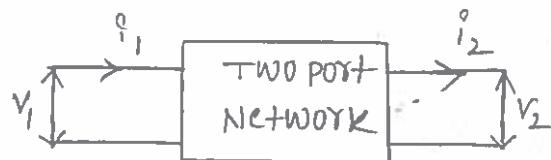


\* UNIT :- 04 \*

## \* ANALYSIS AND DESIGN OF SMALL SIGNAL \*

### \* LOW FREQUENCY BJT AMPLIFIER \*

#### INTRODUCTION:-



TWO PORT NETWORK.

#### Parameters:-

- \* Z - parameters
- \* Y - parameters
- \* h - parameters [hybrid parameters]

#### Z - parameters:-

$$v_1 = z_{11}i_1 + z_{12}i_2$$

$$v_2 = z_{21}i_1 + z_{22}i_2$$

- \*  $v_1$  and  $v_2$  are dependent variables
- \*  $i_1$  and  $i_2$  are independent variables
- \*  $z_{11}, z_{12}, z_{21}, z_{22}$  are Z-parameters

Find  $z_{11} = i_2 = 0$

then

$$v_1 = z_{11}i_1 + 0$$

$$\boxed{z_{11} = \frac{v_1}{i_1}}$$

$$i_Q = 0$$

$$Z_{Q1} = \frac{v_Q}{i_1}$$

where  $i_1 = 0$

$$Z_{1Q} = \frac{v_1}{i_Q}$$

$$i_1 = 0;$$

$$Z_{Q2} = \frac{v_Q}{i_1}$$

Y-parameters:-

$$i_1 = Y_{11} v_1 + Y_{12} v_Q$$

$$i_Q = Y_{21} v_1 + Y_{22} v_Q$$

where  $v_Q = 0$

$$Y_{11} = \frac{i_1}{v_1}$$

where  $v_1 = 0$

$$Y_{12} = \frac{i_1}{v_Q}$$

where  $v_Q = 0$

$$Y_{21} = \frac{i_Q}{v_1}$$

where  $v_1 = 0$

$$Y_{22} = \frac{i_Q}{v_Q}$$

H - parameters :-

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

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

\*  $V_1$  and  $I_2$  are dependent variables

\*  $I_1$  and  $V_2$  are independent variables

\*  $h_{11}, h_{12}, h_{21}, h_{22}$  are called h-parameters.

consider  $V_2 = 0$

$$V_1 = h_{11} I_1 + 0$$

$$\boxed{h_{11} = \frac{V_1}{I_1}}$$

\* Resistance =  $h_{11}$ , because  $r = \frac{V}{I}$ . Then  $h_{11}$  is called input impedance.

\*  $h_{11}$  is input impedance with output voltage is zero

Input impedance with output port is short circuited

$$\boxed{h_{21} = \frac{i_2}{i_1}}$$

\*  $h_{21}$  is output current by input current then it is called current gain (or) Forward current gain

\*  $h_{21}$  is forward current gain with output is short circuited.

similarly  $I_1 = 0$

$$V_1 = 0 + h_{12} V_2$$

$$h_{12} = \frac{V_1}{V_2}$$

\*  $h_{12}$  is input voltage by output voltage then it is called Reverse voltage gain.

\*  $h_{12}$  is Reverse voltage gain with input current is zero  
(or)

Reverse voltage gain with input port is open circuited.

similarly  $i_1 = 0$

$$i_2 = 0 + h_{22} V_2$$

$$h_{22} = \frac{i_2}{V_2}$$

$\therefore \frac{V}{I} = \text{impedance}$

$\therefore \frac{I}{V} = \text{admittance}$

\*  $h_{22}$  is output admittance with input port is open circuited.

