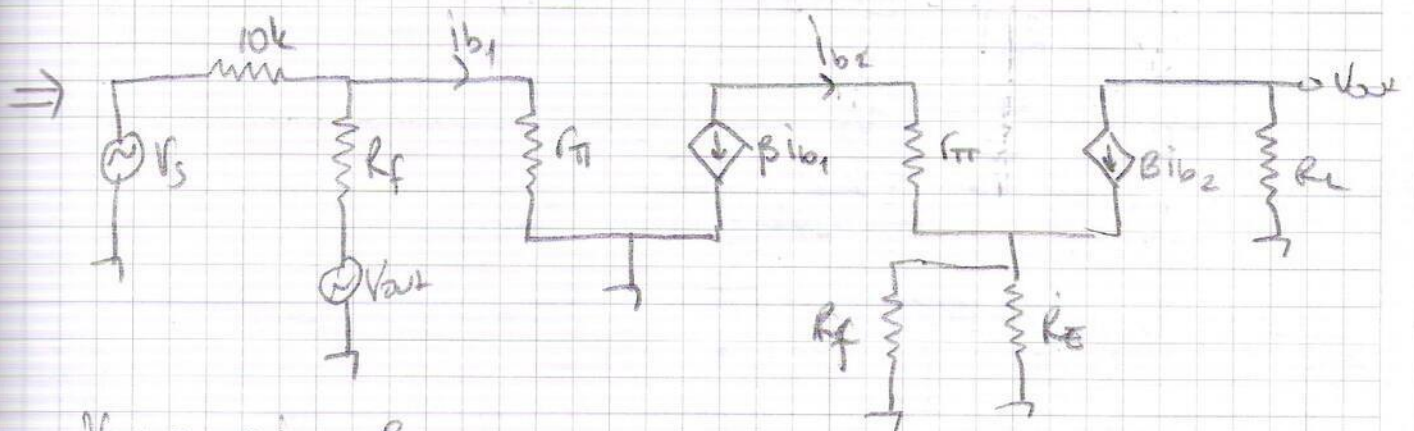
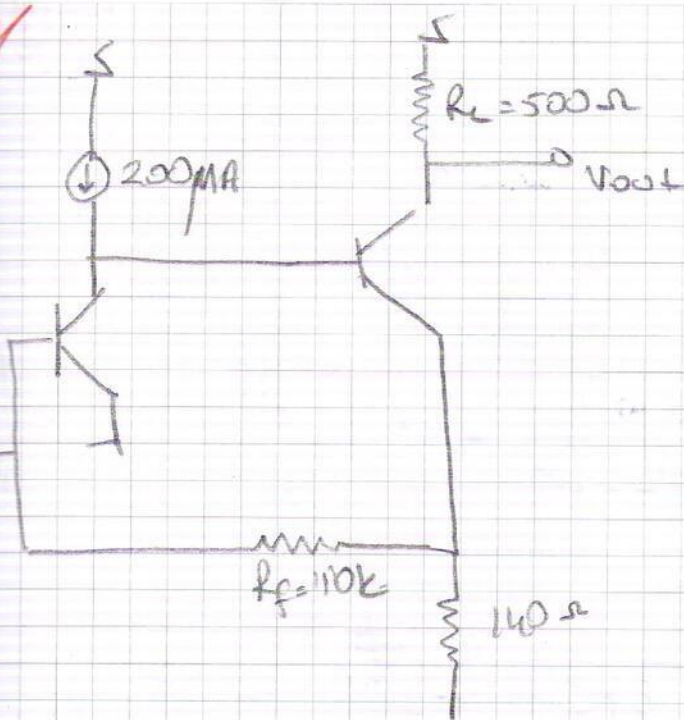




