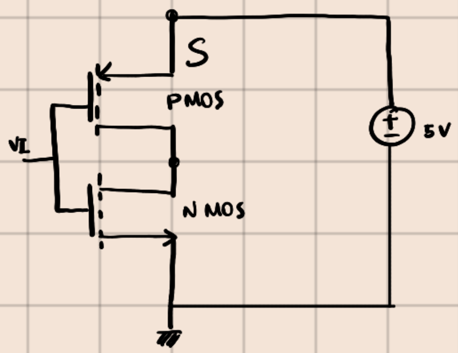
COMPITO 12.11.2019

ES1) $\frac{1}{2}\mu nCox = 100 \frac{\mu A}{V^2}$, $Ln = 0.8\mu m$, $VTH = 0.8V$, $Wn = 8\mu m$

$\frac{1}{2}\mu pCox = 30 \frac{\mu A}{V^2}$, $Lp = 0.8\mu m$, $VTH = -0.8V$

$V_I = 1.5V$

? Wp



$VGS1 = 1.5V > 0.8V$ conduco

SUPPONGO SATURI ENTRAMBI

$$\frac{Kn}{2}(V_I - V_{TH})^2 = \frac{Kp}{2}(VDD - V_I - V_{TP})^2$$

$$\frac{1}{2}\mu nCoxWn\ 0.7^2 = \frac{1}{2}\mu pCoxWp\ (2.7)^2$$

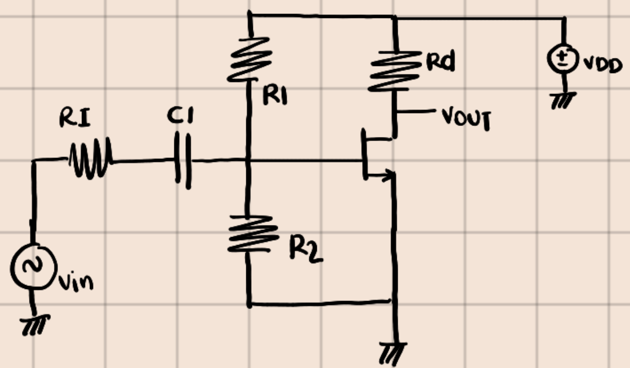
$$Wp = \frac{\frac{1}{2}\mu nCox\ Wn}{\frac{1}{2}\mu pCox}\left(\frac{0.7}{2.7}\right)^2 [\mu m] \cong 1.8\mu m$$

ES2) Si calcoli il guadagno di amplificazione

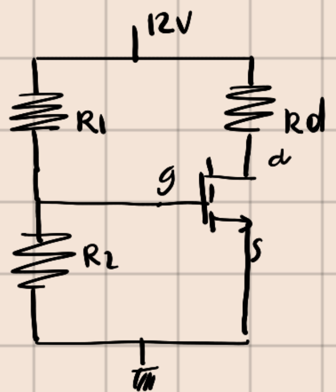
$R_1 = 1M\Omega$ $\quad RI = 10k\Omega$ $\quad Kn = 1\frac{mA}{V^2}$

$R_2 = 200k\Omega$ $\quad VTH = 1V$ $\quad C_1 = 1\mu F$

$Rd = 4k\Omega$ $\quad VDD = 12V$



IN CONTINUA



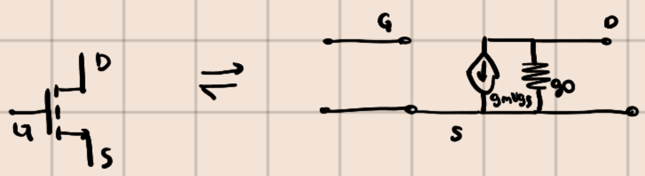
$$VG = \frac{R_2}{R_1+R_2}VDD = \frac{200}{1200}\cdot 12 = 2V > 1V$$

$$I_{DS} = \frac{Kn}{2}(2-1)^2 = 0.5\ mA$$

$$VDS = 12 - Rd\,I_{DS} = 12 - 2 = 10V > 1V \quad SAT$$

$$Q^* = (0.5\ mA, 10V)$$

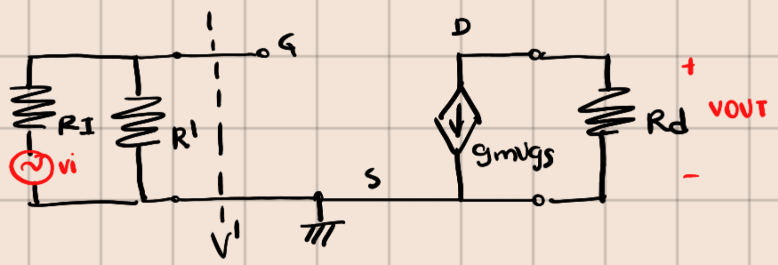
IN ALTERNATA (analisi a centro banda)



$$g_m = \frac{\partial i_{ds}}{\partial v_{gs}}\Big|_{Q^o} = \frac{\partial}{\partial v_{gs}}\left(\frac{k_n}{2}(V_{GS}-V_{TH})^2(1+\lambda v_{ds})\right)\Big|_{Q^o}$$

$$= \frac{2\,I_{DS}^{o}}{(V_{GS}-V_{TH})} = \frac{1\,mA}{1V} = 1\,mS$$

$$g_o \simeq \lambda\, I_{DS}^{o} \to 0$$



$$R' = \frac{R1R2}{R1+R2} = \frac{1000 \cdot \cancel{200}}{6\,\cancel{1200}} \cdot 10^3 \simeq 167\,k\Omega$$

$$v_{gs} = \frac{R'}{RI+R'}\,v_i \qquad v_{out} = -g_m v_{gs} R_d$$

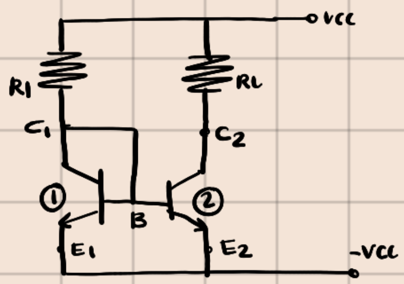
$$V_{OUT} = -g_m \frac{R' R_d}{RI+R'}\, v_i$$

$$\frac{v_o}{v_i} = -\cancel{10^{-3}}[S] \cdot \frac{167 \cdot \cancel{10^3} \cdot 4\, \cancel{10^3}}{177 \cdot \cancel{10^3}}$$

$$= -\frac{167 \cdot 4}{177} \simeq -3.77$$

COMPITO 05.02.2019

1) BJT identici



$R1 = 10K\Omega$

$R_L = 5K\Omega$

$\beta F = 100$

$VCC = 12V$

SONO IDENTICI ED HANNO STESSA VBE → $I_1 = I_2$ IN SAT

PER IL PUNTO DI LAVORO LI SUPPONGO IN RAD $VBE \approx 0.6V$

$VB - VE = 0.6 \rightarrow VB = 0.6 + VE = 0.6 - 12 = -11.4V$

$\rightarrow VC1 = VB = -11.4V \rightarrow I_1 = \frac{VCC - VC1}{R1} = \frac{12 + 11.4}{10} mA = 2.34 mA$