where

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

$$V_1 = h_1^i I_1 + h_1^r V_2$$

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

$$I_2 = h_f^i I_1 + h_0 V_2$$

$$\therefore h_{11} = h_1^i ; h_{12} = h_r ; h_{21} = h_f^i ; h_{22} = h_0$$

$h_i$  = input impedance

$h_r$  = reverse voltage gain

$h_f$  = forward current gain

$h_o$  = output admittance

CB configuration:-

$$v_1 = h_{ib} i_1 + h_{rb} v_2$$

$$I_2 = h_{fb} i_1 + h_{ob} v_2$$

CE configuration:-

$$v_1 = h_{ie} i_1 + h_{re} v_2$$

$$I_2 = h_{fe} i_1 + h_{oe} v_2$$

CC configuration:-

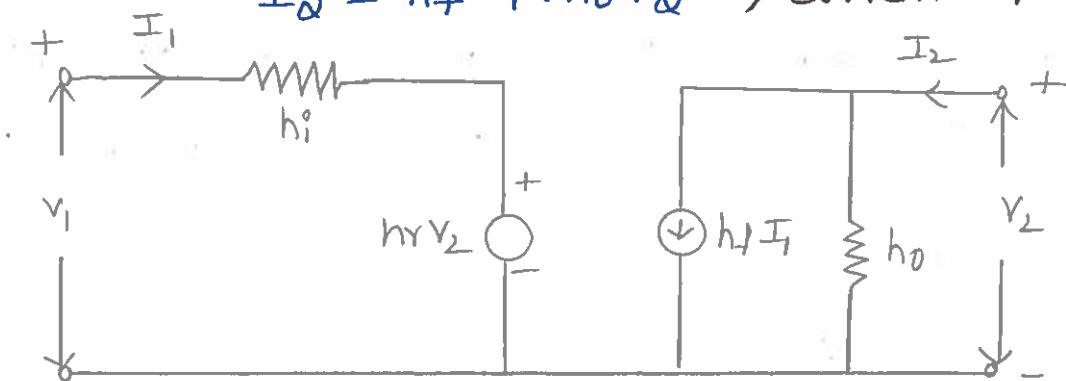
$$v_1 = h_{ic} i_1 + h_{rc} v_2$$

$$I_2 = h_{fc} i_1 + h_{oc} v_2$$

HYBRID MODEL (OR) H-PARAMETER MODEL:-

$$v_1 = h_i I_1 + h_r v_2 \rightarrow \text{voltage equation}$$

$$I_2 = h_f I_1 + h_o v_2 \rightarrow \text{current equation}$$



APPLY KVL to input circuit

$$-v_1 + I_1 h_i + h_r v_2 = 0$$

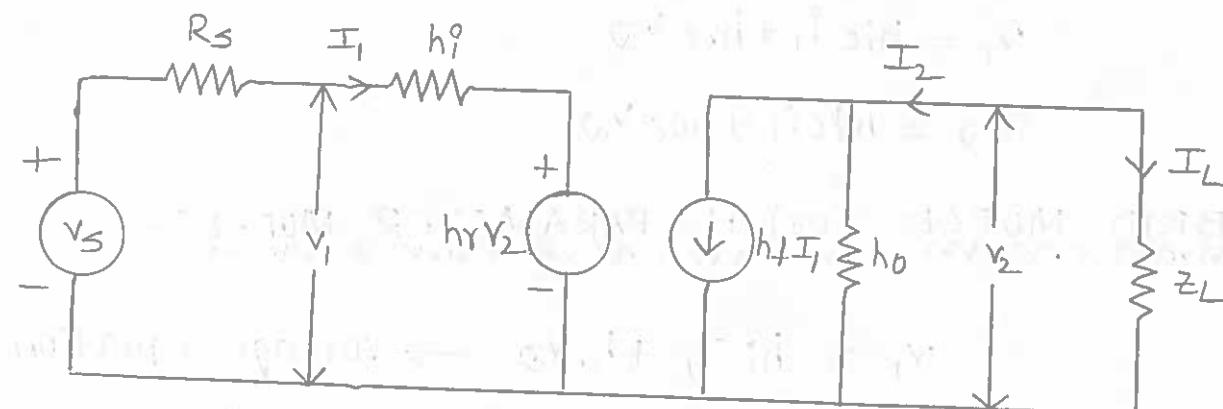
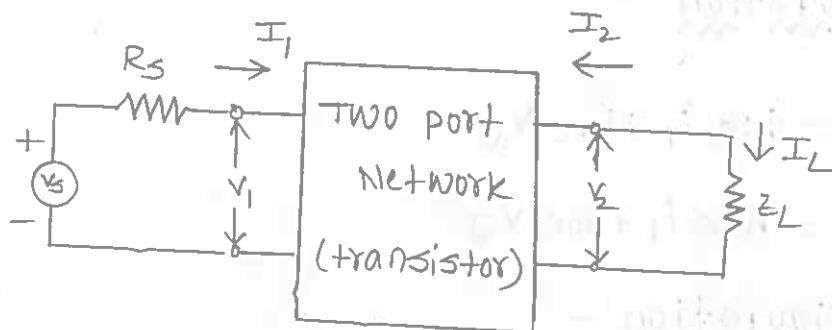
$$v_1 = h_i I_1 + h_r v_2$$

APPLY KCL to output circuit

$$I_2 = h_f I_1 + v_2 / h_o$$

$$I_2 = h_f I_1 + h_o v_2$$

Analysis of transistor amplifier circuit using h parameters



Find 1. current gain (or) current amplification factor ( $A_I$ )

2. input impedance ( $Z_i$ )    3. voltage gain ( $A_v$ ) (or) voltage amplification factor    4. output admittance ( $Y_o$ )

1 current gain:-

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

Consider  $I_L = -I_Q$  [ $\because$  Because  $I_L$  and  $I_Q$  are same currents but opposite in directions]

$$AI = \frac{-I_Q}{I_1} \rightarrow ①$$

Apply KCL to the output circuit

$$I_Q = h_f I_1 + h_o V_Q \rightarrow ②$$

$$V_Q = I_L Z_L = -I_Q Z_L$$

$$V_Q = -I_Q Z_L \rightarrow ③$$

Substitute equation ③ in equation ②

$$I_Q = h_f I_1 + h_o (-I_Q Z_L)$$

$$I_Q = h_f I_1 - h_o I_Q Z_L$$

$$I_Q + h_o I_Q Z_L = h_f I_1$$

$$I_Q (1 + h_o Z_L) = h_f I_1$$

$$I_Q (1 + h_o Z_L) = h_f I_1$$

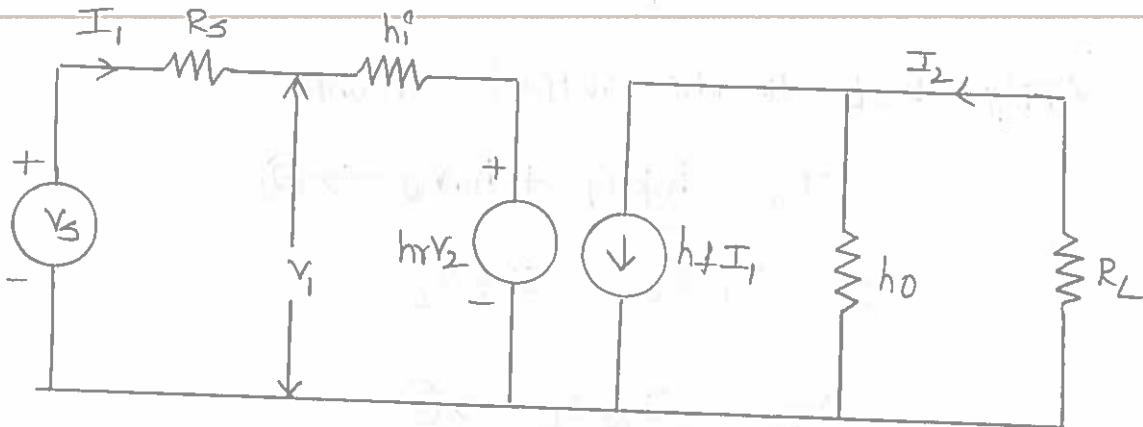
$$\frac{I_Q}{I_1} = \frac{h_f}{1 + h_o Z_L}$$

