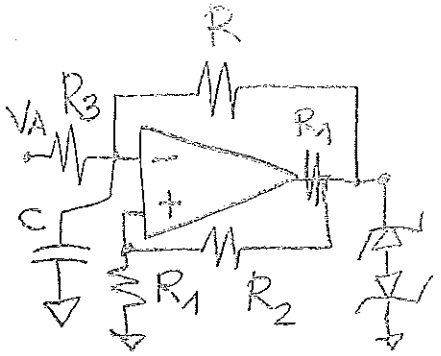
Prova scritta di Elettronica - Corso di Laurea in Ingegneria delle Telecomunicazioni

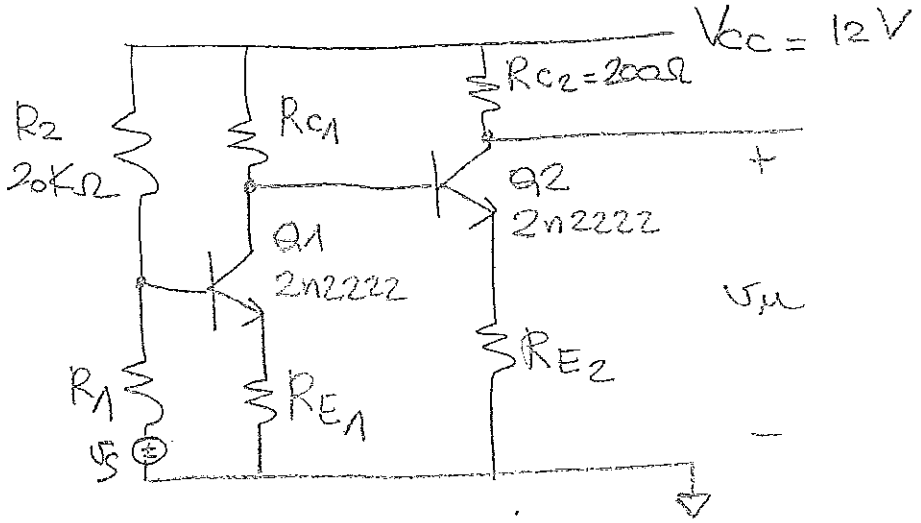
15 settembre 2010

1. Si consideri un amplificatore con amplificazione di tensione A_{v0}=1000, R_{in} = 100 KΩ, R_{out} = 10 KΩ. Si reazioni in modo da ottenere una resistenza di uscita di 1 MΩ (con un errore ammesso del 5%), una resistenza di ingresso minore di 1 KΩ. Si consideri la resistenza del generatore nulla, e l'amplificatore a vuoto. *(punteggio 5/30)*

2. Sia dato il circuito a lato. Calcolare la forma d'onda generata dal circuito, giustificando il procedimento, e rappresentare la tensione di uscita e la tensione sulla capacità sullo stesso asse dei tempi, quotando i punti rilevanti (R_1 = 1 KΩ, R_2 = R_3= R = 10 KΩ, V_Z = 4.7 V, V_A = 1 V, C = 1 μF,). *(punteggio 5/30)*



3. Con riferimento al circuito in basso, calcolare:
   - il valore di R_1, R_{C1} , R_{E1} e R_{E2} in modo da avere come punto di riposo del transistore I_{C1} = 1 mA , V_{CE1} = 5 V, I_{C2} = 5 mA , V_{CE2} = 5 V e i parametri di piccolo segnale del transistore. *(punteggio 8/30).*
   - La funzione di trasferimento a centro banda *(punteggio 5/30).*
   - il limite superiore di banda considerando Q2 resistivo *(punteggio 5/30).*



