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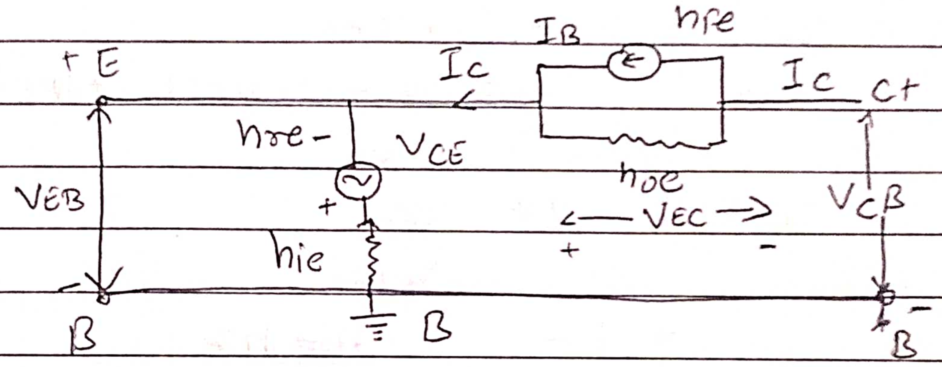
Assignment - 2

Conversion of h parameters in transistor three configurations

Common Base

Circuit of redrawn CB configuration



By definition

$$h_{rb} = \frac{V_{eb}}{V_{cb}} = \frac{V_{ec} + V_{cb}}{V_{cb}}$$

$$h_{rb} = 1 + \frac{V_{ec}}{V_{cb}}$$

If $I_e = 0$, $I_c = -I_B$

$$\therefore \quad I_c = h_{fe} I_B - h_{oe} V_{ec}$$

$$-I_B = h_{fe} I_B - h_{oe} V_{ec}$$

$$h_{oe} V_{ec} = (1 + h_{fe}) I_B$$

Applying KVL at output mesh

$$h_{ie} I_B + h_{re} V_{ce} + V_{ec} + V_{cB} = 0$$

$$h_{ie}\left(\frac{h_{oe} V_{ec}}{1+h_{fe}}\right) - h_{re} V_{ec} + V_{ec} + V_{cb} = 0$$

$$\frac{h_{ie}h_{oe} + (1-h_{re})(1+h_{fe})}{1+h_{fe}} \cdot V_{ec} = -V_{cb}$$

$$\frac{V_{ec}}{V_{cb}} = \frac{-(1+h_{fe})}{h_{ie}h_{oe} + (1-h_{re})(1+h_{fe})}$$

$$\therefore \; h_{rb} = 1 + \frac{V_{ec}}{V_{cb}}$$

$$= 1 - \frac{1+\cancel{h_{fe}}\,h_{fe}}{h_{ie}h_{oe} + \cancel{h_{re}}\,(1-h_{re})(1+h_{fe})}$$

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

$\because \; h_{re} << 1$ and $h_{ie}h_{oe} << 1+h_{fe}$

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

By definition,

$$h_{ob} = \frac{I_c}{V_{cb}} = \frac{-I_B}{V_{cB}}$$

By definition,

$$h_{ob} = \frac{I_c}{V_{cb}} = \frac{-I_B}{V_{cB}}$$

$$= \frac{-I_B(1+h_{fe})}{-(h_{ie}h_{oe} + (1-h_{re})(1+h_{fe})]V_{ec}}$$

$$= \frac{\cancel{(1+h_{fe})}(h_{oe})}{(h_{ie}h_{oe} + (1-h_{re})(1+h_{fe}))\cancel{(1+h_{fe})}}$$

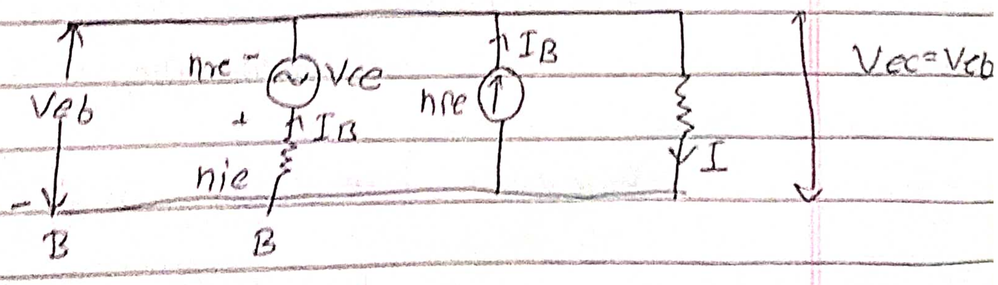
$$= \frac{h_{oe}}{h_{ie}h_{oe} + (1-h_{re})(1+h_{fe})}$$