$$-\frac{I_Q}{I_1} = \frac{-h_f}{1 + h_o Z_L}$$

$$AI = \frac{-h_f}{1 + h_o Z_L}$$

INPUT IMPEDANCE ( $Z_i$ ):-

$$Z_i = \frac{V_1}{I_1} \rightarrow ①$$



APPLY KVL to input circuit

$$-V_1 + h^i I_1 + h_r V_2$$

$$\therefore V_2 = I_L R_L$$

$$V_1 = h^i I_1 + h_r V_2 \rightarrow ②$$

$$V_2 = -I_L R_L$$

Substitute equation ② in equation ①

$$Z_i = \frac{h^i I_1 + h_r V_2}{I_1} = h^i + h_r \frac{V_2}{I_1}$$

$$= h^i + h_r - \frac{I_2 R_L}{I_1}$$

$$Z_i = h^i + h_r A_I R_L$$

$$\therefore R_L = Z_L$$

$$Z_i = h^i + h_r A_I Z_L$$

Substitute  $A_I$  value

$$Z_i = h^i + h_r \frac{-h_f}{1+h_o Z_L} \cdot Z_L$$

$$Z_i = h^i - \frac{h_r h_f}{\left(\frac{1}{Z_L} + h_o\right) Z_L} \cdot Z_L$$

$$z_i^o = h_i^o - \frac{h_r h_f}{\left(\frac{1}{z_L} + h_o\right)}$$

voltage gain (or) voltage amplification factor ( $A_v$ ) :-

$$A_v = \frac{V_Q}{V_I} \rightarrow ①$$

$$V_Q = I_L z_L$$

$$V_Q = -I_L z_L$$

Substitute  $V_Q$  value in equation ①

$$A_v = \frac{-I_L z_L}{V_I}$$

$$[A_I = \frac{-I_L}{I_I}]$$

$$A_v = \frac{A_I I_I z_L}{V_I}$$

$$[-I_Q = A_I I_I]$$

$$A_v = A_I \cdot z_L \cdot \frac{1}{z_i^o}$$

$$\left[ z_i^o = \frac{V_I}{I_I} \right]$$

$$A_v = \frac{A_I z_L}{z_i^o}$$

$$\left[ \because \frac{I_I}{V_I} = \frac{1}{z_i^o} \right]$$

Output admittance ( $Y_o$ ) :-

$$Y_o = \frac{I_Q}{V_Q} ; V_S = 0$$

Apply KCL to the output circuit

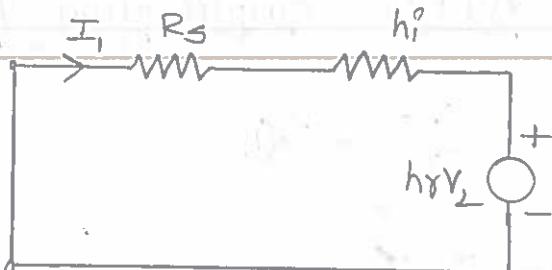
$$I_Q = h_f I_I + h_o V_Q$$

Divide with " $V_Q$ " both sides

$$\frac{I_Q}{V_Q} = h_f \frac{I_I}{V_Q} + h_o$$

$$Y_0 = h_f \cdot \frac{I_1}{V_Q} + h_o \rightarrow ①$$

APPLY KVL to the input circuit.



$$I_1 R_S + h_i^{\circ} I_1 + h_{\pi} V_Q = 0$$

$$I_1 (R_S + h_i^{\circ}) = -h_{\pi} V_Q$$

$$\frac{I_1}{V_Q} = -\frac{h_{\pi}}{R_S + h_i^{\circ}} \rightarrow ②$$

Substitute equation ② in equation ①

$$Y_0 = h_f \left( \frac{-h_{\pi}}{R_S + h_i^{\circ}} \right) + h_o$$

$$Y_0 = h_o - \frac{h_f h_{\pi}}{R_S + h_i^{\circ}}$$

PROBLEM :-

A CE amplifier has the h parameters given by  
 $h_{ie} = 100 \Omega$ ,  $h_{re} = 2 \times 10^{-4}$ ,  $h_{fe} = 50$ ,  $h_{oe} = 25 M\Omega$   
if the both source and load resistance are  $1 k\Omega$   
determine a) current gain ( $A_I$ ) b) voltage gain ( $A_V$ )  
c) input impedance ( $Z_i$ ) d) output admittance ( $Y_0$ ).

Solution:-

Given that:-

$$h_{ie} = 100 \Omega$$

$$h_{re} = 2 \times 10^{-4}$$

$$h_{fe} = 50$$

$$h_{oe} = 25 \mu\Omega$$

$$R_L = 1k\Omega$$

1. current gain (AI) :-

$$AI = \frac{-h_{fe}}{1+h_{oe}Z_L}$$

$$AI = \frac{-50}{1+(25 \times 10^6)(1 \times 10^3)}$$

$$AI = -48.78$$

2. voltage gain (AV) :-

$$AV = \frac{AI \cdot Z_L}{Z_i}$$

$$AV = \frac{(-48.78)(1 \times 10^3)}{90.243}$$

$$AV = -542.756$$

3. INPUT IMPEDENCE ( $Z_i^i$ ) :-

$$Z_i^i = h_{ie} - \frac{h_{re}h_{fe}}{Y_{zL} + h_{oe}}$$

$$Z_i^i = 100 - \frac{(2 \times 10^{-4})(50)}{1 \times 10^3 + 25 \times 10^6}$$

$$Z_i^i = 90.243$$

4. OUTPUT admittance:-

$$Y_0 = h_{oe} - \frac{h_{fe}h_{re}}{R_s + h_{ie}}$$

$$Y_0 = 25 \times 10^{-6} - \frac{50 \times (2 \times 10^{-4})}{(1 \times 10^3) + 100}$$