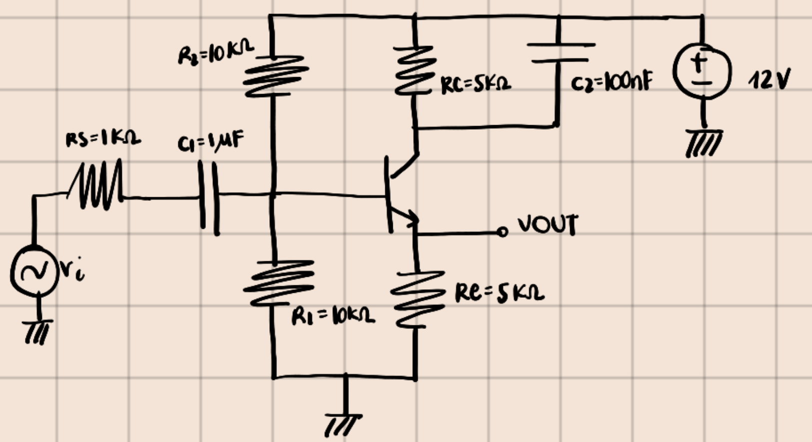
$VCE_1 = -11.4 + 12 = 0.6V > 0.2V$ RAD

$I_2 = I_1 \rightarrow VC2 = 12 - RL I_2 = 12 - 5 \cdot 2.34 = 0.3V$

$VCE_2 = 0.3 + 12 = 12.3 V \rightarrow$ RAD

$Q_1 = (2.34 mA, 0.6V)$ $Q_2 = (2.34 mA, 12.3V)$

ES 2)

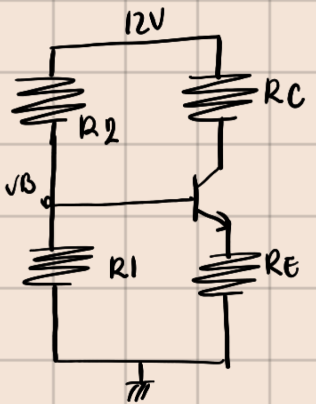


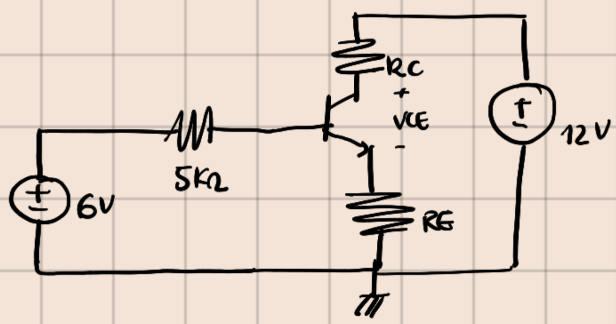
$f \to 0$

$h_{ie} = 5k\Omega$

$h_{fe} = 300$

IN CONTINUA





$$12 = R_C \cdot I_C + V_{CE} + R_E I_E$$

$$6 - 5 \cdot 10^3 \cdot I_B = 0.6 + R_E I_E$$

$$(R_E(\beta_F+1) + 5 \cdot 10^3)\, I_B = 5.4$$

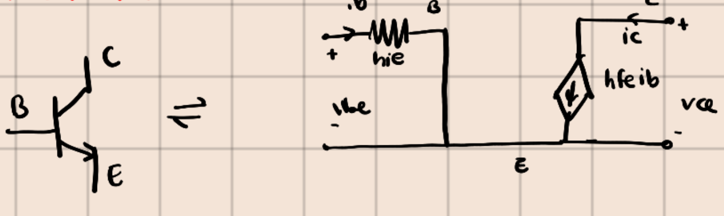
$$I_B = \frac{108 \cdot 10^{-3}}{(\beta_F+2)}$$

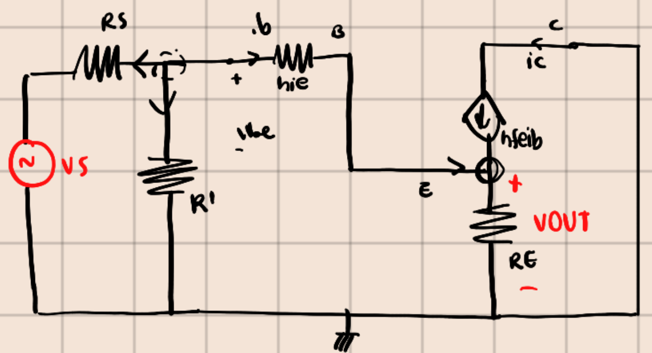
$$V_E = 5 \cdot 301 \cdot \frac{1.08}{302} \simeq 5.38\,V$$

$$V_{CE} = 12 - \frac{5.4}{\beta_F+2} = 12 - \frac{5.4}{302} \simeq 11.9\,V > 0.2\,V$$

$$V_{BC} = V_{BE} - V_{CE} = 0.6 - 11.9 < 0.6 \text{ ok}$$

IN ALTERNATA





RE 301

$v_o = R\, i_b$

$R_S i_1 + v_i = R' i_2 \rightarrow i_2 = \frac{R_S i_1 + v_i}{R'}$

$h_{ie} i_b + v_o = R' i_2$

$i_1 + i_2 = -i_b$

$R_S i_1 + v_i = R' i_2 \rightarrow -R_S(i_2+i_b)+v_i = R' i_2 \rightarrow (R'+R_S)i_2 = v_i - R_S i_b \rightarrow i_2 = \frac{v_i - R_S i_b}{R'+R_S}$

$h_{ie} i_b + v_o = R' i_2 \rightarrow h_{ie} i_b + v_o = \frac{R'}{R'+R_S} v_i - \frac{R'R_S}{R'+R_S} i_b \rightarrow \left(h_{ie} + \frac{R'R_S}{R'+R_S}\right) i_b = \frac{R'}{R'+R_S} v_i - v_o$