4. consegna esercizi con spice *(3 punti)*

1) $A_{V0} = 1000$

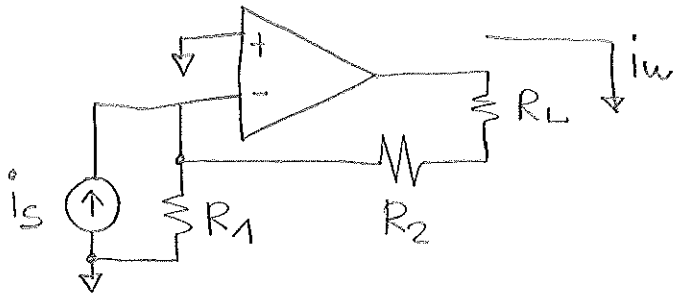
$R_{in} = 100\ K\Omega$

$R_{out} = 10\ K\Omega$

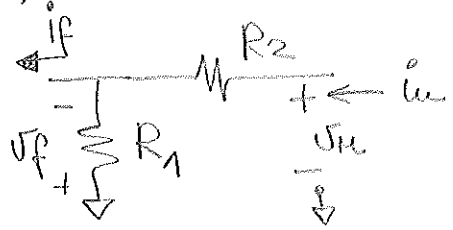
$R_{IF} < 1\ K\Omega$

$R_{OF} = 1\ M\Omega$

Reazione con prelievo di corrente e inserzione di corrente



Rete del β

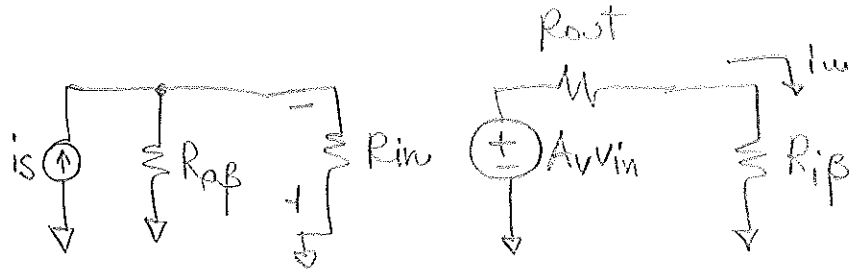


$$i_f = \beta i_u + v_f / R_{o\beta}$$

$$v_u = R'_{i\beta} i_u + k v_f$$

$$\beta = \left.\frac{i_f}{i_u}\right|_{v_f=0} = 1 \qquad R_{o\beta} = \left.\frac{v_f}{i_f}\right|_{i_u=0} = R_1 \qquad R'_{i\beta} = \left.\frac{v_u}{i_u}\right|_{v_f=0} = R_2$$

Ae:



$$A_e = \left.\frac{i_u}{i_s}\right|_{\beta=0} = -\frac{(R_{in} /\!/ R_{o\beta})\, A_V}{R_{i\beta} + R_{out}}$$

$$R_{IF} = \frac{R_{oB} /\!/ R_{in}}{1 - \beta A_e} \qquad R_{oF} = (R_{iB} + R_{out})(1 - \beta A_e)$$

$$R_{IF} = \frac{R_1 /\!/ R_{in}}{(1 - \beta A_e)} < 1K\Omega \quad (R_1 \leftarrow 100K) \qquad R_{oF} = (R_2 + R_{out})(1 - \beta A_e) = 1M\Omega \quad (R_2 \leftarrow 10K)$$

$$1 - \beta A_e = 1 + \frac{A_V \; R_{in} /\!/ R_1}{R_2 + R_{out}} \quad (A_V \leftarrow 1000) \quad \leftarrow 12{,}5$$

poniamo $R_2 = 2{,}5K\Omega$ e $1 - \beta A_e = 80$

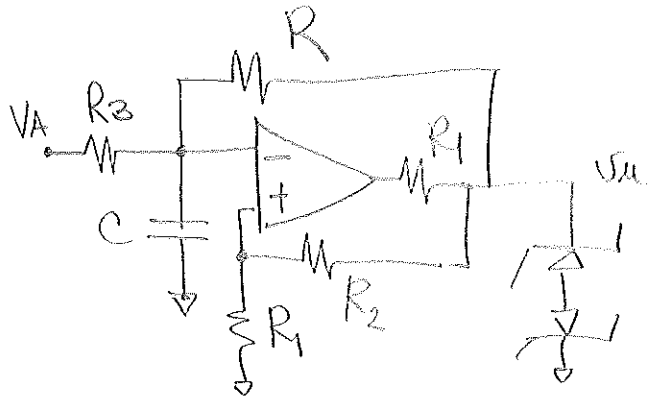
$$1 - \beta A_e = 1 + \frac{A_V \; R_{in} /\!/ R_1}{R_2 + R_{out}} = 80$$

$$R_{in} /\!/ R_1 = \frac{12{,}500 \cdot 79}{1000} = 987.5$$

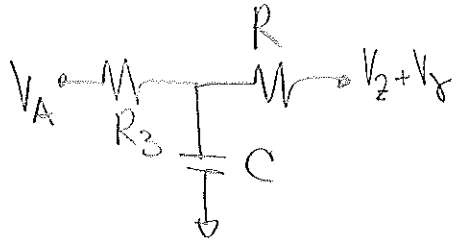
$$\frac{R_{in} \cdot R_1}{R_{in} + R_1} = 987{,}5 R_{in} + 987{,}5 R_1$$

$$R_1 = \frac{987.5 \, R_{in}}{R_{in} - 987{,}5} = 997{,}3 K\Omega$$

2]



Supponiamo che per $t = 0$ si abbia $V_C = 0$ $V_u = +5.4V$



$$\tau = (R /\!/ R_3) C = 0.91 \text{ ms}$$

a sinistra $V_1 = \frac{(V_2 + V_\gamma) R_3 + R V_A}{R_3 + R} = 4{,}7V$

3)

