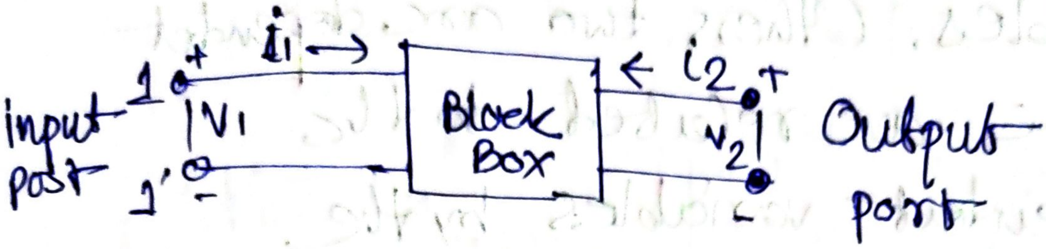
## Transistor as a two-port device & Hybride model.




After the establishment of Q point, suitable DC values of voltages & current, alternating corret or valtager are applied to a pair of input terminal of the transistor amplifier. This liner performance of the amplifier can be studdied analytically by regarding the transistor In any one of its 3 modes as a block box having a pair of input & output terminals. So, there are four variables input corret $i_1$, input valtage $v_1$, output corret $i_2$, output valtage $v_2$

The input current $i_1$ & the output voltage $v_2$ are taken as independent variables. Others two are dependent variable, are related to the independent variables by the following eq^n.

$$v_1 = h_{11} i_1 + h_{12} v_2$$

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

- hence, $h_{11} = \left(\frac{v_1}{i_1}\right)_{v_2 = 0}$ = input impidence with the output port short-circuited for AC

- $h_{12} = \left(\frac{v_1}{v_2}\right)_{i_1 = 0}$ = Reverse voltage amplification factor with the input port open-circuited for AC

- $h_{21} = \left(\frac{i_2}{i_1}\right)_{v_2 = 0}$ = current gain with the output short-circuited for AC

- $h_{22}$

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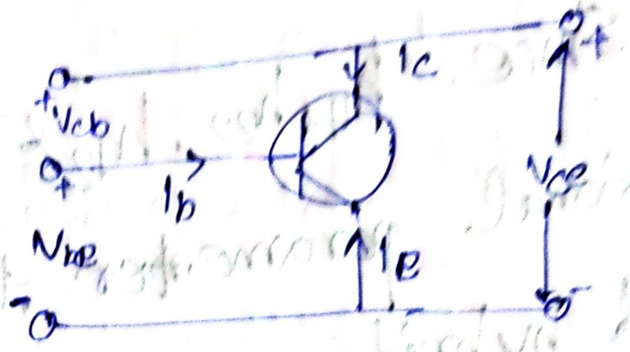
•) $h_{22} = \left(\frac{i_2}{V_2}\right)_{i_1 = 0}$ = output Admittance with the input port open-circuited.

Since, $h_{11}$, $h_{22}$, $h_{12}$ & $h_{21}$ have diffrent dimensional parameter, they are called hybride parameter.

## Conversion formulas for h-parameters of three transistor Modes:




$h_{11} \rightarrow h_i$ (input impedance

$h_{12} \rightarrow h_r$ (reverse voltage Amplification

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

$h_{22} \rightarrow h_o$ (Output Admittance)

According to KCL, $I_c + I_b + I_e = 0$ —— (1)

" " KVL,

$V_{ce} = V_{cb} + V_{be}$ —— (2)

h-parameter eqn are -

$V_{be} = h_{ie} I_b + h_{re} \cdot V_{ce}$ —— (3)

$I_c = h_{fe} I_b + h_{oe} \cdot V_{ce}$ —— (4)

Substituting for $I_B$ from eq(1) & $V_{CE}$ from eq.(2) in eq(3)

$$V_{be} = h_{ie}(-I_c - I_e) + h_{re}(V_{cb} + V_{be})$$

$$V_{be}(1 - h_{re}) = h_{re}V_{cb} - (I_c + I_e)h_{ie}$$

$$V_{be} = \frac{h_{re}V_{cb} - (I_c + I_e)h_{ie}}{(1 - h_{re})} \quad \text{— (5)}$$

Substituting for $I_B$ from eq(1) & $V_{CE}$ from eq(2) in eq(3)

$$I_c = h_{fe}(-I_c - I_e) + h_{oe}\cdot(V_{CB} + V_{be})$$

$$I_c = -h_{fe}(I_c + I_e) + h_{oe}\cdot\left(\frac{h_{re}V_{cb} - (I_c + I_e)h_{ie}}{(1 - h_{re})} + V_{cb}\right)$$

$$\Rightarrow I_c\left(1 + h_{fe} + \frac{h_{oe}h_{ie}}{1 - h_{re}}\right) = -h_{fe}I_e + h_{oe}\left(\frac{h_{re}V_{CB} - I_e h_{ie}}{(1 - h_{re})} + V_{cb}\right) \quad \text{— (6)}$$

$h_{re} \ll 1$ & $h_{oe}\cdot h_{ie} \ll 1$

$I_c(1+h_{fe}) = -h_{fe}I_e + h_{oe}V_{cb}$

$I_c = -\frac{h_{fe}I_e}{1+h_{fe}} + \frac{h_{oe}}{1+h_{fe}}V_{cb}$ — (6)

<u>h-parameter eqⁿ for Cb mode.</u>

$I_c = h_{fb}I_e + h_{ob}V_{cb}$ — (7)

<u>comparing 6 & 7</u>

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