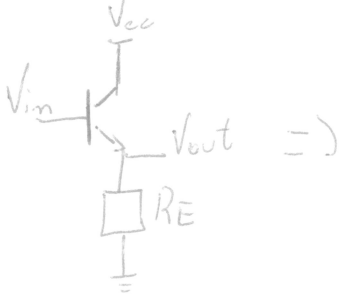
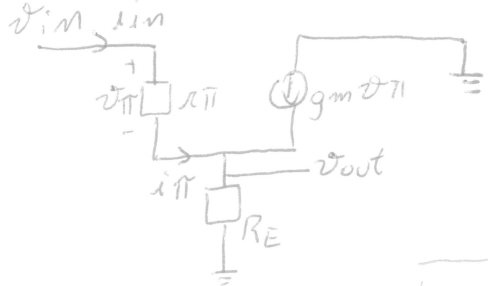
*Seguidor de emisor



=>



$$v_{out} = R_E \cdot (i_\pi + g_m v_\pi) = R_E \cdot \left(\frac{v_\pi}{r_\pi} + g_m v_\pi\right) \Rightarrow \boxed{v_{out} = v_\pi R_E \cdot \left(\frac{1}{r_\pi} + g_m\right)}$$

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

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

$$A_v = \frac{R_E \cdot \left(\frac{g_m(\beta+1)}{\beta}\right)}{1 + R_E\left(\frac{g_m(\beta+1)}{\beta}\right)} = \frac{R_E\left(\frac{g_m(\beta+1)}{\beta}\right)}{\beta + R_E g_m(\beta+1)} = \frac{R_E g_m(\beta+1)}{\beta + R_E g_m(\beta+1)} \cdot g_m^{-1} \cdot g_m^{-1}$$

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

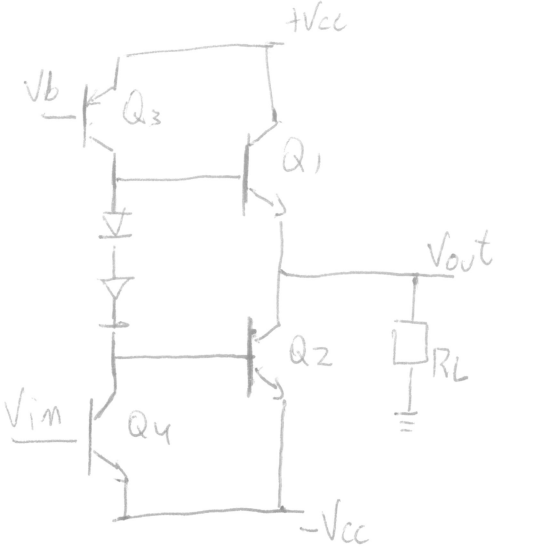
$$i_{in} = \frac{v_\pi}{r_\pi}$$

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

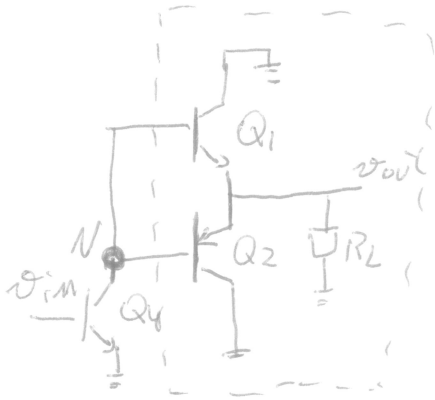
$$z_{in} = r_\pi + R_E r_\pi \cdot \left(\frac{1}{r_\pi} + g_m\right)$$

$$z_{in} = r_\pi + R_E \cdot \left(1 + \underbrace{g_m r_\pi}_{\beta}\right)$$

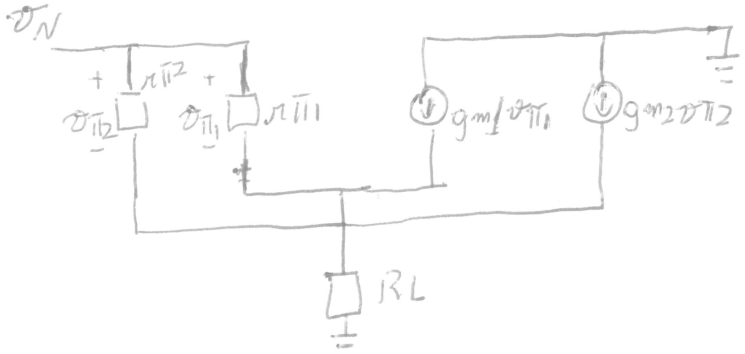
※ PUSH - PULL

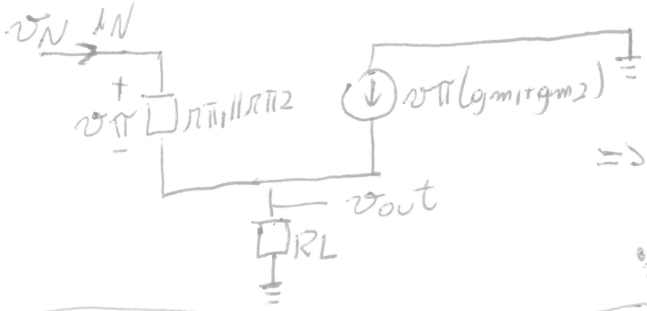


$r_o \sim \infty$
$V_A = \infty$
=>



=> Mod. Pegmos8 in main estágio de saída





=> Similar ao seguidor de emissor

$v_{out} = R_L \cdot \left(\frac{v_\pi}{r_{\pi 1} // r_{\pi 2}} + (g_{m1}+g_{m2}) v_\pi \right)$

