CMR INSTITUTE OF TECHNOLOGY

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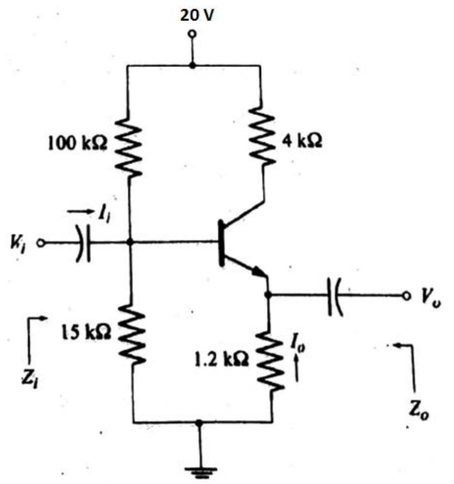
Internal Assesment Test - II

Sub:	**ANALOG ELECTRONIC CIRCUITS**							Code:	18EE34
Date:	25/01/2022	Duration:	90 mins	Max Marks:	50	Sem:	3rd	Branch:	EEE

Answer **Any FIVE FULL** Questions

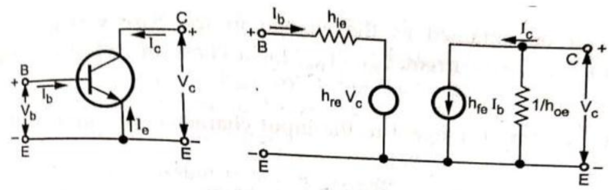
		Marks	OBE CO	OBE RBT
1.	Define h parameter and obtain an equivalent h parameter model of CE, CC and CB configurations. Also write generalized h-parameter equations.	10	CO2	L4
2.	For the Emitter Follower circuit shown below, determine the following: a) r_e b) Z_i c) Z_o d) A_v and e) A_I Take $\beta = 90$ and $r_o = \infty$ 	10	CO2	L4
3.	A transistor in CE mode has h-parameters h_{ie} = 1.1KΩ, h_{re} = 2 x 10^{-4}, h_{fe} = 100 and h_{oe} = 20 μA / V. Determine equivalent CB parameters.	10	CO2	L4
4.	Draw the circuit diagram of Common Emitter amplifier with fixed biasing. Also draw its AC equivalent r_e model. Derive the expression for input impedance, output impedance, voltage gain and current gain.	10	CO2	L4
5.	Derive equations for Miller Input Capacitance and Miller output capacitance with appropriate diagrams.	10	CO2	L4
6.	State and prove Millers Theorem.	10	CO2	L4
7.	What are the advantages of h parameters? Explain the relationship using circuit and equations between the parameters of hybrid model and the r_e model for CE and CB configuration.	10	CO2	L4

CI CCI ` HoD

Solution

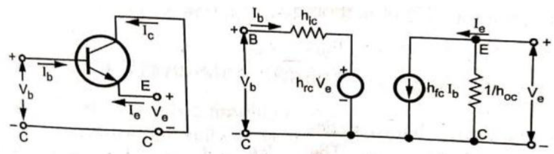
1.
Hybrid means mixed. Here we have mixed parameters.
In hybrid model, the transistor is modelled based on what is happening at its terminals without regard for the physical process taking place inside the transistor.

CE:



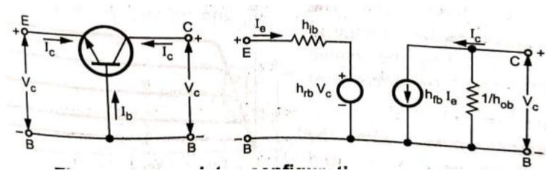
$$v_1 = h_i i_1 + h_r v_2$$
$$i_2 = h_f i_1 + h_o v_2$$
$\Rightarrow$
$$V_b = h_{ie} I_b + h_{re} V_c$$
$$I_c = h_{fe} I_b + h_{oe} V_c$$

CC:



$$v_1 = h_i i_1 + h_r v_2$$
$$i_2 = h_f i_1 + h_o v_2$$
$\Rightarrow$
$$V_b = h_{ic} I_b + h_{rc} V_e$$
$$I_e = h_{fc} I_b + h_{oc} V_e$$

CB:



$$v_1 = h_i i_1 + h_r v_2$$
$$i_2 = h_f i_1 + h_o v_2$$
$\Rightarrow$
$$V_e = h_{ib} I_e + h_{rb} V_c$$
$$I_c = h_{fb} I_e + h_{ob} V_c$$

2.

