (Current amplifier)



$A = \frac{I_o}{I_i}$