$$Y_0 = 25 \times 10^{-6} - \frac{0.01}{1100}$$

$$Y_0 = 25 \times 10^{-6} - 9.0909 \times 10^{-6}$$

$$Y_0 = 1.59091 \times 10^{-5}$$

For CE configuration exact model:-

$$AI = \frac{-hfe}{1+hocz_L}$$

$$AV = \frac{AIz_L}{z_{ie}}$$

$$z_i^e = h_{ie} - \frac{h_{re}h_{fe}}{V_{zL} + h_{oc}}$$

$$Y_0 = h_{oe} - \frac{h_{fe}h_{re}}{R_S + h_{ie}}$$

For CB configuration exact Model:-

$$AI = \frac{-hfb}{1+hobz_L}$$

$$AV = \frac{AIz_L}{z_{ib}}$$

$$z_i^e = h_{ib} - \frac{h_{rb}h_{fb}}{V_{zL} + h_{ob}}$$

$$Y_0 = h_{ob} - \frac{h_{fb}h_{rb}}{R_S + h_{ib}}$$

For CC configuration exact Model:-

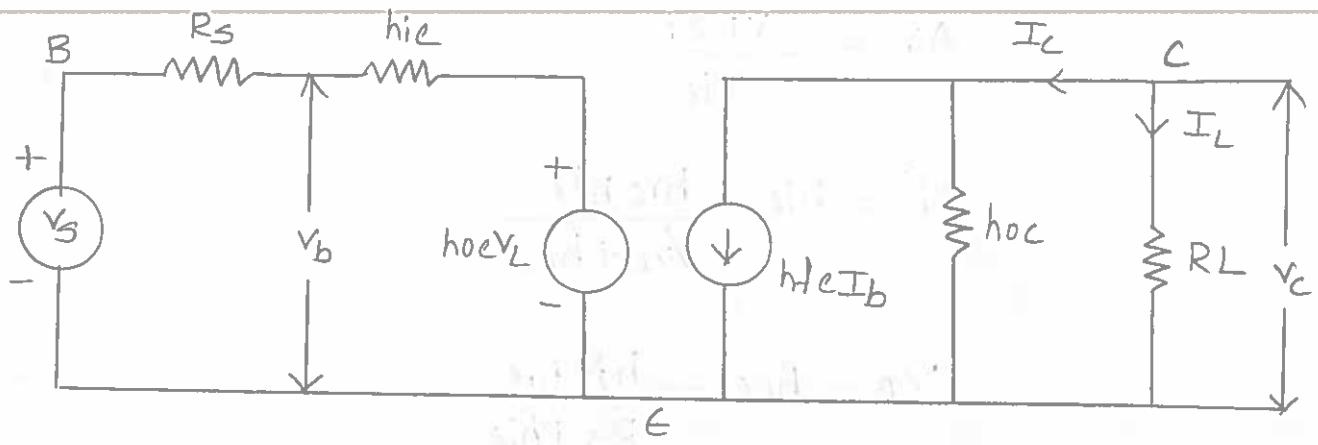
$$AI = \frac{-hfe}{1+hocz_L}$$

$$AV = \frac{AIz_L}{z_{ic}}$$

$$z_i^e = h_{ic} - \frac{h_{rc}h_{fc}}{V_{zL} + h_{oc}}$$

$$Y_0 = h_{oc} - \frac{h_{fe} h_{re}}{R_s + h_{ie}}$$

H-parameter approximate model:-



$$AI = \frac{-h_{fe}}{1+h_{oc}Z_L}$$

$$AI = \frac{-h_{fe}}{1+0}$$

$$\left[ \because \frac{1}{h_{oc}} \ggg R_L \right]$$

$$\left[ 1 \ggg h_{oc}R_L \right]$$

$$AI = -h_{fe}$$

$$Z_i^o = h_{ie} + h_{re} AI Z_L \quad (\text{Where } h_{re} = 0)$$

$$Z_i^o = h_{ie}$$

$$AV = A_i^o Z_L / Z_i^o \quad (\because Z_i^o = h_{ie})$$

$$AV = -h_{fe} \frac{Z_L}{h_{ie}}$$

$$Y_0 = h_{oc} - \frac{h_{fe} h_{re}}{R_s + h_{ie}}$$

$$\left[ \because h_{re} = 0 \right]$$

$$h_{oc} = 0$$

$$Y_0 = 0$$

PROBLEM:-

A CE amplifier is given by a voltage source of internal resistance  $R_s = 800\Omega$  and the load impedance  $R_L = 1000\Omega$ . The h-parameters are  $h_{ie} = 1k\Omega$ ,  $h_{re} = 2 \times 10^4$ ,  $h_{fe} = 50$ ,  $h_{oe} = 25 \times 10^6$  Ampere per ohm. calculate current gain ( $A_I$ ), input resistance ( $R_I$ ), voltage gain ( $A_V$ ) and output resistance ( $R_O$ ) using exact analysis and approximate analysis.

