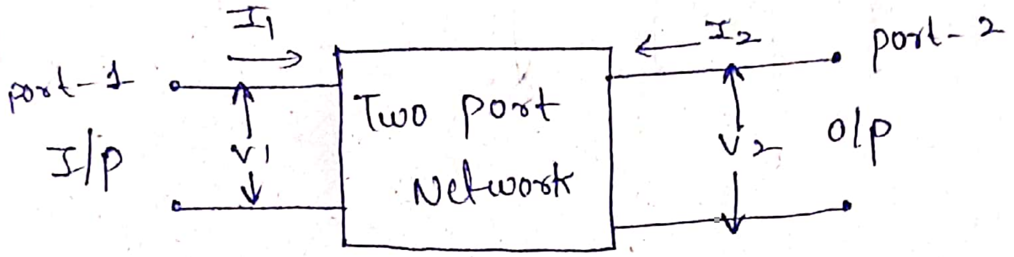
19/12/19 Electronic circuit Analysis

* Two Port Network



$$V_1 = h_{11} I_1 + h_{12} V_2 \rightarrow (1)$$

$$I_2 = h_{21} I_1 + h_{22} V_2 \rightarrow (2)$$

Eq (1) $V_2 = 0$ $\qquad$ $I_1 = 0$

$V_1 = h_{11} I_1$ $\qquad$ $V_1 = h_{12} V_2$

$h_{11} = \frac{V_1}{I_1} = h_i$ $\qquad$ $h_{12} = \frac{V_1}{V_2}$

Eq (2)

$V_2 = 0$ $\qquad$ $I_1 = 0$

$I_2 = h_{21} I_1$ $\qquad$ $I_2 = h_{22} V_2$

$h_{21} = \frac{I_2}{I_1}$ $\qquad$ $h_{22} = \frac{I_2}{V_2} = h_o$

$h_{11} \rightarrow h_i \rightarrow$ Input Impedance

$h_{22} \rightarrow h_o \rightarrow$ output admittance

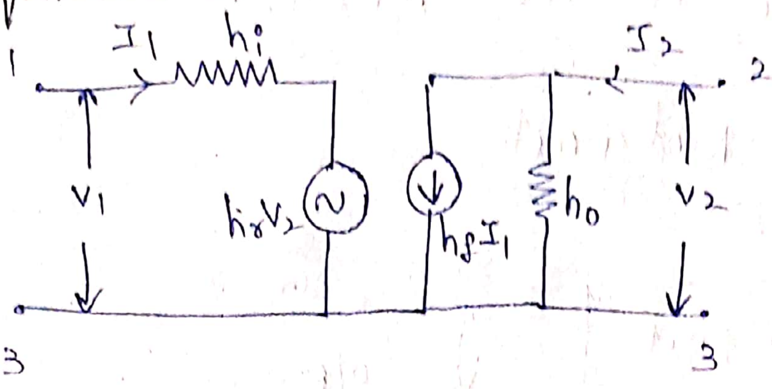
$h_{21} \rightarrow h_f \rightarrow$ forward current gain

$h_{12} \rightarrow h_r \rightarrow$ Reverse voltage gain

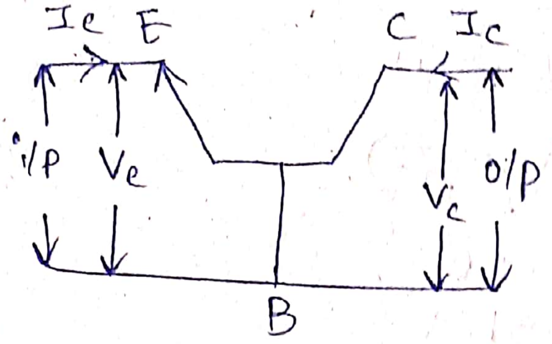
$$V_1 = h_i I_1 + h_r V_2 \longrightarrow (3)$$

$$I_2 = h_f I_1 + h_o V_2 \longrightarrow (4)$$

Equivalent ckt

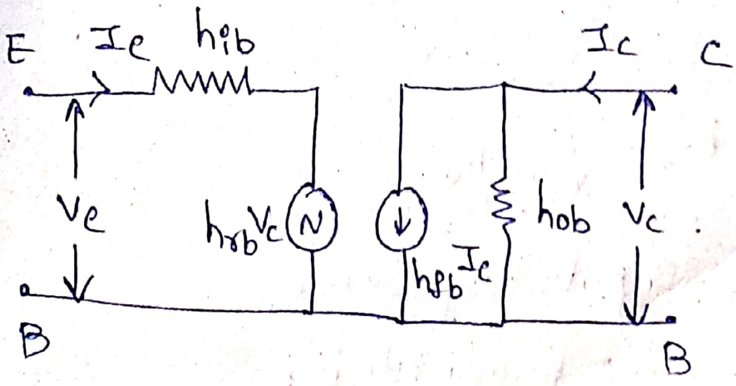


Common Base

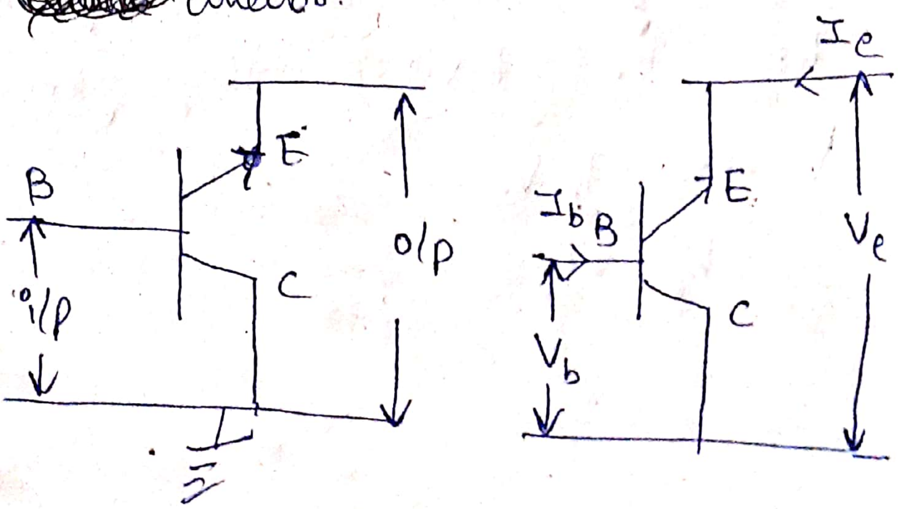


$$V_e = h_{ib} I_e + h_{rb} V_c$$

$$I_c = h_{fb} I_e + h_{ob} V_c$$

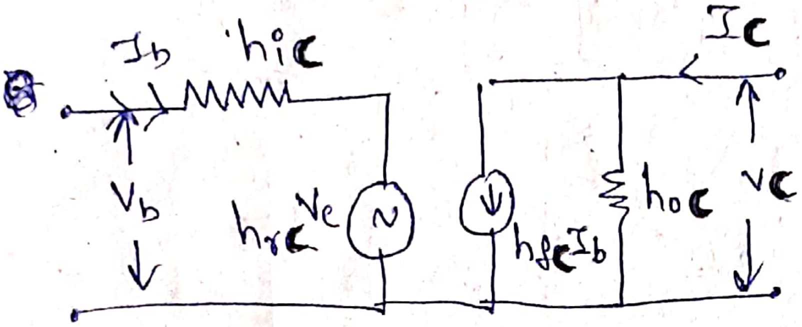


Common collector:-

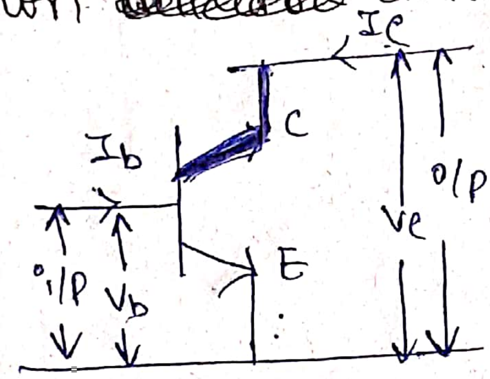


$V_b = h_{ic} I_b + h_{rc} V_C$

$I_C = h_{fc} I_b + h_{oc} V_C$

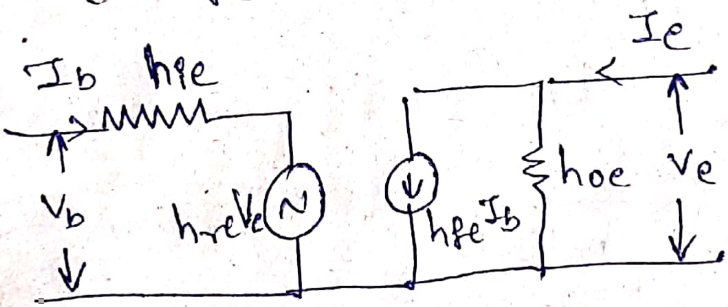


Common emitter:-

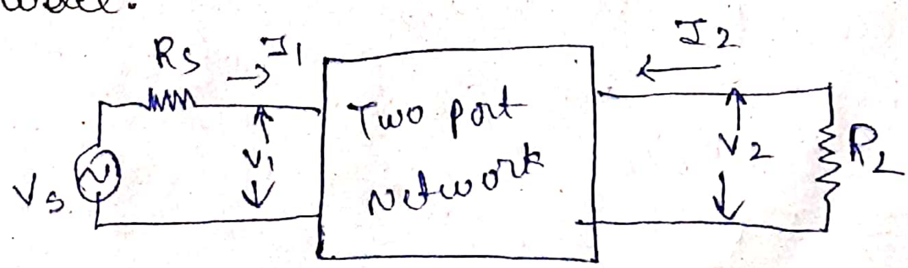


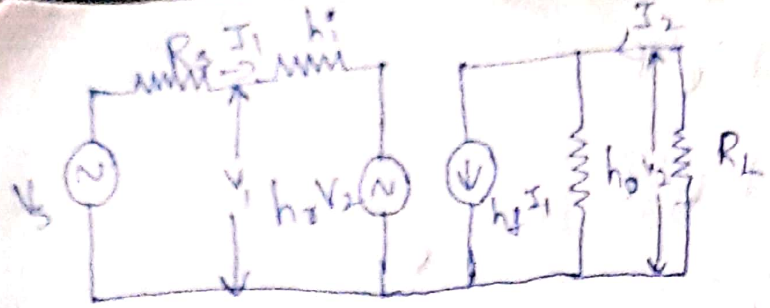
$V_b = h_{ie} I_b + h_{re} V_e$

$I_e = h_{fe} I_b + h_{oe} V_e$



* Analysis of two port network using h-parameter Model:





$$V_1 = h_i I_1 + h_r V_2 \quad — (1)$$

$$I_2 = h_f I_1 + h_o V_2 \quad — (2)$$

Current gain :- $A_I = \frac{-I_2}{I_1}$

from Eq (2)

$$I_2 = h_f I_1 + h_o V_2$$

$$V_2 = -I_2 R_L$$

$$I_2 = h_f I_1 - h_o I_2 R_L$$

$$I_2 + h_o I_2 R_L = h_f I_1$$

$$I_2 [1 + h_o R_L] = h_f I_1$$

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

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

$$\boxed{A_I = \frac{-h_f}{1 + h_o R_L}}$$

Input Resistance:- $R_i = \frac{V_1}{I_1}$

$$V_1 = h_i I_1 + h_r V_2$$

$$V_2 = -I_2 R_L$$

w.k.T.

$$-I_2 = A_I I_1$$

$$\frac{V_1}{I_1} = \frac{h_i I_1 + h_r A_I I_1 R_L}{I_1}$$

$$\boxed{R_i = h_i + h_r A_I R_L}$$

Voltage gain: $A_V = \frac{V_2}{V_1}$

$$V_2 = -I_2 R_L$$

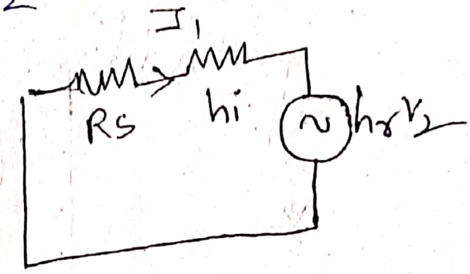
$$V_2 = A_I I_1 R_L$$

$$\frac{V_2}{V_1} = \frac{A_I I_1 R_L}{V_1}$$

$$A_V = A_I \left(\frac{I_1}{V_1}\right) R_L$$

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

output Admittance: $Y_o = \frac{I_2}{V_2}$



$$\frac{I_2}{V_2} = \frac{h_f I_1}{V_2} + \frac{h_o V_2}{V_2}$$

$$Y_o = h_f\left(\frac{I_1}{V_2}\right) + h_o$$

apply KVL

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

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

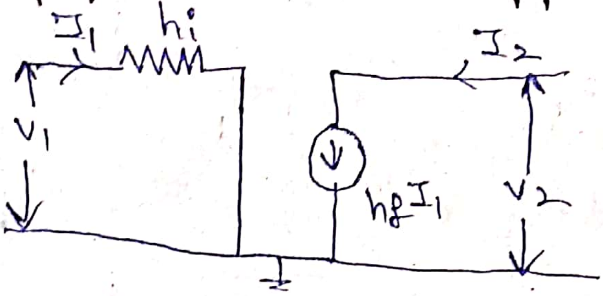
$$\frac{I_1}{V_2} = \frac{-h_r}{R_S + h_i}$$

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

$$\boxed{Y_o = h_o - \frac{h_f h_r}{R_s + h_i}}$$

	CE	CB	CC
$A_I = \frac{-h_f}{1+h_o R_L}$	$A_I = \frac{-h_{fe}}{1+h_{oe} R_L}$	$A_I = \frac{-h_{fb}}{1+h_{ob} R_L}$	$A_I = \frac{-h_{fc}}{1+h_{oc} R_L}$
$R_i = h_i + h_r A_I R_L$	$R_i = h_{ie} + h_{re} A_I R_L$	$R_i = h_{ib} + h_{rb} A_I R_L$	$R_i = h_{ic} + h_{rc} A_I R_L$
$A_V = \frac{A_I R_L}{R_i}$	$A_V = \frac{A_I R_L}{R_i}$	$A_V = \frac{A_I R_L}{R_i}$	$A_V = \frac{A_I R_L}{R_i}$
$Y_o = h_o - \frac{h_f h_r}{R_s + h_i}$	$Y_o = h_{oe} - \frac{h_{fe} h_{re}}{R_s + h_{ie}}$	$Y_o = h_{ob} - \frac{h_{fb} h_{rb}}{R_s + h_{ib}}$	$Y_o = h_{oc} - \frac{h_{fc} h_{rc}}{R_s + h_{ic}}$

* Simplified Model or approximation model



T^r $\rightarrow$ I/P F.B $\rightarrow$ Dep $\downarrow$ $\rightarrow$ $\downarrow$
$\rightarrow$ O/P R.B $\rightarrow$ Dep $\uparrow$ $\rightarrow$ $\uparrow$

	CB	CE	CC
$A_I = \frac{-h_f}{1+h_o R_L} \Rightarrow -h_f$	$-h_{fb}$	$-h_{fe}$	$-h_{fc}$
$R_i = h_i + h_r A_I R_L \Rightarrow h_i$	h_{ib}	h_{ie}	h_{ic}
$A_V = \frac{A_I R_L}{R_i}$ = same	$\frac{A_I R_L}{R_i}$	$\frac{A_I R_L}{R_i}$	$\frac{A_I R_L}{R_i}$
$Y_o = h_o - \frac{h_f h_r}{R_s + h_i} \Rightarrow 0$	0	0	0

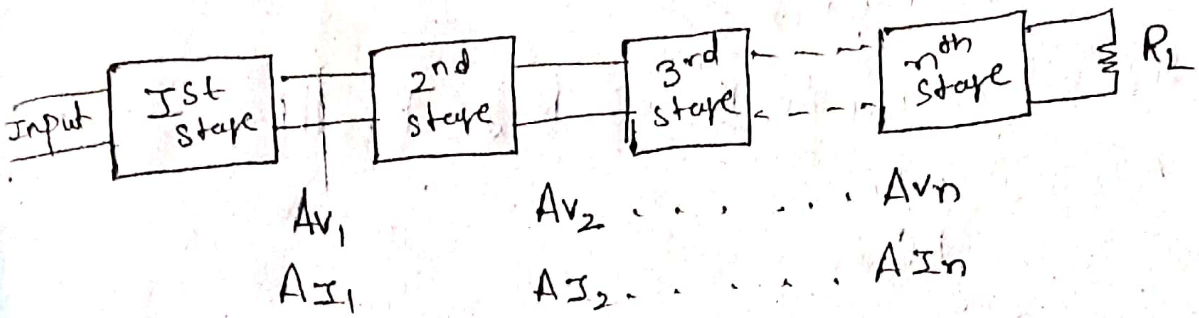
21/5/19

* classification of Amplifiers

1. According to the number of stages
   (a) Single stage amplifier
   (b) Multi stage amplifier.
2. According to the couplings
   (a) RC coupled Amplifier
   (b) Direct coupled Amplifier
   (c) Transformer coupled Amplifier
3. According to the load impedance
   (a) Tune amplifiers
   (b) Un-Tune amplifiers
4. According to the frequencies
   (a) Audio Amplifier
   (b) Radio frequency Amplifier
   (c) Very high frequency amplifier.
   (d) ultra high frequency amplifier.
   (e) Micro wave frequency amplifier.
5. According to the Large Signal
   (a) class-A power amplifier
   (b) class-B power "
   (c) class-C power "
   (d) class-AB power "

(e) class - D power amplifier

* Analysis of multistage Amplifier.

