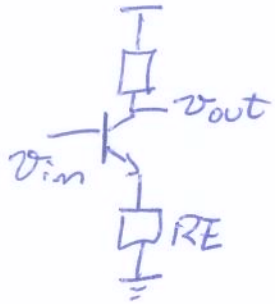
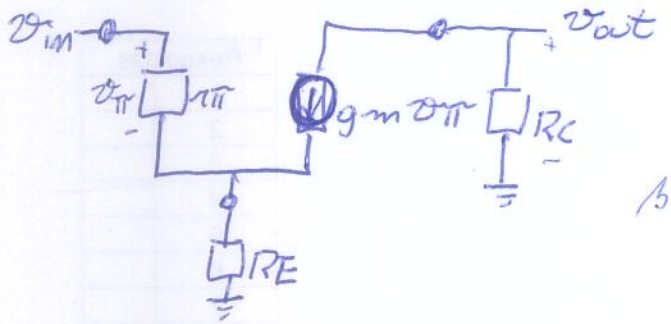
Aula 8B - Amplificadores com TBJ

- Emissor comum com degeneração de emissor



$\Rightarrow$



$\beta = r\pi \cdot g_m$

A_v

$$v_{out} = -g_m v_\pi R_C$$

$$v_{in} = v_\pi + v_{RE} = v_\pi + R_E\left(g_m v_\pi + \frac{v_\pi}{r_\pi}\right) = v_\pi + R_E v_\pi\left(g_m + \frac{1}{r_\pi}\right)$$

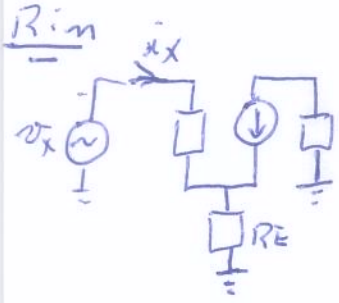
$$v_{in} = v_\pi\left[1 + R_E\left(g_m + \frac{1}{r_\pi}\right)\right]$$

$$A_v = \frac{v_{out}}{v_{in}} = \frac{-g_m v_\pi R_C}{v_\pi\left[1 + R_E\left(g_m + \frac{1}{r_\pi}\right)\right]} = \frac{-g_m R_C}{1 + R_E\left(g_m + \frac{g_m}{\beta}\right)}$$

($\frac{g_m}{\beta} \sim g_m$)

$$A_v = \frac{-g_m R_C}{1 + R_E g_m} \quad \div g_m \Rightarrow \boxed{A_v = \frac{-R_C}{\frac{1}{g_m} + R_E}}$$

R_{in}



$$v_x = v_\pi \cdot \left[1 + R_E\left(g_m + \frac{1}{r_\pi}\right)\right]$$

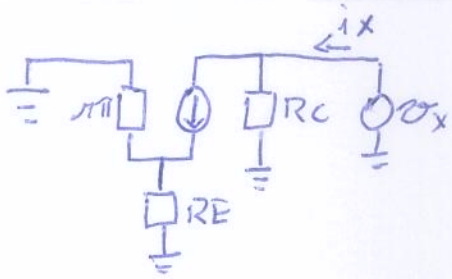
$$i_x = \frac{v_\pi}{r_\pi}$$

$$R_{in} = \frac{v_x}{i_x} = r_\pi\left[1 + R_E\left(g_m + \frac{1}{r_\pi}\right)\right] = r_\pi + R_E r_\pi\left(g_m + \frac{1}{r_\pi}\right)$$

$$R_{in} = r_\pi + R_E r_\pi g_m + R_E \quad (r_\pi g_m = \beta)$$

$$\boxed{R_{in} = r_\pi + R_E \cdot (\beta + 1)}$$

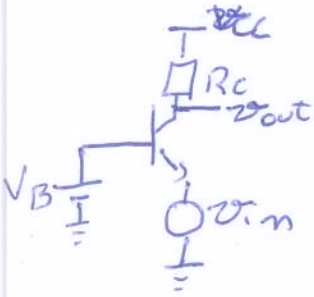
Rout



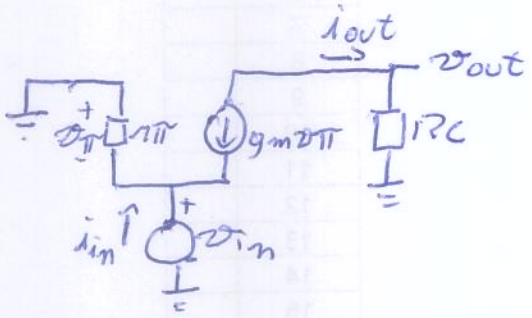
$\Rightarrow v_\pi = 0 \Rightarrow g_m v_\pi = 0 \Rightarrow \frac{v_x}{i_x} = R_C$

