★ FEEDBACK AMPLIFIER

- In a feedback amplifier we sample the output voltage or current by means of a sampling network and apply these sampled signal to the i/p through a two port n/w reffered to as the feedback n/w.]

- The sample is taken from o/p which is in phase with i/p signal is called +ve feedback.

- The sample is out of phase from the i/p signal is known as -ve feedback.

→ Classification on the basis of +ve and -ve feedback

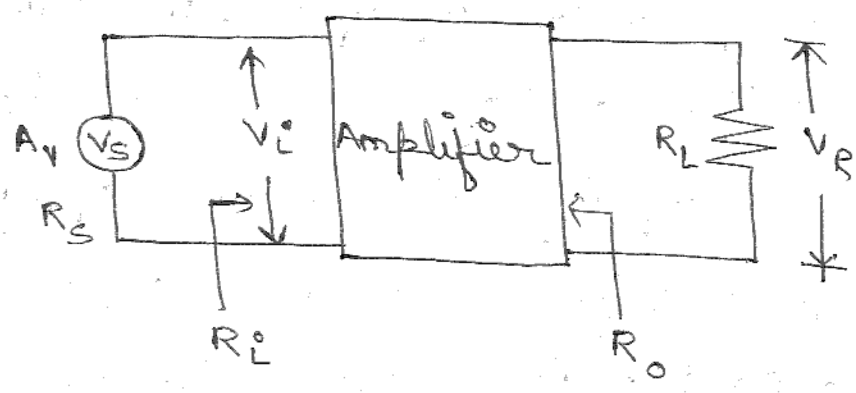
1) Voltage amplifier

11) Current amplifier

111) Transconductance amplifier

1V) Transresistance amplifier

Voltage Amplifier



$R_i \gg R_S$ $\quad$ $R_L \gg R_o$

$V_i \approx V_S$ $\quad$ $V_o \approx A_V \cdot V_i \approx A_V \cdot V_S$

The voltage o/p is proportional to voltage i/p. The proportionality factor do not depends on the mag. of source and load resistance. Hence, the ampli is called voltage amplifier.
For ideal amplifier R_i should be infinite and R_L should be zero.

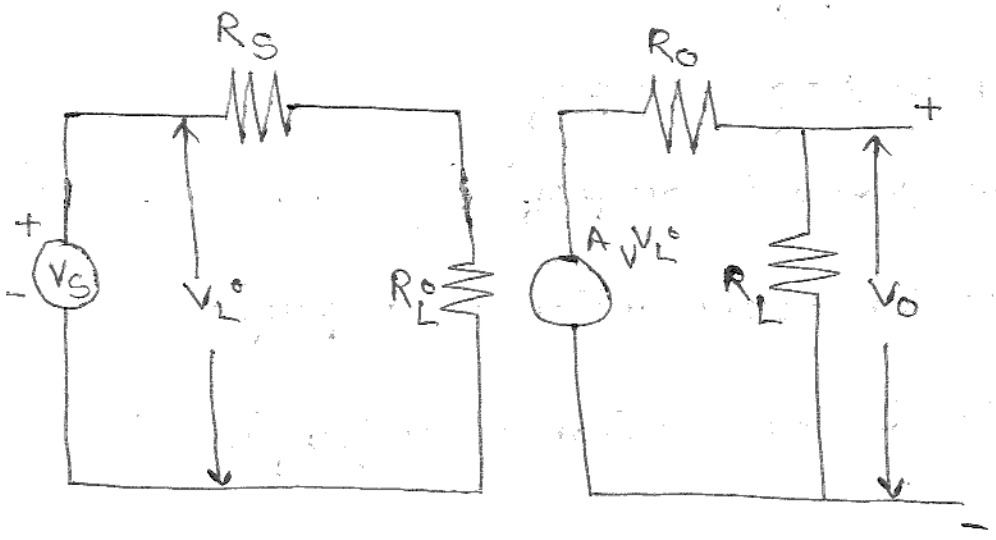
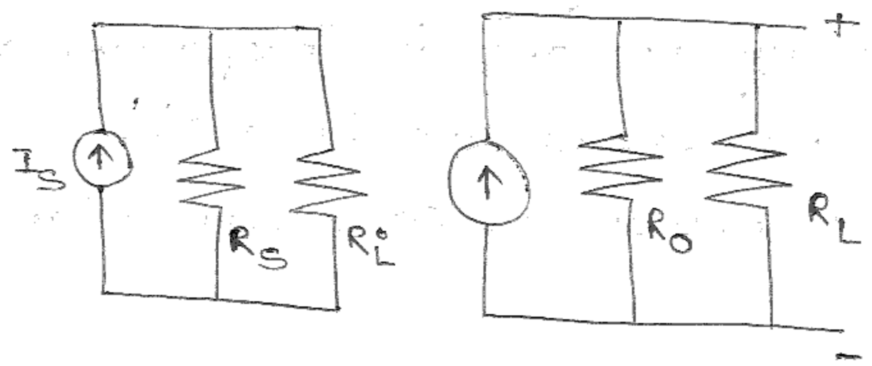