a) $I_E = 1.23\text{ mA}$

$$r_e = \frac{26\text{mV}}{I_E} = \frac{26\text{mV}}{1.23\text{mA}} = 21.13\ \Omega$$

b)

$$Z_b = \beta(r_e + R_E) = 100\ (21.13\ \Omega + 1.2\text{ k}\Omega) = 122.11\text{ k}\Omega$$

$$Z_i = R_B \parallel Z_b$$

$$R_B = 100\text{ k}\Omega \parallel 15\text{ k}\Omega = 13.04\text{ k}\Omega$$

$$Z_i = 13.04\text{ k}\Omega \parallel 122.11\text{ k}\Omega = 11.78\text{ k}\Omega$$

$$Z_o = R_E \parallel r_e = 1.2\text{ k}\Omega \parallel 21.13\ \Omega = 20.76\ \Omega$$

c) $A_v = 1$

$$A_I = -\frac{A_V Z_i}{R_E} = -\frac{(0.983)(11.78\text{ k}\Omega)}{(1.2\text{ k}\Omega)} = -9.65$$

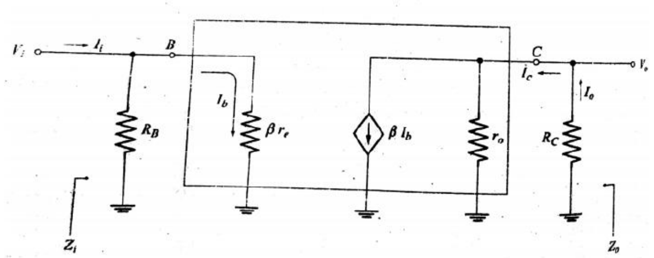
3.

solution

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

$$h_{fb} = \frac{-h_{fe}}{1+h_{fe}}, \quad h_{ob} = \frac{h_{oe}}{1+h_{fe}}.$$

4.



Input Impedance (Z_i):

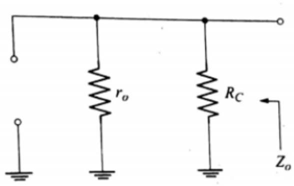
$$Z_i = R_B \parallel \beta r_e$$

If $R_B \geq 10\beta r_e$ $\quad Z_i = \beta r_e$

Output Impedance (Z_o):

Reduce $V_i = 0$ to find output impedance.

$V_i = 0$, $I_i = 0$, $I_b = 0$. Therefore $\beta I_b = 0$



$$Z_o = r_o \parallel R_C$$

If $r_o \geq 10R_c$ (or) $r_o = \infty$, $\quad Z_o = R_c$

Voltage Gain (A_V):

$$V_o = -\beta I_b [r_o \| R_C]$$

From the input circuit,

$$V_i = I_b [\beta r_e]$$

Voltage Gain, $$A_V = \frac{V_o}{V_i}$$

$$= \frac{-\beta I_b [r_o \| R_C]}{I_b [\beta r_e]}$$

$$\boxed{A_V = -\frac{r_o \| R_C}{r_e}} \text{ (or) } \boxed{A_V \approx -\frac{R_C}{r_e}}$$

Current Gain (A_I):

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

$$V_0 = -I_o R_C$$

$$I_o = \frac{-V_o}{R_C}$$

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

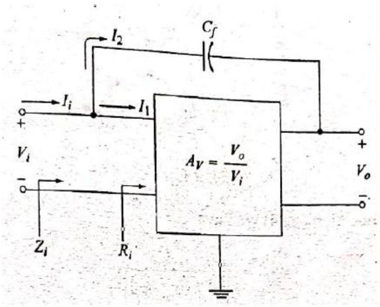
$$A_I = \left[\frac{-V_o}{R_C}\right] \div \left[\frac{V_i}{Z_i}\right]$$

$$= -\left[\frac{V_o}{V_i}\right]\left[\frac{Z_i}{R_C}\right]$$

$$\boxed{A_I = -\frac{A_V Z_i}{R_C}}$$

5.

Miller Input Capacitance (C_{Mi})



Let $R_i = \frac{V_i}{I_1} \Rightarrow I_1 = \frac{V_i}{R_i}$

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

Apply KCL at input node,

$$I_i = I_1 + I_2$$

$$I_2 = \frac{V_i - V_o}{X_{C_f}}$$

$$= \frac{V_i - A_V V_i}{X_{C_f}} \quad [\because V_o = A_V V_i]$$

$$\frac{V_i}{Z_i} = \frac{V_i}{R_i} + \frac{[1 - A_V] V_i}{X_{C_f}}$$

By Eliminating V_i,

$$\frac{1}{Z_i} = \frac{1}{R_i} + \frac{1}{\left[\frac{X_{C_f}}{1 - A_V}\right]}$$

$$\frac{1}{Z_i} = \frac{1}{R_i} + \frac{1}{X_{C_{Mi}}}$$

where $X_{C_{Mi}} = \frac{X_{C_f}}{1 - A_V}$

$$X_{C_f} = \frac{1}{2\pi f C_f}$$

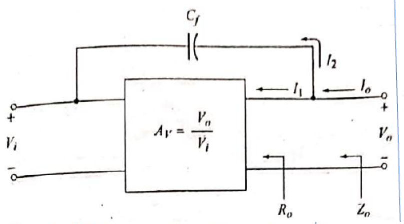
$$X_{C_{Mi}} = \frac{1}{2\pi f [1 - A_V] C_f}$$

$$X_{C_{Mi}} = \frac{1}{2\pi f C_{Mi}}$$

where $\boxed{C_{Mi} = [1 - A_V] C_f}$

where C_{Mi} is Miller input capacitance

Miller Output Capacitance (C_{Mo})



