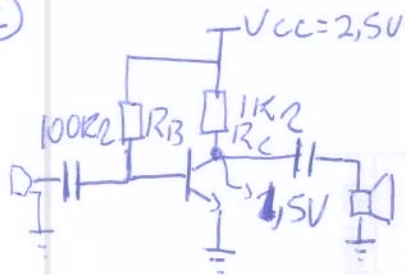


AULA 08

①



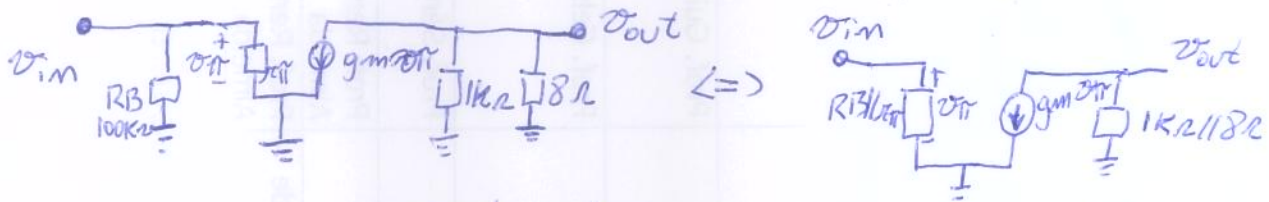
- $V_{CE} = 1,5V$
- $I_C = \frac{V_{CC} - V_{CE}}{1k\Omega} = 1mA$
- $V_{BE} = V_T \ln(I_C/I_S) = 0,7963V$
 $V_T = 26mV$
- $g_m = \frac{I_C}{V_T} = 0,0385S$
- $r_{\pi} = \frac{\beta}{g_m} = 1,5261k\Omega$

$I_S = 5 \cdot 10^{-17} A$

$I_B = \frac{V_{CC} - V_{BE}}{100k\Omega} = 0,017mA$

$\beta = \frac{I_C}{I_B} = 58,6956$

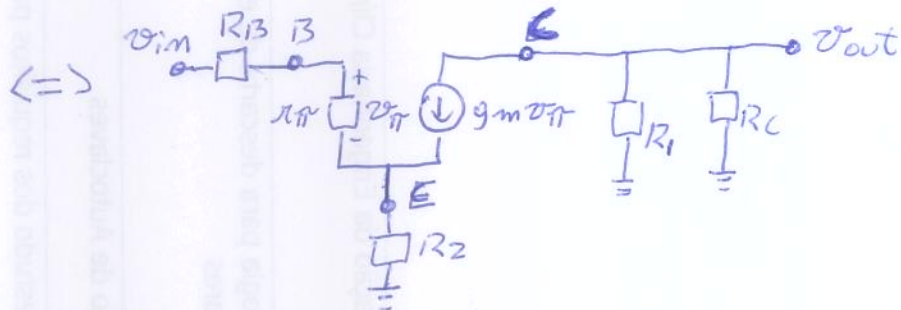
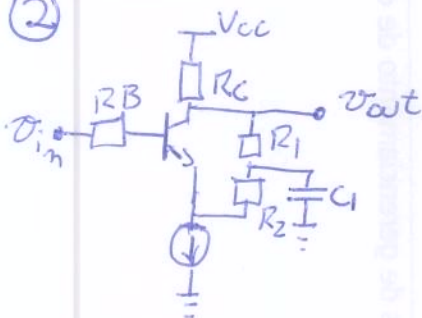
$L_{região Ativa V_{BE} < V_{CC}$



$v_{out} = -g_m v_{\pi} \cdot (1k\Omega || 8\Omega) \Rightarrow \frac{v_{out}}{v_{in}} = -g_m (1k\Omega || 8\Omega)$
 $7,9365\Omega$

$A_v = \frac{v_{out}}{v_{in}} = 0,3053$

②



• $v_{out} = -g_m v_{\pi} (R_1 || R_C)$

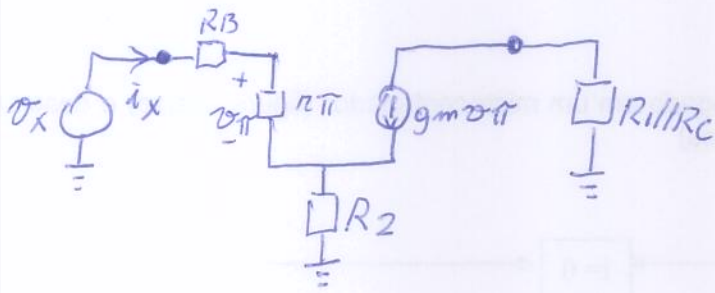
• $v_{in} = \frac{v_{\pi}}{r_{\pi}} \cdot (R_B + r_{\pi}) + \left(\frac{v_{\pi}}{r_{\pi}} + g_m v_{\pi} \right) \cdot R_2$