$$V_{out} = -\beta i_{b2} \cdot R_C$$

$$= -\beta (-\beta i_{b1}) R_C$$

$$= \beta^2 i_{b1} R_C$$

$$= \beta^2 \left(\frac{V_s + V_{out}}{30k} \right) R_C$$

$$V_s - i_x \cdot 10k - i_{b1} \cdot 10k = 0$$

$$V_s - i_x \cdot 10k - 10k (i_x - i_{b1}) - V_{out} = 0$$

$$i_x + i_{b1} = V_s / 10k$$

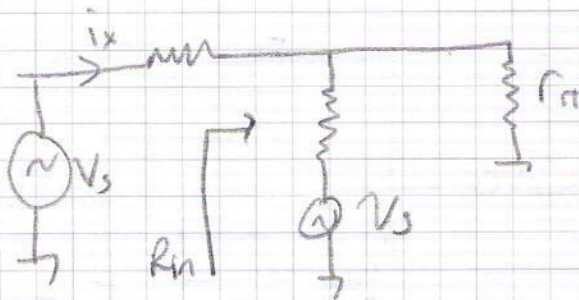
$$2i_x - i_{b1} = \frac{V_s - V_{out}}{10k}$$

$$i_x = \frac{2V_s - V_{out}}{30k}$$

$$i_{b1} = \frac{V_s}{10k} - \frac{2V_s - V_{out}}{30k}$$

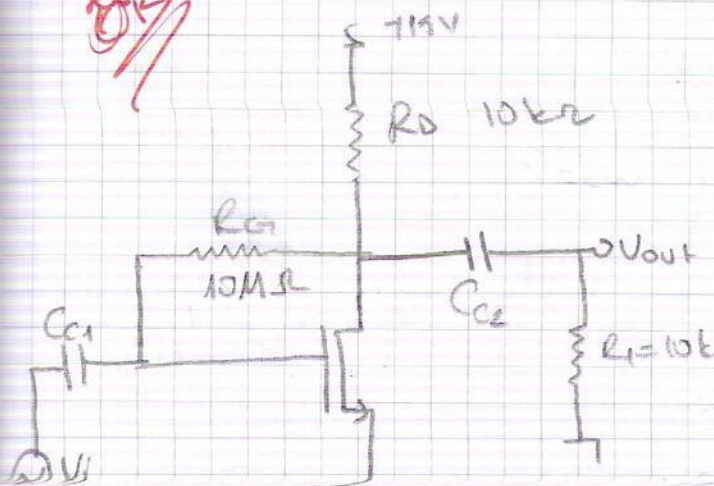
$$= \frac{V_s + V_{out}}{30k}$$

$$A_v = \frac{\frac{\beta^2 R_L}{30k}}{1 - \frac{\beta^2 R_L}{30k}} = \frac{5 \cdot 10^6}{30 \cdot 10^3 - 5 \cdot 10^6} = -1$$



$$R_{in} = \frac{V_s}{i_x} = \frac{V_s}{3V_s/30k} = 10k$$

0.5



$$\beta_m = 0.725 \text{ mA/V}$$

$$r_o = 47 \text{ k}\Omega$$

$$V_o/V_i = -3.3$$

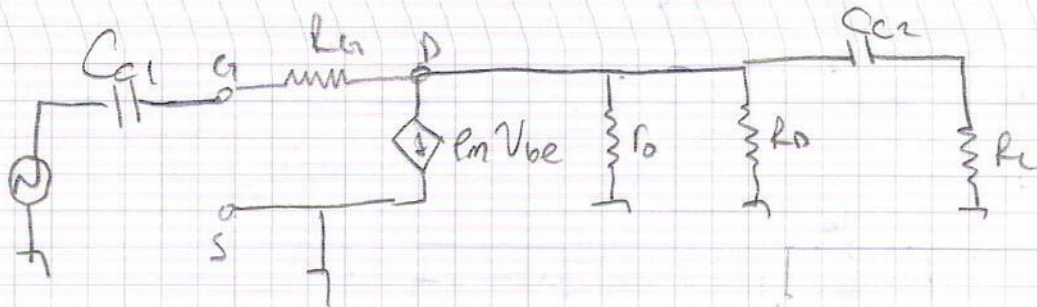
$$R_{in} = 2.33 \text{ M}\Omega$$

$$f_1 = 10 \text{ Hz}$$

circuits

$$f_2 < 1 \text{ Hz}$$

fact



$$C_{c1}, R_{in}$$

$$C_{c2}, r_o \parallel R_D + R_L$$

$$C_{c2}, R_L$$

$$\left(R_L + \frac{1}{s C_{c2}} \right) \parallel (r_o \parallel R_D)$$

$$= \frac{(r_o \parallel R_D) \cdot \left(R_L + \frac{1}{s C_{c2}} \right)}{(r_o \parallel R_D) + R_L + \frac{1}{s C_{c2}}}$$