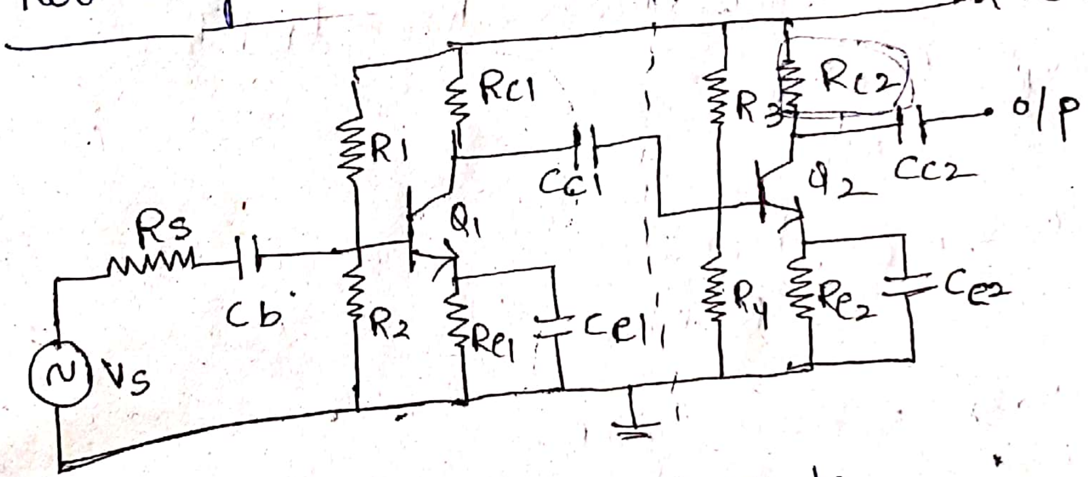


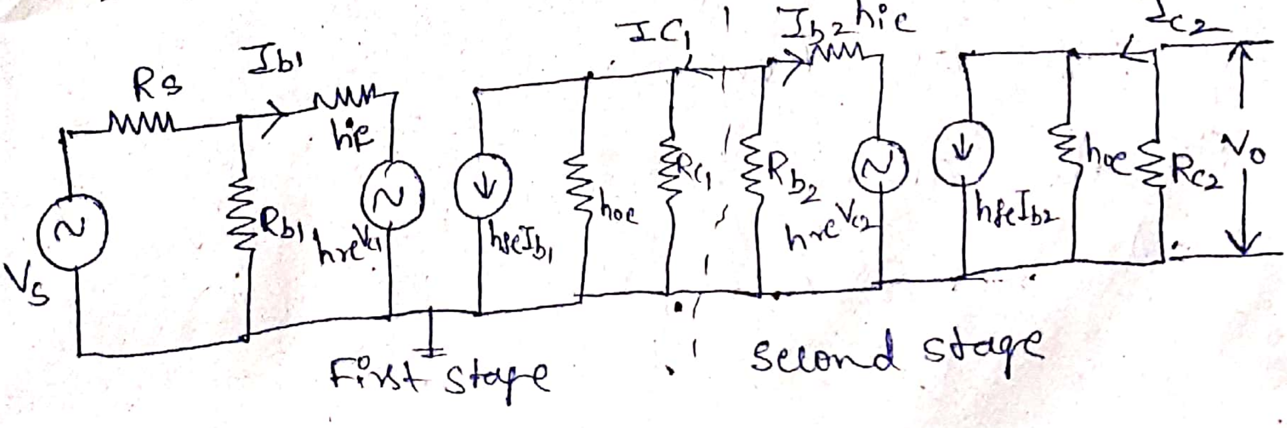
$A_v = A_{vn} \cdots \times A_{v_2} \times A_{v_1}$

$A_I = A_{In} \cdots \times A_{I_2} \times A_{I_1}$

The analysing is done from output to the input.

Two stage CE RC coupled Amplifier





First stage

Second stage

$R_{b1} = R_1 || R_2$

$R_{b2} = R_3 || R_4$

Second stage Analysis

$$A_{I2} = \frac{-h_{fe}}{1 + h_{oe} R_{c2}}$$

$$R_{i2} = h_{ie} + h_{re} A_{I2} R_{c2} \Rightarrow R'_{i2} = R_{b2} \| R_{i2}$$

$$A_{v2} = \frac{A_{I2} R_{c2}}{R'_{i2}}$$

$$Y_{o2} = h_{oe} - \frac{h_{fe} h_{re}}{R_s + h_{ic}}$$

First stage Analysis

$$A_{I1} = \frac{-h_{fe}}{1 + h_{oe} R_{c1}}$$

$$R_{i1} = h_{ie} + h_{re} A_{I1} R_{c2} \Rightarrow R'_{i1} = R_{b1} \| R_{i1}$$

$$A_{v1} = \frac{A_{I1} R_{c1}}{R'_{i1}}$$

$$Y_{o1} = h_{oe} - \frac{h_{fe} h_{re}}{R_s + h_{ie}}$$

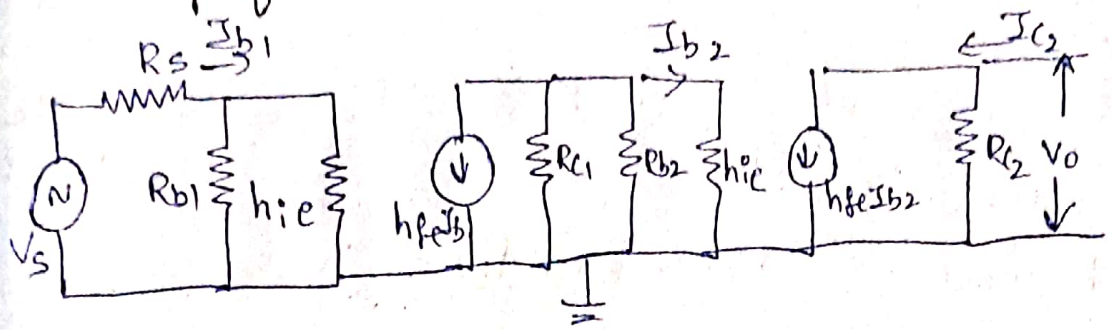
Overall voltage gain

$$A_v = A_{v2} \times A_{v1}$$

Overall current gain

$$A_I = A_{I2} \times A_{I1} .$$

* Simplified Model



Approximate Analysis

Second stage Analysis.

$$A_{I2} = -h_{fe}$$

$$R'_{i2} = R_{b2} \| h_{ie}$$

$$A_{V2} = \frac{A_{I2} R_{c2}}{R'_{i2}}$$

$$Y_{o2} = \frac{1}{R_{c2}}, \quad R_o = R_{c2}$$

First stage Analysis

$$A_{I1} = -h_{fe}$$

$$R'_{i1} = R_{b1} \| h_{ie}$$

$$A_{V1} = \frac{A_{I1} R_{c1}}{R'_{i1}}$$

$$Y_{o1} = \frac{1}{R_{c1}}, \quad R_o = R_{c1}$$

$A_V = A_{V2} \times A_{V1} \rightarrow$ voltage gain

$A_I = A_{I2} \times A_{I1} \rightarrow$ current gain

(1) For a CE, CE cascade amplifier find ~~Rs = 1k, R~~ R_i, A_I, A_V, R'_i, R'_o & R_o with the following parameters

$R_s = 1k$ $\quad h_{ie} = 1.2k\Omega$

$R_1 = 200k$ } First stage $\quad h_{fe} = 50$

$R_2 = 20k$ } $\quad h_{re} = 2.5\times10^{-4}$

$R_{C1} = 15k$ $\quad h_{oe} = 25\mu A/V$

$R_{e1} = 100\Omega$

$R_{C2} = 4k$

$R_{e2} = 330\Omega$

$R_1 = 47k$ } second stage

$R_2 = 47k$ }

Sol: Second stage Analysis

$$A_{I2} = \frac{-50}{1+25\times10^{-6}\times4\times10^{3}} = -45.45$$

$$R'_{i2} = R_{b2} \| R_{i2}$$

$$R_{i2} = h_{ie} + h_{re}A_{I2}R_{C2}$$

$$= 1.2\times10^{3} + 2.5\times10^{-4}(-45.45)4\times10^{3}$$

$$= 1154.55$$

$$R_{b2} = R_1 \| R_2 = \frac{47\times10^{3}\times47\times10^{3}}{47\times10^{3}+47\times10^{3}}$$

$$= 23500$$

$$R'_{i2} = 23500 \| 1154.55$$

$$= 1100.48$$

$$A_{V2} = \frac{A_{I2}R_{C2}}{R'_{i2}} = \frac{(-45.45)(4\times10^{3})}{1100.48}$$

$A_{V2} = -165.200$

$R_o = R_{C2} = 4\times10^3$

$\cancel{Y_o = \frac{1}{R_o} = \frac{1}{4\times10^3} = 2.5\times10^{-4}}$

$$Y_o = 25\times10^{-6} - \frac{50\times2.5\times10^{-4}}{1\times10^3+1.2\times10^3}$$

$= 1.931\times10^{-5}$

$R_o = \frac{1}{Y_o} = 51786.63$

First stage Analysis

$$A_{I1} = \frac{-50}{1+25\times10^{-6}(15\times10^3)} = -36.36$$

$R_{i_1} = 1.2\times10^3 + 2.5\times10^{-4}(-36.36)(4\times10^3)$

$R_{i_1} = 1163.64$

$R'_{i_1} = R_{b_1} \| R_{i_1}$

$R_{b_1} = 200k \| 20k$

$$R_{b1} = \frac{200\times10^3\times20\times10^3}{200\times10^3+20\times10^3} = 18181.81$$

$R'_{i_1} = 18181.81 \| 1163.64$

$R'_{i_1} = 1093.64$

$$A_{V_1} = \frac{(-36.36)(15\times10^3)}{1093.64} = -498.7$$

$R_o = \cancel{R_{e2} = 330\,\Omega}$

$\cancel{Y_o = \frac{1}{330} = 3.03\times10^{-3}}$

Simplified Model

$A_{I2} = -h_{fe} = -50.$

$R'_{i_2} = R_{b2} \| h_{ie}$

$R_{b2} = R_1 \| R_2 = \dfrac{470\times10^3 \times 470\times10^3}{470\times10^3 + 470\times10^3} = 23500$

$h_{ie} = 1.2\times10^3$

$R'_{i_2} = \dfrac{23500\times1.2\times10^3}{23500+1.2\times10^3} = 1141.700$

$A_{V_2} = \dfrac{A_{I_2} R_{C_2}}{R'_{i_2}} = \dfrac{(-50)(4\times10^3)}{1141.700} = -175.177$

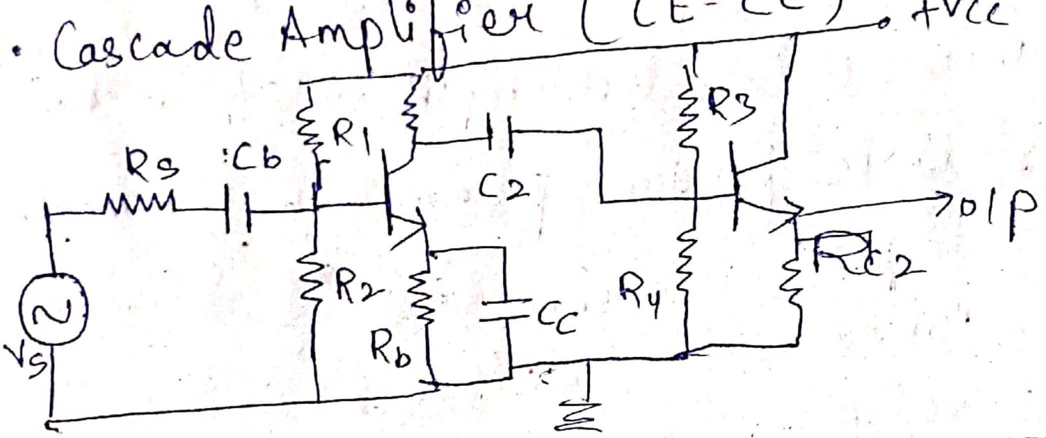
$R_o = 4\times10^3$

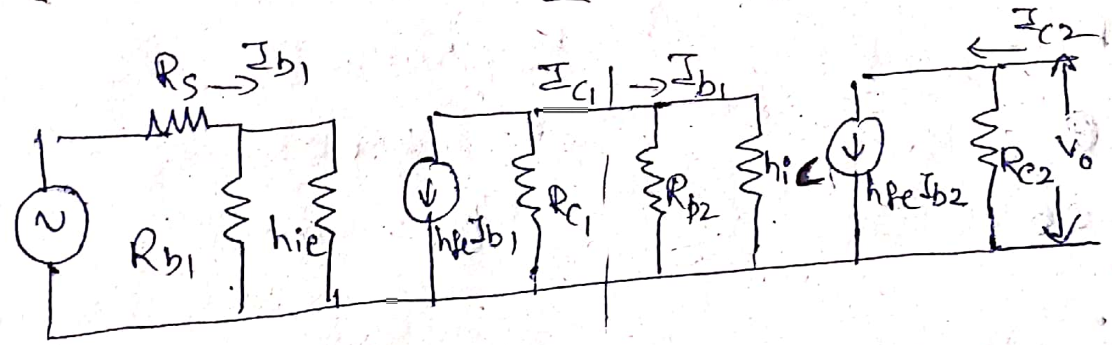
1. Cascade Amp → CE-CE, → CE-CC

2. Cascode Amp → CE-CB

3. Darlington Amp

1. Cascade Amplifier (CE-CC)





$A_{I2} = -h_{fc}$

$R_{i2}' = R_{b2} \| h_{ie}$

$A_{v2} = \dfrac{A_{I2} R_{e2}}{R_{i2}'}$

$R_o = R_{c2}$

$A_{I1} = -h_{fc}$

$R_{i1}' = R_{b1} \| h_{ie}$

$A_{v1} = \dfrac{A_{I1} R_{e1}}{R_{i1}'}$

$R_o = R_{c1}$

Note:-

① $R_L = R_{c1} \| R_{b2} \| h_{ie}$ (output stage of first resistance)

② $R_{c1} \| R_{b2} \| h_{ie}$ → I/p of 2^{nd} stage.

① For a CE-CE Cascade amplifier find the A_V, A_I, R_i, R_o for the parameters given below

First stage

$R_{C1} = 10k\Omega$

$R_1 = 20k\Omega$

$R_2 = 200k\Omega$

$R_E = 10k\Omega$

$R_S = 1k\Omega$

Second stage

$R_{C2} = 5k\Omega$

$R_1 = 50k\Omega$

$R_2 = 300k\Omega$

$R_{E2} = 100k\Omega$

$h_{ie} = 1.2k\Omega$

$h_{re} = 2.5 \times 10^{-4}$

$h_{oe} = 25\mu A/V$

$h_{fe} = 50$

$\boxed{\text{Approximation mode } h_o \cdot R_L < 1}$

$h_{oe} R_L >> 1$ → exact model

$h_{oe} R_L << 1$ → Approxi model

$h_{oe} R_L = h_{oe} = 25\mu A/V \quad R_L = R_{c2} = 5k\Omega$

$h_{oe} R_L = 25 \times 10^{-6} \times 5 \times 10^3$

$h_{oe} R_L = 0.125$

$h_{oe} R_L < 1.$

we can use approximate model

second stage Analysis

$A_{I_2} = -h_{fe} = -50$

$R_{i_2} = h_{ie} = 1.2k\Omega$

Voltage gain $A_{v_2} = \dfrac{A_{I_2} R_{C_2}}{R_{i_2}}$

$= \dfrac{-50 \times 5 \times 10^3}{1.2 \times 10^3} = -208.3$

output impedance $R_{o_1} = R_{C_1} = 10k\Omega$

first stage Analysis:-

Current gain $A_{I_1} = -h_{fe}$

$= -50$

Input impedance $R_{i_1} = h_{ie} = 1.2k\Omega$

$A_{v_1} = \dfrac{A_{I_1}(R_{C_1} \| R_{b_1} \| h_{ie})}{R_{i_1}}$

$h_{oe} = R_{b_1} = R_1 \| R$

$R_1 = 20k\Omega$

$R_2 = 200k\Omega$

$R_{C_1} = 10k\Omega$

$h_{ie} = 1.2k\Omega$

$= \dfrac{-50(10k\Omega \| 20k\Omega \| 200k\Omega \| 1.2k\Omega)}{1200}$

$= \dfrac{-50 \times 102.14}{1200}$

$A_{v_1} = 42.17$

(18) output impedance $R_{o2} = R_{C2} = 5k\Omega$

Overall voltage gain $A_V = A_{V_1} A_{V_2}$

$$= (208.3)(42.1)$$

$$A_V = 8785.2$$

(2) The CE-CC amplifier uses $R_s = 1k\Omega$, $R_{C_1} = 2k\Omega$ $R_{e_2} = 1.2k\Omega$, the h-parameters are $h_{ie} = 1k\Omega$, $h_{fe} = 50$, $h_{re} = 1\times10^{-4}$, $h_{oe} = 10^{-4}$ A/V $h_{ie} = 1k\Omega$, $h_{fe} = 50$, $h_{rc} = 1$, $h_{oc} = 10^{-4}$ A/V compute

a) Input impedance (b) o/p admittance

(c) A_I, A_V for individual stages

d) overall (A_I, A_V)

Sol: $A_{I_2} = \dfrac{-h_{fe}}{1+h_{oc}R_{e2}} = \dfrac{-51}{1+10^{-4}\times 1.2\times10^{3}}$

$$A_{I2} = -45.54$$

$$R_{i2} = h_{ic} + h_{rc} A_{I2} R_{e2}$$

$$R_{i2} = 1\times10^{3} + (1\times45.54)\times 1.2\times10^{3}$$

$$= -53.64$$

$$A_{V_2} = \frac{A_{I_2} R_{e_2}}{R_{i_2}} = \frac{-45.54\times1.2\times10^{3}}{-53.6\times10^{3}}$$

$$A_{V_2} = 1.018$$

$$R_{o1} = h_{oe} - \frac{h_{fe} h_{re}}{h_{ie} + R_s}$$

$$= 1\times10^{-4} - \frac{50\times10^{-4}}{1\times10^{3}+1\times10^{3}}$$

$$R_{o1} = 9.75\times10^{-5}\ A/V$$

$$Y_{o1} = \frac{1}{R_{o1}} = \frac{1}{9.75\times10^{-5}}$$

$$Y_{o1} = 10.26\ k\Omega$$

__First stage Analysis:-__

The net load impedance R_{L1} of first stage is obtained by

$$R_{e_1} = R_{C_1} \| R_{i2}$$

$$= \frac{2k\times53.6k}{2k+53.6k} = 1.92\times10^{3}$$

Current gain $A_{I_1} = \frac{-h_{fe}}{1+h_{oe}R_{e1}}$

$$= \frac{-50}{1+10^{-4}+1.92k} = -41.91$$

$$R_{i1} = h_{ie} + h_{re}A_{I_1}R_{e1}$$

$$= 1k + 10^{-4}\times -41.91\times1.93k$$

$$R_{i1} = 991.91$$

$$A_{v_1} = \frac{A_{I_1}R_{e_1}}{R_{i1}} = \frac{-41.91\times1.93k}{999.91} = -81.5$$

output impedance $= h_{oe} - \frac{h_{fe}h_{re}}{R_s+h_{ie}}$

$$= 10^{-4} - \frac{50\times10^{-4}}{10^{3}+10^{3}}$$

$$R_{o2} = 9.75\times10^{-5}\ A/V$$

$$Y_{o2} = \frac{1}{R_{o2}}$$

$$= \frac{1}{9.75\times10^{-5}} = 10.26k\Omega$$

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* Effect of cascading of Gain

In the earlier sections, gain of a single stage amplifier is computed. In this section, we will compute the overall gain for coupled amplifier using 'n' identical stages.