SOLUTION:-

$$\text{current gain } A_I = \frac{-h_{fe}}{1+h_{oe}R_L}$$

$$A_I = \frac{-50}{1+(25 \times 10^6)1000}$$

$$A_I = -48.7804$$

$$\text{input impedance } R_I^o = h_{ie} + A_I h_{re} R_L$$

$$R_I^o = 1 \times 10^3 + (-48.7804)(2 \times 10^4)(1000)$$

$$R_I^o = 0.99 k\Omega \text{ (or) } 990.24 \Omega$$

$$\text{voltage gain } A_V = A_I \cdot \frac{R_L}{R_I}$$

$$A_V = -48.7804 \cdot \frac{1000}{990.24}$$

$$A_V = -49.2611$$

$$\text{output admittance } Y_0 = h_{oe} - \frac{h_{fe}r_e}{h_{ie} + R_s}$$

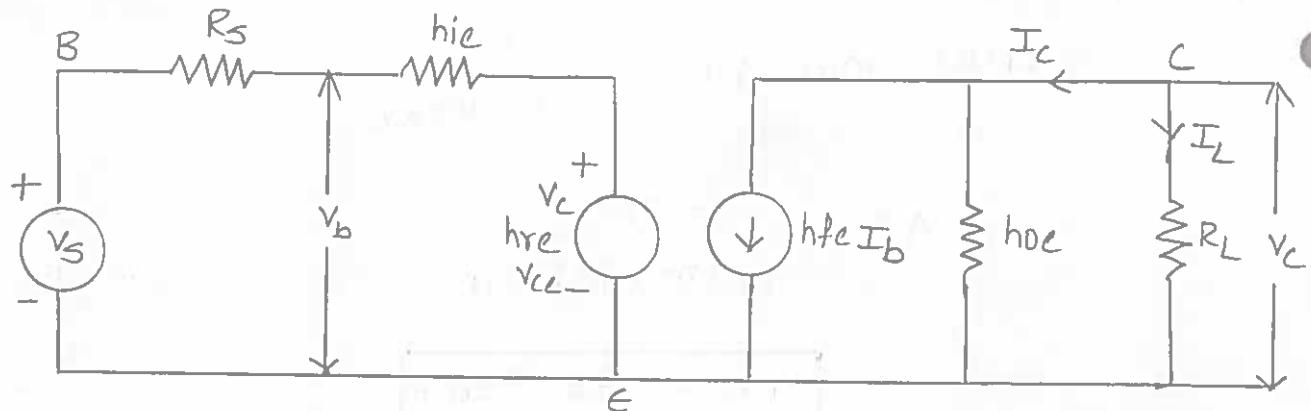
$$Y_0 = 25 \times 10^{-6} - \frac{50 \times 2 \times 10^4}{1 \times 10^3 + 800}$$

$$Y_0 = 1.95 \times 10^{-5} \text{ mho}$$

$$R_0 = \frac{1}{Y_0}$$

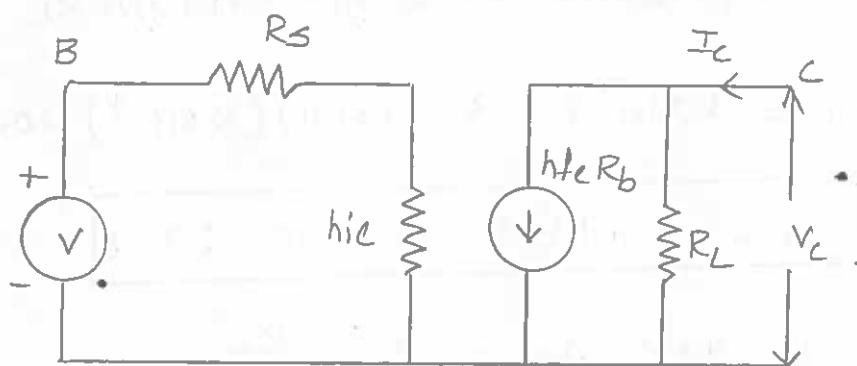
$$R_0 = 51546 \cdot 39 \Omega \text{ (or) } 51.5 \text{ k}\Omega$$

H - parameters approximate model for CE configuration:-



$$\frac{1}{h_{oe}} \ggg R_L$$

$$1 \ggg h_{oe} R_L$$



Above circuit is approximate circuit of common emitter.

From exact model

$$AI = \frac{-h_{fe}}{1 + h_{oc} z_h}$$

hoe is Neglected in approximate model.

$$AR = \frac{-hfe}{1+0}$$

$$AR = -hfe$$

From exact model

$$Z_i^o = hie + hre AR Z_L$$

$$Z_i^o = hie$$

$\therefore$  hre is Neglected i.e  
 $hre = 0$

From exact model

$$Y_o = hoe - \frac{hfe hre}{R_s + hie}$$

$$Y_o = 0 - \frac{0 \cdot hre}{R_s + hie}$$

$\therefore$  hoe, hre values are  
Neglected

$$Y = 0$$

From exact model

$$\therefore AV = AIE \frac{Z_L}{Z_I}$$

$$AV = -hfe \frac{Z_L}{Z_I}$$

$$AR = -hfe$$

For common emitter configuration exact model.