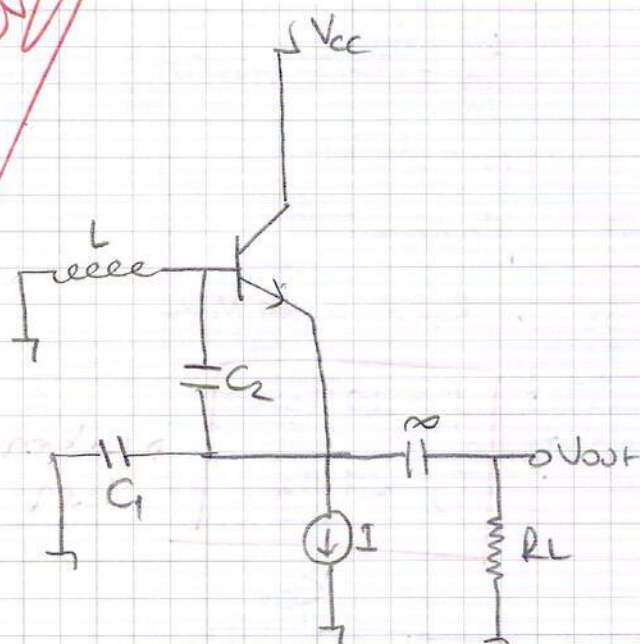
$$\omega_1' = \sqrt{\frac{1}{R_{in} C_{c1}}} = 2\pi = 2\pi f_2$$

$$= \frac{r_o \parallel R_D (1 + R_L s C_{c2})}{1 + s C_{c2} (r_o \parallel R_D + R_L)}$$

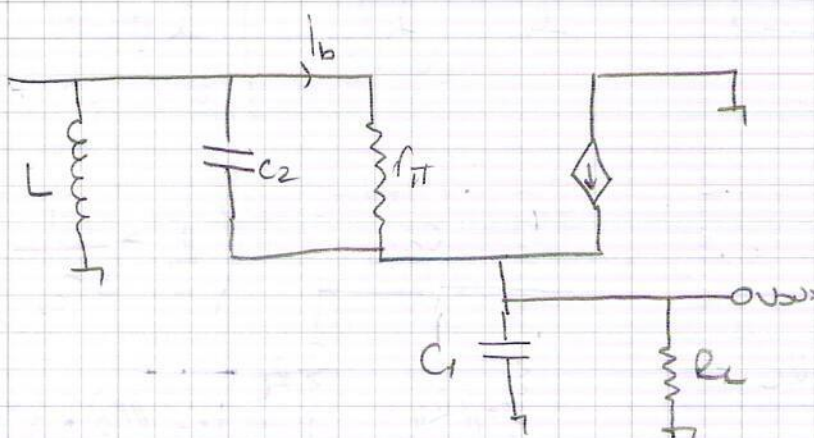
$$\omega_2' = \sqrt{\frac{1}{C_{c2} (r_o \parallel R_D + R_L)}} = 20 \text{ Hz} = 2\pi f_1$$

$$\omega_3' = \sqrt{\frac{1}{C_{c2} (r_o \parallel R_D \cdot R_L)}}$$

~~20~~



$\omega_0 = ?$



$$sL + \frac{r_{\pi} \cdot \frac{1}{sC_2}}{r_{\pi} + \frac{1}{sC_2}} = sL + \frac{r_{\pi}}{1 + r_{\pi} sC_2}$$

$$= j\omega L + \frac{r_{\pi}}{1 + j\omega r_{\pi} C_2}$$

$$= j\omega L + \frac{r_{\pi}}{1 + \omega^2 r_{\pi}^2 C_2^2} \cdot (1 - j\omega r_{\pi} C_2)$$

$$\frac{r_{\pi}}{1 + \omega^2 r_{\pi}^2 C_2^2} + j\omega \left(L - \frac{\omega r_{\pi} \cdot C_2}{1 + \omega^2 r_{\pi}^2 C_2^2} \right)$$

$$\frac{\frac{r_{\pi}^2}{(1 + \omega^2 r_{\pi}^2 C_2^2)^2} + \omega^2 \left(L - \frac{\omega r_{\pi} \cdot C_2}{1 + \omega^2 r_{\pi}^2 C_2^2} \right)^2}{\frac{r_{\pi}}{1 + \omega^2 r_{\pi}^2 C_2^2} - j\omega \left(L - \frac{\omega r_{\pi} \cdot C_2}{1 + \omega^2 r_{\pi}^2 C_2^2} \right)}$$