$\Rightarrow \boxed{R_{out} = R_C}$

BASE COMUM



$\Rightarrow$

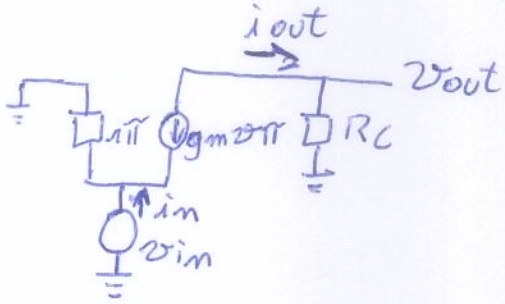


$v_{in} = -v_\pi$

Av

$v_{out} = -g_m v_\pi R_C \Rightarrow v_{out} = g_m v_{in} R_C \Rightarrow \frac{v_{out}}{v_{in}} = \boxed{A_v = g_m R_C}$

Ai



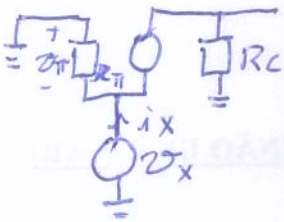
$i_{in} = -\frac{v_\pi}{r_\pi} - g_m v_\pi = -v_\pi \left(\frac{1}{r_\pi} + g_m\right)$

$i_{in} = -v_\pi \frac{r_\pi g_m + 1}{r_\pi} = -v_\pi \frac{\beta + 1}{r_\pi} \quad (r_\pi \rightsquigarrow \beta/g_m)$

$i_{in} = -v_\pi \cdot \frac{\beta + 1}{\beta / g_m} \Rightarrow i_{in} = -v_\pi g_m \left(\frac{\beta+1}{\beta}\right)$

$i_{out} = -g_m v_\pi \Rightarrow \frac{i_{out}}{i_{in}} = \frac{-g_m v_\pi}{-v_\pi g_m \left(\frac{\beta+1}{\beta}\right)} = \frac{\beta}{\beta+1} \Rightarrow \boxed{A_i = \alpha}$

Rin

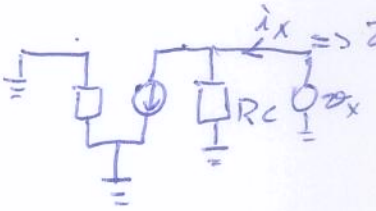


$i_x = -\frac{v_\pi}{r_\pi} - g_m v_\pi \Rightarrow i_x = -v_\pi \left(\frac{1}{r_\pi} + g_m\right)$

$v_x = -v_\pi \Rightarrow i_x = v_x \left(\frac{1}{r_\pi} + g_m\right) \Rightarrow \frac{v_x}{i_x} = \frac{1}{\frac{r_\pi g_m + 1}{r_\pi}}$ ($\frac{v_x}{i_x} = A_i$)

$A_i = \frac{1}{\frac{\beta+1}{r_\pi}} = r_\pi \cdot \frac{1}{\beta+1} = \frac{\beta}{g_m} \cdot \frac{1}{\beta+1} \Rightarrow \boxed{A_i = \frac{\alpha}{g_m}}$

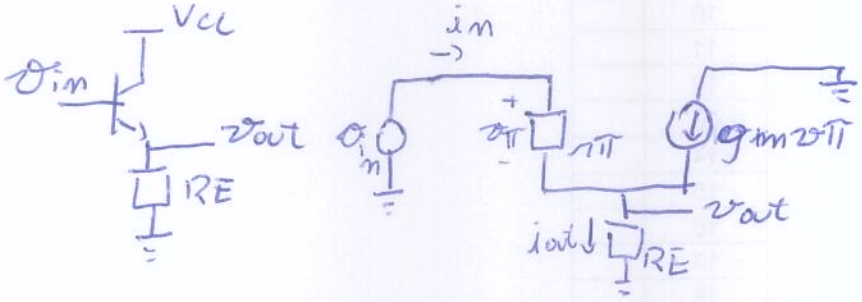
Rout



$\Rightarrow v_\pi = 0 \Rightarrow g_m v_\pi = 0 \Rightarrow R_{out} = R_C$

$\Rightarrow$ Refazer considerando o efeito Early

- COLETOR COMUM - Seguidor de emissor



$$v_{out} = R_E \cdot \left(\frac{v_\pi}{r_\pi} + g_m v_\pi\right) = R_E v_\pi \left(\frac{1}{r_\pi} + g_m\right) = R_E v_\pi \frac{1 + r_\pi g_m}{r_\pi} \approx R_E v_\pi \frac{\beta}{g_m}$$