$i_1 + i_2 = -i_b \rightarrow i_1 = -i_2 - i_b$

$$(h_{ie}(R'+R_S) + R'R_S)\, i_b = R' v_i - (R'+R_S) v_o$$

$$i_b = \frac{10^{-3} v_i}{7} - \frac{6\cdot 10^{-3} v_o}{35} = \frac{1}{7}10^{-3} v_i - \frac{6}{35}10^{-3} v_o$$

$$v_o = R i_b = \frac{R}{7}10^{-3} v_i - \frac{6}{35} R 10^{-3} v_o \qquad R = 5.301\cdot 10^3$$

$$v_o = \frac{5}{7}.301\, v_i - \frac{301.6}{7} v_o$$

$$\rightarrow 7 + 301.6\, v_o = 5.301\, v_i \rightarrow \frac{v_o}{v_i} = \frac{5.301}{7+301.6} = 0.83$$

ES 3

$V_{TH} = 1V$

calcolare punto di lavoro

$k_n = 2 \frac{mA}{V^2}$

$V_{CC} = 13V$

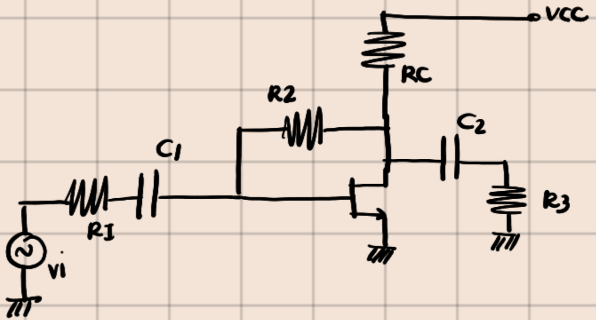
$R_I = 1k\Omega$

$C_1 = C_2 = 100nF$

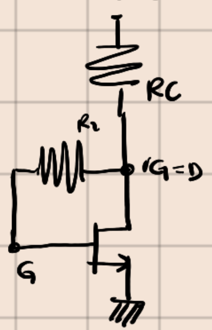
$R_C = 1k\Omega$

$R_2 = R_3 = 10M\Omega$

$V_1 = 10V + \sin(2\pi f t)$ $f = 1kHz$



PER IL PUNTO DI LAVORO SIAMO IN CONTINUA



SE $V_G > V_{TN}$ SONO SEMPRE IN SATURAZIONE

$I_{DS} = \frac{k_n}{2}(V_{GS}-V_{TH})^2 \rightarrow V_{GS}^2 - 2V_{TH}V_{GS} + V_{TH}^2 = \frac{2}{k_n R_C} V_{CC} - \frac{2}{k_n R_C} V_{GS}$

$I_{DS} = \frac{V_{CC}-V_{GS}}{R_C}$

$V_{GS}^2 - 2V_{GS} + 1 - 13 + V_{GS} = 0$

$V_{GS}^2 - V_{GS} - 12 = 0$

$V_{GS} = \frac{1\pm\sqrt{1+48}}{2} = \frac{1\pm 7}{2}$ → 4V, -3V

$I_{DS} = \left[\frac{mA}{\cancel{V^2}}\right]\cdot 9\cancel{V^2} = 9\,mA$

$V_{DS} = V_{GS} = 4V$

$Q^P = (9\,mA, 4V)$

COMPITO 14.11.2018

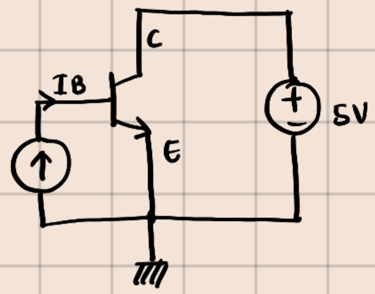
ES 1

$I_S = 10^{-16}\ A$

$\alpha_F = 0.95$

$V_C = 5V$

$I_B = 100\mu A$



? I_C, I_E, V_{BE}

$$I_C = \beta_F I_B \quad \rightarrow \quad I_C = 1{,}9\ mA$$
$$I_E = (\beta_F+1) I_B \quad \rightarrow \quad I_E = 2 mA$$

$$\alpha_F = \frac{I_C}{I_E} = \frac{\beta_F}{\beta_F+1}$$

$\rightarrow \alpha_F(\beta_F+1) = \beta_F$

$\rightarrow \beta_F(1-\alpha) = \alpha$

$\rightarrow \beta_F = \frac{\alpha}{1-\alpha} = \frac{0.95}{0.05} = 19$

$$I_B = I_S\left(e^{\frac{V_{BE}}{V_T}} - 1\right)$$

$$\frac{I_B}{I_S} + 1 = e^{\frac{V_{BE}}{V_T}} \rightarrow V_{BE} = V_T \ln\left(\frac{I_B + I_S}{I_S}\right)$$

$$= 25 \cdot 10^{-3} [V] \cdot \ln\left(\frac{0.1 + 10^{-13}}{10^{-13}}\right)$$

$$\cong 0.69\ V$$

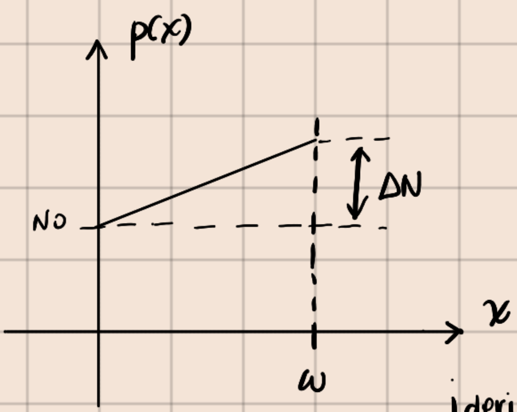
se V_{BC} e' < 0.6 allora sono in RAD

$V_C = 5\ V$

$V_B = 0.69\ V \quad \rightarrow V_{BC} = 0.69 - 5 = -4.31 < 0.6$ ✓

ES 2

calcolare la distribuzione di carica non compensata e di campo elettrico.