$$AIE = \frac{-hfe}{1+hoe Z_L} \quad [\text{current Gain}]$$

$$Z_I = hie + hre AIE Z_L \quad [\text{input impedance}]$$

$$AV = \frac{AIE Z_L}{Z_I} \quad [\text{voltage gain}]$$

$$Y_o = hoe - \frac{hre hfe}{R_s + hie} \quad [\text{output admittance}]$$

$Z_L \rightarrow 12k\Omega$

common collector:-

$$AI = \frac{-h_{fe}}{1+h_{oc}Z_L}$$

$$Z_I = h_{ie} + h_{re} AI Z_L$$

$$AV = AIC Z_L / Z_I$$

$$Y_0 = h_{oc} - \frac{h_{re} h_{fe}}{R_S + h_{ic}}$$

common base:-

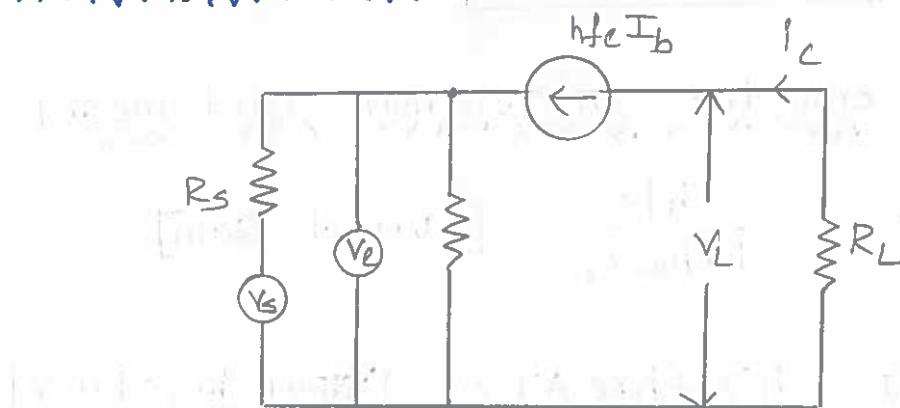
$$AI = \frac{-h_{fb}}{1+h_{ob}Z_L}$$

$$Z_I = h_{ib} + h_{rb} AI Z_L$$

$$AV = \frac{AIB Z_L}{Z_I}$$

$$Y_0 = h_{ob} - \frac{h_{rb} h_{fb}}{R_S + h_{ib}}$$

h-parameters. approximate model for CB.



$$AI = \frac{-I_C}{I_E}$$

$$AI = \frac{-h_{fe} \cdot I_B}{-h_{fe} I_B - I_B} \quad [I_E + h_{fe} I_B - I_B = 0]$$

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

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

$$AI = -h_{fb}$$

$$RI = V$$

$$v_e = h_{ie} I_b$$

$$v_e = -h_{ie} I_b$$

$$R_i^o = \frac{v_e}{I_e}$$

$$= \frac{-h_{ie} \cdot I_b}{-h_{fe} I_b - I_b}$$

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

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

$$R_i^o = h_{ib}$$

Voltage Gain:-

$$AV = \frac{AI \cdot Z_L}{Z_i^o}$$

$$= \frac{\frac{h_{fe}}{1+h_{fe}} \cdot Z_L}{\frac{h_{ie}}{1+h_{fe}}}$$

$$AV = \frac{h_{fe} \cdot Z_L}{h_{ie}}$$

Output admittance:-

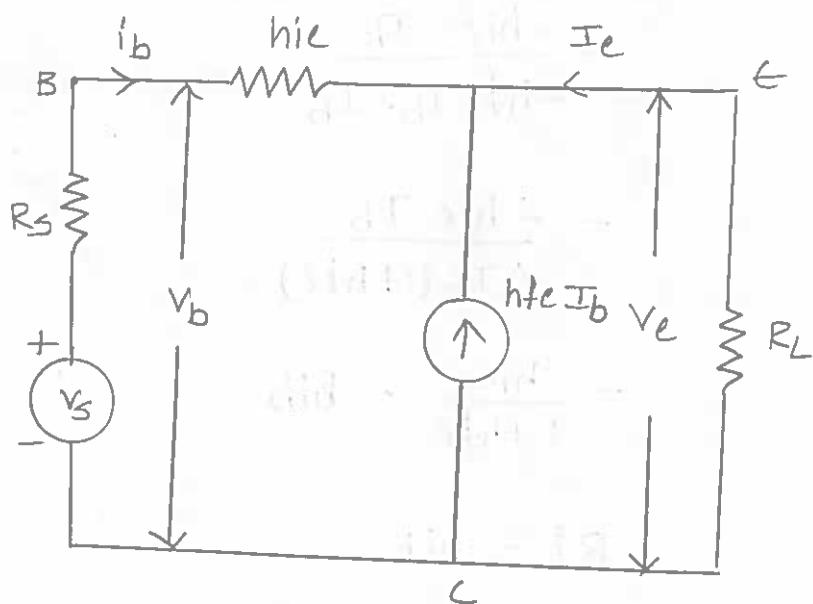
$$V_S = 0$$

$$I_C = 0; I_B = 0, I_E = 0$$

$$Y_0 = \frac{I_C}{V_C} = 0$$

$$\text{Output resistance} = \frac{1}{Y_0} = \frac{1}{0} = \infty$$

Approximate h-parameter model for cc configuration:-



$$AI = \frac{-I_e}{I_b}$$

Apply KCL at node 1

$$I_b + I_e + h_{fe} I_b = 0$$

$$I_e = -h_{fe} I_b - I_b$$

$$AI = \frac{-(-h_{fe} I_b - I_b)}{I_b}$$

$$= \frac{hfe I_b + I_b}{I_b}$$

$$= \frac{I_b (hfe + 1)}{I_b}$$

$$A I = 1 + hfe$$

INPUT RESISTANCE ( $Z_i$ ):-

$$R_i^o = \frac{V_b}{I_b}$$

APPLY KVL to the circuit

$$-V_b + hie I_b + R_L (-(-hfe I_b - I_b)) = 0$$

$$-V_b + hie I_b + R_L (hfe I_b + I_b) = 0$$

$$V_b = hie I_b + I_b (1 + hfe) R_L$$

$$R_i^o = \frac{hie I_b + I_b (1 + hfe) R_L}{I_b}$$

$$R_i^o = \frac{I_b (hie + (1 + hfe) R_L)}{I_b}$$

$$R_i^o = hie + (1 + hfe) R_L$$

Voltage gain:-

$$AV = \frac{A I \cdot R_L}{R_i^o}$$

$$AV = \frac{(1+hfe) \cdot RL}{R_i^o}$$

$$= \frac{hie + (1+hfe)RL - hie}{R_i^o}$$

$$AV = \frac{R_i^o - hie}{R_i^o}$$

$$AV = 1 - \frac{hie}{R_i^o}$$

Output admittance -

$$V_S = 0$$

$$Y_o = \frac{1+hfe}{hie + R_S}$$

$$R_o = \frac{hie + R_S}{1+hfe}$$

PROBLEM :-

A voltage source of internal resistance  $R_S = 900\Omega$  drives a CC amplifier using load resistance  $R_L = 2000\Omega$ . The CE h-parameters are  $hie = 1200\Omega$ ,  $hre = 2 \times 10^{-4}$ ,  $hfe = 60$ ,  $hoe = 25 \times 10^{-6}$  MA/V. Calculate current gain (AI), input resistance ( $R_I$ ), voltage gain (AV), output resistance ( $R_o$ ) using approximate analysis and exact analysis.