Fig : Thevenin's eq. ckt

Current Amplifier

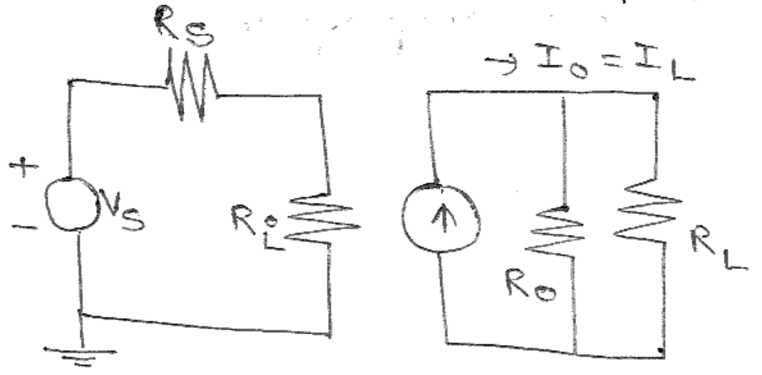


If $R_i \to 0$ then $I_i \approx I_o$

If $R_o \to \infty$ then $I_L \approx I_i$

The current o/p is proportional to the signal current. The proportionality factor is independent of source and load resistance will which is called as current amplifier.

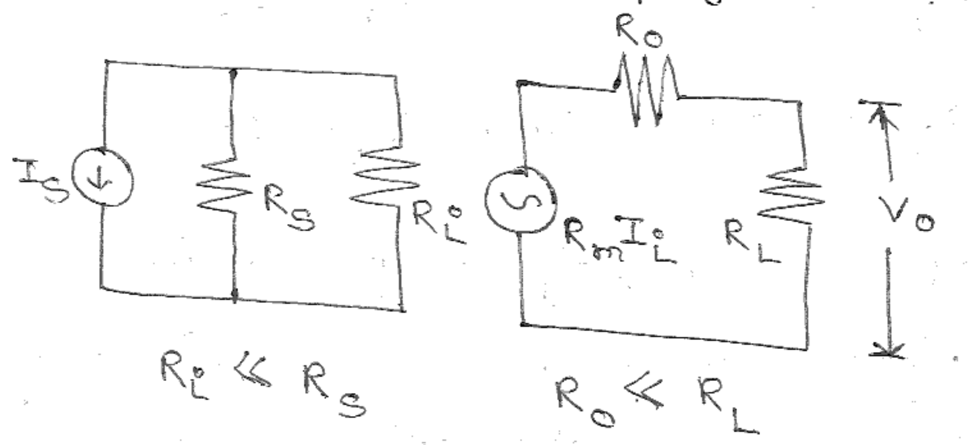
Transconductance Amplifier



$R_i \gg R_S$ $\quad\quad$ $R_o \gg R_L$

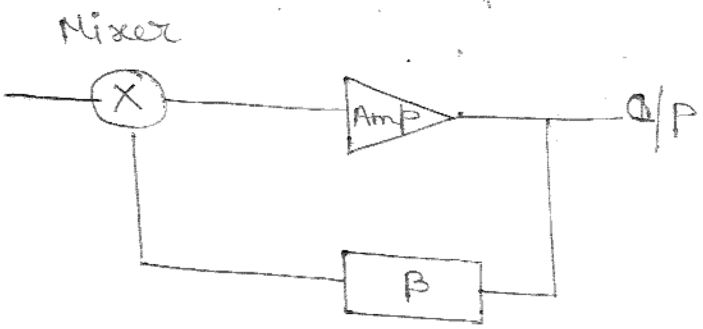
output ~~the~~ current is proportional to the i/p signal voltage. The proportionality constant is independent of magnitude and source and load resistance. This is known as transconductance ampli.

Transresistance Amplifier



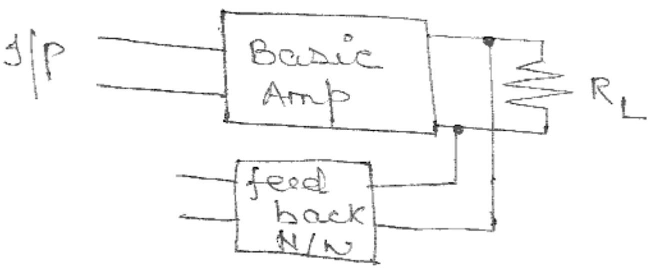
output voltage is proportional to the i/p signal current. The proportionality constant is independent of source and load resistance. This is known as trans resistance amplifier.

★ Sampling Network

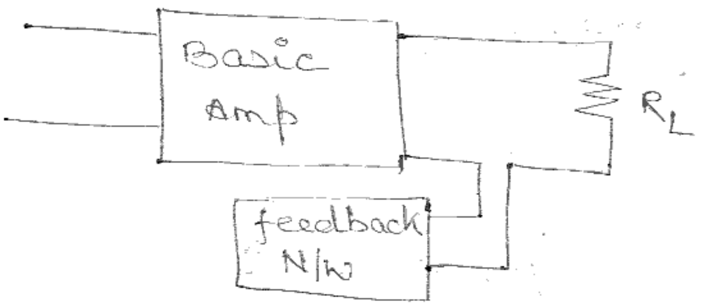


- Two types of sample output can be taken out from any circuit for the feedback n/w to get the desired output. The sampling parameters either may be voltage or current. For current sampling the output current is sampled by connecting the feedback n/w in series with the output.

- For voltage sample output voltage is sampled by connecting the feedback n/w in parallel with the output.



Voltage (or) Node sampling



* Feedback Network

It is consist of resistor, capacitors and inductors.

$$V_f = \beta \cdot V_o$$

where,

β = feedback factor or feedback ratio

Its value lies b/w 0 and 1.