$p(x) = mx + c$

$p(\emptyset) = c = N_O$

$p(\omega) = m\omega + \cancel{N_O} = \cancel{N_O} + \Delta N$

$m = \frac{\Delta N}{\omega} \qquad \rightarrow p(x) = \frac{\Delta N}{W} x + N_O$

$$= \frac{\Delta N}{W}\left(x + \frac{W}{\Delta N} \cdot N_O\right)$$

$j_{deriva} = -j_{diff}$

$$\cancel{q}\mu_p E = \cancel{q} \frac{D_p}{p} \frac{\partial p(x)}{\partial x} \rightarrow E(x) = V_T \frac{1}{x + \frac{W}{\Delta N} N_O}$$

$$\nabla \cdot E(x) = \frac{\rho(x)}{\varepsilon}$$

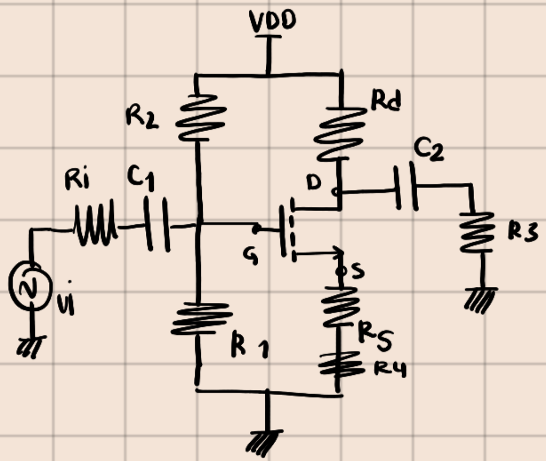
$$\rho(x) = \varepsilon \frac{\partial E(x)}{\partial x} = -\varepsilon \frac{V_T}{\left(x + \frac{W}{\Delta N} \cdot N_O\right)^2}$$

$$E \cdot S = \frac{Q}{\varepsilon} \rightarrow E(x) = \frac{\sigma(x)}{\varepsilon} \rightarrow \sigma(0) = \varepsilon V_T \frac{1}{\frac{W}{\Delta N} N_O}$$

$$\sigma(\omega) = -\varepsilon \frac{V_T}{\omega} \frac{\Delta N}{\Delta N + N_O}$$

COMPITO 11.09.2018

ES 1



$K_n = 0.5\ \frac{mA}{V^2}$

$V_{TH} = 1V$

$\lambda = 0.0133\ \frac{1}{V}$

$Q = (0.241\ mA,\ 3.81V)$

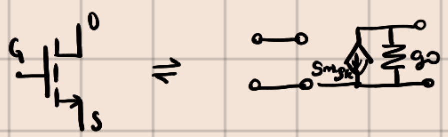
$R_I = 1k\Omega$ $\quad R_d = 22k\Omega$

$R_1 = 1.5M\Omega$ $\quad R_4 = 10k\Omega$

$R_2 = 2.2M\Omega$ $\quad R_3 = 100k\Omega$

$R_S = 2k\Omega$ $\quad V_{dd} = 12V$

$C_1, C_2 : Z_{C1}, Z_{C2} \to 0$ per $\omega \neq 0$



$$\frac{K_n}{2}(V_{GS}-V_{TH})^2(1+\lambda V_{DS}) = I_{DS}$$

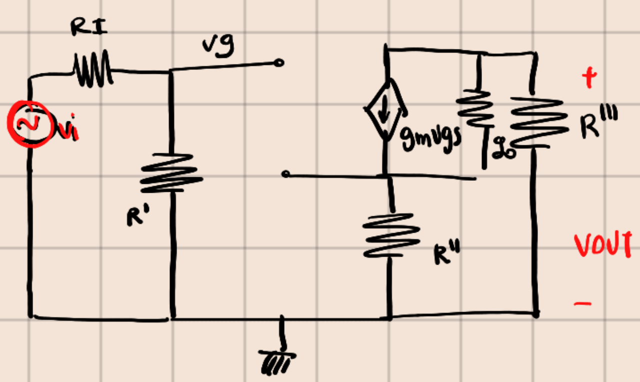
$$V_{GS}-V_{TH} = \sqrt{\frac{2\,I_{DS}}{K_n(1+\lambda V_{DS})}}$$

$$V_{GS} = V_{TH} + \sqrt{\frac{2\,I_{DS}}{K_n(1+\lambda V_{DS})}} = 1 + \sqrt{\frac{4 \cdot 0.241\,\cancel{10^{-3}}}{\cancel{10^{-3}}(1+0.0133 \cdot 3.81)}}$$

$$\simeq 1.96\ V$$

$$g_m = \frac{2 I_{DS}}{V_{GS}-V_{TH}} \simeq 0.5\ mS$$

$$g_o \simeq 3.2\ \mu S$$



$$R' = \frac{R_1 R_2}{R_1+R_2} = 892\,\Omega$$

$$R'' = R_4 + R_S = 12\ k\Omega$$

$$R''' = \frac{R_3 R_D}{R_3+R_D} = 18\ k\Omega$$

$$v_g = \frac{R'}{R'+R_I}\,v_i = \frac{0.89}{1.89}\,v_i \simeq 0.47\,v_i$$

$$v_s = R''(g_m(v_g - v_s) + g_o(v_o - v_s))$$

$$(1 + R''(g_m + g_o))\,v_s = R'' g_m v_g + R'' g_o v_o$$

$$(1 + 12 \cdot \cancel{10^3}(0.5 \cdot \cancel{10^{-3}} + 3.2 \cdot 10^{-3}))\,v_s = 6\,v_g + 12 \cdot 3.2 \cdot 10^{-3}\,v_o$$

$$v_s = \underbrace{\frac{6}{7.04}}_{\simeq 0.85} v_g + \underbrace{\frac{12 \cdot 3.2}{7.04}}_{\simeq} 10^{-3} v_o = 0.85\,v_g + 0.005\,v_o$$

$$v_o = -R'''(g_m(v_g - v_S) + g_o(v_o - v_S))$$

$$= -R'''(g_m(0.15\,v_g - 0.005\,v_o) + g_o \cdot 0.995\,v_o - g_o(0.85)\,v_g)$$

$$v_o = -R'''(g_m \cdot 0.15\,v_g - g_o(0.85)\,v_g) - R'''(-g_m\,0.005\,v_o + g_o \cdot 0.995\,v_o)$$

$$(1 + R'''(g_o \cdot 0.995 - g_m\,0.005))v_o = -R'''(g_m \cdot 0.15 - g_o(0.85))v_g$$

$$[1 + 18 \cdot 10^3(3.2 \cdot 10^{-6} \cdot 0.995 - 0.5 \cdot 10^{-3} \cdot 0.005)]v_o = -18 \cdot 10^3(0.5 \cdot 10^{-3} \cdot 0.15 - 3.2 \cdot 10^{-6} \cdot 0.85)v_g$$

$$1.01\,v_o = -1.30\,v_g$$

$$v_o \cong -1.29\,v_g = -1.29 \cdot 0.47\,v_i \approx -0.6\,v_i$$

$$v_{gs} < 2(V_{GS} - V_{TH})$$

$$v_g - v_S = 0.47\,v_i - 0.89 \cdot 0.47\,v_i + 0.005 \cdot 0.6\,v_i$$

$$\cong 0.078\,v_i$$

$$0.078\,v_i < 2(0.96) \rightarrow v_i < 24.6\,V$$

2) Si calcoli corrente DEL TRANSISTOR e k_n sapendo che:

$V_{GS} = 1V$

$V_{ds} = 0.1V$

$V_{TH} = 1.5V$

$W = 10\mu m$

$L = 1\mu m$

$d = 25nm$

$\mu_n = 500 \frac{cm^2}{V \cdot s}$

$\varepsilon_{OX} = 3.9$

$\varepsilon_0 = 8.854 \cdot 10^{-14} \frac{F}{cm}$

$V_{GS} < V_{TH}$ NON CONDUCO

$$k_n = \frac{C_{ox}'' W \mu_n}{L}$$

$-12+9 \quad -6+4$

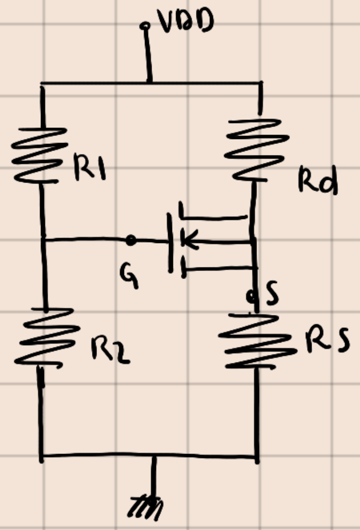
$$= \frac{\varepsilon}{d} \cdot \frac{W\mu_n}{L} = \frac{(3.9)(8.854 \cdot 10^{-12})\left[\frac{F}{m}\right]}{25 \cdot 10^{-9}[m]} \cdot \frac{10 \cdot 10^{-6}[m] \cdot 500 \cdot 10^{-4}\left[\frac{m^2}{V \cdot s}\right]}{10^{-6}[m]}$$

$F = \frac{C}{V}$

$$\cong 6.9\;10^{-3}\left[\frac{C}{V^2 s}\right] = 6.9\,\frac{mA}{V^2}$$

COMPITO 13.02.2018

ES 1



$V_{DD} = 18V$

$R_1 = 5.6 k\Omega$

$R_2 = 4.7 k\Omega$

$R_S = 1.2 k\Omega$

$R_d = 2.2 k\Omega$

$k_n = 0.4 \frac{mA}{V^2}$

$V_{TH} = 3V$

? Si calcoli il punto di lavoro

$V_G = \frac{4.7}{10.1} 18 \cong 8.38V$ Suppongo in SAT $V_S < 5.38$

$$\frac{k_n}{2}(5.38 - V_S)^2 = \frac{V_S}{R_S}$$

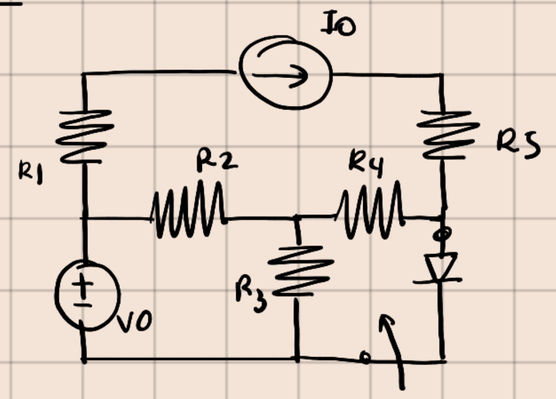
$$(5.38)^2 - 2 \cdot 5.38 \cdot V_S + V_S^2 - \frac{2}{k_n R_S} V_S = 0$$

$$V_S^2 - 15\, V_S + 29 = 0 \qquad \frac{15 \pm \sqrt{109}}{2} = \begin{cases} 12.7V \\ 2.28V \end{cases}$$

$$I_{DS} = 0.2 \left[\frac{mA}{\cancel{V^2}}\right] (3.1)^2 \cancel{V^2} = 1.92 \, mA$$

$$V_D = 18 - 2.2 \cdot 1.92 \cong 13.78V \quad \rightarrow V_{DS} \cong 11.5 V \overset{?}{>} 3.1V$$

ES 2



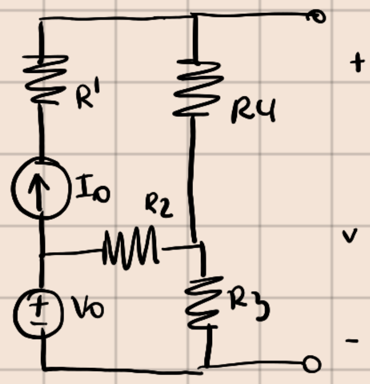
$V_0 = 2.5V$

$I_0 = 65\mu A$

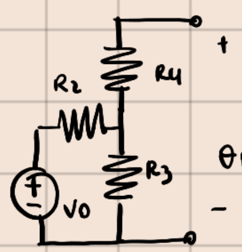
$R_1 = 10k\Omega$ $R_3 = 20k\Omega$ $R_5 = 15k\Omega$

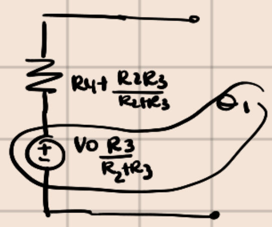
$R_2 = 10k\Omega$ $R_4 = 15k\Omega$ $V_{TH} = 0.7V$

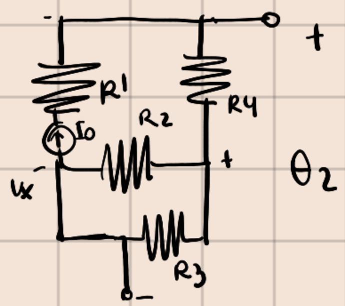
? Si calcoli corrente diodo



$V = \theta_1 + \theta_2$





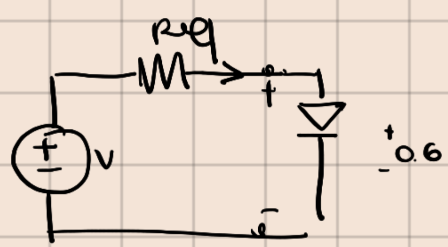


$V_x = (R' + R_4) I_0$

$\theta_2 = (R' + 2R_4) I_0$

$\rightarrow V = \frac{R_3}{R_2+R_3} V_0 + (R' + 2R_4) I_0$

$= 1.66V + 3.57V = 5.23V$



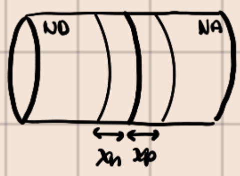
$R_{eq} = R_4 + \frac{R_2 R_3}{R_2 + R_3}$