Continue calculation

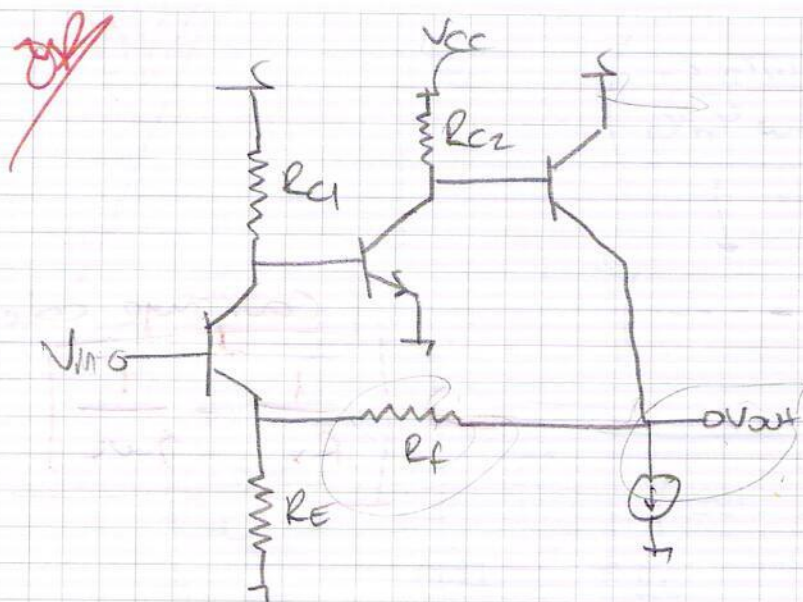
$$\Rightarrow \left[\frac{1}{R_x} + \frac{1}{j\omega L} \right]$$

$$\omega_0 = \frac{1}{\sqrt{L_{eq} \cdot C_{eq}}}$$

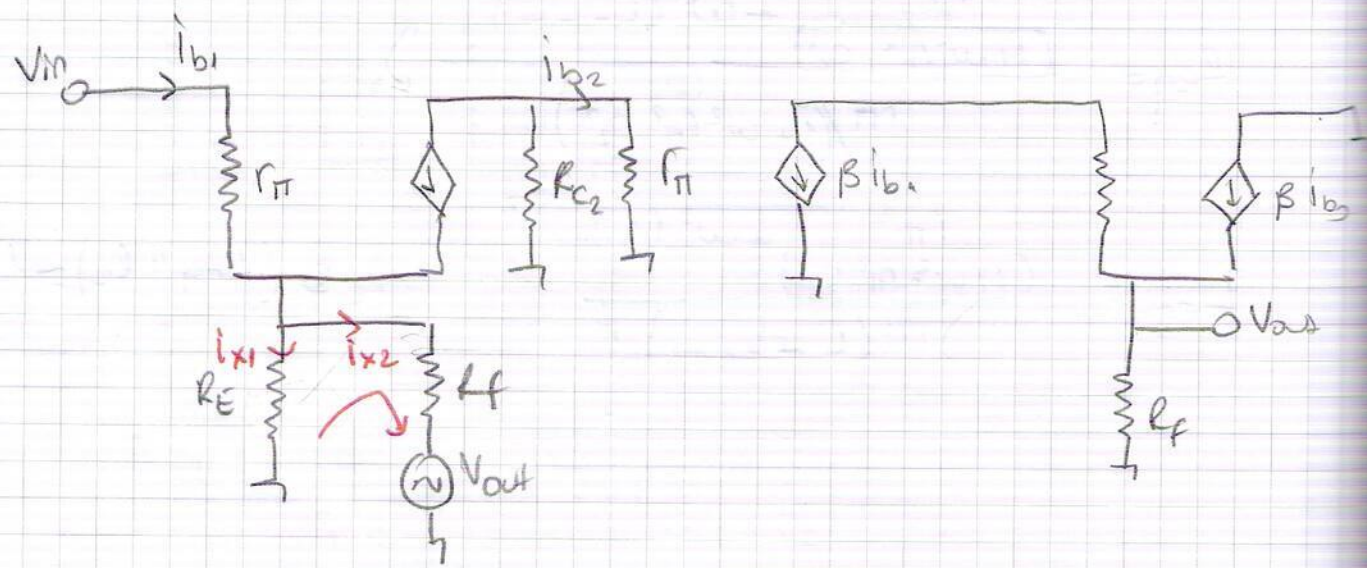
$$R_{eq} = \frac{\frac{r_{\pi}^2}{(1 + \omega^2 r_{\pi}^2 C_2^2)} + \omega^2 \left(L - \frac{\omega r_{\pi} \cdot C_2}{1 + \omega^2 r_{\pi}^2 C_2^2} \right)^2}{r_{\pi} / (1 + \omega^2 r_{\pi}^2 C_2^2)}$$