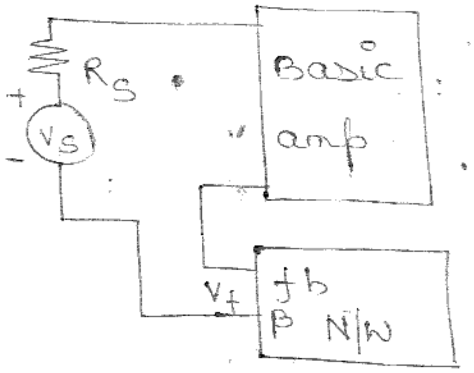
- For CE amplifier $\beta > 1$.

* Mixer Network

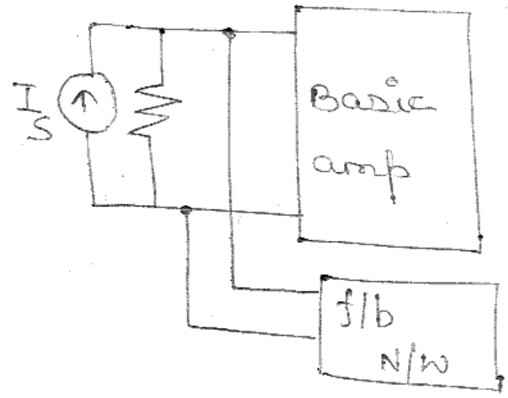
→ Two types

- Series
- Shunt

• Series



• Shunt



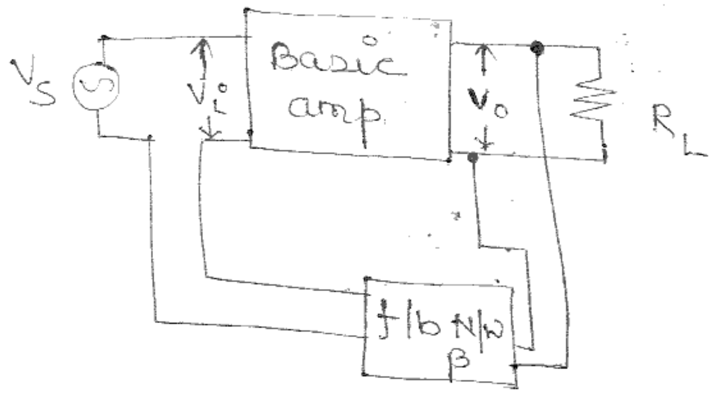
By connecting the sampled output may be the voltage of the current and f/b o/p to the i/p in series or shunt will provide the high i/p impedance to the circuit.

★ Types Of Feedback Amplifier

- Voltage series f/b amp
- Current series " "
- Voltage shunt " "
- Current shunt " "

