Topic 2.3 : Analysis of Transistor amplifier circuit using h parameters

Midband Analysis of BJT single stage Amplifiers

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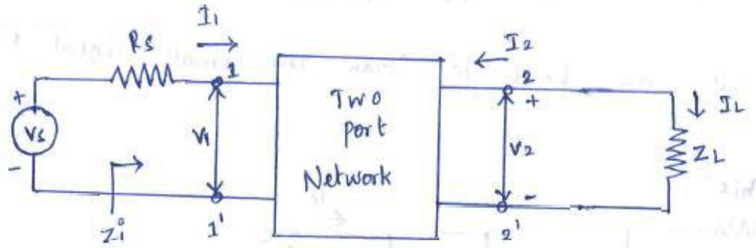
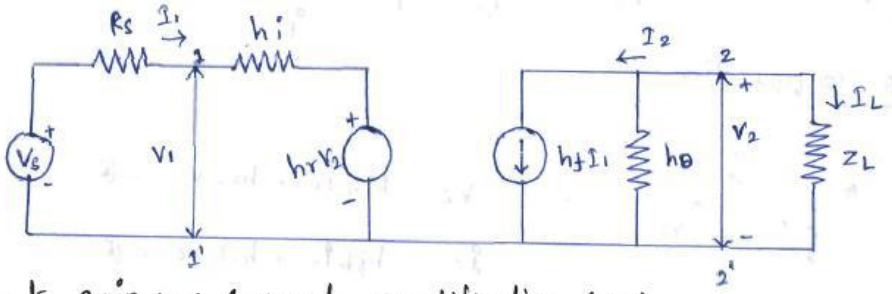


A Transistor can be constructed by connecting an external load & signal source as indicated & biasing the transistor properly.



1. current gain (or) Current Amplification (A_I)

It's the ratio of output current to input current.

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

Here I_L & I_2 are equal in magnitude but opposite in sign

ie $I_L = -I_2$

From the circuit

$$I_2 = h_f I_1 + h_o V_2$$

Then

$$V_2 = I_L Z_L = -I_2 Z_L$$

Substitute V_2 in I_2

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

$$I_2 + h_o I_2 Z_L = h_f I_1$$

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

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

$$\therefore A_I = \frac{-I_2}{I_1} = \frac{-h_f}{1 + h_o Z_L}$$

2. Input Impedance (Z_i)

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

From input circuit

$$V_1 = h_i I_1 + h_r V_2$$

Substitute V_1 in Z_i

$$Z_i = \frac{h_i I_1 + h_r V_2}{I_1} = h_i + h_r \frac{V_2}{I_1} \quad \text{— (1)}$$

$$\because V_2 = -I_2 Z_L$$

$$= -(-A_I I_1) Z_L$$

$$V_2 = A_I I_1 Z_L \quad \text{— (2)}$$

sub (2) in (1)

$$Z_i = h_i + h_r \frac{A_I I_1 Z_L}{I_1}$$

$$= h_i + h_r A_I Z_L$$

Sub A_I in Z_i

$$Z_i = h_i + h_r\left(\frac{-h_f}{1 + h_o Z_L}\right) Z_L$$

$$= h_i - \frac{h_r h_f \cdot Z_L}{1 + h_o Z_L} = h_i - \frac{(h_r h_f) Z_L}{Z_L(\frac{1}{Z_L} + h_o)}$$

$$= h_i - \frac{h_r h_f}{\frac{1}{Z_L} + h_o} \qquad \because Y_L = \frac{1}{Z_L}$$

$$Z_i = h_i - \frac{h_r h_f}{Y_L + h_o} \quad \text{(5)}$$

→ The input impedance is the function of Load impedance.

3. Voltage gain (or) Voltage Amplification factor (A_v)

It's the ratio of output voltage to input voltage

$$A_v = \frac{V_2}{V_1}$$

$$V_2 = -I_2 Z_L = A_I I_1 Z_L \qquad \because A_I = \frac{-I_2}{I_1}$$

Sub V_2 in A_v

$$A_v = \frac{A_I I_1 Z_L}{V_1} \qquad \frac{I_1}{V_1} = \frac{1}{Z_i}$$

$$A_v = \frac{A_I Z_L}{Z_i}$$

4. Output Admittance (Y_o)

It's the ratio of output current (I_2) to the output voltage (V_2).

$$Y_o = \frac{I_2}{V_2} \text{ with } V_s = 0$$

$$I_2 = h_f I_1 + h_o V_2 \quad —① $$

divide eqn① by V_2

$$Y_o \Leftarrow \frac{I_2}{V_2} = \frac{h_f I_1 + h_o V_2}{V_2} = \frac{h_f I_1}{V_2} + h_o \quad —②$$

With $V_s = 0$ by Apply KVL to the above circuit

$$R_s I_1 + h_i I_1 + h_r V_2 = 0$$

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

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

$$\frac{I_1}{V_2} = \frac{-h_r}{(R_s + h_i)}$$

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

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

$\Rightarrow$ Output impedance is a function of source resistance. If the source Impedance is resistive then Y_o is real.

⑥