current

solution:-

Given that

$$R_s = 900 \Omega$$

$$R_L = 2000 \Omega$$

$$h_{ie} = 1200 \Omega$$

$$h_{re} = 2 \times 10^{-4}$$

$$h_{fe} = 60$$

$$h_{oe} = 25 \times 10^6 \text{ mA/V}$$

current gain (AI)

$$AI = 1 + h_{fe}$$

$$AI = 1 + 60$$

$$AI = 61$$

input resistance!-

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

$$= 1200 + (1 + 60) \times 2000$$

$$= 1200 + 61 \times 2000$$

$$R_I = 1,23,200$$

voltage gain!-

$$AV = \frac{61 \times 2000}{1,23,200} = \frac{1,22,000}{1,23,200} = 0.990$$

Output Resistance :-

$$R_o = \frac{h_{ie} + R_s}{1 + h_{fe}} = \frac{1200 + 900}{1 + 60} = \frac{2100}{61} = 34.4 \Omega$$

$$Y_o = \frac{1 + h_{fe}}{h_{ie} + R_s} = \frac{1 + 60}{1200 + 900} = \frac{61}{2100} = 0.029$$

Exact Model :-

common collector

$$A_I = \frac{-h_{fe}}{1 + h_{oc} Z_L}$$

$$R_i = h_{ic} + h_{re} A_I Z_L$$

common collector in common emitter

$$h_{ic} = h_{ie}$$

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

$$h_{rc} = 1$$

$$h_{oc} = h_{oe}$$

$$h_{ic} = 1200 \Omega, h_{fc} = -(1 + 60) = -61$$

$$h_{rc} = 1, h_{oc} = 25 \times 10^6$$

$$A_I = \frac{-h_{fc}}{1 + h_{oc} Z_L} = \frac{-(-61)}{1 + (25 \times 10^6)(1200)}$$

$$= \frac{61}{1 + (0.0000025)(1200)}$$

$$AI = \frac{61}{1.05}$$

$$AI = 58.09$$

$$RI = 1200 + 1(58.09) (2000)$$

$$RI = 117.380.$$

$$AV = \frac{AI_C Z_L}{Z_I} = \frac{AI_C Z_L}{RI}$$

$$= \frac{58.09 \times 2000}{117.380} = \frac{116.180}{117.380} = 0.989$$

$$Y_0 = h_{OC} - \frac{h_{RE} h_{FC}}{R_s + h_{IC}}$$

$$= 25 \times 10^{-6} - \frac{1 \times (-61)}{117380 + 1200}$$

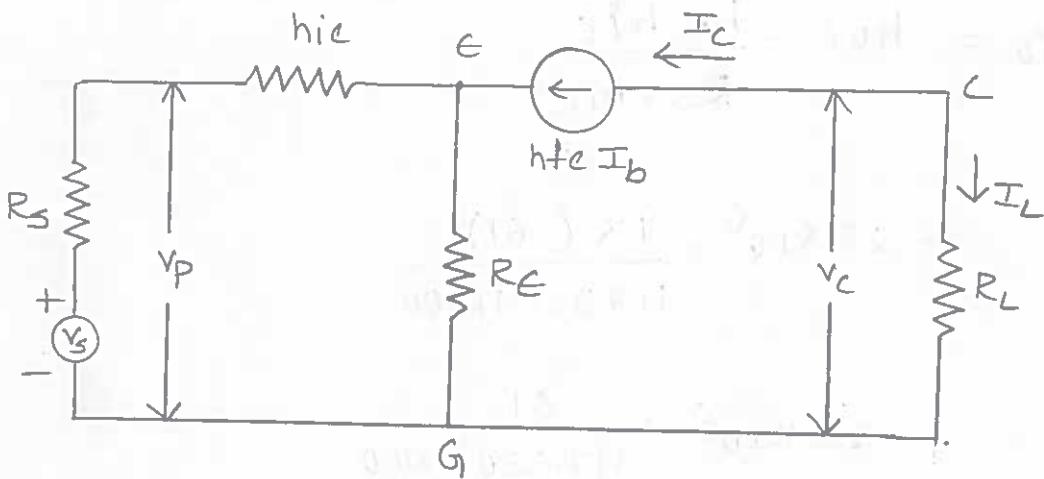
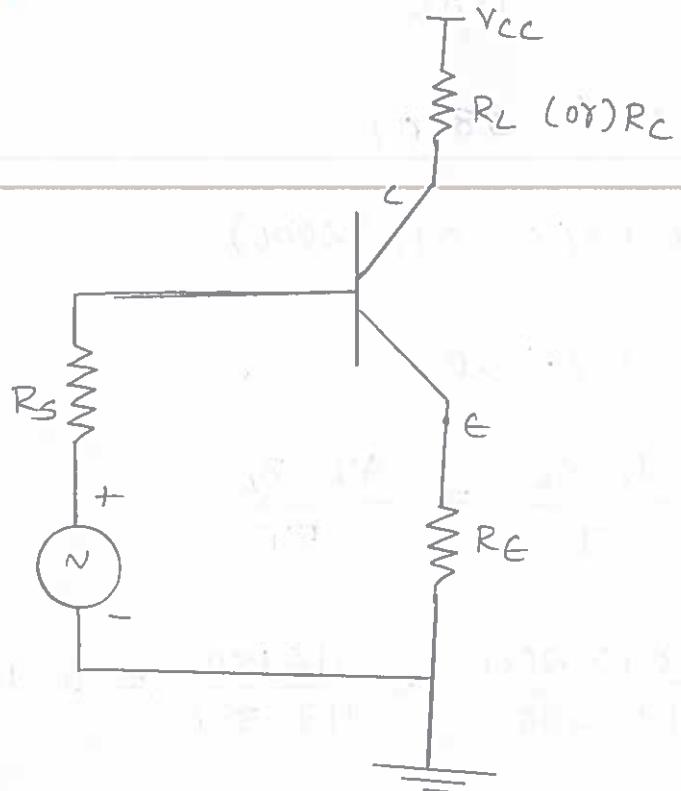
$$= 25 \times 10^{-6} + \frac{61}{117.380 + 1200}$$