O/P I/P

• Voltage Series

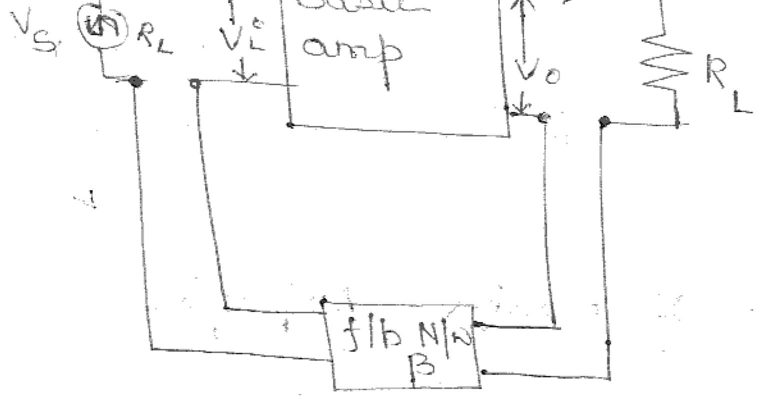


$$V_f = \beta V_o$$

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

$$\text{Voltage series } A_f = \frac{V_o}{V_S}$$

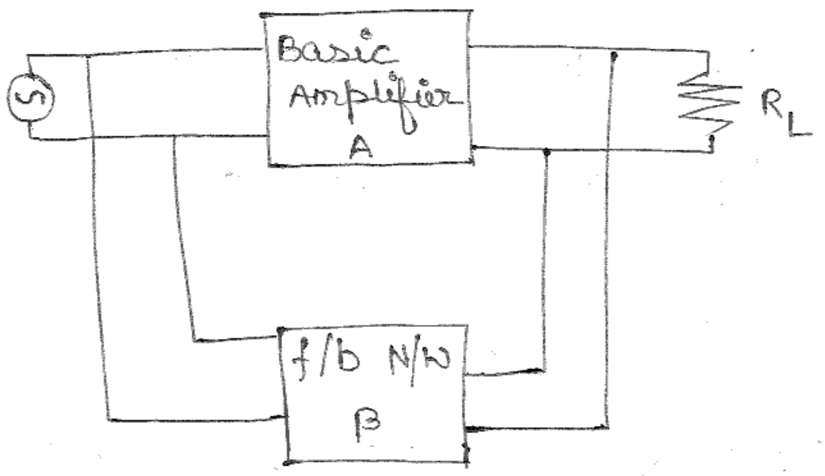
• Current Series



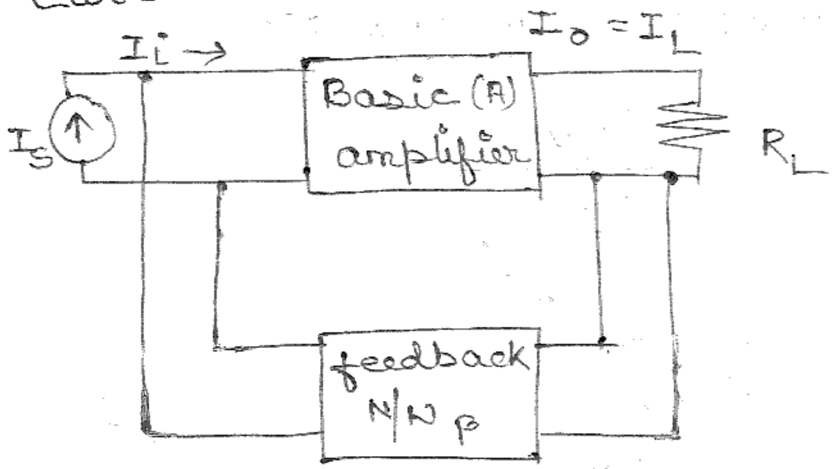
$$V_f = \beta I_o$$

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

★ Voltage Shunt



★ Current Shunt



★ Gain with feed back

The symbol A is used to represent transfer gain of basic amplifier without feedback and symbol A_f is used to represent with feed back.

$$A = \frac{X_o}{X_i} \quad , \quad A_f = \frac{X_o}{X_s}$$

where

X_o = o/p voltage or current

X_i = i/p voltage or current

X_s = source voltage or current

$$X_i = X_s + (-X_f)$$

$\Rightarrow X_f$ = feedback voltage or f/b current

$$\therefore A_f = \frac{X_o}{X_s} = \frac{X_o}{X_i + X_f}$$

÷ by x_i to num and deno

$$A_f = \frac{X_o / X_i}{1 + X_f / X_i}$$

$$A_f = \frac{A}{1 + \left(\frac{X_f}{X_i}\right)}$$

where,

$$A = \frac{X_o}{X_i}$$

$$A_f = \frac{A}{1 + \beta A} \quad ; \quad \left(\beta = \frac{X_f}{X_i}\right)$$

lly.

$$A_{vf} = \frac{A_V}{1 + A_V \beta}$$

$A_V \rightarrow$ open loop gain

$\beta \rightarrow$ feedback factor

ent

★ Loop Gain :-

The difference s/l X_c is multiplied by the gain A is passing through the amplifier is multiplied by β in transmission through the feedback n/w and is multiplied by -1 in the mixing. The gain of the low place is the product of $-A\beta$ this is known as loop gain of return ratio.

* Transfer Ratio or Gain

The ratio of o/p signal to the i/p signal of the basic amplifier is represented by A.

$$\frac{V}{V_i} = A_v \Rightarrow \text{Voltage gain} \quad \text{--- (1)}$$

$$\frac{I}{I_i} = A_i \Rightarrow \text{current gain} \quad \text{--- (2)}$$

$$\frac{I}{V_i} = G_m \Rightarrow \text{Transconductance} \quad \text{--- (3)}$$

$$\frac{V}{I_i} = R_m \Rightarrow \text{Trans resistance} \quad \text{--- (4)}$$

* Cutoff frequency with feedback

W.K.T.

$$A_f = \frac{A}{1+\beta A}$$ using this eq we can write

$$A_{f\,mid} = \frac{A_{mid}}{1+\beta A_{mid}} \quad \text{--- (1)}$$

$$A_{f\,low} = \frac{A_{low}}{1+\beta A_{low}} \quad \text{--- (2)}$$

$$A_{f\,high} = \frac{A_{high}}{1+\beta A_{high}} \quad \text{——— (3)}$$

re-

★ Advantages of -ve feedback

- High i/p resistance of the voltage end can be made high.

- Low o/p resistance of a voltage amplifier can be lowered.

- which improves the freq. response of amplifier.

- Significant improvement in the linearity of operation of feedback amplifier.