$v_{in} = v_\pi + v_{out}$

$i_{in} = \frac{v_\pi}{r_{\pi 1} // r_{\pi 2}}$

$$\therefore \frac{v_{out}}{v_N} = \frac{R_L \left(\frac{1}{r_{\pi 1} // r_{\pi 2}} + (g_{m1}+g_{m2}) \right)}{1 + R_L \left(\frac{1}{r_{\pi 1} // r_{\pi 2}} + (g_{m1}+g_{m2}) \right)}$$

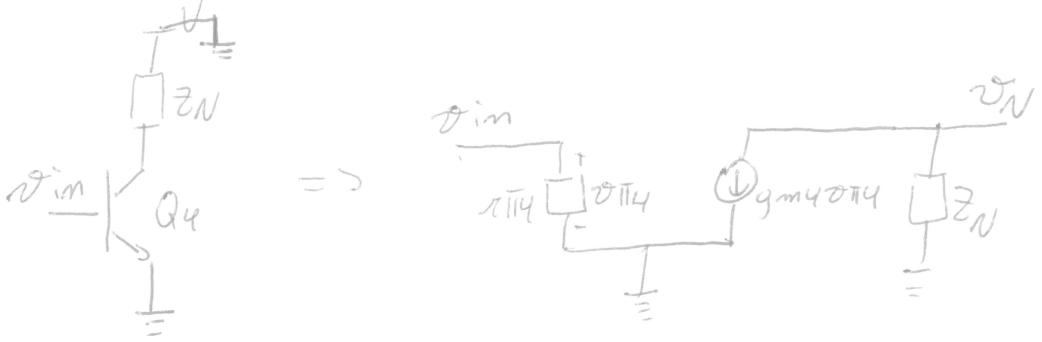
$$\frac{v_{out}}{v_N} \cong \frac{R_L}{\frac{1}{g_{m1}+g_{m2}} + R_L}$$

$$Z_N = \frac{v_N}{i_N} = \frac{r_\pi \left(1 + R_L \cdot \left(\frac{1}{r_{\pi 1} // r_{\pi 2}} + g_{m1}+g_{m2} \right) \right)}{v_\pi / r_{\pi 1} // r_{\pi 2}}$$

$$Z_N = r_{\pi 1} // r_{\pi 2} + R_L + \left(1 + \underbrace{(g_{m1}+g_{m2})}_{\gg 1} \cdot r_{\pi 1} // r_{\pi 2} \right)$$

$$Z_N \cong r_{\pi 1} // r_{\pi 2} + R_L (g_{m1}+g_{m2}) \cdot r_{\pi 1} // r_{\pi 2}$$

✱ Modelo pequenos sinais estágio de entrada



$$v_N = -g_{m4} v_{\pi 4} Z_N \qquad v_{in} = v_{\pi 4}$$

$$\Rightarrow \frac{v_N}{v_{in}} = -g_{m4} Z_N$$

✱ GANHO TOTAL - A_v

$$A_v = \frac{v_N}{v_{in}} \cdot \frac{v_{out}}{v_N} \cong -g_{m4} Z_N \cdot \frac{R_L}{R_L + \frac{1}{g_{m1}+g_{m2}}}$$

$r_{\pi 1} \| r_{\pi 2} + R_L \cdot (g_{m1}+g_{m2}) \cdot r_{\pi 1} \| r_{\pi 2}$

- Assumindo $\beta_1 = \beta_2 = \beta$ e $I_{C1} = I_2$

$$g_{m1} + g_{m2} = \frac{\beta}{r_{\pi 1}} + \frac{\beta}{r_{\pi 2}} = \frac{\beta (r_{\pi 1} + r_{\pi 2})}{r_{\pi 1} \cdot r_{\pi 2}} \Rightarrow \boxed{g_{m1} + g_{m2} = \frac{\beta}{r_{\pi 1} \| r_{\pi 2}}}$$

$$\therefore A_v \cong -g_{m4} \cdot \left[r_{\pi 1} \| r_{\pi 2} + R_L (g_{m1}+g_{m2}) \cdot r_{\pi 1} \| r_{\pi 2} \right] \cdot \frac{R_L}{R_L + \frac{1}{g_{m1}+g_{m2}}}$$

(β sobre o termo entre colchetes; $\frac{r_{\pi 1} \| r_{\pi 2}}{\beta}$ sobre $\frac{1}{g_{m1}+g_{m2}}$)

$$A_v \cong -g_{m4} \left[r_{\pi 1} \| r_{\pi 2} + \beta R_L \right] \cdot \frac{R_L}{R_L + \frac{r_{\pi 1} \| r_{\pi 2}}{\beta}}$$

$R_L \gg \frac{r_{\pi 1} \| r_{\pi 2}}{\beta} \Rightarrow A_v \cong -g_{m4} \left[r_{\pi 1} \| r_{\pi 2} + \beta R_L \right]$

$\beta R_L \gg r_{\pi 1} \| r_{\pi 2} \Rightarrow$

$$\boxed{A_v \cong -g_{m4} \cdot \beta R_L \quad \text{OU} \quad A_v \cong -g_{m4} (g_{m1}+g_{m2}) \cdot r_{\pi 1} \| r_{\pi 2} \cdot R_L}$$