$$= \frac{61}{1181580}$$

$$= 0.005$$

$$Y_0 = 25 \times 10^{-6} + 0.0005$$

common emitter amplifier with emitter resistance:-



current gain:-

$$AI = \frac{I_L}{I_B}$$

$$= -\frac{I_C}{I_B} \quad [ \because I_C = hfe I_B ]$$

$$= -hfe \frac{I_B}{I_B}$$

$AI = -hfe$

Input impedance :-

$$Z_i^o = \frac{V_b}{I_b}$$

Apply KVL to the input loop

$$-V_b + h_{ie} I_b + (I_b + h_{fe} I_b) R_E = 0$$

$$V_b = h_{ie} I_b + R_E I_b + h_{fe} I_b R_E$$

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

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

$$Z_i^o = \frac{I_b (h_{ie} + (1+h_{fe}) R_E)}{I_b}$$

$$\boxed{Z_i^o = h_{ie} + (1+h_{fe}) R_E}$$

Voltage gain (AV) :-

$$AV = \frac{A I Z_L}{R_i^o}$$

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

Output admittance :-

$$Y_o = 0$$

$$Y_o = \frac{I_C}{V_C}$$

$$R_o = \infty$$

PROBLEM:-

FOR A CB transistor amplifier is given by a voltage source of internal resistance  $R_S = 1200\Omega$  the load impedance is a resistor  $R_L = 1000\Omega$ , the h-parameters are  $h_{ib} = 22\Omega$ ,  $h_{rb} = 3 \times 10^{-4}$ ,  $h_{fb} = -0.98$  and  $h_{ob} = 0.5 \text{ mA/V}$ . calculate current gain, input impedance, voltage gain, output impedance using exact and approximate Analysis.

Given that:-

$$h_{ib} = 22\Omega ; h_{rb} = 3 \times 10^{-4} ; h_{fb} = -0.98$$

$$h_{ob} = 0.5 \text{ mA} ; R_S = 1200 ; R_L = 1000$$

exact Model:-

$$A_I = \frac{-h_{fb}}{1 + h_{ob}Z_L} = \frac{-(-0.98)}{1 + (0.5)(10^6)(1000)}$$

$$A_I = \frac{0.98}{1 + 0.0005} = \frac{0.98}{1.0005} = 0.979$$

$$Z_i^o = h_{ib} + h_{rb} A_I R_L$$

$$= 22 + 3 \times 10^{-4} \times 0.979 \times 1000$$

$$= 22 + 0.003 \times 0.979 \times 1000$$

$$= 22 + 0.2937$$

$$Z_i^o = 22.3$$

$$AV = \frac{AIB RL}{Z_i} = \frac{0.979 \times 1000}{22.3} = \frac{979}{22.3}$$

$$AV = 43.90$$

$$\begin{aligned} Y_D &= h_{ob} - \frac{h_{fb} h_{fb}}{R_s + h_{ib}} \\ &= (0.5)(10^6) - \frac{(3 \times 10^4)(-0.98)}{1200 + 22} \\ &= 0.0000005 + \frac{(0.0003)(0.98)}{1222} \\ &= 0.0000005 + \frac{0.000294}{1222} \\ &= (0.5)(10^6) + \frac{(0.94)(10^4)}{1222} \end{aligned}$$

$$Y_D = 0.5 \times 10^6 + (0.000294)$$

Approximate Model:-

$$AI = -h_{fb} = -(-0.98) = 0.98$$

$$R_i = h_{ib} = 22$$

$$AV = \frac{AI - RL}{Z_i} = \frac{0.98 \times 500}{22 \times 11} = 44.54$$

$$Y_D = \infty$$

$$R_D = \infty$$

$$\text{Area} = \frac{\pi r^2}{4} \times 4 = \pi r^2$$

$$r = \sqrt{\frac{\text{Area}}{\pi}}$$

$$\text{Radius} = \sqrt{\frac{\text{Area}}{\pi}}$$

(a)  $\text{Area} = \pi r^2$   $\Rightarrow r = \sqrt{\frac{\text{Area}}{\pi}}$

$$(a) \text{Area} = \pi r^2 \Rightarrow r = \sqrt{\frac{\text{Area}}{\pi}}$$

$$r = \sqrt{\frac{100\pi}{\pi}} = \sqrt{100} = 10$$

$$\text{Circumference} = 2\pi r = 2\pi(10) = 20\pi$$

$$= 20\pi \times 0.0314 = 62.8$$

$\approx 63$  cm

$$\text{Circumference} = 2\pi r = 2\pi(10) = 20\pi$$

$$= 20\pi \times 0.0314 = 62.8$$

$$L = \pi r = \frac{\pi \times 10}{\sqrt{100}} = \frac{10\pi}{10} = \pi$$

$$= 3.14 \times 3.14 = 9.86$$