★ Distortion in feedback

can

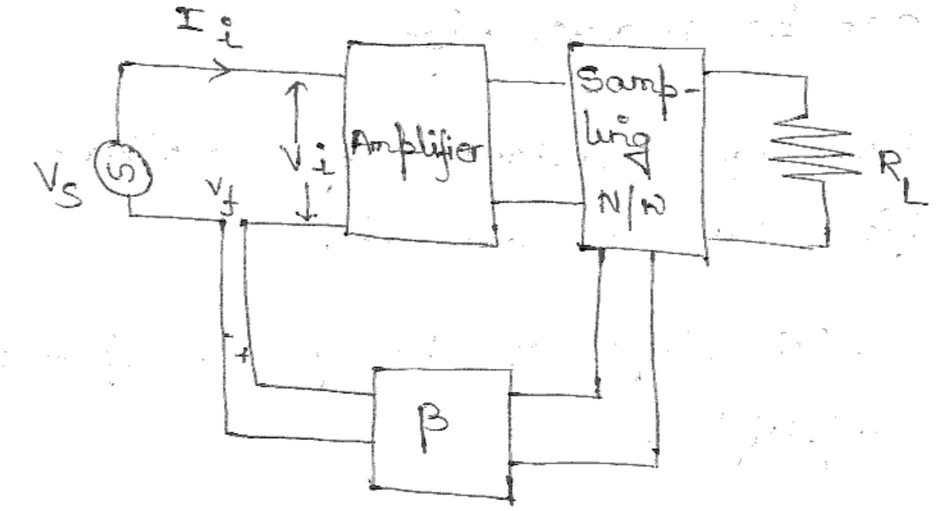
• <u>Frequency distortion</u>

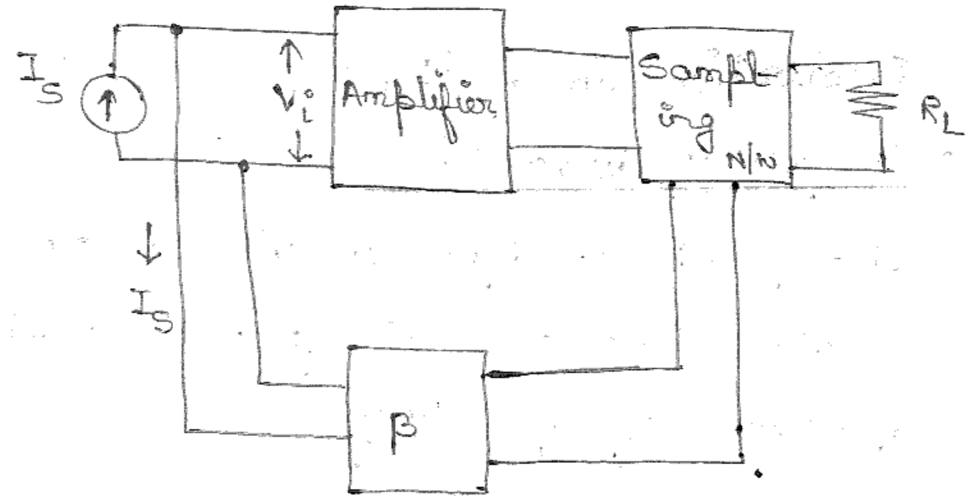
The feedback n/w doesn't contain reactive element. The over all gain is not a function of frequency.

* Noise And Non-linear distortion

The signal feedback reduces the amount of noise signal and non-linear distortion for considerable improvments.

- Input and output resistance





ʰear

ⁿts.

i The feedback signal is added to the i/p in series with the applied voltage. It increases the input resistance. Since V_f opposes V_s

ii If f/b signal is added to the i/p ~~at~~ shunt to the applied voltage it decreases the i/p resistance.

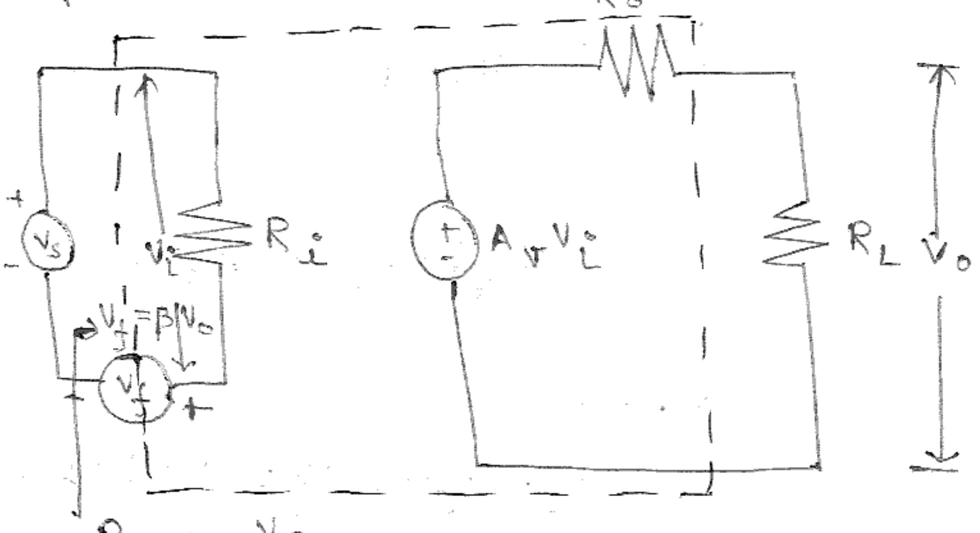
Since

$$I_s = I_i + I_f$$

iii The current I_s drawn from the signal source is increased over.

- Voltage series feedback

Input Resistance



$$R_{if} = \frac{V_s}{V_f}$$

The voltage series feedback topology with amplifier is replaced by thevenin's model and A_v represents the open ckt voltage gain taking R_S into account (R_s = part of amplifier).