• $A_v = \frac{v_{out}}{v_{in}} = \frac{-g_m \cdot (R_1 || R_C)}{\left(\frac{1}{r_{\pi}} + g_m \right) R_2 + \frac{(R_B + r_{\pi})}{r_{\pi}}} = \frac{-g_m (R_1 || R_C)}{\left(\frac{g_m}{\beta} + g_m \right) R_2 + \frac{g_m}{\beta} \cdot (R_B + r_{\pi})}$

$A_v = \frac{R_1 || R_C}{\left(\frac{1}{\beta} + 1 \right) R_2 + \frac{R_B + r_{\pi}}{\beta}} = \frac{R_1 || R_C}{R_2 + \frac{R_B + r_{\pi}}{\beta}} = \frac{R_1 || R_C}{R_2 + \frac{R_B}{\beta} + \frac{1}{g_m}}$

$A_v = \frac{R_1 || R_C}{R_2 + \frac{R_B}{\beta} + \frac{1}{g_m}}$

* R_{in}



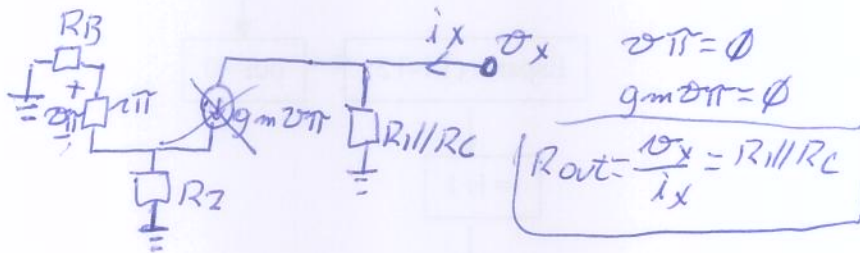
$$i_x = \frac{v_x}{r_{\pi}}$$

$$v_x = R_B i_x + r_{\pi} i_x + R_2 (i_x + g_m v_{\pi}) \Rightarrow v_x = R_B i_x + r_{\pi} i_x + R_2 i_x + g_m i_x r_{\pi} R_2$$

$$v_x = R_B \frac{v_x}{r_{\pi}} + r_{\pi} \frac{v_x}{r_{\pi}} + R_2 \frac{v_x}{r_{\pi}} + g_m v_{\pi} R_2$$

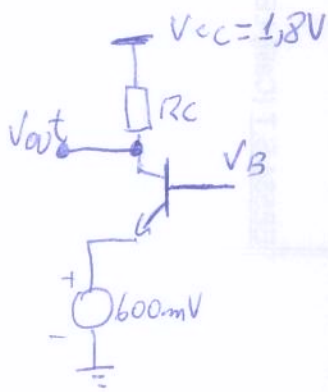
$$R_{in} = \frac{v_x}{i_x} = R_B + r_{\pi} + R_2 + R_2 g_m r_{\pi} \Rightarrow R_{in} = R_B + r_{\pi} + R_2 (1 + \beta)$$

* R_{out}



$$R_{out} = \frac{v_x}{i_x} = R_L || R_C$$

3



$$I_S = 5 \cdot 10^{-17} \quad \beta = 100$$

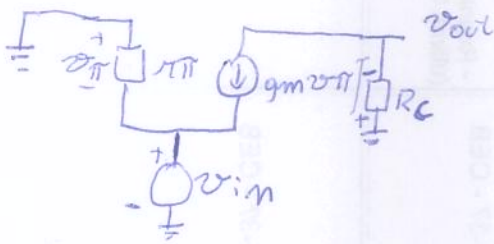
$$I_C = 0,2 \text{ mA} \Rightarrow g_m = \frac{I_C}{V_T} = \frac{0,2}{26} \Rightarrow g_m = 1506 \text{ S} \quad \text{or } 0,0077$$

$$V_{BE} = V_T \cdot \ln\left(\frac{I_C}{I_S}\right) = 0,7545 \text{ V}$$

$$V_B = 0,600 + V_{BE} = 1,3545 \text{ V}$$

$$V_C \gg V_B$$

$$V_{CC} - R_C I_C \gg V_B \Rightarrow R_C \ll \frac{V_{CC} - V_B}{I_C} \Rightarrow R_C \leq 2,2277 \text{ k}\Omega$$



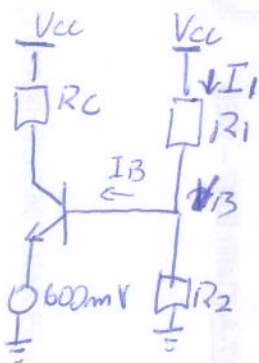
$$v_{out} = -v_{RC} = -R_C \cdot g_m v_{\pi}$$

$$v_{\pi} = -v_{in}$$

$$v_{out} = -R_C g_m (-v_{in})$$

$$A_v = \frac{v_{out}}{v_{in}} = g_m R_C \Rightarrow A_{v_{max}} = 1506 \cdot 2,2277 \cdot 10^{-3} = 17,1365$$