Let A_{mid} be the individual mid frequency gain of each stage, then overall mid frequency gain of n identical stages will be given by

$$|A_{mid}(overall)| = |A_{mid}| \cdot |A_{mid}| , \dots n$$

$$= |A_{mid}|^n$$

But Gain in low-frequency region is given by,

$$A_{VL} = \frac{A_{mid}}{\sqrt{1+\left(\frac{f_L}{f}\right)^2}}$$

so, overall low frequency gain will be

$$\left|\frac{A_{VL}}{A_{mid}}\right|^n = \frac{1}{\left(\sqrt{1+\left(\frac{f_L}{f}\right)^2}\right)^n}$$

$$\Rightarrow |A_{VL}|^n = \frac{|A_{mid}|^n}{\left[1+\left(\frac{f_L}{f}\right)^2\right]^{n/2}}$$

Hence, in general, the gain of a multistage amplifier at any frequency below lower cut-off frequency can be computed using the above equation.

Ily overall gain of n identical multistage amplifier at any frequency is defined as

$$|A_{VH}|^n = \frac{|A_{mid}|^n}{\left[1+\left(\frac{f}{f_H}\right)^2\right]^{n/2}}$$

CC

$h_{ic} = h_{ie}$

$h_{fc} = -(1+h_{fe})$

$h_{rc} = 1$

$h_{oc} = h_{oe}$

CB

$h_{ib} = \frac{h_{ie}}{1+h_{fe}}$

$h_{fb} = \frac{-h_{fe}}{1+h_{fe}}$

$h_{rb} = \frac{h_{ie}h_{oe}}{1+h_{fe}} - h_{re}$

$h_{ob} = \frac{h_{oe}}{1+h_{fe}}$

(1) Determine voltage gain, A_I, Input Resistance output Resistance

$R_S = 1k\Omega$

$R_{C_1} = 2k\Omega$

$R_{C_2} = 1.2k\Omega$

h-parameter's

CE	CC
$h_{ie} = 1k\Omega$	$h_{ic} = 1k\Omega$
$h_{fe} = 50$	$h_{fc} = 51$
$h_{re} = 1\times10^{-4}$	$h_{rc} = 1$
$h_{oe} = 10^{-4} A/V$	$h_{oc} = 10^{-4} A/V$

Sol: Second stage Analysis

$$A_{I_2} = \frac{-h_{fc}}{1+h_{oe}R_{e_2}} = \frac{1+h_{fe}}{1+h_{oe}R_{e_2}}$$

$$= \frac{1+50}{1+10^{-4}(1.2\times10^3)}$$

$$= 45.53$$

$$R_{i_2} = h_{ic} + h_{rc}A_{I_2}R_{e_2}$$

$$= h_{ie} + (1)(45.53)(1.2\times10^3)$$

$$= 1\times10^3 + (45.53)(1.2\times10^3)$$

$$= 55636$$

$$A_{V_2} = \frac{A_{I_2}R_{L_2}}{R_{i_2}}$$

$$= \frac{(45.53)R_{e_2}}{(55636)} = \frac{(45.53)(1.2\times10^3)}{55636}$$

$$= 0.982$$

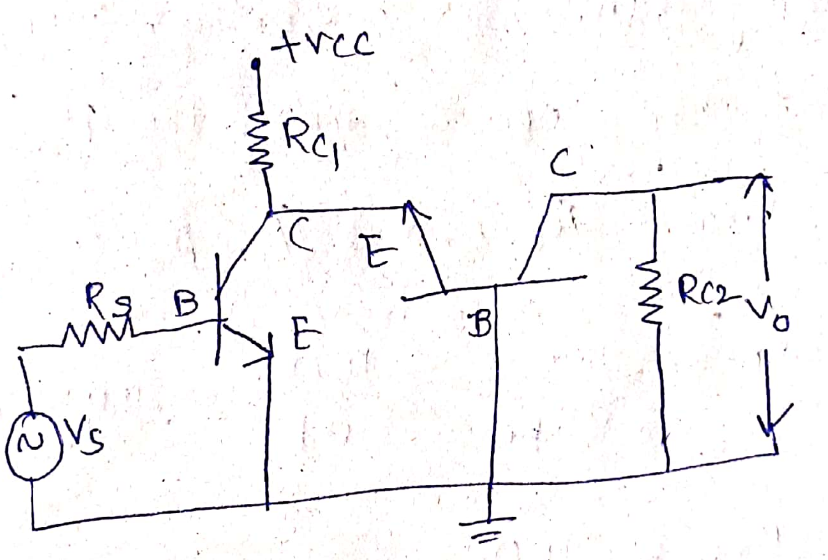
$$Y_o = h_{oc} - \frac{h_{fc} h_{rc}}{R_s + h_{ie}}$$

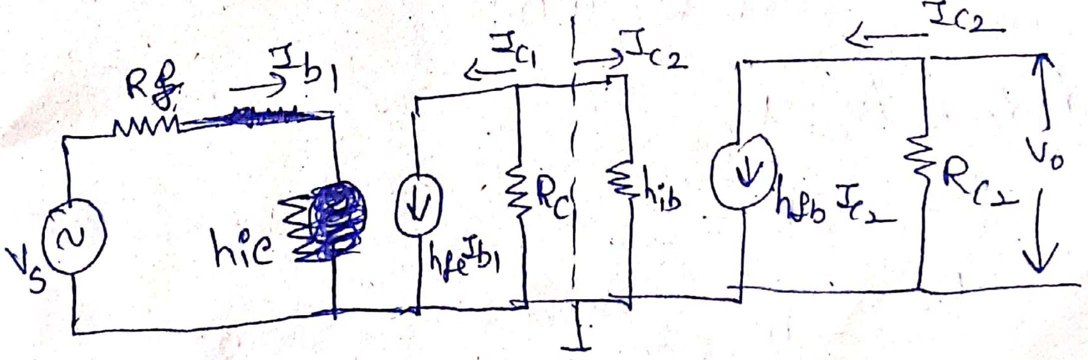
$$= h_{oe} + \frac{(51)(1)}{10^3 + 10^3}$$

$$= 10^{-4} + \frac{51}{10^6}$$

$$= 0.0256$$

* Cascode Amplifier [CE−CB]





Second stage

$A_{I_2} = -h_{fb}$ ~~$\frac{h_{fe}}{1+h_{fe}}$~~ $R_{O2} = R_{C2}$ → CB h_{fb} value

$R_{i_2} = h_{ib}$ ~~$\frac{h_{ie}}{1+h_{fe}}$~~ → CB hib val

$$A_{v_2} = \frac{A_{i_2} \times R_{C_2}}{R_{i_2}}$$

First stage:

$A_{I_1} = -h_{fe}$ $\Rightarrow$ ~~$A_{I_1} = -h_{fe}$~~ $= \frac{h_{fe}}{1+h_{fe}}$

$R_{i_1} = h_{ie}$ $\Rightarrow$ ~~$R_{i_1} = h_{ie}$~~ $= \frac{h_{fe}}{1+h_{fe}}$

$A_{v_1} = \frac{A_{I_2} R_{c_1}}{R_{i_1}}$ $\Rightarrow 1.$

$R_o = R_{c_1} \| h_{ib}$

(1) For the cascode Amplifier $R_c = 2.2$ $R_L = 2.7$ having transistors identical with $h_{ie} = 1.2k$ and $h_{fe} = 100$ neglecting the effect of R_1 and R_2 Derive ~~Av~~ overall (A_v, A_I)

$$A_{I2} = -h_{fb} = \frac{h_{fe}}{1+h_{fe}} = \frac{100}{101} = 0.99$$

$$A_{I1} = -h_{fe} = -100$$

$$A_{v_2} = \frac{A_{i_2} R_{c2}}{R_{i2}}$$

$$R_{i_2} = h_{ib} = \frac{h_{ie}}{1+h_{fe}} = \frac{1.2 \times 10^3}{1+100}$$

$$R_{i_2} = 11.88$$

$$A_{v_2} = \frac{(0.99)(2.2)}{11.88} = 0.183$$

(OR)

Given

$R_C = 2.2\Omega$

$R_L = 2.7\Omega$

$h_{ie} = 1.2k\Omega$

$h_{fe} = 100$

Second stage Analysis

$$A_{I2} = \frac{h_{fe}}{1+h_{fe}}$$

$$= \frac{100}{101} = 0.99.$$

$$R_{i2} = \frac{h_{fe}}{1+h_{fe}} = \frac{100}{101} = 0.99$$

$$A_{V2} = \frac{A_{i2} \times R_{C2}}{R_{i2}} = \frac{0.99 \times 2.7}{0.99}$$

$$= 2.7$$

$R_{O2} = 2.7$

First stage Analysis

$A_{I1} = -h_{fe} = -100$

$R_{i1} = h_{ie} = 1.2k\Omega$

$$A_{V1} = \frac{A_{I1} R_{C1}}{R_{i1}} = \frac{-100}{1.2 \times 10^3} \times 2.2 = -0.183$$

$$R_O = R_{C1} \| \frac{h_{fe}}{1+h_{fe}} \Rightarrow 2.2 \| 0.99$$

$$= 1.3724$$

overall voltage gain $= A_{V_2} \times A_{V_1}$

$= 2.7(-0.018)$

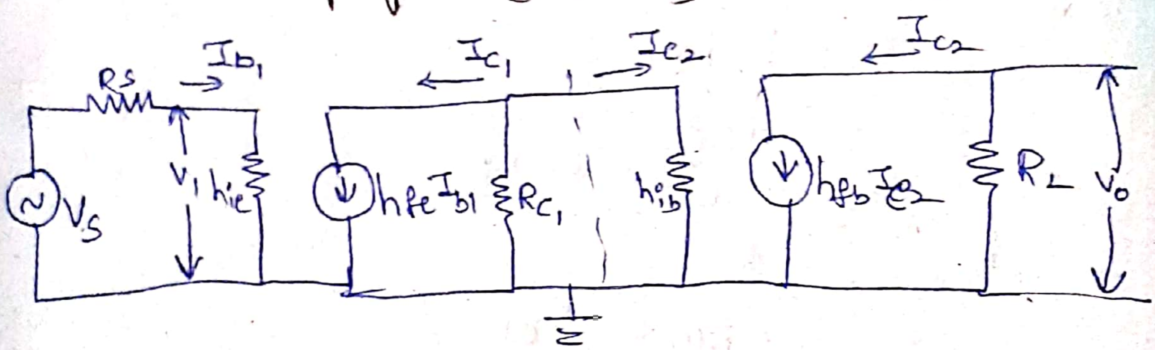
$= -0.468$

overall current gain $= A_{I_2} \times A_{I_1}$

$= 0.99 \times (-100)$

$= -99$

* Cascode Amplifier (CE-CB)



Voltage gain:- $A_V = \frac{V_o}{V_i}$

$V_o = I_o R_L$

$= -I_{c_2} R_L$

$V_o = -h_{fb} I_{e_2} R_L$

$I_2 = I_{c1} \times \frac{R_{c_1}}{R_{c_1} + h_{ib}}$

$I_{c2} = h_{fe} I_{b_1} \frac{R_{c_1}}{R_c + h_{ib}}$

$V_o = \frac{h_{fb} h_{fe} I_{b1} R_c R_L}{R_c + h_{ib}}$

$V_o = \frac{h_{fb} h_{fe} I_{b1} R_c R_L}{R_c + h_{ib}}$

$$V_i = I_{b1} h_{ie}$$

$$A_v = \frac{\dfrac{h_{fb} h_{fe} I_{b1} R_C R_L}{R_C + h_{ib}}}{I_{b1} h_{ie}}$$

$$= \frac{h_{fb} h_{fe} \cancel{I_{b1}} R_C R_L}{(R_C + h_{ib})(\cancel{I_{b1}} h_{ie})}$$

$$A_v = \frac{h_{fb} h_{fe} R_C R_L}{(R_C + h_{ib}) h_{ie}}$$

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

$$h_{fb} = \frac{-h_{fe}}{1 + h_{fe}}$$

$$= \frac{\left(\dfrac{-h_{fe}}{1 + h_{fe}}\right) h_{fe} R_C R_L}{\left(R_C + \dfrac{h_{fe}}{1 + h_{fe}}\right) h_{ie}}$$

$$= \frac{\dfrac{-h_{fe}}{\cancel{1 + h_{fe}}} h_{fe} R_C R_L}{\left(\dfrac{R_C(1 + h_{fe}) + h_{fe}}{\cancel{1 + h_{fe}}}\right) h_{ie}}$$

$$= \frac{-h_{fe}^{2} R_C R_L}{R_C + R_C h_{fe} + \cancel{h_{fe}} h_{ie}} = \frac{-h_{fe} R_C R_L}{R_C(1 + h_{fe}) + h_{ie}}$$

Current gain:- $A_I = \frac{I_o}{I_i}$

$$A_I = \frac{-I_{e2}}{I_{b1}}$$

$$I_{e2} = -h_{fb} I_{c2}$$

$$I_{c2} = I_{c1} \times \frac{R_c}{R_c + h_{ib}}$$

$$I_{c2} = \frac{-h_{fe} I_{b1} R_c}{R_c + h_{ib}}$$

$$I_{c2} = \frac{-h_{fb} h_{fe} I_{b1} R_c}{R_c + h_{ib}}$$

$$A_I = \frac{\frac{-h_{fb} h_{fe} I_{b1} R_c}{R_c + h_{ib}}}{I_{b1}}$$

$$A_I = \frac{-h_{fb} h_{fe} \cancel{I_{b1}} R_c}{(R_c + h_{ib}) \cancel{I_{b1}}}$$

$$A_I = \frac{-h_{fb} h_{fe} R_c}{(R_c + h_{ib})}$$

* Frequency Analysis of CE Amplifier

① A Two Stage RC coupled Amplifier shown in the ckt find A_v, A_I, R_i, R_o

$h_{ie} = 1.2\,k\Omega$

$h_{re} = 2.5 \times 10^{-4}$

$h_{oe} = 25\,\mu A/V$

$\beta = 50$

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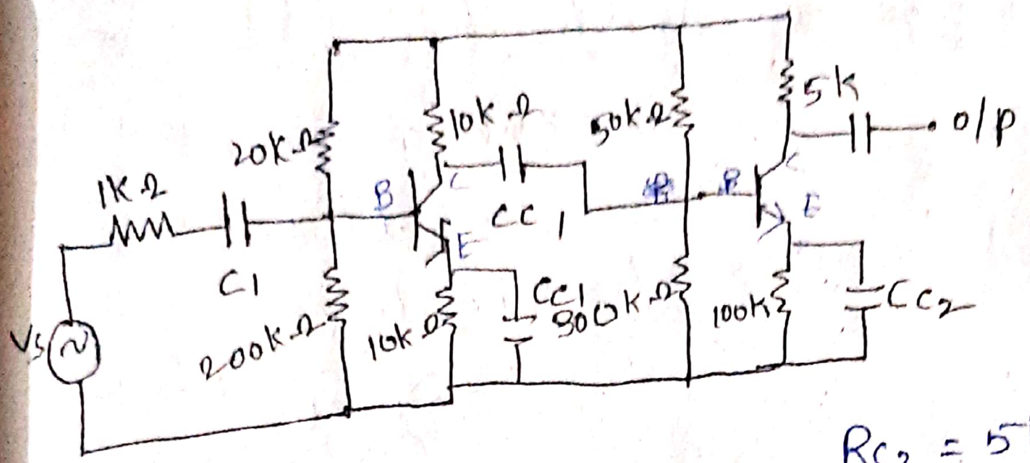

$R_{C2} = 5k\Omega$

$R_1 = 50k\Omega$

$R_2 = 300k\Omega$

$R_{e2} = 100k\Omega$

Second stage Analysis

$A_{I2} = -h_{fe} = -50$

$R_{i2} = h_{ie} = 1.2k\Omega$

$$A_{V_2} = \frac{A_{I2} R_{C2}}{R_{i2}}$$

$$= \frac{(-50)(5\times10^3)}{1.2\times10^3} = -208.3$$

$R_{o2} = R_{C_2} = 5\times10^3$

first stage Analysis:-

$A_{I1} = -h_{fe} = -50$

$R_{i_1} = h_{ie} = 1.2k\Omega$

$$A_{V_1} = \frac{A_{I1}(R_{C_1} \| R_{b_1} \| h_{ie})}{R_{i_1}}$$

$h_{oe} = R_{b1} = R_1 \| R$

$$= \frac{-50(10k\Omega \| 20k\Omega \| 200k\Omega \| 1.2k\Omega)}{1200}$$

$A_{V_1} = 42.17$

$R_{o} = R_{C_1} = 10k\Omega$

overall voltage gain $A_V = A_{V_2} \cdot A_{V_1}$.