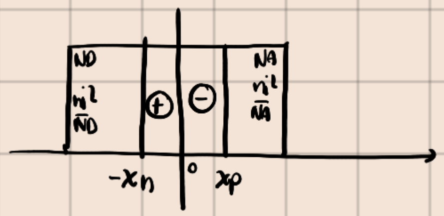
$= 21.6 k\Omega$

$i_d = \frac{V - 0.6}{R_{eq}} = \frac{5.23 - 0.6}{21.67} mA = 0.21 mA$

ES 3

Diodo PN a sezione circolare





$r = 2nm$

$NA = 10^{17} \frac{1}{cm^3}$

$ND = 10^{18} \frac{1}{cm^3}$

$q = 1.6\,10^{-19}\,C$

$\varepsilon = 80 \cdot 10^{-14} \frac{F}{cm}$

$EG = 1.12V$

$r = 5 \cdot 10^{-18} \frac{1}{S \cdot cm^3}$

$\mu n = 1350 \frac{cm^2}{V \cdot S}$

? corrente del diodo

$$\phi = V_T \ln\left(\frac{ND \cdot NA}{ni^2}\right) = 25 \cdot 10^{-3}[V] \cdot \ln\left(10^{25}\right) \cong 1.44V$$

$$ni \cong e^{\frac{EG}{2V_T}} \approx 0.5 \cdot 10^{10} \Rightarrow ni^2 \approx 10^{20}$$

$$w = \sqrt{\frac{2\varepsilon}{q}\phi\left(\frac{1}{NA} + \frac{1}{ND}\right)} = \sqrt{\frac{2 \cdot 80 \cdot 10^{-14}\left[\frac{F}{cm}\right]}{1.6 \cdot 10^{-19}[C]} \cdot 1.44[V] \cdot \left(10^{-17} + 10^{-18}\right)[cm^3]}$$

$$= \sqrt{27.72 \cdot 10^{-12}[cm^2]} = 5.26 \cdot 10^{-6}[cm]$$

$$\approx 52.6\ nm$$

$$S = \pi r^2 = \pi \cdot 4 \cdot 10^{-18}[m^2]$$

$$Is = qS\sqrt{\frac{Dn\,r}{NA}}\,ni^2$$

$$qS\sqrt{\frac{\mu n V_T r}{NA}}\,ni^2 = 1.6 \cdot 10^{-19}[C] \cdot 4\pi \cdot 10^{-14}[\cancel{cm^2}] \sqrt{\frac{1350\left[\frac{cm^2}{V \cdot S}\right] \cdot 25 \cdot 10^{-3}[V] \cdot 5 \cdot 10^{-18}\left[\frac{1}{\cancel{cm^3} s}\right]}{10^{17}\left[\frac{1}{\cancel{cm^3}}\right]}} \cdot 10^{20}\left[\frac{1}{cm^3}\right]$$

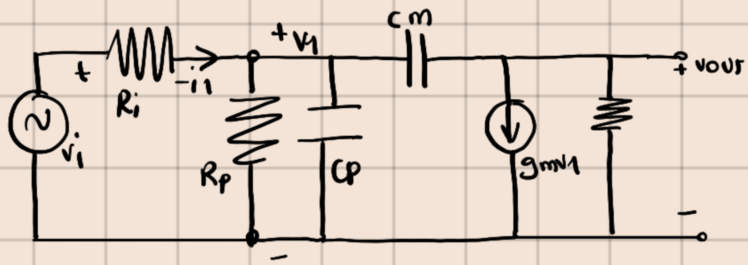
$$= 1.6 \cdot 4\pi \cdot 10^{-13}\left(\frac{C}{\cancel{cm}}\right)\sqrt{1687 \cdot 10^{-34}}\left(\frac{\cancel{cm}}{s}\right)$$

$$= 82.58 \cdot 10^{-13} \cdot 10^{-17}\ A$$

$$\approx 0.82 \cdot 10^{-28}\ A$$

COMPITO 22.01.2018

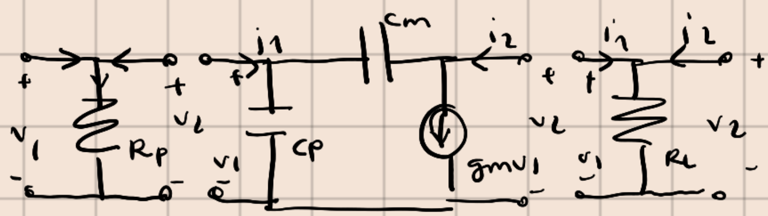
ES 1)



? zin, Zout, guadagno

TEOREMA DI MILLNER O ASSOLUTO

Parametri di trasmissione in cascate si moltiplicano



$$T = \begin{bmatrix} 1 & 0 \\ \frac{1}{R_p} & 1 \end{bmatrix}$$

$T?$

$$T = \begin{bmatrix} 1 & 0 \\ \frac{1}{R_L} & 1 \end{bmatrix}$$

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = T \begin{bmatrix} v_{out} \\ i_{out} \end{bmatrix}$$

$$V_1 = V_i - R I_1$$

$$t_{11} v_{out} = v_i - R t_{21} v_{out}$$

$$\rightarrow v_{out} = \frac{-v_i}{R t_{21} - t_{11}} \rightarrow A = \frac{1}{R_i t_{21} - t_{11}}$$

$$z^{in} = \frac{t_{11}}{t_{21}} \rightarrow y^{in} = \frac{t_{21}}{t_{11}}$$

$$z^{out} = \frac{t_{12} R_1}{t_{11} R_1 + t_{22}} \qquad y^{out} = \frac{t_{21}}{t_{22}} + \frac{1}{R_1}$$

$$\frac{1}{A} = R_1 t_{21} - t_{11} = R_1 \left(t_{21} - \frac{t_{11}}{R_1} \right)$$