V_B ?



$$I_B = \frac{I_C}{\beta} = 0,2 \cdot 10^{-2} \text{ mA}$$

$$I_1 \gg I_B$$

$$I_1 = 10 I_B$$

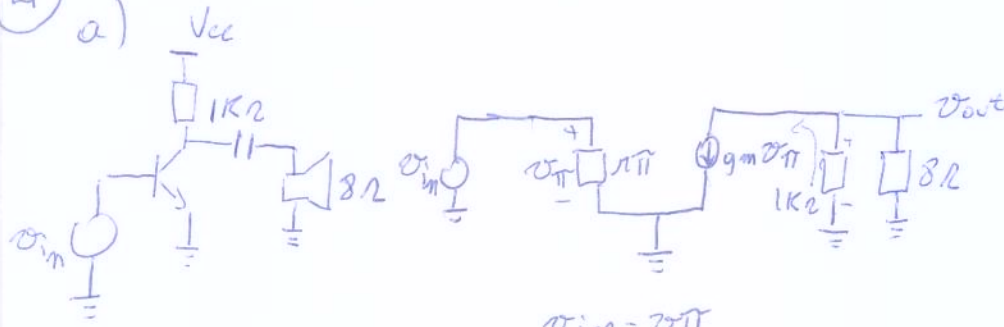
$$I_1 = 0,02 \text{ mA}$$

$$\frac{V_{CC}}{R_1 + R_2} = 0,02 \text{ mA} \Rightarrow R_1 + R_2 = 90 \text{ k}\Omega$$

$$V_B = I_1 \cdot R_2 \Rightarrow \begin{cases} R_2 = 67,7225 \text{ k}\Omega \\ R_1 = 22,2775 \text{ k}\Omega \end{cases}$$

(4)

a)



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

$$v_o = -(1k // 8\Omega) \cdot g_m v_{\pi}$$

$$A_v = \frac{v_o}{v_{in}} = -(1k // 8\Omega) \cdot g_m$$

$$A_v = -(1k // 8\Omega) \cdot g_m$$

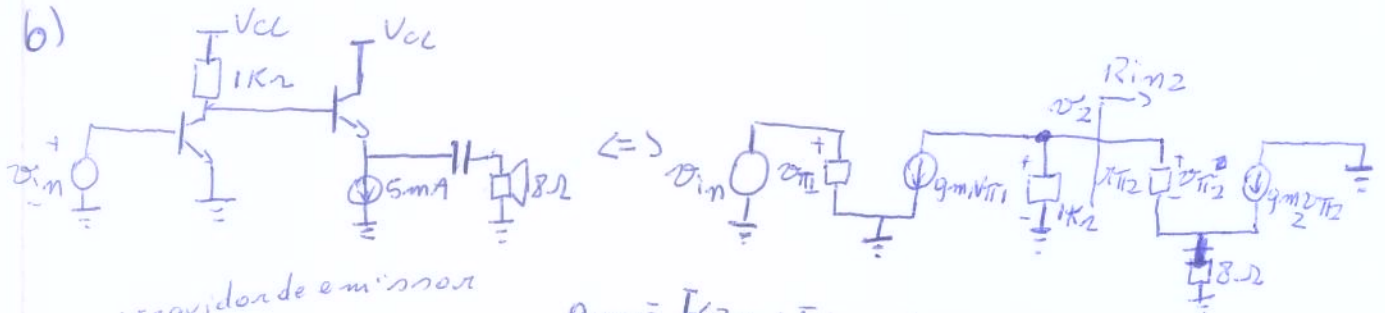
sem $8\Omega \Rightarrow A_v \Rightarrow 20$

$$A_v = -1k \cdot g_m \Rightarrow g_m = 0,025$$

com 8Ω

$$A_v = -(1k // 8) \cdot g_m \Rightarrow \boxed{A_v = 0,1587}$$

b)



seguidor de emissor

$$A_{v2} = \frac{R_E}{R_E + \frac{1}{g_{m2}}} \Rightarrow A_{v2} = 0,6020$$

$$g_{m2} = \frac{I_{C2}}{V_T} = \frac{\alpha I_{E2}}{V_T} = \frac{0,98 \cdot 5mA}{26mV} \Rightarrow g_{m2} = 0,18915$$

$$r_{\pi2} = \frac{\beta}{g_{m2}} \Rightarrow r_{\pi2} = 528,8543$$

$$R_{in2} = r_{\pi2} + R_E \cdot (1 + \beta) = 1336,9\Omega$$

$$A_{v1} = -(1k // R_{in2}) \cdot g_{m1} \xrightarrow{0,02} A_{v1} = 11,4415$$

$$A_v = A_{v1} \cdot A_{v2} \Rightarrow \boxed{A_v = 6,88}$$