$= \cancel{42.11} \cdot (208.3)(42.1)$

$\simeq 8769.2$

overall current gain $A_I = A_{I_2} \cdot A_{I_1}$

$= (-50)(-50)$

$\simeq 2500$

* Frequency Response of an Amplifier

Effect of cascading on bandwidth

For a single stage Amplifier the lower cut of frequency is given by

$$A_{VL} = \frac{A_{mid}}{\sqrt{1+\left(\frac{f_L}{f}\right)^2}} \quad \text{--- (1)}$$

$A_{VL} \rightarrow$ Gain at low frequency

$$A_{VH} = \frac{A_{mid}}{\sqrt{1+\left(\frac{f}{f_H}\right)^2}} \quad \text{--- (2)}$$

$A_{VH} \rightarrow$ Gain at high frequency

*Considering multi stage amplifiers

(a) Lower cutoff frequency at 3dB

$$|A_{mid}|_{overall} = |A_{mid_1}| \cdot |A_{mid_2}| \cdots |A_{mid_n}|$$

$$= |A_{mid}|^n$$

$$|A_n|^n = \frac{|A_{mid}|^n}{\left[\sqrt{1+\left(\frac{f_L}{f}\right)^2}\right]^n}$$

$$\left|\frac{A_{VL}}{A_{mid}}\right|^n = \frac{1}{\left[1+\left(\frac{f_L}{f}\right)^2\right]^{n/2}}$$

$$\frac{1}{\sqrt{2}} = \frac{1}{\left[1+\left(\frac{f_L}{f}\right)^2\right]^{n/2}}$$

$$\left[1+\left(\frac{f_L}{f}\right)^2\right]^n = 2$$

$$1+\left(\frac{f_L}{f}\right)^2 = 2^{1/n}$$

$$\left(\frac{f_L}{f}\right)^2 = 2^{1/n}-1$$

$$\frac{f_L}{f_L(n)} = \sqrt{2^{1/n}-1}$$

$$f_L(n) = \frac{f_L}{\sqrt{2^{1/n}-1}} \rightarrow (3)$$

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(b) Higher cutoff frequency at 3 dB

$$|A_{vH}|^n = \frac{|A_{mid}|^n}{\left[\sqrt{1+\left(\frac{f}{f_H}\right)^2}\right]^n}$$

$$\left|\frac{A_{vH}}{A_{mid}}\right|^n = \frac{1}{\left[1+\left(\frac{f}{f_H}\right)^2\right]^{n/2}}$$

$$\left(\frac{1}{\sqrt{2}}\right) = \frac{1}{\left[1+\left(\frac{f}{f_H}\right)^2\right]^{n/2}}$$

$$\left[1+\left(\frac{f}{f_H}\right)^2\right]^n = 2$$

$$1+\left(\frac{f}{f_H}\right)^2 = 2^{1/n}$$

$$\left(\frac{f}{f_H}\right)^2 = 2^{1/n}-1$$

$$\left(\frac{f}{f_H}\right)^2 = 2^{1/n}-1 \Rightarrow \frac{f_{H(n)}}{f_H} = \left(\sqrt{2^{1/n}-1}\right)$$

$$f_H(n) = f_H\left(\sqrt{2^{1/n}-1}\right) \rightarrow (4)$$

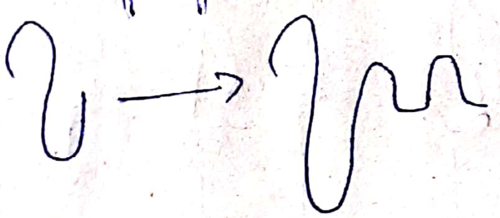
It is clearly observed from the above equations (3) & (4) the low frequency will increased and the high frequency will decreased due to the bandwidth is decreased.

Disortion in Amplifiers

→ Amplitude Distortion
→ frequency Distortion
→ phase Distortion

① Amplitude changes w.r. to time

② we give one i/p the o/p get different types of cycles



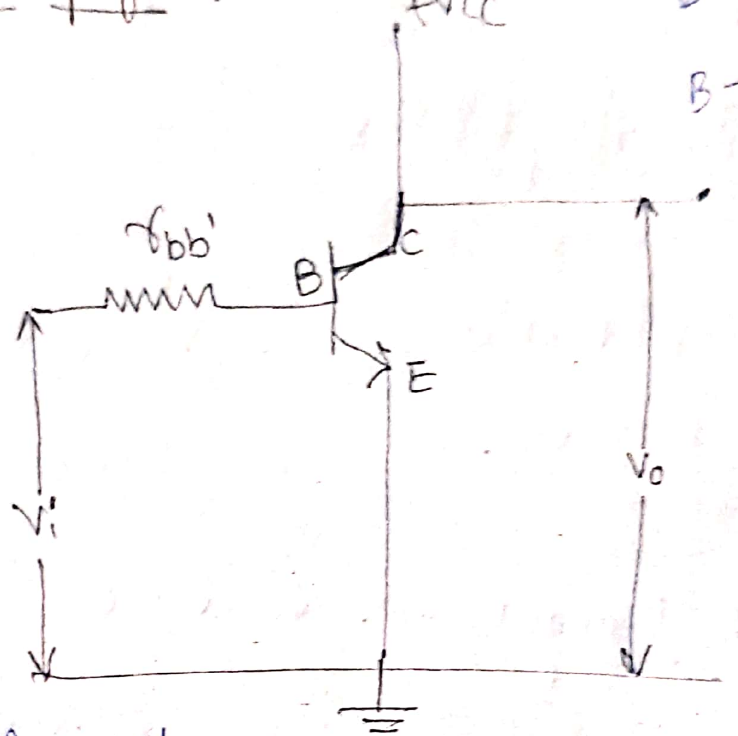
③ change in angle is called phase distortion.

* Hybrid π-Model:-

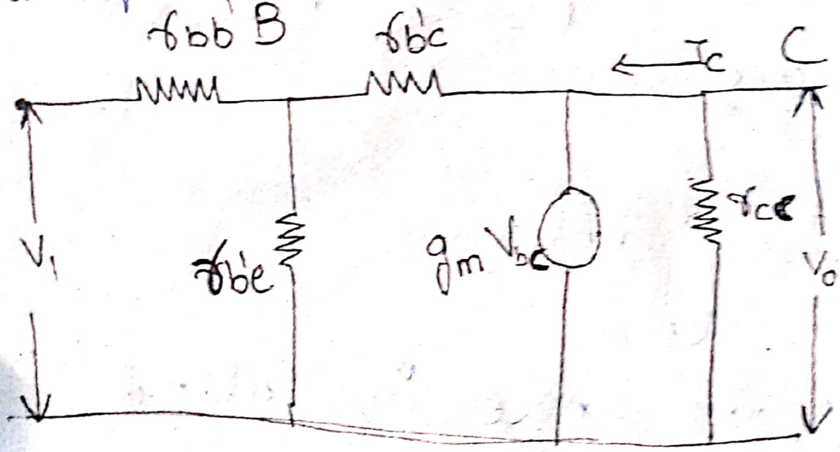
CE amplifier:-

B → C,
B → E

C
↓
E,



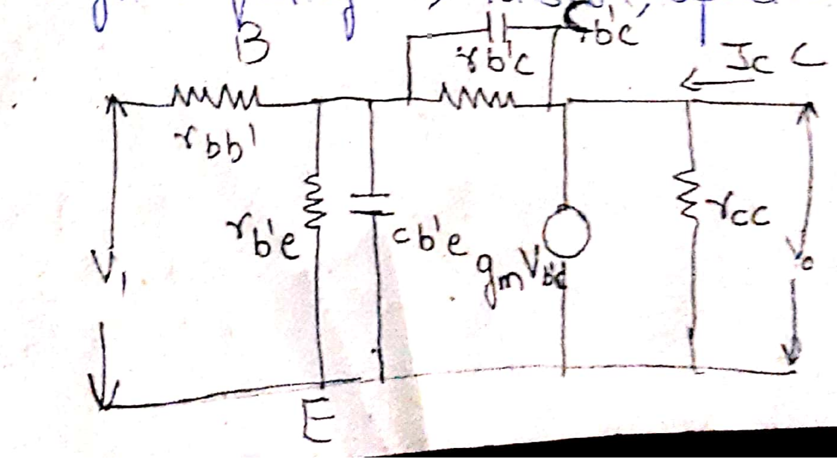
Low frequency



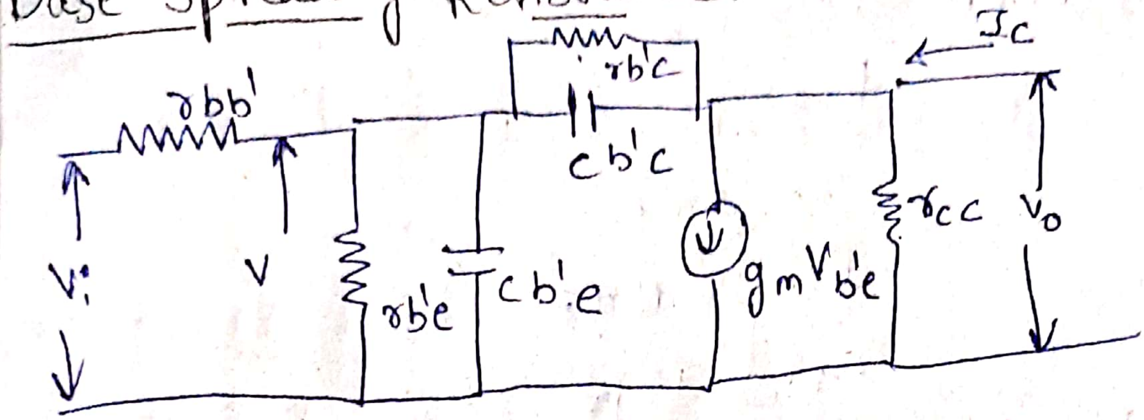
$g_m = \frac{I_c}{V_{b'e}}$

Low frequency → only resistor

High frequency → resistor, capacitor



Base Spreading Resistance:-



(1) $r_{bb'} = h_{ie} - r_{b'e}$

Input conductance:-

$$g_{b'e} = \frac{g_m}{h_{fe}}$$

Feed back conductance:-

$$g_{b'c} = \frac{h_{re}}{r_{b'e}}$$

output conductance:-

$$g_{ce} = h_{oe} - g_m h_{re}$$

Collector Junction capacitances $\quad V_T = 26mV$

$$C_E = \frac{g_m}{2\pi f_T} \qquad g_m = \frac{I_C}{V_T}$$

(1) A BJT has $h_{ie} = 6K\Omega$, $h_{fe} = 224$, ~~at~~ $I_C = 1mA$ with $f_T = 80MHz$, $C_{b'c} = 12pf$ Determine

(i) g_m (ii) $r_{b'e}$ (iii) $r_{bb'}$ (iv) $C_{b'e}$ at room temp & a collector current of $1mA$.

Sol. Given $h_{ie} = 6k\Omega$

$h_{fe} = 224$

$I_C = 1mA$

$f_T = 80MHz$

$C_{b'c} = 12\,pf$

(i) $g_m = \frac{I_c}{V_T} = \frac{1\times 10^{\cancel{-3}}}{26\times 10^{\cancel{-3}}} = 0.03$

(ii) $r_{b'e} = \frac{h_{fe}}{g_m} = \frac{224}{0.03} = 5894.73$

$= 5.89 k\Omega$

(iii) $r_{bb'} = h_{ie} - r_{b'e}$

$= 6\times 10^3 - 5.89\times 10^3$

$= 0.11 k\Omega$

(iv) $C_{b'e} = C_E = \frac{g_m}{2\pi f_T} = \frac{0.03}{2\pi \times 80\times 10^6}$

$= 7.563\times 10^{-11}$

Reasonable values of CE and $C_{b'e}$ are 3pF & 100 pF respectively.

The following low frequency parameters are known for a given transistor at $I_C = 10mA$, $h_{ie} = 500\Omega$

$h_{fe} = 100$, $I_C = 10mA$, $f_T = 50HZ$, $h_{oe} = 10^{-5}$

$V_{CE} = 10V$, $h_{re} = 10^{-4}$, $C_{ob} = 3pF$

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Find hybrid π-model parameters.

Sol: $g_m = \frac{I_c}{V_T} = \frac{10 \times 10^{-3}}{26 \times 10^{-3}} = 0.038$

$C_{b'e} = \frac{g_m}{2\pi f_T} = \frac{0.038}{2\pi \times 50} = 1.22\,mF.$

$g_{b'e} = \frac{g_m}{h_{fe}} = \frac{0.038}{100} = 3.8 \times 10^{-3} = 3.8\,mA$

$g_{b'c} = \frac{h_{re}}{r_{b'e}} = \frac{10^{-4}}{263.15} = 3.80 \times 10^{-7}$

$r_{b'e} = \frac{h_{fe}}{g_m} = \frac{100}{0.038} = 263.15$

$g_{ce} = h_{oe} - g_m h_{re}$

$= 10^{-5} - (0.38)(10^{-4})$

$= -2.8 \times 10^{-5}$

$r_{bb'} = h_{ie} - r_{b'e}$

$= 500 - 263.15$

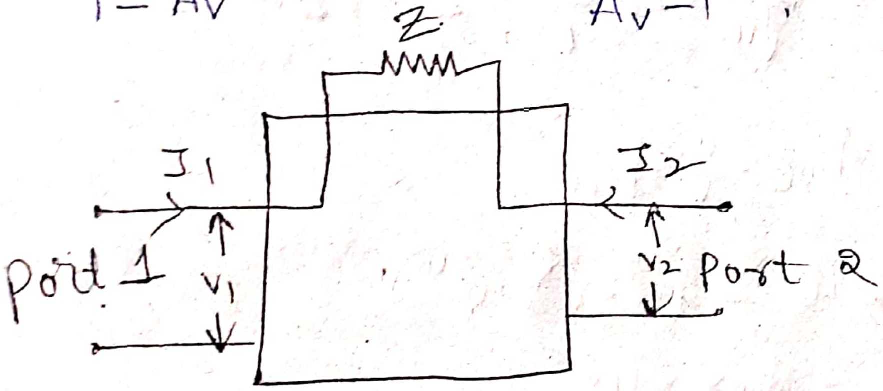
$= 239.59$

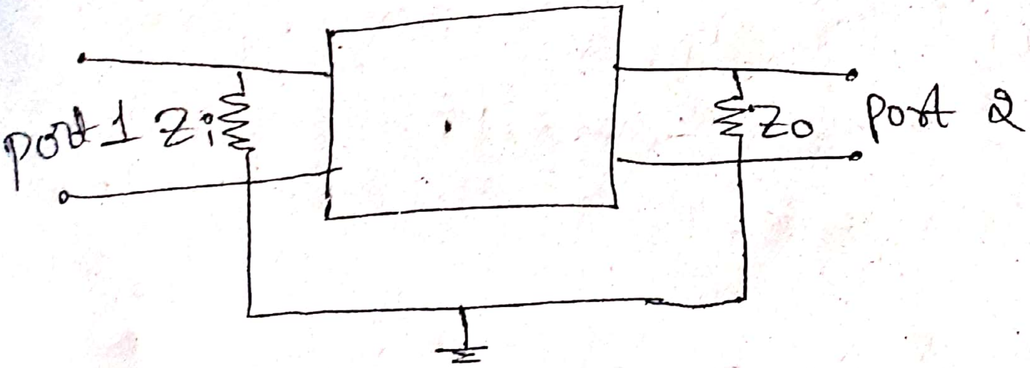
$C_{ob} \rightarrow I_o$

* Miller's Theorem

Statement: In any linear bilateral two port network, if an impedance Z is connected between the input and output terminal of the network with a voltage gain A_v, an equivalent ckt that gives the same effect can be drawn by removing Z and connecting an impedance ~~at~~ the i/p

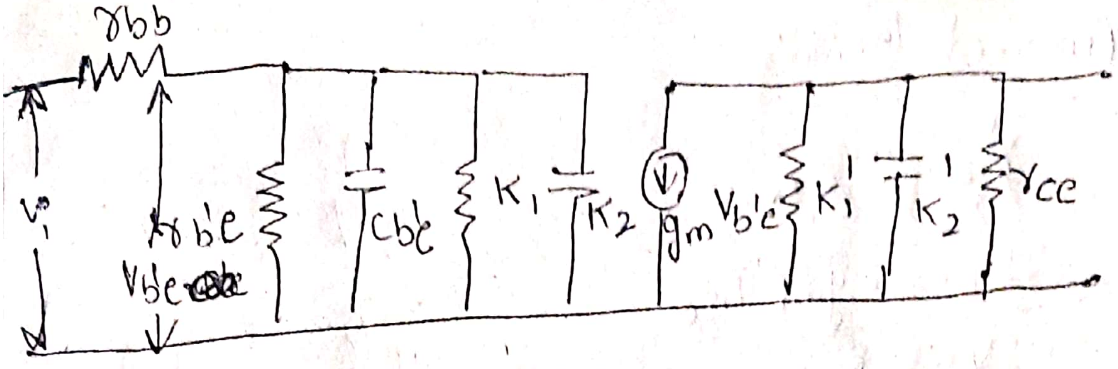
$Z_i = \dfrac{Z}{1 - A_v}$ and $Z_o = \dfrac{Z A_v}{A_v - 1}$ across the o/p