$$V_1 = t_{11} V_2 - t_{12} i_2$$

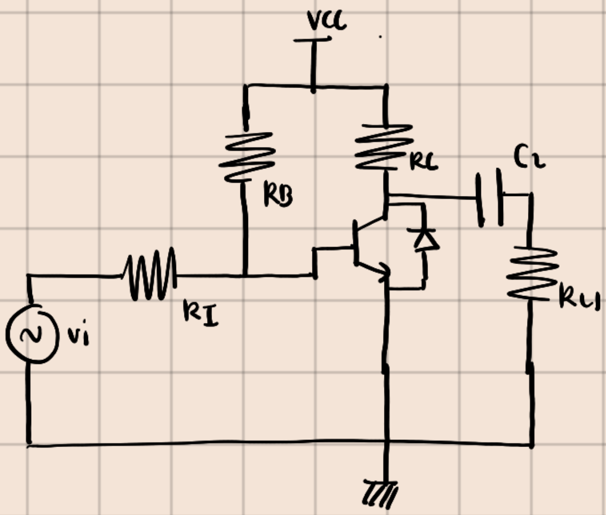
$$I_1 = t_{21} V_2 - t_{22} i_2$$

$$V_2 = \frac{I_1 + t_{22} i_2}{t_{21}} \qquad V = \frac{1}{t_{21}} \begin{bmatrix} t_{11} & \det T \\ 1 & t_{22} \end{bmatrix}$$

$$V_1 = \frac{t_{11} I_1}{t_{21}} + \frac{t_{11} t_{22}}{t_{21}} i_2 - t_{12} i_2$$

$$\frac{V_1}{I_1} = \frac{t_{11}}{t_{21}} \qquad \frac{V_0}{I_0} = \frac{t_{22}}{t_{21}} // \frac{1}{R_1}$$

ES 2)



$\beta_F = 90$

$V_{CC} = 12V$

$R_I = 2k\Omega$

$R_1 = 360k\Omega$

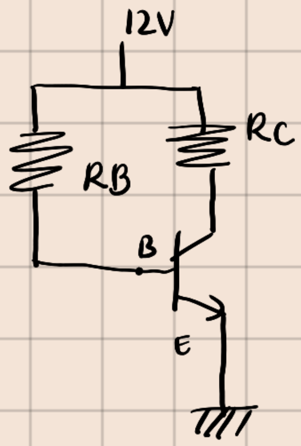
$R_2 = 750k\Omega$

$R_b = 8k\Omega$

$R_c = 4k\Omega$

? Punto di lavoro, corrente I_B, I_E.

DC



Tensione diodo 0.6V

Se conduce $V_{CE} = -0.6V$

→ NON SONO IN RAD

SUPPONGO $V_B = 0.6V$

$\rightarrow I_B = \frac{12-0.6}{8} (mA) = 1.42\ mA$

$\rightarrow I_C = \beta_F \cdot I_B = 128\ mA$

$V_C = 12 - R_C I_C = 12 - 4 \cdot 128 \approx -500\ V$

NO RAD

$V_C > 0.2$

$I_C < \frac{12-0.2}{4} = 2.95\ mA$

$\rightarrow I_B < 33\ \mu A$

$I_B = \frac{12 - V_B}{R_B} < 33\ \mu A$

$12 - V_B < 33 \cdot 10^{-6} \cdot R_B$

$\rightarrow V_B > 12 - 33 \cdot 10^{-6} R_B = 11.74\ V$, ma di solito $V_{be} \approx \in (0.6, 0.8)$

$I_B < 33\ \mu A$ $\qquad V_C > 0.2V$

$I_C < 2.95\ mA$ $\qquad V_B > 11.74V$

$I_E < 3\ mA$

ES 3) $N_A = 10^{17} \frac{1}{cm^3}$

$N_D = 10^{20} \frac{1}{cm^3}$

$q = 1.6\ 10^{-19}\ C$

$\varepsilon \simeq 80 \cdot 10^{-14} \frac{F}{cm}$

$E_G = 1.12V$

$W = 100\mu m$? non so a che mi serve

? ϕ, W

$E_G = E_C - E_V$

$E_F = \frac{E_C + E_V}{2}$

$n_i \propto e^{-\frac{E_C - E_F}{kT}} \propto e^{+\frac{E_G q}{2 V_T q}} \propto 10^{10}$

$n_i^2 \propto 10^{20} \frac{1}{cm^6}$

La parte svotata sarà maggiore nella parte P

in quanto $N_d x_d = N_a x_p$

$\rightarrow x_p = \frac{N_d}{N_A} x_n = 10^3 x_n$

$\phi = V_T \ln\left(\frac{N_D \cdot N_A}{n_i^2}\right) = 25 \cdot 10^{-3} (V) \ln\left(10^{17}\right)$

$\simeq 0.98\ V$

$W = \sqrt{\frac{2\varepsilon}{q} \phi \cdot \left(\frac{1}{N_A} + \frac{1}{N_D}\right)}$

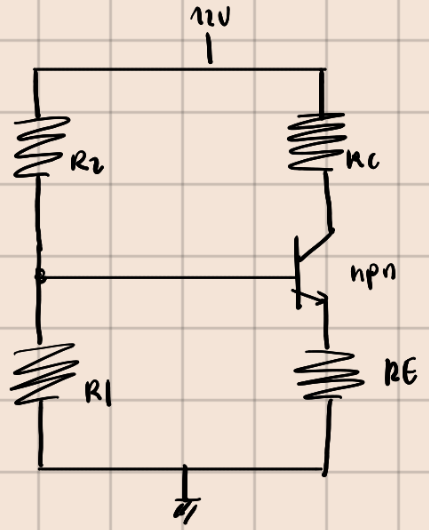
$= \sqrt{\frac{160 \cdot 10^{-14} \cancel{[F/cm]}}{1.6 \cdot 10^{-19} \cancel{[C]}} \cdot 0.98 \cancel{[V]} \cdot 10^{-17} (1 + 10^{-3}) [cm^3]}$

$= \sqrt{98 \cdot 10^{-12}} = 9.9 \cdot 10^{-6}\ (cm)$

$\simeq 100\ nm = 0.1 [\mu m]$

20.06.2018

1)