$$L_{eq} = \frac{\frac{r_{\pi}^2}{(1 + \omega^2 r_{\pi}^2 C_2^2)} + \omega^2 \left(L - \frac{\omega r_{\pi} \cdot C_2}{1 + \omega^2 r_{\pi}^2 C_2^2} \right)^2}{\omega \left(L - \frac{\omega r_{\pi} \cdot C_2}{1 + \omega^2 r_{\pi}^2 C_2^2} \right)}$$

$$\beta (R_{eq} \parallel L_L) = 1$$



- a) If $R_E = 50 \Omega$ $R_f = ?$ to have $A_v = 25$
 b) $R_{in} = ?$



$$\begin{aligned}
 V_{out} &= (\beta + 1) I_{b3} \cdot R_f \\
 &= (\beta + 1) \cdot -\beta I_{b2} \cdot \frac{R_{C2}}{R_{C2} + r_{\pi} + \beta R_f} \cdot R_f \\
 &= -\beta (\beta + 1) \cdot \frac{R_{C2} R_f}{R_{C2} + r_{\pi} + \beta R_f} \cdot -\beta I_{b1} \cdot \frac{R_{C1}}{R_{C1} + r_{\pi}}
 \end{aligned}$$

$$V_{in} = i_{b1} \cdot r_{\pi} + i_{x1} \cdot R_E$$

$$-i_{x1} R_E + i_{x2} R_f - V_{out} = 0$$

$$i_{x1} + i_{x2} = (\beta + 1) i_{b1}$$

$$R_f i_{x2} - R_E i_{x1} = V_{out}$$

$$R_E i_{x1} + i_{x2} = (\beta + 1) i_{b1}$$

$$(R_f + R_E) i_{x2} = V_{out} + (\beta + 1) i_{b1} \cdot R_E$$

$$i_{x2} = \frac{V_{out} + (\beta + 1) i_{b1} \cdot R_E}{R_f + R_E}$$

$$i_{x1} = \frac{(\beta + 1) i_{b1} \cdot R_f - V_{out}}{R_f + R_E}$$

$$V_{in} = i_{b1} \cdot r_{\pi} + \frac{(\beta + 1) i_{b1} \cdot R_f}{R_f + R_E} - \frac{V_{out}}{R_f + R_E}$$

$$V_{in} \left(1 - \frac{25}{R_f + R_E} \right) = \left(r_{\pi} + \frac{(\beta + 1) R_f}{R_f + R_E} \right) i_{b1}$$

$$R_{in} = \frac{r_{\pi} + \frac{(\beta + 1) R_f}{R_f + R_E}}{1 - \frac{25}{R_f + R_E}} \quad R_{out} = \frac{V_{out}}{i_{out}}$$

$$i_x = i_{out} + i_{e3}$$

$$V_{out} = i_x \cdot R_f$$

$$V_{out} = R_f (i_{out} + i_{e3})$$

$$= R_f (i_{out} + (\beta + 1) i_{b3})$$

$$= R_f \left(i_{out} + (\beta + 1) - \beta i_{o2} \frac{R_{c2}}{R_{c2} + (\beta + 1) R_f} \right)$$