$$v_{out} = R_E v_\pi \cdot g_m \cdot \frac{\beta+1}{\beta}$$

$$v_{in} = v_\pi + v_{out} \Rightarrow v_{in} = v_\pi + R_E v_\pi \cdot g_m \frac{\beta+1}{\beta}$$

$$v_{in} = v_\pi \cdot \left(1 + R_E g_m \frac{\beta+1}{\beta}\right)$$

$$A_v = \frac{v_{out}}{v_{in}} = \frac{R_E v_\pi g_m \cdot \frac{\beta+1}{\beta}}{v_\pi \left(1 + R_E g_m \frac{\beta+1}{\beta}\right)} = \frac{R_E g_m (\beta+1)}{\beta + R_E g_m (\beta+1)}$$

$$A_v = \frac{R_E g_m (\beta+1) \div g_m}{\beta + R_E g_m (\beta+1) \div g_m} \Rightarrow \boxed{A_v = \frac{R_E (\beta+1)}{(\beta+1) R_E + \frac{\beta}{g_m}} \cong \frac{R_E}{R_E + \frac{1}{g_m}}}$$

Ao

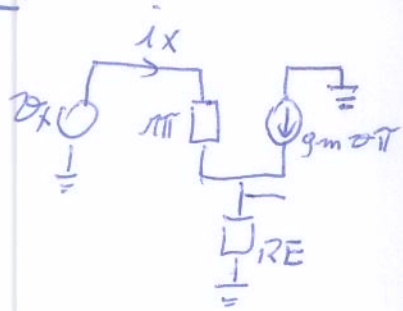
A_i

$$i_{out} = \frac{v_{out}}{R_E} = v_\pi g_m \frac{\beta+1}{\beta}$$

$$i_{in} = \frac{v_\pi}{r_\pi}$$

$$A_i = \frac{i_{out}}{i_{in}} = r_\pi \overset{\beta}{\widetilde{\pi}} g_m \frac{\beta+1}{\beta} \Rightarrow \boxed{A_i = \beta+1}$$

Rin



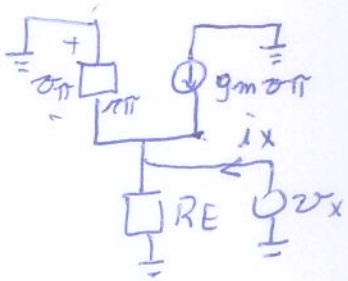
$$i_x = \frac{v_\pi}{r_\pi}$$

$$v_x = v_\pi \cdot \left(1 + R_E g_m \frac{\beta+1}{\beta}\right)$$

$$\frac{v_x}{i_x} = r_\pi \cdot \left(1 + R_E g_m \frac{\beta+1}{\beta}\right) = r_\pi \cdot \left(1 + R_E \frac{\beta}{r_\pi} \cdot \frac{\beta+1}{\beta}\right)$$

$$\boxed{R_{in} = \frac{v_x}{i_x} = r_\pi + R_E(\beta+1)}$$

Rout



$$i_x = \frac{v_x}{R_E \| r_\pi} - g_m v_\pi \quad \xrightarrow{v_\pi = -v_x} \quad i_x = \frac{v_x}{R_E \| r_\pi} + g_m v_x$$

$$i_x = v_x \left(\frac{1}{R_E \| r_\pi} + g_m\right)$$

$$i_x = v_x \cdot \left(\frac{R_E + r_\pi}{R_E r_\pi} + g_m\right) = v_x \left(\frac{R_E + r_\pi + R_E r_\pi g_m}{R_E r_\pi}\right) = v_x \cdot \left(\frac{R_E(1+\beta) + r_\pi}{R_E r_\pi}\right)$$

$\div\beta$, $\div\beta$

$$\Rightarrow i_x \cong v_x \cdot \frac{R_E + r_\pi/\beta}{R_E \cdot r_\pi/\beta} \Rightarrow i_x \cong v_x \cdot \frac{R_E \| 1/g_m}{R_E \| 1/g_m}$$

$$R_{out} = \frac{v_x}{i_x} \cong \frac{1}{\frac{R_E + r_\pi/\beta}{R_E \cdot r_\pi/\beta}} \cong R_E \| \frac{r_\pi}{\beta} \Rightarrow \boxed{R_{out} = R_E \| 1/g_m}$$

Recalcular para $V_A < \infty$