Let $R_o = \frac{V_o}{I_1} \Rightarrow I_1 = \frac{V_o}{R_o}$

and $Z_o = \frac{V_o}{I_o} \Rightarrow I_o = \frac{V_o}{Z_o}$

Apply KCL at output node,

$$I_o = I_1 + I_2$$

$$I_2 = \frac{V_o - V_i}{X_{C_f}}$$

Using $V_i = \frac{V_o}{A_V}$ we have

$$I_2 = \frac{V_o - \frac{V_o}{A_V}}{X_{C_f}} = \frac{V_o\left[1 - \frac{1}{A_V}\right]}{X_{C_f}}$$

$$I_o = \frac{V_o}{R_o} + \frac{V_o\left[1 - \frac{1}{A_V}\right]}{X_{C_f}}$$

Usually R_o is large, so V_o/R_o neglected

Now $I_o \approx \frac{V_o\left[1 - \frac{1}{A_V}\right]}{X_{C_f}}$

$$Z_o = \frac{V_o}{I_o} = \frac{X_{C_f}}{\left[1 - \frac{1}{A_V}\right]}$$

$$Z_o = \frac{1}{2\pi f\left[1 - \frac{1}{A_V}\right]C}$$

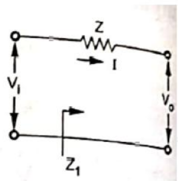
$$Z_o = \frac{1}{2\pi f C_{Mo}}$$

where $C_{Mo} = \left[1 - \frac{1}{A_V}\right]C_f$

where C_{Mo} is Miller output Capacitance

6.

Miller's Theorem states that, the effect if resistance Z on the input circuit is a ratio of input voltage V_i to the current I which flows from the input to the output.



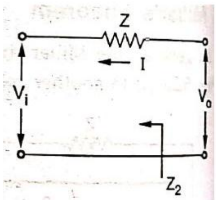
Therefore,

$$Z_1 = \frac{V_i}{I}$$

where, $I = \frac{V_i - V_o}{Z} = \frac{V_i\left[1 - \frac{V_o}{V_i}\right]}{Z} = \frac{V_i[1 - A_v]}{Z}$

$$\therefore Z_1 = \frac{Z}{1 - A_v} = \frac{Z}{1 - K} \quad \left[\because \frac{V_o}{V_i} = A_v = K\right]$$

Miller's Theorem states that, the effect of resistance Z on the output circuit is a ratio of output voltage V_o to the current I which flows from the output to the input.



Therefore,

$$Z_2 = \frac{V_o}{I}$$

where, $I = \frac{V_o - V_i}{Z} = \frac{V_o\left[1 - \frac{V_i}{V_o}\right]}{Z} = \frac{V_o\left[1 - \frac{1}{A_v}\right]}{Z}$

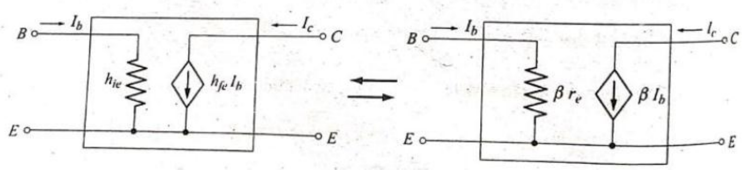
$$= \frac{V_o\left[\frac{A_v - 1}{A_v}\right]}{Z}$$

$$\therefore Z_2 = \frac{V_o}{I} = \frac{Z}{\left[\frac{A_v - 1}{A_v}\right]} = \frac{ZA_v}{A_v - 1} = \frac{Z \cdot K}{K - 1}$$

$$\left[\because \frac{V_o}{V_i} = A_v = K\right]$$

7.

Relation between the parameters of Hybrid model and r_e model for CE configuration.

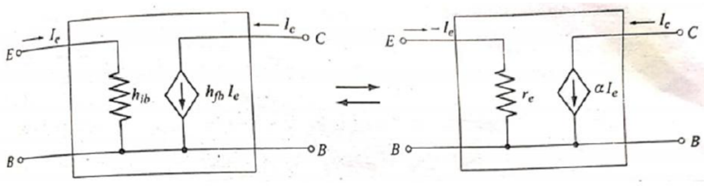


By comparing the two models,

$$h_{ie} = \beta r_e$$

$$h_{fe} = \beta$$

Relation between the parameters of Hybrid model and r_e model for CB configuration.



By comparing,

$$h_{ib} = r_e$$

$$h_{fb} = -\alpha \ (\alpha \approx 1).$$

Benefits of h-parameter

- Easy to measure
- Can be obtained from the transistor characteristic curves
- Convenient to use in circuit analysis and design.
- Most of the transistor manufacturers specify the h-parameter.