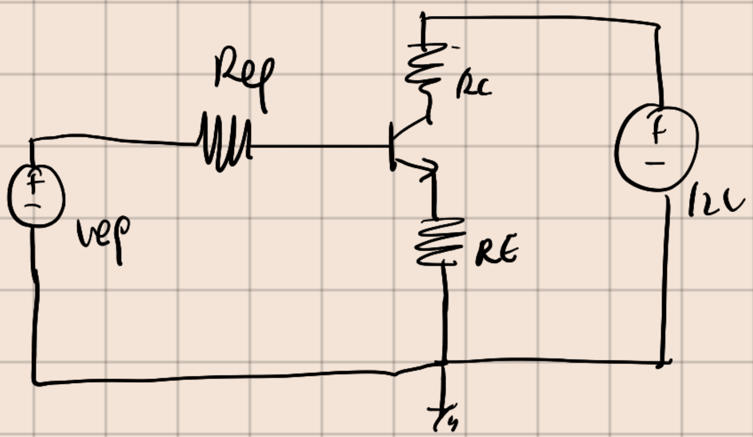
$R_1 = 180\,k\Omega$

$R_2 = 360\,k\Omega$

$R_E = 16\,k\Omega$

$R_C = 22\,k\Omega$

Suppongo in RAD $\quad V_{BE} = 0.7V$



$R_{eq} = 120\,k\Omega$

$V_{eq} = 4V$

$\beta_r \in (10, 50)$

$\beta_f \in [50, 200)$

$V_{eq} = (R_{eq} + (\beta+1)R_E)I_B + 0.7 \rightarrow I_B = \dfrac{V_{eq} - 0.7}{R_{eq} + (\beta+1)R_E} = \dfrac{4-0.7}{120 + (\beta+1)\cdot 16}\,10^{-3}$

$12 = R_C \beta I_B + V_{CE} + R_E(\beta+1)I_B$

$V_{CE} = 12 - (R_C\beta + R_E(\beta+1))\, I_B$

$\beta=50$: $I_B = \dfrac{3.3}{120+51\cdot 16}\,10^{-3} = 3.5\,\mu A \rightarrow I_C = 0.17\,mA$

$\beta=200$: $I_B = \dfrac{3.3}{120+201\cdot 16} = 0.98\,\mu A \rightarrow I_C = 0.2\,mA$

$\beta=50$: $V_{CE} = 12 - (50\cdot 22 + 16\cdot 51)\,3.5\cdot 10^{-3} \cong 5.3V$

$\beta=100$: $V_{CE} = 12 - (200\cdot 22 + 16\cdot 201)\cdot 0.98\cdot 10^{-3} \cong 4.54V$

$E_g = 1.12\ eV = 1.12 q\ J$

$K = 8.62 \cdot 10^{-5} \cdot q \cdot \frac{J}{K}$

$B = 10^{31} \frac{1}{K^3 cm^6}$

$v_e = -\mu E$

$j = \sigma E = NqV = -\mu N q E$

$T_K = 35 + 273.15 = 308.15$

$T = 35°C$

$\mu_e = 1350 \frac{cm^2}{V \cdot s}$

$\mu_p = 500 \frac{cm^2}{Vs}$

$V_T = \frac{KT}{q} = 8.62 \cdot 10^{-5} \cdot 308.15\ V = 26.55 mV$

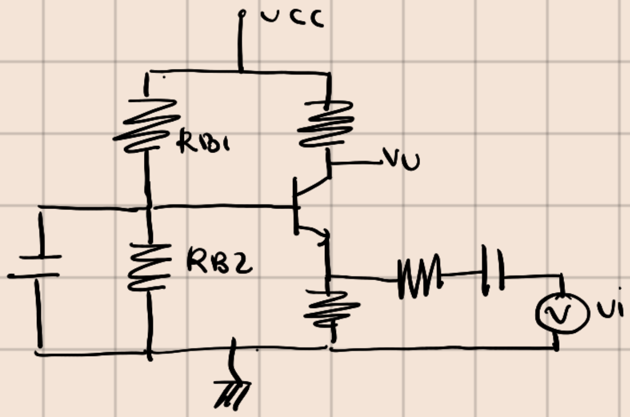
$n_i \propto e^{-\frac{E_G}{2KT}} = e^{-\frac{1.12}{2 \cdot 26.55} 10^3} \simeq 7 \cdot 10^{10}$

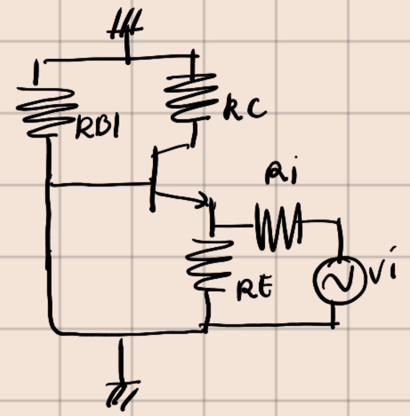
$\sigma = n_i q (\mu_n + \mu_p) = 7 \cdot 10^{10} \cdot 1.6\ 10^{-19}\ 1850 \simeq 20.7 \quad \left(\frac{\mu S}{cm}\right)$

$\rho = 48262\ \Omega cm$

08.01.2024

Es 2)





$I_C^q = 1mA$

$\beta_F = 150$

$V_{BE} = 0.7V$

$r_{bb'} = 100\Omega$

$V_T = 26mV$

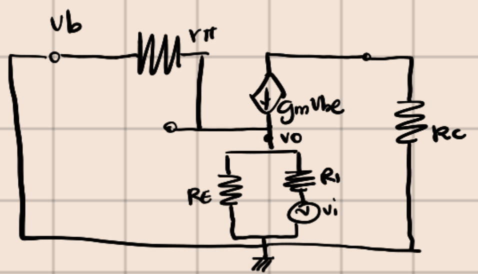
$g_o \to 0_S$

$h_{fe} = 200$

$V_{DD} = 15V$

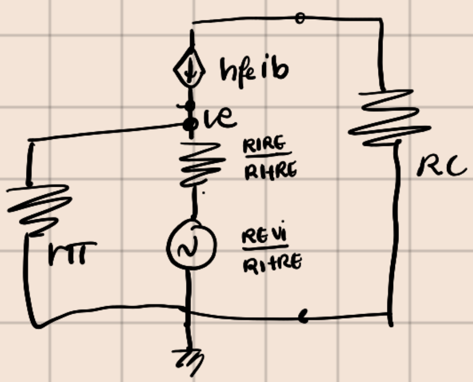
$g_m = 38.5\ mS$

$g_\pi = \frac{g_m}{\beta_0} = \frac{38.5\ mS}{200} = 192.5\mu S = 5.19k\Omega$



$v_O = \frac{R_E v_b}{R_E + R_i}$

$\frac{v_b - v_o}{r_\pi} = i_b$



$$V_o = \frac{\frac{R_E v_i}{\cancel{R_I + R_E}} \cdot \frac{\cancel{R_I + R_E}}{R_I R_E}}{\frac{1}{r_\pi} + \frac{R_I + R_E}{\cancel{R_I R_E}}}$$

$$= \frac{R_E r_\pi v_i}{r_I R_E + r_\pi R_I + r_\pi R_E}$$

$\frac{v_o}{v_i} =$