$\because$ $h_{re} << 1$ and $h_{ie}h_{oe} << 1+h_{fe}$

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

If terminals C and B are connected,

$V_{ec} = V_{eb}$



Applying KVL at Input mesh,

$$V_{eb} + h_{re} V_{ce} + h_{ie} I_b = 0$$

$$V_{eb} - h_{re} V_{ec} + h_{ie} I_b = 0$$

$$I_b = -\frac{(1-h_{re}) V_{eb}}{h_{ie}}$$

Applying KCL at node:

$$I_b + I_e + h_{fe} I_b - h_{oe} V_{eb} = 0$$

$$I_e = -(1+h_{fe}) I_b + h_{oe} V_{eb}$$

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

By definition,

$$h_{ib} = \frac{V_{eb}}{I_e}$$

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

since, $h_{re} << 1$ and $h_{oe} h_{ie} << 1 + h_{fe}$

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

By definition,

$$h_{fb} = \frac{i_c}{i_e}$$

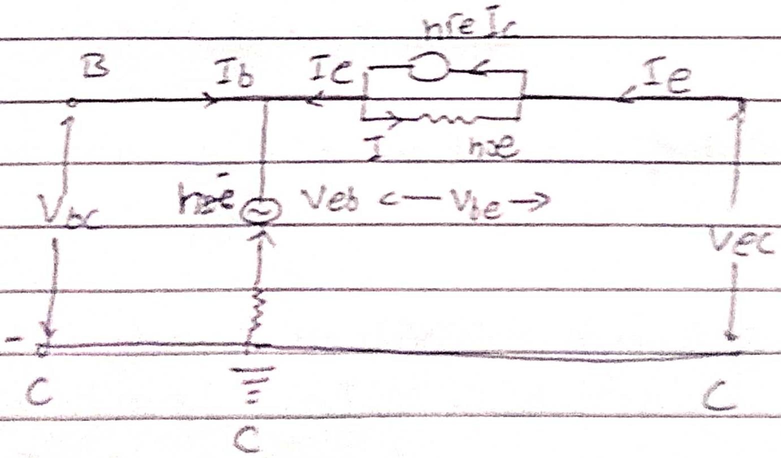
$$= \frac{V_{eb}\left(\frac{-h_{fe}(1-h_{re}) - h_{ie}h_{oe}}{h_{ie}}\right)}{V_{eb}\left(\frac{h_{ie}h_{oe} + (1-h_{re})(1+h_{fe})}{h_{ie}}\right)}$$

$$= -\left(\frac{h_{ie}h_{oe} + (1-h_{re})h_{fe}}{h_{ie}h_{oe} + (1-h_{re})(1+h_{fe})}\right)$$

$\because$ $h_{re} << 1$ and $h_{ie}h_{oe} << 1+h_{fe}$

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

Common Collector configuration



By definition,

$$h_{rc} = \frac{V_{bc}}{V_{ec}} = \frac{V_{be} + V_{ec}}{V_{ec}}$$

$$= 1 + \frac{V_{be}}{V_{ec}} = 1 - \frac{V_{be}}{V_{ce}}$$

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

since $I_b = 0$,

$$I_e = -I_c$$

$$h_{oc} = \frac{-I_c}{V_{ec}} = \frac{I_c}{V_{ce}}$$

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

If terminals C and E are connected,

$$V_{be} = V_{bc}$$

$$h_{ic} = \frac{V_{bc}}{I_b} = \frac{V_{be}}{I_b}$$

$$\boxed{h_{ic} = h_{ie}}$$

since, $h_{fc} = \frac{I_e}{I_b}$

applying KCL at node,

$$I_e + I_b + I_c = 0$$

$$I_e = -(I_b + I_c)$$

$$h_{fc} = -\frac{I_b + I_c}{I_b}$$

$$= -\left(1 + \frac{I_c}{I_b}\right)$$

since, $\frac{I_c}{I_b} = h_{fe}$

$\cancel{h_{fe}}$

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