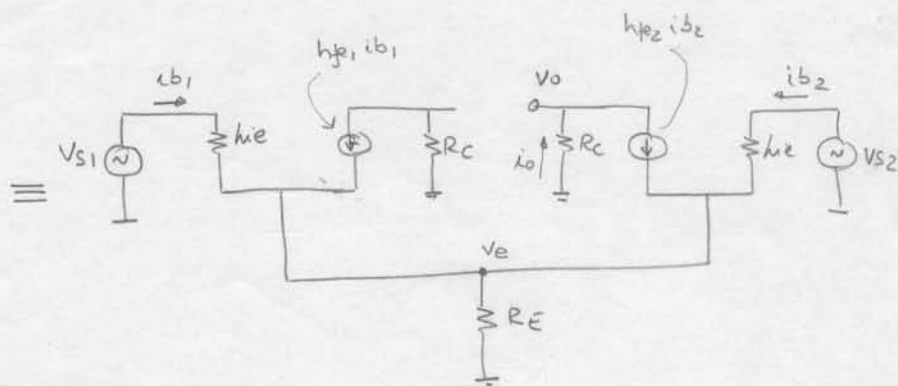
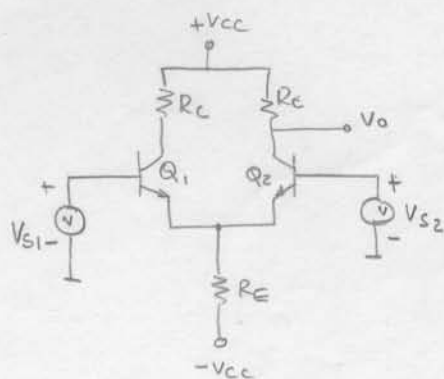




Considerando $Q_1 \equiv Q_2$

$$\begin{cases} h_{ie1} = h_{ie2} \\ h_{fe1} = h_{fe2} \end{cases}$$

Aplicando o Teorema de Norton ao nó V_e :

$$V_e = \frac{\frac{V_{S1} (h_{fe}+1)}{h_{ie}} + \frac{V_{S2} (h_{fe}+1)}{h_{ie}}}{\frac{1}{R_E} + \frac{h_{fe}+1}{h_{ie}} + \frac{h_{fe}+1}{h_{ie}}} = \frac{\frac{(h_{fe}+1)}{h_{ie}} (V_{S1} + V_{S2})}{\frac{h_{ie} + 2(h_{fe}+1)R_E}{h_{ie}R_E}}$$

$$V_e = \frac{(h_{fe}+1) R_E}{h_{ie} + 2(h_{fe}+1) R_E} (V_{S1} + V_{S2})$$

$$\left. \begin{aligned} V_o &= -i_o R_C = -h_{fe} i_b R_C \\ i_b &= \frac{V_{S2} - V_e}{h_{ie}} \end{aligned} \right\} \Rightarrow V_o = -\frac{h_{fe} R_C}{h_{ie}} (V_{S2} - V_e)$$

i) OPERAÇÃO EM MODO COMUM : $V_{S1} = V_{S2} = V_C$

$$V_e = \frac{2(h_{fe}+1) R_E}{h_{ie} + 2(h_{fe}+1) R_E} V_C \Rightarrow V_e \approx V_C$$

$$V_o = -\frac{h_{fe} R_C}{h_{ie}} \left(1 - \frac{2(h_{fe}+1) R_E}{h_{ie} + 2(h_{fe}+1) R_E} \right) V_C \Rightarrow A_C = \frac{V_o}{V_C} = -\frac{h_{fe} R_C}{h_{ie} + 2(h_{fe}+1) R_E}$$

ii) OPERAÇÃO EM MODO DIFERENCIAL : $V_{S2} = -V_{S1} = -\frac{V_d}{2}$

$$V_e = 0 \rightarrow \text{TERRA VIRTUAL}$$

$$V_o = -\frac{h_{fe} R_C}{h_{ie}} \left(-\frac{V_d}{2} \right) \Rightarrow A_d = \frac{h_{fe} R_C}{2 h_{ie}}$$

iii) OPERAÇÃO COM UMA DAS ENTRADAS ATERRADA: $V_{S1} = 0$ e $V_{S2} = V_d$

$$V_e = \frac{(h_{fe} + 1) R_E}{h_{ie} + 2(h_{fe} + 1) R_E} V_d \Rightarrow \boxed{V_e \approx \frac{V_d}{2}}$$

$$V_o = - \frac{h_{fe} R_c}{h_{ie}} \left(- \frac{(h_{fe} + 1) R_E}{h_{ie} + 2(h_{fe} + 1) R_E} \right) V_d$$

$$\boxed{A_d = \frac{V_o}{V_d} = \frac{h_{fe} R_c}{h_{ie}} \cdot \frac{(h_{fe} + 1) R_E}{h_{ie} + 2(h_{fe} + 1) R_E}} \Rightarrow \boxed{A_d \approx \frac{h_{fe} R_c}{2 h_{ie}}}$$

OBS.: Este modo de operação funciona de forma idêntica ao modo diferencial.

IMPEDÂNCIA DE ENTRADA:

i) OPERAÇÃO EM MODO COMUM: $V_{S1} = V_{S2} = V_c$

$$\tilde{Z}_{ic} = \frac{V_c}{\frac{V_c - V_e}{h_{ie}}} = \frac{h_{ie}}{1 - \frac{V_e}{V_c}} = \frac{h_{ie}}{1 - \frac{2(h_{fe} + 1) R_E}{h_{ie} + 2(h_{fe} + 1) R_E}}$$

$$\boxed{\tilde{Z}_{ic} = h_{ie} + 2(h_{fe} + 1) R_E}$$

ii) OPERAÇÃO EM MODO DIFERENCIAL: $V_{S2} = -V_{S1} = -\frac{V_d}{2}$

$$\tilde{Z}_{id} = \frac{V_{S1} - V_{S2}}{\frac{V_{S1} - V_e}{h_{ie}}} = h_{ie} \frac{V_d}{\frac{V_d}{2}} \Rightarrow \boxed{\tilde{Z}_{id} = 2 h_{ie}}$$

iii) OPERAÇÃO COM UMA DAS ENTRADAS ATERRADA: $V_{S1} = 0$ e $V_{S2} = V_d$

$$\tilde{Z}_{id} = \frac{V_{S2}}{\frac{V_{S2} - V_e}{h_{ie}}} = h_{ie} \frac{1}{1 - \frac{V_e}{V_{S2}}} = \frac{h_{ie}}{1 - \frac{V_d/2}{V_d}} \Rightarrow \boxed{\tilde{Z}_{id} = 2 h_{ie}}$$