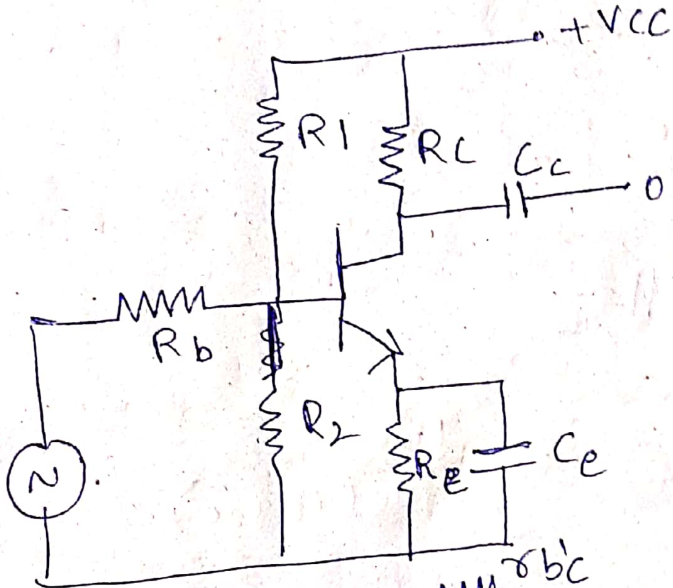


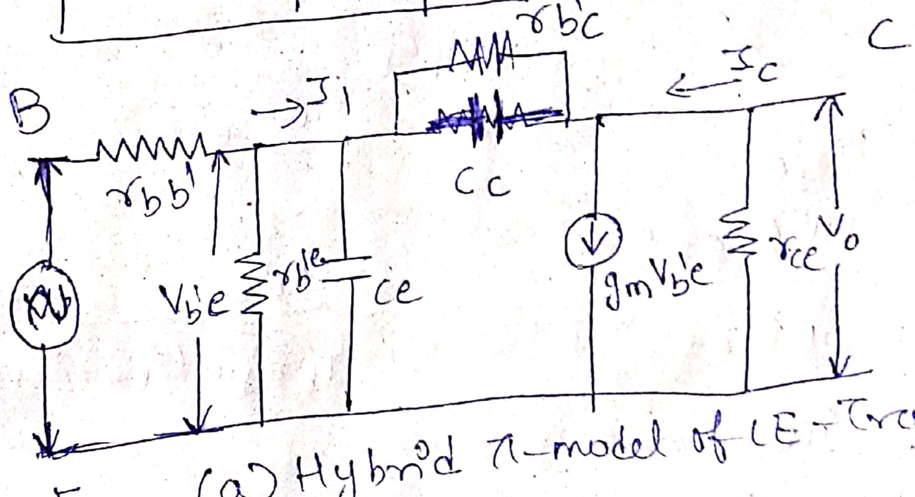
$K_1 = \dfrac{r_{b'c}}{1 - A_v}$ $\qquad$ $K_1' = \dfrac{r_{b'c} A_v}{A_v - 1}$

$K_2 = \dfrac{r_{b'c}}{1 - A_v}$ $\qquad$ $K_2' = \dfrac{C_{b'c} A_v}{A_v - 1}$

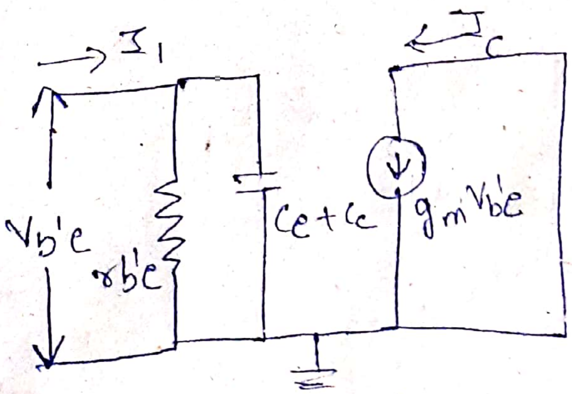


CE short ckt current gain:-





(a) Hybrid π-model of CE-Transistor



(b) Approximation model

* Current Gain:

$$A_I = \frac{I_L}{I_1}$$

$$I_L = -g_m V_{b'e}$$

$$V = IR$$

$$V_{b'e} = I_1 \times r_{b'e} \parallel \frac{1}{j\omega C}$$

$$C = C_e + C_c$$

$$C_{b'e} + C_{b'c}$$

$$I_1 = \frac{V_{b'e}}{r_{b'e} \parallel \frac{1}{j\omega(C_e+C_c)}}$$

$$r_{b'e} \parallel \frac{1}{j\omega(C_e+C_c)} = \frac{\frac{r_{b'e}}{j\omega(C_e+C_c)}}{r_{b'e} + \frac{1}{j\omega(C_e+C_c)}}$$

$$= \frac{\frac{r_{b'e}}{\cancel{j\omega(C_e+C_c)}}}{\frac{r_{b'e}\,j\omega(C_e+C_c)+1}{\cancel{j\omega(C_e+C_c)}}} = \frac{r_{b'e}}{r_{b'e}\,j\omega(C_e+C_c)+1}$$

$$I_1 = \frac{V_{b'e}}{\frac{r_{b'e}}{r_{b'e}\,j\omega(C_e+C_c)+1}}$$

$$I_1 = \frac{V_{b'e}\left[r_{b'e}\,j\omega(C_e+C_c)+1\right]}{r_{b'e}}$$

$$V_{b'e} = \frac{I_1 r_{b'e}}{r_{b'e}\, j\omega (C_e + C_c) + 1}$$

$$I_c = -g_m V_{b'e}$$

$$I_c = -g_m \left[\frac{I_1 r_{b'e}}{r_{b'e}\, j\omega (C_e + C_c) + 1} \right]$$

$$-\frac{I_c}{I_1} = \frac{g_m r_{b'e}}{r_{b'e}\, j\omega (C_e + C_c) + 1}$$

$$A_I = \frac{g_m r_{b'e}}{r_{b'e}\, j\omega (C_e + C_c) + 1}$$

$$A_I = \frac{-h_{fe}}{1 + r_{b'e}\, j\omega (C_e + C_c)}$$

where $\omega_\beta = \frac{1}{r_{b'e}(C_e + C_c)}$, $f_\beta = \frac{1}{2\pi r_{b'e}(C_e + C_c)}$

$$A_I = \frac{-h_{fe}}{1 + j\left(\frac{\omega}{\omega_\beta}\right)}$$

$$= \frac{-h_{fe}}{1 + j\left(\frac{f}{f_\beta}\right)}$$

$f_\beta \rightarrow$ cutoff frequency

* f_α (cut off frequency for CE)

$$A_I = \frac{I_2}{I_1}$$

$$= \frac{-h_{fe}}{1 + j\left(\frac{f}{f_\beta}\right)}$$

$$f_\alpha = \frac{1}{2\pi r_{b'e}(1+h_{fe})C_{b'c}}$$

$$f_\alpha = \frac{h_{fe}}{2\pi r_{b'e} C_{b'e}}$$

$$f_\beta = \frac{1}{2\pi r_{b'e}(C_{b'e} + C_{b'c})}$$

$$\cancel{A_I = \frac{I_2}{I_1} = \frac{-h_{fe}}{1 + j\left(\frac{f}{f_\beta}\right)}}$$

$$f_\alpha = \frac{f_\alpha C_{b'e}}{h_{fe}(C_b + C_e)}$$

$$f_\alpha = \frac{h_{fe} f_\beta (C_e + C_c)}{C_{b'e} \text{ or } C_e}$$

24 * f_T (unity gain frequency)

when the current gain is tends to be unity..

we have $|A_I| = \left| \frac{h_{fe}}{1 + j\omega\left(\frac{f}{f_\beta}\right)} \right|$

$$A_I = \frac{h_{fe}}{\sqrt{1+\left(\frac{f}{f_\beta}\right)^2}}$$

$A_I = 1$, $\frac{f}{f_\beta} >> 1$, $f = f_T$

$$1 = \frac{h_{fe}}{\frac{f_T}{f_\beta}} \Rightarrow \frac{f_T}{f_\beta} = h_{fe}$$

$$\therefore \boxed{f_T = h_{fe} f_\beta}$$

① The following data for the parameters of BJT $I_C = 2mA$, $V_{CE} = 10V$ at room temp $h_{fe} = 15$, $f_T = 15MHz$, $C_{b'c} = 3pF$. Calculate g_m, $r_{b'e}$, f_β, f_α and $C_{b'e}$

② If short ckted $A_I = 50$ CE amplifier at frequency of 5MHz, $f_\beta = 1MHz$, Calculate f_T, h_{fe}

1) Sol: $g_m = \frac{I_C}{V_T} = \frac{\cancel{2}^{1} \times 10^{-3}}{\cancel{26}_{13} \times 10^{-3}} = 0.076$

$$r_{b'e} = \frac{h_{fe}}{g_m} = \frac{15}{0.076} = 197.3$$

$$C_{b'e} = \frac{g_m}{2\pi f_T} = \frac{0.076}{2\pi \times 15 \times 10^6} = 8.06 \times 10^{-10}$$

$$f_\beta = \frac{1}{2\pi(197.36)(8.06\times10^{-10} + 3\times10^{-12})}$$

$$= 196830245.7$$

$$f_\alpha = \frac{h_{fe} f_\beta (C_e + C_c)}{C_{b'e}}$$

$$f_\alpha = \frac{(15)(196830245.7)(8.06\times10^{-10} + 3\times10^{-12})}{8.06\times10^{-10}}$$

$$f_\alpha = 2963446149$$

Derive, A_I (current gain), voltage gain, I/p Resistance, O/P Resistance of Darlington pair.

2 Sol: Given

$A_I = 50$

$f = 5\times10^{6}\,Hz$

$f_\beta = 10^{6}\,Hz$

$$A_I = \frac{h_{fe}}{\sqrt{1+\left(\frac{f}{f_\beta}\right)^2}}$$

$$50 = \frac{h_{fe}}{\sqrt{1+\left(\frac{5\times\cancel{10^6}}{\cancel{10^6}}\right)^2}}$$

$$50 = \frac{h_{fe}}{\sqrt{1+25}}$$

$$50\sqrt{26} = h_{fe}$$

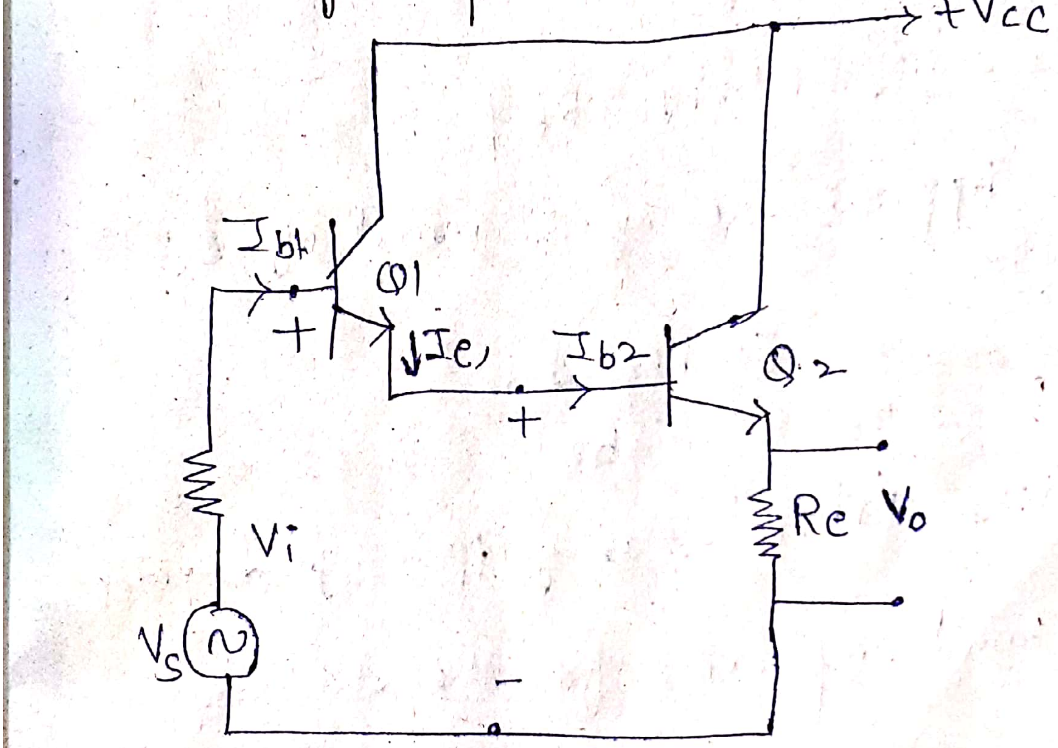
$$h_{fe} = 254.950$$

$$f_T = h_{fe} f_\beta$$

$$= (254.950)(10^6)$$

$$f_T = 254950 \, mA$$

* Darlington pair



A single stage Emitter follower (Common Collector Amplifier) can produce current gain and input impedance i.e.; large in comparison to CB & CE configuration.

To increase that current gain and input

impedance further, we can connect Emitter followers in cascade. Such a cascaded condition is known as Darlington pair.

The purpose of darlington ckt. is to ↑ the current gain & i/p impedance

$$Z_{i2} = \text{Input impedance of second stage} = \frac{V_{b2}}{V_{b2}}$$

$$Z_{i2} = \frac{h_{ie} I_{b2} + (1+h_{fe}) I_{b2} R_e}{I_{b2}}$$

$$\boxed{Z_{i2} = h_{ie} + (1+h_{fe}) R_e}$$

From Approximate hybrid model of CE amplifier

$$A_{I2} = \frac{I_{e2}}{I_{b2}} = \frac{(1+h_{fe}) I_{b2}}{I_{b2}}$$

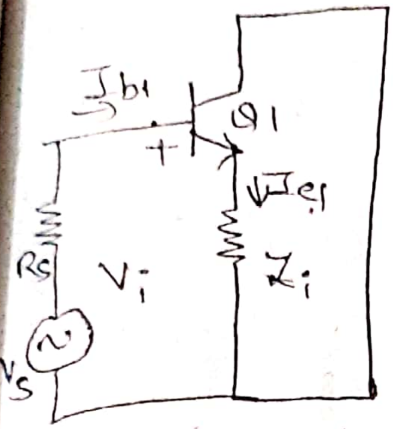
$$\boxed{A_{I2} = 1+h_{fe}} \rightarrow \text{using Approx hybrid model}$$

The Load impedance for the 1st stage is Z_{L1}

$$Z_{L1} = Z_{i2} \| \infty = Z_{i2}$$

Since the condition $h_{oe} Z_L < 0.1$, we cannot use the Approximate hybrid model there whose the analysis of 1st stage.

Therefore Exact hybrid model have to used.



First stage of i/p impedance is

$$Z_{i_1} = h_{ie} + h_{rc} A_I \times Z_{i_2}$$

$$h_{rc} = 1 - h_{re}$$

$$h_{re} << 1$$

$$h_{rc} \simeq 1$$

$$Z_{i_1} = h_{ie} + A_{I_1} Z_{i_2}$$

$$Z_{i_1} = h_{ie} + A_{I_1}\left[h_{ie} + (1+h_{fe})R_e\right]$$

$$A_{I_1} = \frac{I_{e1}}{I_{b1}} = \frac{-h_{fc}}{1+h_{oc}Z_{i_2}} = \frac{(1+h_{fe})}{1+h_{oe}\left[h_{ie}+(1+h_{fe})R_e\right]}$$

$$A_{I_1} = \frac{1+h_{fe}}{1+h_{ie}h_{oe}+h_{oe}(1+h_{fe})R_e} \rightarrow (2)$$

$$Z_i = h_{ie} + \frac{(1+h_{fe})\left[h_{ie}+(1+h_{fe})R_e\right]}{1+h_{ie}h_{oe}+h_{oe}(1+h_{fe})R_e}$$

$$(1+h_{fe})R_e >> h_{ie}$$

$$h_{oe}(1+h_{fe})R_e >> h_{ie}h_{oe}$$

$$Z_{i_1} = h_{ie} + \frac{(1+h_{fe})(1+h_{fe})R_e}{1+h_{oe}(1+h_{fe})R_e}$$

$$Z_{i_1} = h_{ie} + \frac{(1+h_{fe})^2 R_e}{(1+h_{oe}(1+h_{fe})R_e}$$

$$Z_i \simeq (1+h_{fe})^2 R_e$$

$$\boxed{Z_i \simeq h_{fe}^2 R_e}$$

The overall current gain

$$A_I = \frac{I_{e2}}{I_{b1}}$$

$$A_I = \frac{I_{e2}}{I_{b2}} \times \frac{I_{b2}}{I_{b1}} \quad \Big| \; I_{b2} = I_e$$

$$A_I = \frac{I_{e2}}{I_{b2}} \times \frac{I_{e1}}{I_{b1}}$$

$$A_I = A_{I_2} \times A_{I_1}$$

$$\boxed{\begin{aligned} A_I &= (1+h_{fe})^2 \\ R_i &= h_{fe}^2 R_e \end{aligned}}$$

$$A_I = \frac{(1+h_{fe})(1+h_{fe})}{1+h_{fe} h_{oe} + (1+h_{fe}) h_{oe} R_e}$$

More than two stages of darlington connection is not used pratically because the reverse saturation current at the final stage will be very high. which will make the Amplifier stage unstable

* **Gain Bandwidth products:-**

(2M) **Gain Bandwidth product for voltage:-** (GBWVp)

It is the product of Amplifer B.W and the gain in which the B.W is measured.