I/p resistance with f/b

$$R_{if} = \frac{V_S}{I_i} \quad \text{——} \quad (1)$$

Applying KVL to the i/p side

$$V_S = I_i R_i + V_f$$

$$= I_i R_i + \beta V_o \quad \text{——} \quad (2)$$

o/p voltage V_o is given as

$$V_o = \frac{A_v V_i R_L}{R_o + R_L}$$

$$= A_v I_i R_i = A_v V_i \quad \text{——} \quad (3)$$

where

A_v = open ckt voltage gain without f/b

A_V = Voltage gain with f/b with R_L into account

Sub' V_o from eq ③ in eq ②

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

$$V_s = I_i R_i + \beta A_V V_i$$

$$= V_i + \beta A_V V_i$$

$$= V_i (1 + \beta A_V)$$

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

$\div\ i_i$

$$\frac{V_s}{I_i} = R_i (1 + \beta A_V)$$

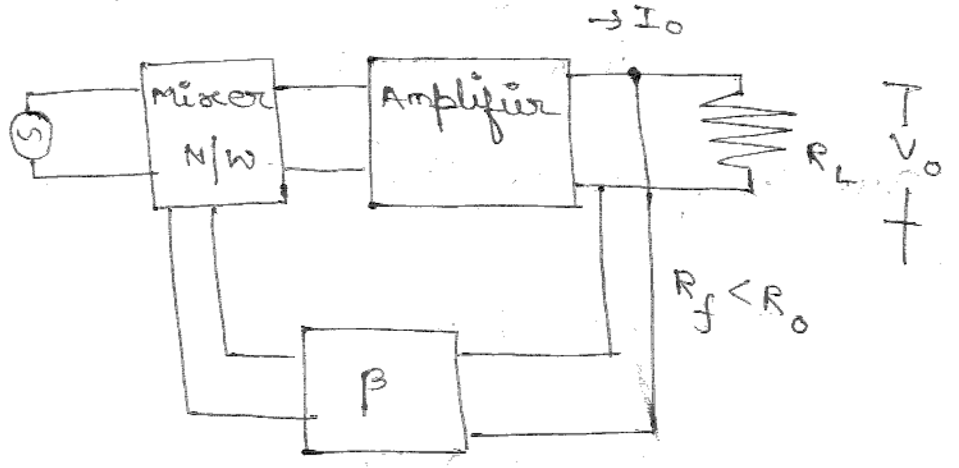
$$\Rightarrow \boxed{R_{if} = R_i [1 + \beta A_V]}$$

Here,

$$R_{if} = \frac{V_s}{I_i}$$

Output resistance

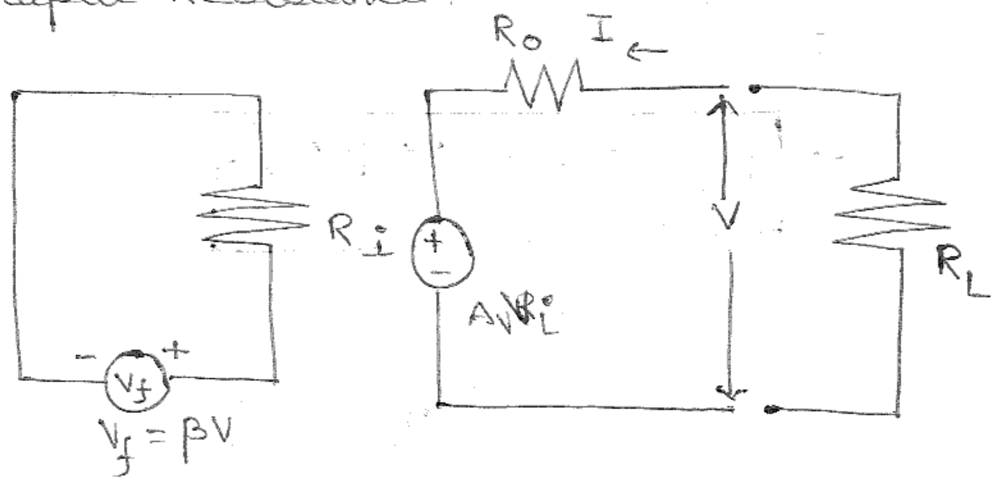
The -ve f/b which samples the o/p voltage regardless of how this o/p signal is return to the i/p.



In -ve f/b which is used in the f/b amplifier tends to increase the o/p resistance.

- Voltage series feedback

Output Resistance



In this topology o/p resistance can be measured by shorting the i/p source $V_S = 0$. The o/p terminal with R_L is connected.

Applying KVL to o/p side

$$A_V V_i + I R_o - V = 0$$

$$I R_o = V - A_V V_i$$

$$I = \frac{V - A_V V_i}{R_o} \quad \text{——— (1)}$$

i/p voltage

$$V_i = -V_f = -\beta V \quad \text{——— (2)}$$

Subst V_i from eq (2) to eq (1)

$$I = \frac{V + A_V \beta V}{R_o}$$

$$I = \frac{V[1 + A_v\beta]}{R_o}$$

$$R_{of} = \frac{V}{I} = \frac{R_o}{[1 + A_v \beta]}$$

where,

A_v = open loop gain without taking R_L into account.

$$R_{of}' = R_{of} \| R_L$$

$$R_{of}' = \frac{R_{of} R_L}{R_{of} + R_L}$$

Sub R_{of} in above eq

$$R_{of}' = \frac{\frac{R_o R_L}{1+A_v\beta}}{\frac{R_o}{1+A_v\beta} + R_L}$$

$$R_{of}' = \frac{R_o R_L}{R_o + R_L(1+A_v\beta)}$$

$$= \frac{R_o R_L}{R_o + R_L + R_L \beta A_v}$$

Divide num and deno. by $(R_o + R_L)$

$$R_{of}' = \frac{\frac{R_o R_L}{R_o + R_L}}{\frac{R_o + R_L + R_L \beta A_v}{R_o + R_L}}$$

Put $\frac{R_o R_L}{R_o + R_L} = R_L'$

$$\frac{A_v R_L}{R_o + R_L} = A_V$$

$$R_{of}' = \frac{R_L'}{1+\beta A_V}$$

Here, A_V = open loop voltage gain taking R_L into account.