→ The GBWVp is given by

$$A_{vs(low)} \times f_H = \frac{h_{fe} R_L}{R_s + h_{ie}} \times \frac{1}{2\pi R_{eq} C_{eq}}$$

$A_{vs} \Rightarrow$ overall voltage gain

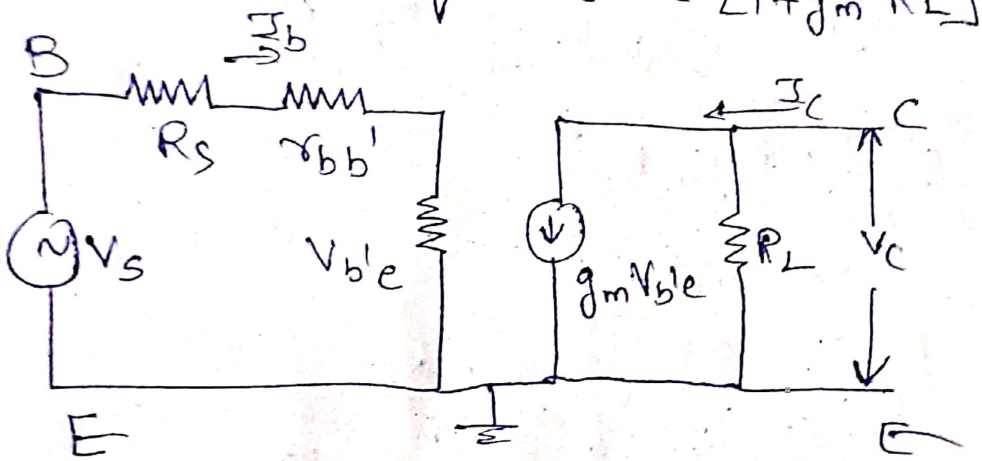
* Note: $$A_{vs(low)} = \frac{h_{fe} R_L}{R_s + h_{ie}}$$

$$f_H = \frac{1}{2\pi R_{eq} C_{eq}} \qquad h_{fe} = g_m r_{b'e}$$

$$h_{ie} = r_{bb'} + r_{b'e}$$

where $R_{eq} = r_{b'e} \| (r_{bb'} + R_s)$ and

$$C_{eq} = C_e + C_c\left[1 + g_m R_L\right]$$



$$r_{b'e} \| (r_{bb'} + R_s) = \frac{r_{b'e}(r_{bb'} + R_s)}{r_{b'e} + r_{bb'} + R_s}$$

$$= \frac{h_{fe} R_L}{R_s + h_{ie}} \times \frac{1}{2\pi C_{eq}\left[\dfrac{r_{b'e}(r_{bb'} + R_s)}{r_{b'e} + r_{bb'} + R_s}\right]}$$

$$= \frac{h_{fe} R_L}{\cancel{R_s + h_{ie}}} \times \frac{\cancel{R_s + h_{ie}}}{2\pi C_{eq}\, r_{b'e}(r_{bb'} + R_s)}$$

$$= \frac{h_{fe} R_L}{2\pi C_{eq} r_{b'e} (r_{bb'} + R_s)}$$

$$= \frac{g_m \cancel{r_{b'e}} R_L}{2\pi C_{eq} \cancel{r_{b'e}} (r_{bb'} + R_s)}$$

$$= \frac{g_m}{2\pi C_{eq}} \cdot \frac{R_L}{(R_s + r_{bb'})}$$

$$= \frac{g_m}{2\pi [C_e + C_c (1 + g_m R_L)]} \cdot \frac{R_L}{R_s + r_{bb'}}$$

$$C_c [1 + g_m R_L]$$

$$= C_c g_m R_L$$

$$= \frac{g_m}{2\pi [C_e + C_c g_m R_L]} \cdot \frac{R_L}{R_s + r_{bb'}}$$

where $f_T = \dfrac{g_m}{2\pi C_e}$

$$g_m = f_T 2\pi C_e$$

$$= \frac{f_T 2\pi C_e}{2\pi [C_e + C_c (f_T 2\pi C_e) R_L]} \cdot \frac{R_L}{R_s + r_{bb'}}$$

$$= \cancel{\frac{f_T 2\pi C_e}{2\pi C_e [1 + f_T C_c R_L]} \cdot \frac{R_L}{R_s + r_{bb'}}}$$

$$A_{VS(low)} \times f_H = \frac{f_T}{\cancel{1+2\pi f_T C_c R}}$$

$$= \frac{f_T\, 2\pi C_e}{2\pi C_e + 2\pi C_c f_T\, 2\pi C_e R_L} \cdot \frac{R_L}{R_S + r_{bb'}}$$

$$= \frac{\cancel{2\pi C_e} \cdot f_T}{\cancel{2\pi C_e}\left[1 + 2\pi C_c f_T R_L\right]} \cdot \frac{R_L}{R_S + r_{bb'}}$$

$$\boxed{A_{VS(low)} \times f_H = \frac{f_T}{\left[1 + 2\pi C_c f_T R_L\right]}\left(\frac{R_L}{R_S + r_{bb'}}\right)}$$

* Gain Bandwidth product for current

The GBWIp is given by

$$A_{IS(low)} \times f_H = \frac{h_{fe} \boxed{R_S}}{R_S + h_{ie}} \times \frac{1}{2\pi R_{eq} C_{eq}}$$

R_L

$$A_{IS(low)} \times f_H = \left(\frac{f_T}{1 + 2\pi f_T C_c R_S}\right)\left(\frac{R_S}{R_S + r_{bb'}}\right)$$

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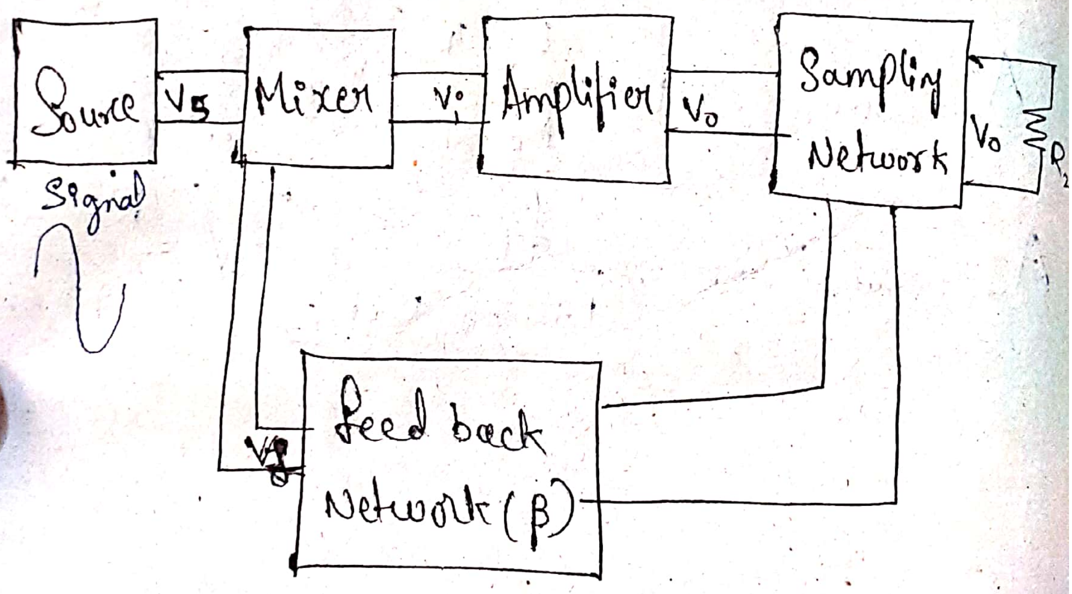
Unit - 2 Feed back Amplifiers:

* Block diagram of feedback Amplifier

Amplifier → which strengthens the weak signals to high signals

feed back Amplifier → The o/p of the amplifier is connected back to the i/p. is known as feed back

Purpose:- To reduce the noise and distortion



A_V / A_T / A / Gain of open loop

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

$$A_f = \frac{V_o}{V_S}$$ (Gain in feed / closed loop)

feed back ratio $\beta = \frac{V_f}{V_o}$

Types of feed back amplifiers

1. Negative feed back
2. positive feed back

* positive feed back amplifier:-
  If source signal & feed back signal both are in phase it is called positive feed back amplifier.

* Negative feed back amplifier:-
out of phase with each other

* positive feed back:-

$V_i = V_s + V_f$ $\quad\quad \beta = \frac{V_f}{V_o}$ $\quad\quad \beta = \frac{V_f}{V_o}$

$V_s = V_i - V_f$ $\quad\quad V_f = \beta V_o$

$= V_i - \beta V_o$

$V_s = V_i - \beta A V_i$

$\frac{V_s}{V_o} = \frac{V_f(1-\beta A)}{V_o}$

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

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

If $A\beta = 1$

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

$$A_f = \frac{A}{0} = \infty$$

If gain $\rightarrow \infty$ then ckt will be acts as an oscillator.

Disadvantages:-

→ B.W decreases, gain increases, noise decreases and Distortion ~~de~~ increases.

* Negative feed back

→ If source signal and feed back signal out of phase is known as negative feed back amplifier.

$$V_i = V_s - V_f$$

$$V_s = V_i + V_f$$

$$= V_i + \beta V_o$$

$$= V_i + \beta A V_i$$

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

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

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

if $A\beta = 1$

$$A_f = \frac{A}{2}$$

Gain → finite

disadvantages:-

→ B.W increases

→ Gain ~~decreases~~ finite

→ Noise ~~de~~ increases

→ Distortion decrease

* Sensitivity:-

We know that -ve feed back gain is given by $A_f = \frac{A}{1+A\beta} \rightarrow (1)$

$\frac{vu' - uv'}{v^2}$

diff eq (1) w.r.t A

$$\frac{\partial A_f}{\partial A} = \frac{\partial}{\partial A}\left[\frac{A}{1+A\beta}\right]\frac{u}{v} = \frac{(1+A\beta)(1) - (A)(\beta)}{(1+A\beta)^2}$$

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

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

$$\frac{\partial A_f}{\partial A} = \frac{1}{(1+A\beta)^2}$$

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

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

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

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

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

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

$$\boxed{D_S = 1+A\beta}$$

(1) Calculate the gain of a -ve feed back amplifier, with an internal gain 100 and feedback collector 1/10

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

Internal Gain $A = 100$

$$\beta = \frac{1}{10} = 0.1$$

$$A_f = \frac{100}{1+100(0.1)} = 9.090$$

(2) An amplifier with -ve feed back has a voltage gain of 100 if is found that without feedback an input signal of 50mV is

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required to produce a gain output, ~~50mV~~ whereas with feedback, the i/p signal must be 0.6V for the same o/p calculate the value of A & β.

$100 \times \frac{6}{10}$

$A_f = 100$

$V_i = 50mV$

without feedback V_i/V_o

$V_s = 0.6V$ $V_o = A_f V_s = 60V$

with feedback V_o/V_s

$A_f = \frac{V_o}{V_s}$ $\frac{1200}{1+(1200)(\frac{V_f}{60})} = 100$ $\Rightarrow V_f = 0.55$

$V_o = (100)(0.6)$

$V_o = 60V$

$\beta = \frac{V_f}{V_o} = \cancel{\frac{50\times10^{-3}}{60}}$ 9.16mA ~~= 1200 = 8.33×10^{-4}~~ = 0.83mA

$A = \frac{60}{50\times10^{-3}} = 1200$

③ An amplifier has a open loop gain of 100 an feed back ratio of 0.04. If the open loop gain changes by 10% due to temperature, find the percentage change in gain of the amplifier with feedback.

$\beta = 0.04$ $\frac{\partial A}{A} = 10\%$

$A = 100$ $\frac{\partial A_f}{A_f} = ?$

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

$$= \frac{10}{100} \times \frac{1}{1+(100)(0.04)}$$

$$= 0.02$$

Characteristics of -ve feedback amplifiers

1. Stability of gain $S = \frac{1}{1+A\beta}$
2. Reduction in forward gain $A_f = \frac{A}{1+A\beta}$
3. Reduction in Noise
4. Reduction in distortion
5. Increase in i/p impedance
6. Decrease in o/p impedance
7. Increase in bandwidth

Reduction in distortion.

If D is the distortion of an amplifier then distortion with feedback is given by

$$D_f = \frac{D}{1+A\beta}$$

1.

① If Amplifier has a midgain of 125 an B.W of 250KHZ

(i) If 4% -ve feedback is introduced find the new B.W & Gain.

(ii) If B.W is restricted to 1MHZ find the feedback ratio.

Sol:

$$A = 125$$

$$B.W = 250KHZ$$

$$\beta = 0.4$$

$$A_f = \frac{A}{1+A\beta} = \frac{125}{1+(125)(0.4)} = 2.450$$

$$B.W_f = BW(1+A\beta)$$

$$= 250\times10^3(1+125(0.4))$$

$$= 12750$$

~~$B.W_f = BW(1+A\beta)$~~

~~$= 250\times10^3(1+125(10^6))$~~

$$= 3.125\times10^{13}\ HZ$$

$$1MHZ = 250\times10^3(1+A\beta)$$

$$\frac{1\times10^6}{250\times10^3} = 1+A\beta$$

Topologies
* classifications of -ve feedback amplifier

-ve feedback amplifiers are classified into 4 types

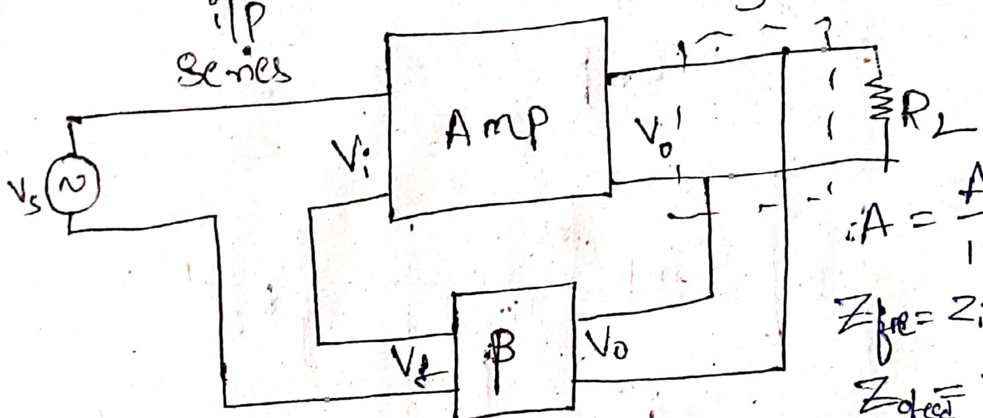
1. voltage series feedback
2. voltage shunt feedback
3. Current series feedback
4. Current shunt feedback

(1) Voltage series feedback / shunt series

Voltage (o/p) Series (i/p)

Shunt (o/p)

i/p Series

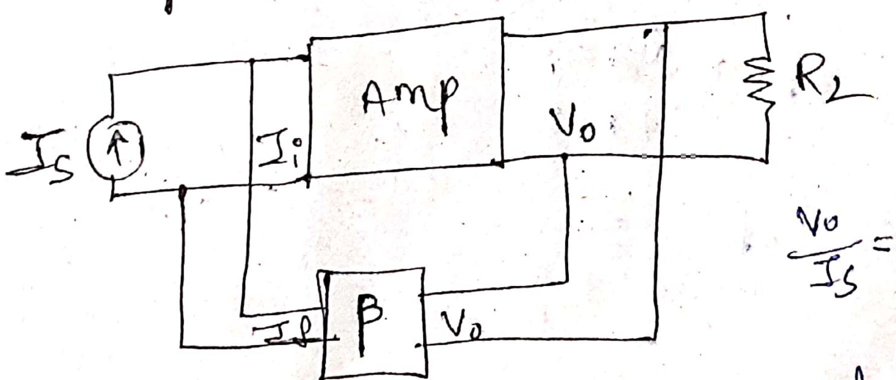


$$A = \frac{A_v}{1+A_v\beta}$$

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

$$Z_{of} = \frac{\cancel{Z}}{1+A\beta}$$

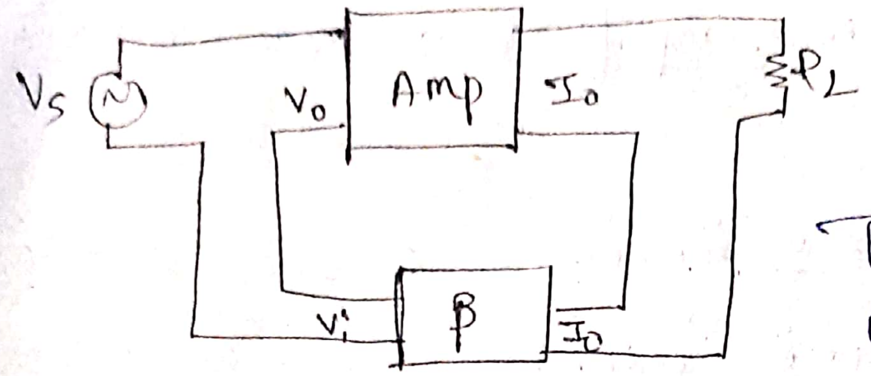
(2) Voltage shunt feedback / Trans resistance



$$\frac{V_o}{I_s} = R_m$$

$\frac{V_o}{I_s}$ (i/p shunt) → current divide

$$R_{mf} = \frac{R_m}{1+R_m\beta}$$



Trans Conductance Amp

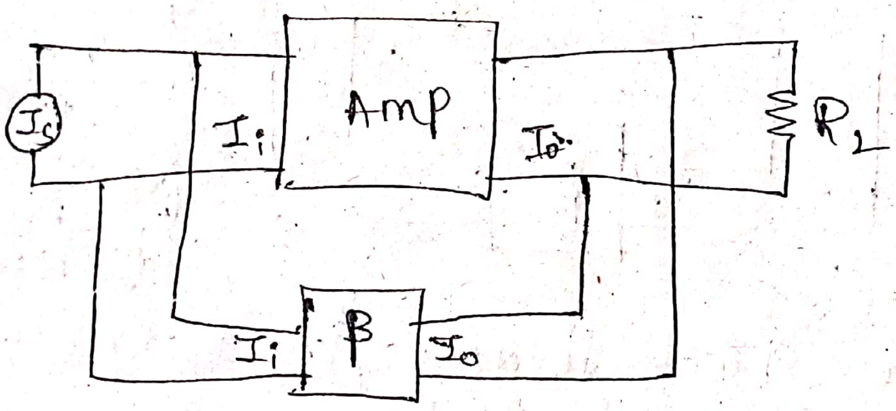
$$G_m = \frac{I}{V}$$

$$Z_{if} = Z_i(1 + G_m\beta).$$

$$Z_{o\,feed} = Z_o(1 + G_m\beta)$$

$$G_{mf} = \frac{G_m}{1 + G_m\beta}$$

(4)



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

$$Z_{of} = \frac{Z_o}{1 + A_I\beta}$$

Bandwidth of a feedback amplifier

Lower cut off frequency:-

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

$$A_{fL} = \frac{A_L}{1+A_L\beta}$$

$$A = \frac{A_{mid}}{1-j\left(\frac{f_L}{f}\right)}$$

$$A_{fL} = \frac{\dfrac{A_{mid}}{1-j\left(\frac{f_L}{f}\right)}}{1+\beta\left(\dfrac{A_{mid}}{1-j\left(\frac{f_L}{f}\right)}\right)}$$

$$A_{fL} = \frac{A_{mid}}{1-j\left(\frac{f_L}{f}\right)+\beta A_{mid}}$$

divide with $1+A\beta$

$$A_{fL} = \frac{\dfrac{A_{mid}}{\cancel{1+A_{mid}\beta}}}{\dfrac{1-j\left(\frac{f_L}{f}\right)+\beta A_{mid}}{\cancel{1+A_{mid}\beta}}}$$

$$A_{fL} = \frac{\frac{A_{fm}}{1-j\left(\frac{f_L}{f}\right)}}{1+A_m\beta} \qquad \left[A_{fm} = \frac{A_m}{1+A_m\beta}\right]$$

$$A_{fL} = \frac{A_{fm}}{1-j\left(\frac{f_L}{f(1+A_m\beta)}\right)}$$

$$A_{fL} = \frac{A_{fm}}{1-j\left(\frac{f_{Lf}}{f}\right)}$$

$$\boxed{f_{Lf} = \frac{f_L}{1+A_m\beta}}$$

higher ~~cutt off~~ cutt off frequency

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

$$A_{fh} = \frac{A}{1+A_h\beta}$$

$$A = \frac{A_{mid}}{1-j\left(\frac{f}{f_h}\right)}$$

$$A_{fh} = \frac{\frac{A_{mid}}{1-j\left(\frac{f}{f_h}\right)}}{1+\beta\left(\frac{A_{mid}}{1-j\left(\frac{f}{f_h}\right)}\right)}$$

$$A_{fh} = \frac{A_{mid}}{1-j\left(\frac{f}{f_h}\right)+\beta A_{mid}}$$

divide with $1+A\beta$

$$A_{fh} = \frac{\frac{A_{mid}}{1+A_{mid}\beta}}{\frac{1-j\left(\frac{f}{f_h}\right)+\beta A_{mid}}{1+A_{mid}\beta}}$$

$$A_{fh} = \frac{A_{fm}}{\frac{1-j\left(\frac{f}{f_h}\right)}{1+A_{mid}\beta}}$$

$$A_{fh} = \frac{A_{fm}}{1-j\left[\frac{f}{f_h(1+A_{mid}\beta)}\right]}$$

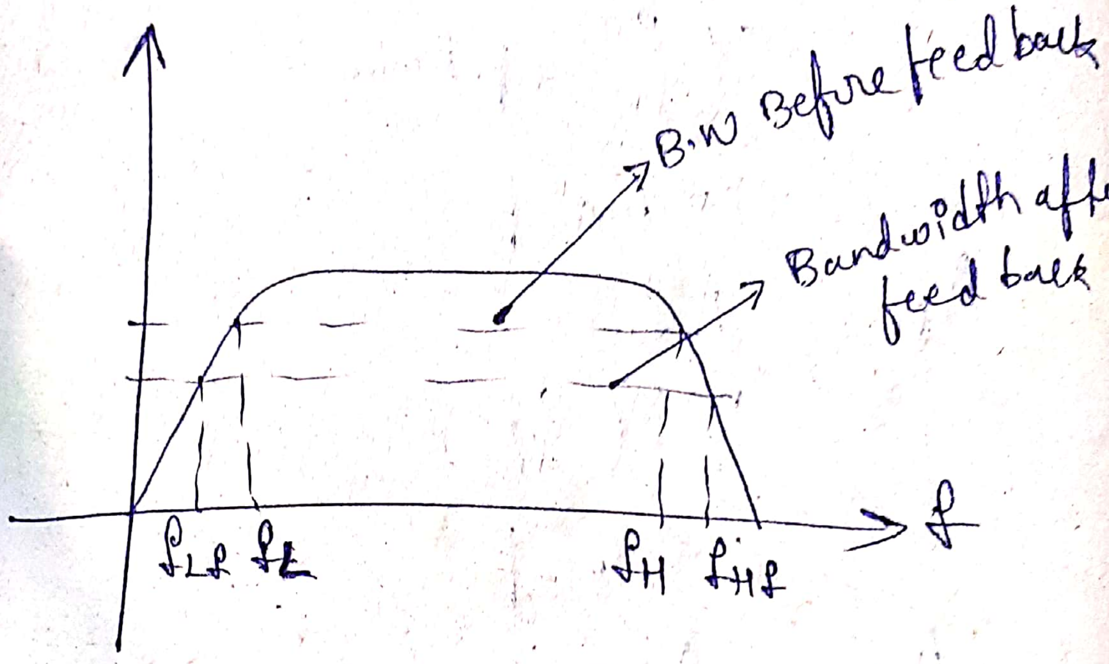
$$A_{fh} = \frac{A_{fm}}{1-j\left(\frac{f}{f_{hf}}\right)}$$

$$\boxed{f_{hf} = f_h(1+A_{mid}\beta)}$$

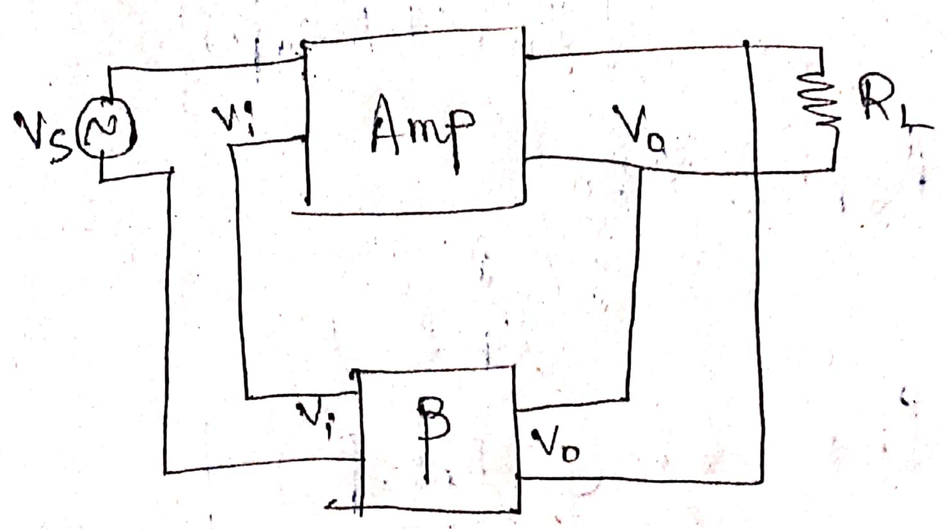
$B.W = f_{hf} - f_{Lf}$

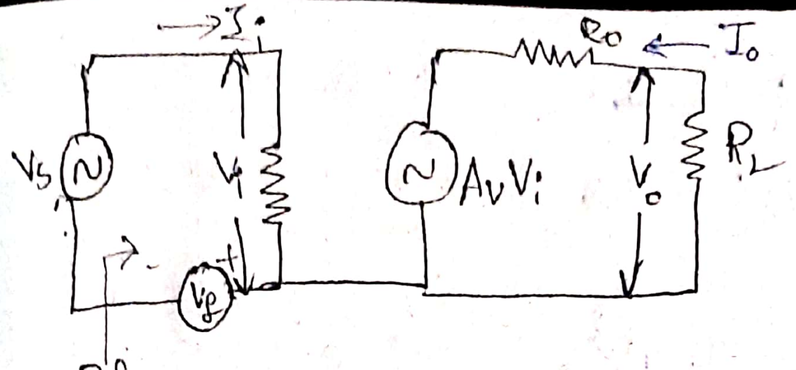
$$B.W = f_h(1+A_{mid}\beta) - \frac{f_L}{1+A_{mid}\beta}$$

Bandwidth is the frequency at which the gain starts to drop when frequency increases. So if lowering the gain by using feedback moves that point to higher frequency then the B.W ↑.



* Voltage Series -ve Feedback Amplifier:-





Input Resistance with feedback (R_{if})

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

$$V_i = V_s - V_f$$

$$V_s = V_i + V_f$$

$$= V_i + \beta V_o$$

$$= V_i + \beta A_v V_i$$

$$\frac{V_s}{I_i} = \frac{V_i}{I_i}(1+\beta A_v)$$

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

output Resistance with feedback (R_{of}):

$$R_{of} = \frac{V_o}{I_o}\Big|_{V_s=0}$$

$$V_o = I_o R_o + A_v V_i$$

$$V_s = V_i + V_f$$

$$V_i = -V_f$$

$$V_i = -\beta V_o$$

$$V_o = I_o R_o - A_v \beta V_o$$

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

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

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

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

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

(1) A voltage series -ve feed back amplifie has voltage gain without feed back of gain 500, i/p resistance 3kΩ, o/p resistance 20kΩ and feed back ratio 0.01 calculate Av, i/p Resis, o/p Resis, of the Amplifier with feed back.

$R_i = 3k\Omega$

$R_o = 20k\Omega$

$A_v = 500$

$\beta = 0.01$

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

$$= 3\times10^3(1+500(0.01))$$

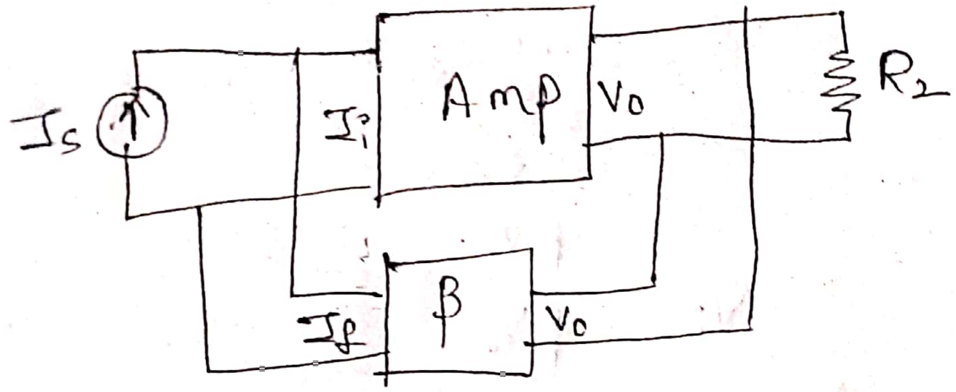
$$= 18k\Omega$$

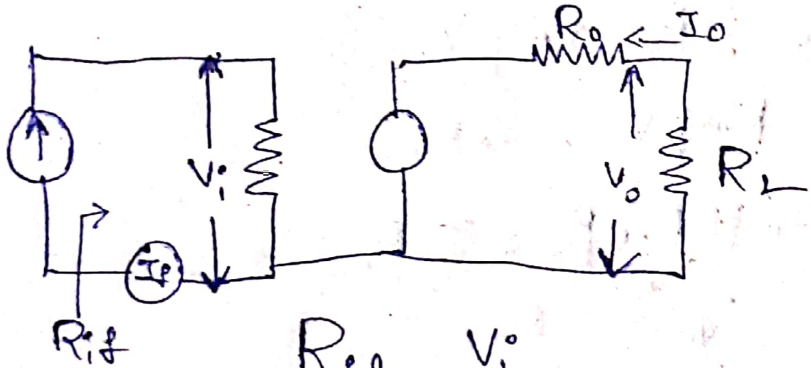
$$R_{of} = \frac{R_o}{1 + A_v \beta} = \frac{20 \times 10^3}{1 + (500)(0.01)}$$

$$R_{of} = 3333.3 = 3.3\,k\Omega$$

$$A_f = \frac{500}{1 + (500)(0.01)} = 83.33$$

* Voltage shunt feedback Amplifier





$$R_{if} = \frac{V_i}{I_s}$$

$$I_i = I_s - I_f$$

$$I_s = I_i + I_f$$

$$I_s = I_i + \beta V_o$$

$$= I_i + \beta R_m I_i$$

$$\frac{I_s}{V_i} = \frac{I_i}{V_i}(1 + R_m \beta)$$

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

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

* o/p Resistance with feedback

$$R_{of} = \frac{V_o}{I_o}\bigg|_{I_s=0}$$

$$V_o = I_o R_o + R_m I_i$$

$$I_s = I_i + I_f$$

$$I_i = -I_f$$

$$= -\beta V_o$$

$$V_i = -\beta V_o$$

$$V_o = I R_o - R_m \beta V_o$$

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

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

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

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

(1) A voltage shunt -ve feed back amplifier

Gain of the Amp without feed back

prop constant $\rightarrow R_m$ 3kΩ i/p impedance 2kΩ o/p impedance 20kΩ, feed back ratio 0.05 calculate gain, i/p impedance o/p impedance of the amp with feedback

Sol: $R_m = 3k\Omega$

$R_i = 2k\Omega$, $R_o = 20k\Omega$

$\beta = 0.05$

$$\cancel{R}_{if} = \frac{R_i}{1+R_m\beta} = \frac{2\times10^3}{1+(3\times10^3)(0.05)}$$

$$Z_{if} = 3.99\times10^{-3}$$

$$Z_{of} = \frac{20\times10^3}{1+(3\times10^3)(0.05)}$$

$$Z_{of} = 132.45$$

$$A_m = \frac{R_m}{1+R_m\beta}$$

$$A_m = \frac{3\times10^3}{1+(3\times10^3)(0.05)}$$

$$A_m = 19.867$$

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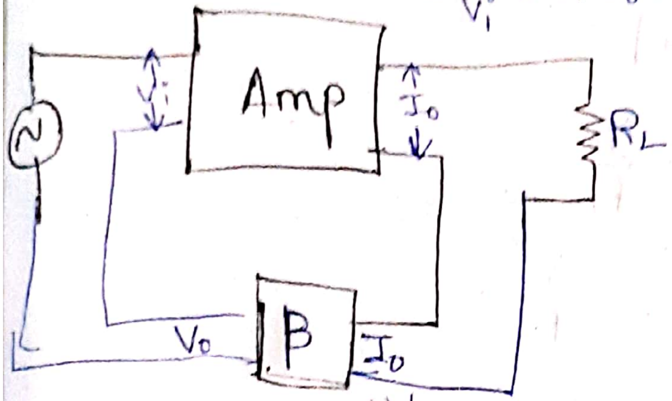
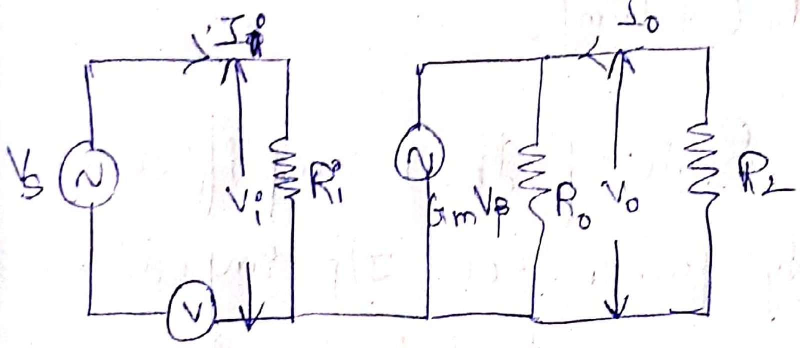
Current Series feedback Amplifier:

$G_m = \frac{I_o}{V_i} \Rightarrow I_o = G_m V_i$



$V_f = \beta I_o$

$G_{mf} = \frac{G_m}{1+G_m\beta}$



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

$V_i = V_s - V_f$

$V_s = V_i + V_f$

$V = V_i + \beta I_o$

$= V_i + G_m \beta V_i$

$\frac{V_s}{I_i} = \frac{V_i(1+G_m\beta)}{I_i}$

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

$R_{of} = \frac{V_o}{I_o}\Big|_{V_s=0}$

$I_o = \frac{V_o}{R_o} - G_m V_i \longrightarrow (a)$

$V_i = -V_f$

$V_i = -\beta I_o$

$\boxed{I = -I_o}$

Current flowing in opp. direction

$$V_i = \beta I_o$$

$$I_o = \frac{V_o}{R_o} - G_m \beta I_o$$

$$I_o + G_m \beta I_o = \frac{V_o}{R_o}$$

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

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

$$R_{of} = R_o (1 + G_m \beta).$$

① A current series feedback amplifier has a proportionality factor 500, I/p impedance 3k, o/p impedance 30kΩ, feed back ratio 0.01. Calculate gain i/p impedance, o/p impedance with feed back.

Sol:

$$G_m = 500$$

$$Z_i = 3k\Omega, \quad Z_o = 30k\Omega$$

$$\beta = 0.01$$

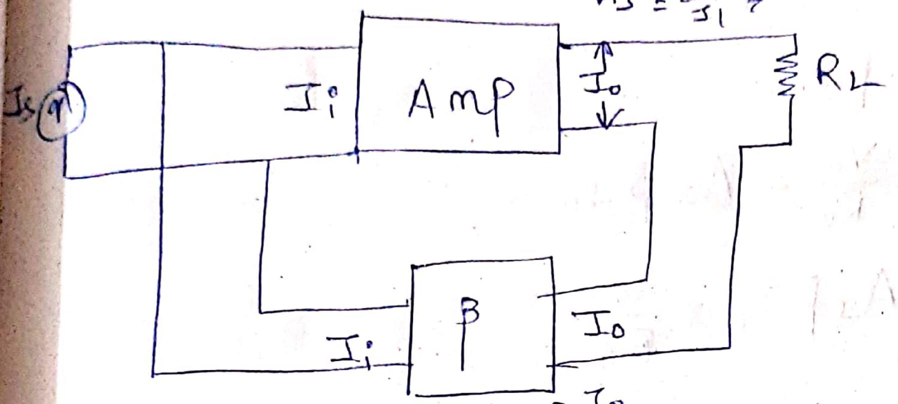
$$R_{of} = 30 \times 10^3 (1 + (500)(0.01))$$

$$R_{of} = 180k\Omega$$

$$\text{Gain} = \frac{G_m}{1 + G_m \beta} = \frac{500}{1 + (500)(0.01)} = 83.33$$

* Current shunt feedback amplifier

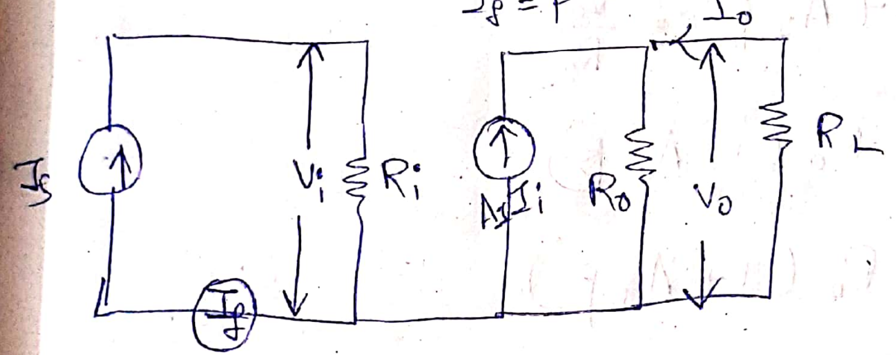
$A_I = \frac{I_o}{I_i} \Rightarrow A_I I_i = I_o$



$V = IR$

$I = \frac{V}{R}$

$I_f = \beta I_o$



$$R_{if} = \frac{V_i}{I_f}$$

$$I_i = I_s - I_f$$

$$I_s = I_i + I_f$$

$$I_s = I_i + \beta I_o$$

$$= I_i + A_I \beta I_i$$

$$\frac{I_s}{V_i} = \frac{I_i}{V_i}[1 + A_I \beta]$$

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

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

$$R_{of} = \left.\frac{V_o}{I_o}\right|_{I_s = 0}$$

$$I_o = \frac{V_o}{R_o} - A_I I_i$$

$$I_1 = -I_f$$

$$= -\beta I_o$$

$$\boxed{I = -I_o}$$

$$I_1 = \beta I_o$$

$$I_o = \frac{V_o}{R_o} - A_I \beta I_o$$

$$I_o + A_I \beta I_o = \frac{V_o}{R_o}$$

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

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

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

① A current shunt feed back amplifier of current gain 100 i/p imp 2kΩ o/p imp 15kΩ feedback ratio 0.05 calculate i/p, o/p imp and gain with feed back.