★ Method Of Identifying Feedback Topology And Analysis Of A Feedback Amplifier

To analyse the feedback amplifier i.e. necessary to go through four types of f/b. type of sampling n/w.

i) By shorting o/p V = 0, if feedback signal becomes zero then it is said as voltage shunt sampling.

ii) By opening the o/p loop I = 0 with f/b signal = 0 then it is represented as current shunt.

- To find out the type of mixing signal

i) The f/b signal is subtracted from externally applied voltage i.e. series mixing.

ii) The f/b is subtracted from externally applied curret i.e. shunt mixing.

- Find the i/p circuit

i) Voltage ~~shunt~~ sampling makes V=0 by Shorting the o/p.

ii) For current sampling by making the opening o/p.

- Find the o/p ckt

i) For series mixing I=0 by opening the i/p loop.

ii) For shunt mixing V=0 by shorting the i/p.

- Optional

i) Replace each active device by its h-parameter model at low frequency.

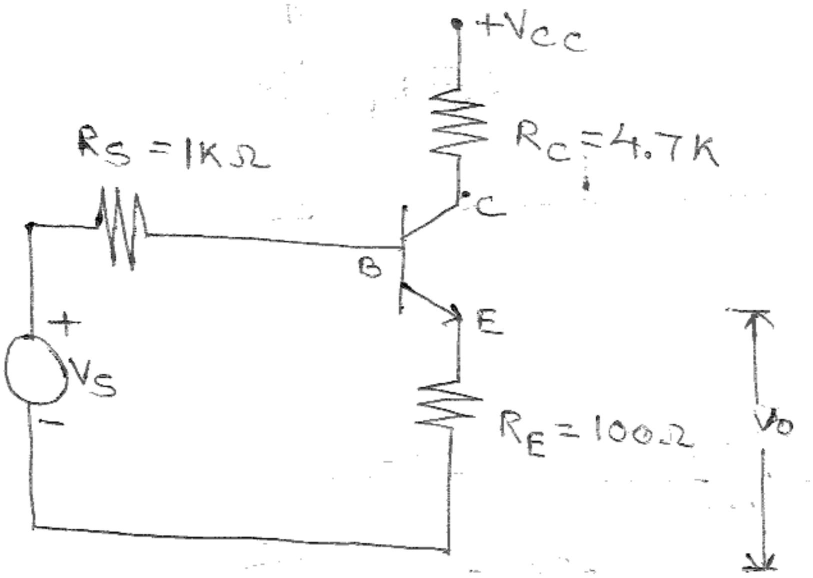
- Find the open loop gain A of the amplifier.

- Indicate X_f and X_o on the ckt and evaluate $\beta = X_f \cdot X_o$

- From A and β find A_f or A_m, R_{of}, R_{if} and R'_{of}.

★ Analysis of feedback amplifier

- Transistor Emitter follower

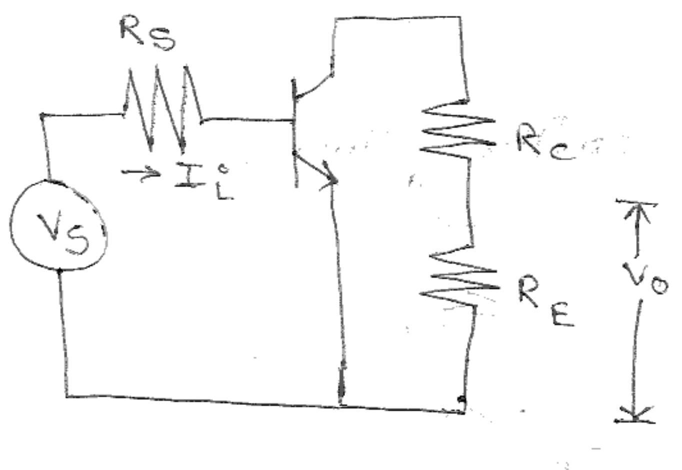


1) If $V_o = 0$ the feedback signal becomes zero. Hence, it is voltage shunt.

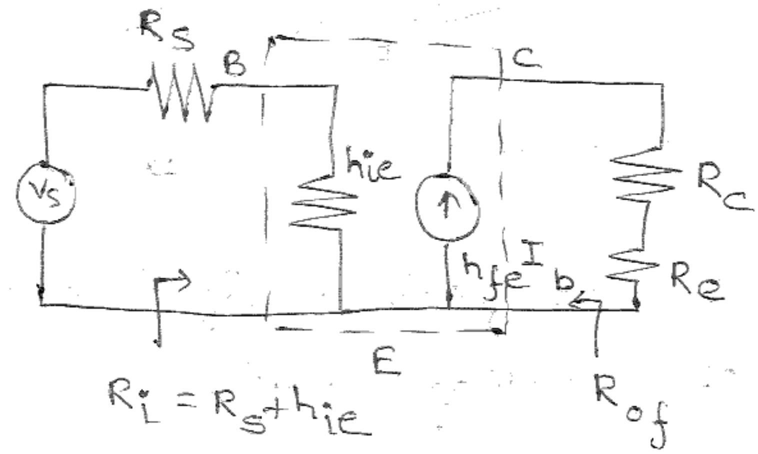
ii) V_f is subtracted from the externally applied signal source V_S. Hence, it is Series mixing.