Sol: $A_I = 100$, $Z_i = 2k\Omega$, $Z_o = 15k\Omega$

$\beta = 0.05$

$$R_{if} = \frac{R_i}{1 + A_I \beta} = \frac{2 \times 10^3}{1 + (100)(0.05)}$$

$$R_{if} = 333.33\,\Omega$$

$R_{of} = 15 \times 10^3$ ...

$= 90k$ ...

$A_{If} = \frac{A_I}{1+ \ldots}$

$= 1$ ...

* Method ...

The follo...

obtain N...

Rules

Rule-1. Identif...

(i) Find t...

→ If th...

from the...

Then it...

→ If ...

from ...

Source, ...

(ii) Find ...

→ short ...

feedbac...

is volt...

→ open ...

$R_{of} = 15\times10^3 (1+(100)(0.05))$

$= 90k\Omega$

$A_{If} = \dfrac{A_I}{1+A_I\beta} = \dfrac{100}{1+(100)(0.05)}$

$= 16.66$

* Method of Analysing feedback amplifier

The following rules may be applied to obtain Network Topology.

Rules

Rule-1. Identify the feedback Topology.

(i) Find the type of Mixing Network

→ If the feedback signal is subtracted from the applied voltage signal source, Then it is Series Mixing.

→ If the feedback signal is subtracted from the applied ~~Short~~ current signal source, Then it is Shunt Mixing.

(ii) Find the type of Sampler

→ Short the o/p side i.e., $V_o = 0$, if feedback signal becomes zero then it is voltage sampler.

→ open the o/p side i.e., $I_o = 0$, if

feedback Signal becomes zero, then it is current Sampler.

2. (Rule-2):-

(i) To find the i/p ckt

→ For voltage Sampling set $V_0 = 0$, i.e., short ckt the o/p

→ For current Sampling set $I_0 = 0$, i.e., open the o/p loop.

(ii) To find the o/p ckt

→ For shunt comparison set $V_i = 0$, i.e., short the i/p node.

→ For Series comparison set $I_i = 0$, i.e., open the i/p loop.

3. Replace each active device by its model namely the h-parameter model for low frequencies and hybrid π-model for a transistor at high frequencies

4. Using Thevinin's Source if X_f (feed back Signal) is a voltage and a nodal Source if X_f is a current.

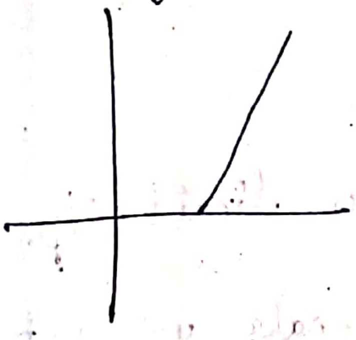
5. Indicate X_f and X_o on the ckt obtain on carrying out steps 1, 3 & 4. Evaluate $\beta = \frac{X_f}{X_o}$

6. Evaluate gain (A) by applying KVL & KCL to the equivalent ckt after step 3 ~~to the~~ ~~Equivalent ckt~~

7. Finally from A & β find A_f, R_{if} and R_{of}

→ Linear elements are R, L, C

→ The graph does not start from zero



It starts linearly increasing with time.

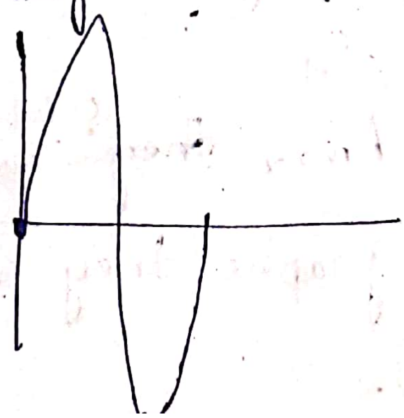
→ The non linear elements are diode, FET, Transistor.

→ The transistor has high voltage gain and high current gain compare to FET.

→ In Transistor we have CB, CE, CC from these three we use CE compare to CB and CC.

→ Amplifiers are used in both Transistors and FET.

Amplification → which strengthen the weak signal to high signal.



The signal not only sinusoidal wave but signal is an information..

→ For Ac Supply we use 220V

→ For Transistor we take i/p in mV.

1V – 100V

100 – 1000V

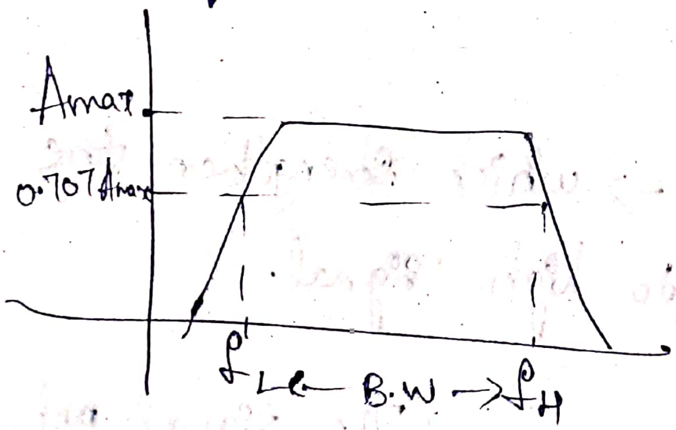
→ For FET we take up to limit i/p.

→ Cascade (Multiplying the signals we get the high o/p). Cascode

→ ~~Bands~~ RMS (Root mean Square) and Avg.

→ In America they use Ac for 50Hz and 110V

→ Bandwidth is the difference between higher frequency and lower frequency



→ Instead of 0.707 Amax ~~they can~~ or calculate $\frac{A_{max}}{\sqrt{2}}$. For some graphs they take –3dB (decibals).

→ We calculate the $20 \log A_v$ for the gain output.

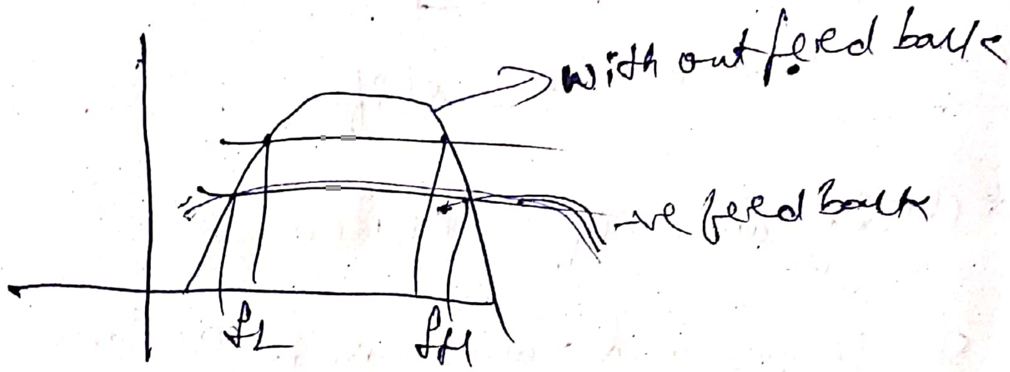
→ we know that $P = VI$

$$= V \cdot \frac{V}{R} = \frac{V^2}{R}$$

$$= \frac{V^2}{2} = \left(\frac{V}{\sqrt{2}}\right)^2$$

→ In Negative feedback the gain decreases

$A_f < A$ with -ve feedback.



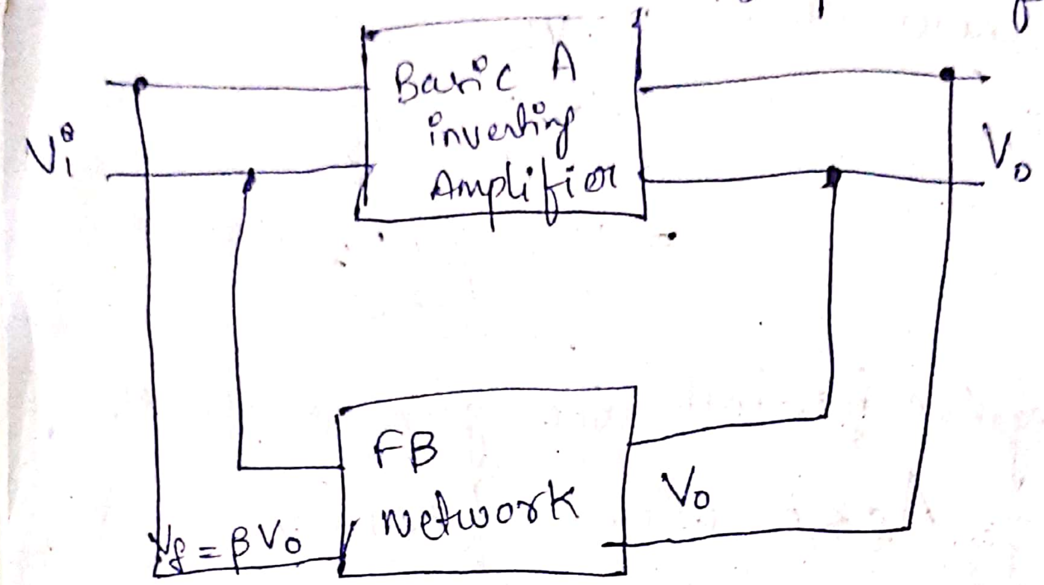
→ $A_f = \frac{A}{1 - A\beta}$ when $A\beta$ reaches to 1 then it becomes zero the gain will becomes infinite (Maximum) in +ve feed back.

→ In RC the gain will decrease.

* oscillator ckt

+ve Feedback

180° phase shift



-180° phase shift

* classification of oscillators

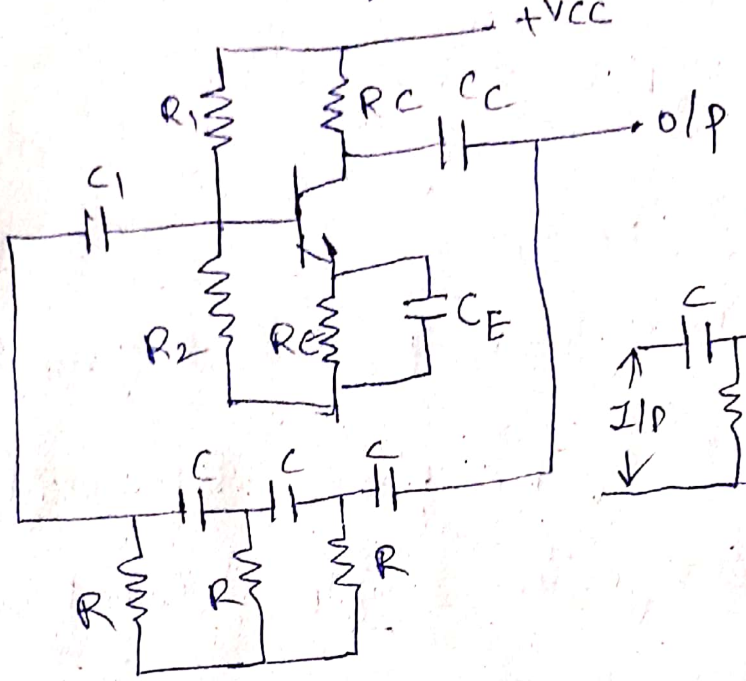
1. Sinusoidal and non-sinusoidal oscillators
2. feedback and non-feedback oscillators.
3. ckt components are RLC tuned oscillators and crystal oscillators

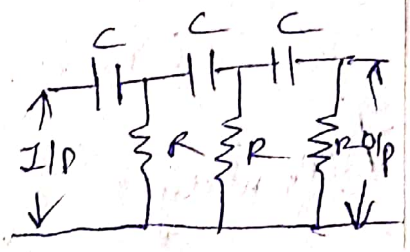
*4) Range of operating frequency.

1. Audio frequency oscillator. (20 – 20kHz).
2. RFO (Radio frequency oscillator) → 20KHz – 30kHz
3. VHF (very high frequency) → 30 – 300MHz
4. UHF (ultra high frequency) → 300MHz – 3GHz

5. MWFO (Microwave frequency oscillator)
$> 3GHz$

* RC phase shift oscillator





→ It consist of CE amplifier and RC feed back.

→ feedback ~~resistance~~ n/w consist of Resistor & capacitor.

→ Ladder phase shift oscillator feed back n/w must introduce a phase shift of 180° to obtain total phase shift around 360°.

→ one RC phase shift n/w produces 60° total phase shift = 180° (∵ 60×3)

→ o/p gain is -ve. o/p of amplifier produces 180°. o/p of an amplifier is given to fb n/w phase shift around a loop is 180°

~~* Oscillators: UNIT-3~~

→ due to 3 RC N/w

$$f = \frac{1}{2\pi RC\sqrt{6}} \text{ Hz}$$

$$f = \frac{1}{2\pi RC\sqrt{6+4K}}$$

where $K = R_c/R$ → is very small

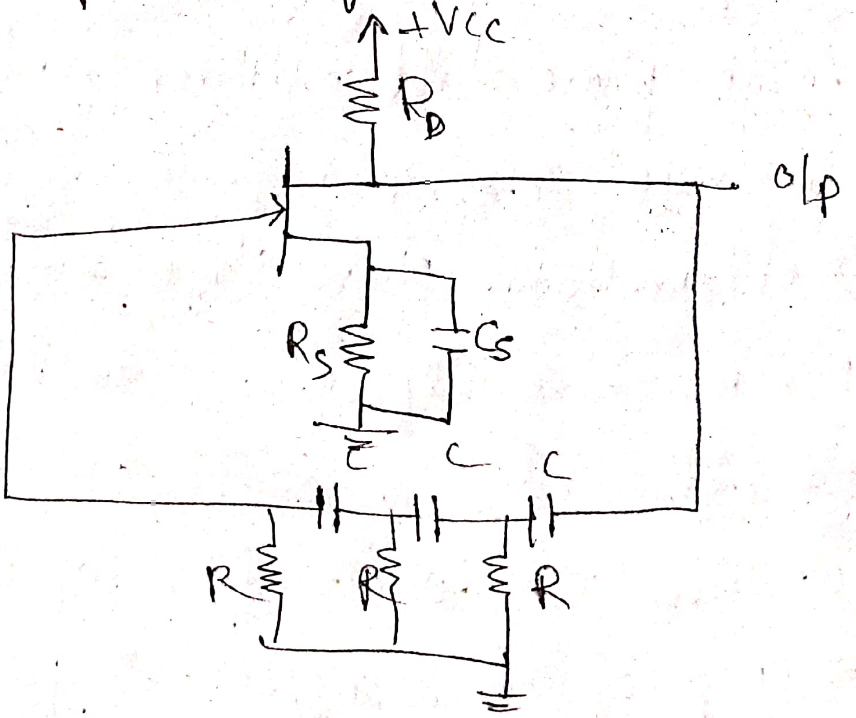
Advantages of RC phase shift oscillator

→ ckt design is simple it can produce audio frequency (less frequency) Range.

→ produces sinusoidal o/p waveform.

→ It is a fixed frequency oscillator

* FET phase shift oscillator



→ FET amplifier is self bias with capacitor by passed source Resistance R_S and bias Resistance R_D

→ The important parameters of FET are g_m, R_D.

$|A| = g_m R_L$ where $R_L = R_D || R_D$

with FB $|A| = 291k$ $|\beta| = 1/2$

Problems

(1) In a RC phase shift oscillator, the phase shift N/w uses the R each of 4.7k Ω and C each of 0.47 μf. Find the frequency

Sol: $R = 4.7 k\Omega$

$C = 0.47 \mu f$

$$F = \frac{1}{2\pi RC\sqrt{6}}$$

$$= \frac{1}{2\pi \times 4.7 \times 10^{3} \times 0.47 \times 10^{-6} \sqrt{6}}$$

$f = 29.413 Hz$

(2) For an RC phase shift oscillator, the feed back N/w uses $R = 6k\Omega$ & $C = 1500 pF$. The transistorized amplifier used as a collector resistance of 18kΩ calculate the frequency of oscillations.

Sol)

$R = 6\,k\Omega$

$C = 1500\,pF$

$R_c = 18\,k\Omega$

$$k = \frac{R_c}{R} = \frac{\cancel{18}^{3}\cancel{k}}{\cancel{6}_{1}\cancel{k}_{1}} = 3$$

$$f = \frac{1}{2\pi RC\sqrt{6+4k}}$$

$$f = \frac{1}{2\pi \times 6\times 10^{3} \times 1500\times 10^{-12}\sqrt{6+4(3)}}$$

$$f = 4.168\,kHz$$