Step 2 & 3 i) To find i/p ckt set $V_o = 0$. Hence V_S is in series with R_S and R_E. R_S appears b/w base and emitter.

ii) For o/p ckt set the value of $I_i = I_b = 0$



Step 4



Step 5. Find open loop gain

$$A_V = \frac{V_o}{V_s} = \frac{h_{fe} I_b \cdot R_e}{V_s} \quad \text{---} (1)$$

Applying KVL to i/p loop

$$V_s = I_b (R_s + h_{ie}) \quad \text{---} (2)$$

Sub (2) in (1)

$$A_V = \frac{h_{fe} \cancel{I_b} R_e}{\cancel{I_b} (R_s + h_{ie})}$$

$$A_V = \frac{h_{fe} R_e}{R_s + h_{ie}}$$

Step 6. Indicate the value of V_o and V_f.

$$\beta = \frac{V_f}{V_o} = 1$$

Step 7. Calculate D, A_{vf}, R_{if}, R_{of}

D = Desensitivity $= 1 + \beta A_V$

if $A_V = 2.3$, $\beta = 1$

$D = 3.3$

$$A_{vf} = \frac{A_v}{D} = 0.7$$

$$R_i = R_s + h_{ie}$$

if $h_{ie} = 1.1K$

$$R_i = 2.1 K\Omega$$

$$R_o = \infty$$

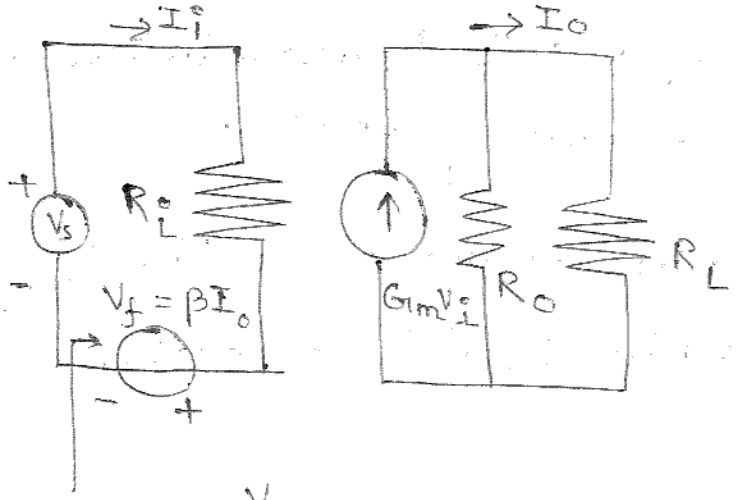
$$\Rightarrow R_{of} = \infty$$

$$R_{of}' = \frac{R_o}{D} = \frac{R_e}{D} = \frac{100}{3.38} = 29.58\Omega$$

★ Current Series Feedback

This topology is shown below in the ckt.

The amplifier ~~equivalent~~ i/p ckt is represented by thevenin's equi ckt and o/p ckt is represented by Norton's equivalent ckt.



$$R_{if} = \frac{V_S}{I_i}$$

I/p resistance with feedback

$$R_{if} = \frac{V_S}{I_i}$$

by applying KVL to i/p side

$$V_S - I_i R_i - V_f = 0$$

$$V_S = I_i R_i + V_f = 0$$

$$V_S = I_i R_i + \beta I_o \quad \text{—— (5)}$$

$$I_o = \frac{G_m V_i R_o}{R_o + R_L} = \frac{G_M V_i}{} \quad \text{—— (6)}$$

where

$$G_M = \frac{G_m R_o}{R_o + R_L}$$

$G_m \rightarrow$ Open ckt transconductance without feedback.

$G_M \rightarrow$ Transconductance without f/b while R_L into account.

subst I_o in eq (5)

$$V_S = I_i R_i + \frac{\beta G_m V_i R_o}{R_o + R_L}$$

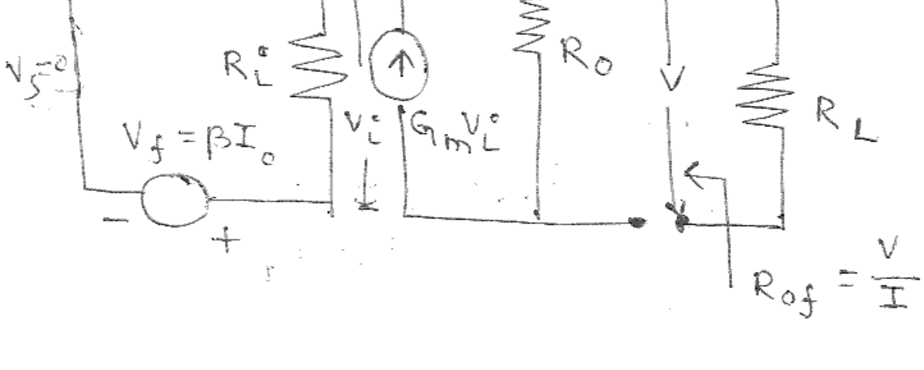
$$V_S = I_i R_i + \beta V_i G_M$$

$$V_S = I_i R_i + \beta I_i R_i G_M$$

$$V_S = I_i R_i [1 + \beta G_M]$$

$$R_{if} = \frac{V_S}{I_i} = R_i [1 + \beta G_M] \quad \text{—— (7)}$$

o/p resistance



In this topology the resistance is measured by shorting the i/p $V_s = 0$ with R_L is disconnected.

Applying KCL to o/p node

$$I = \frac{V}{R_o} - G_m V_i \quad \text{——} (8)$$

I/P voltage is given as

$$V_i = -V_f = -\beta I_o$$

$$V_i = \beta I \quad \text{——} (9) \qquad \because I = -I_o$$