$V_{C2} = V_{CC} - R_{C2} I_{C2} = 12 - 0.2 \cdot 5 = 11\,V$

$V_{E2} = 6\,V$

$R_E = \frac{V_{E2}}{I_{E2}} = \frac{6}{5} = 1.2\,K\Omega$

$V_{C1} = V_{E2} + V_{BE_{ON}} = 6.7\,V$

$V_{E1} = V_{C1} - V_{CE_{ON}} = 1.7\,V$

$R_{C1} = \frac{V_{CC} - V_{C1}}{I_{C1}} = \frac{5.3}{1} = 5.3\,K\Omega$

$R_{E1} = \frac{V_{E1}}{I_{C1}} = 1.7\,K\Omega$

$V_{B1} = V_{E1} + V_{BE_{ON}} = 2.4\,V$

$I_2 = \frac{V_{CC} - V_{B1}}{R_2} = \frac{12 - 2,4}{20} = 0.48\,mA \sim I_1$

$R_1 = \frac{V_{B1}}{I_1} = \frac{2,4}{0,48} = 5\,K\Omega$

$h_{ie_1} = 5\,K\Omega$ $r_{bb} = 450\,\Omega$ $r_{be} = 4550\,\Omega$ $h_{fe_1} = 175$

$f_{T_1} = 90\,MHz$ $g_{m_1} = \frac{I_{C1}}{V_T} = 0,0384\,\Omega^{-1}$ $h_{oe_1} = 20 \cdot 10^{-6}\,\Omega^{-1}$

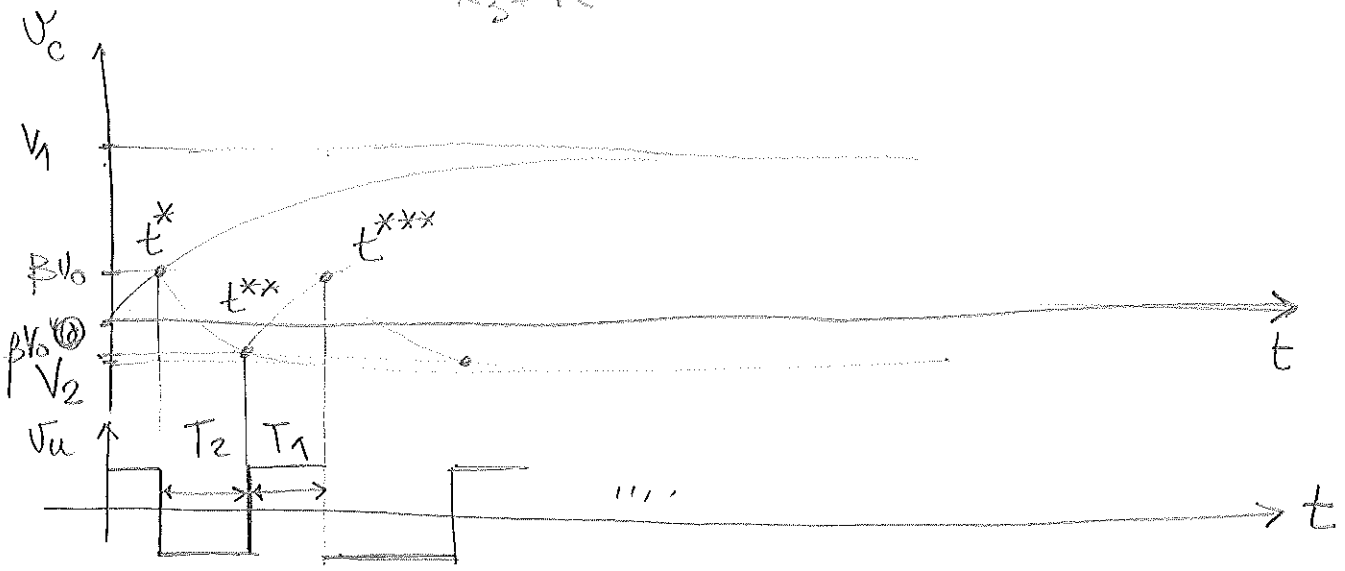
$\underline{C_{bc_1} = 5pF}$ $C_{bc_1} C_{be_1} = \frac{g_{m1}}{2\pi f_T} = 68\,pF$ $\underline{C_{be_1} = 63pF}$

$g_{m_2} = 0,192\,\Omega^{-1}$ $h_{fe_2} = 175$

$r'_{be_2} = \frac{h_{fe2}}{g_{m_2}} = 911\,\Omega$ $h_{ie_2} = r'_{be_2} + r_{bb} = 1361\,\Omega$

$h_{oe_2} = 10^{-4}\,\Omega^{-1}$

asintoto $V_2 = \dfrac{-(V_2+V_J)R_3 + R V_A}{R_3 + R} = 0.7\ V$



$$\beta V_0 = \frac{5.1}{11} = 0.49\ V$$

$t^{**} < t < t^{***}$

$$v_c(t) = -\beta V_0 + (V_1 + \beta V_0)\left(1 - e^{-\frac{t-t^{**}}{\tau}}\right)$$

$$\beta V_0 = -\beta V_0 + (V_1 + \beta V_0)\left(1 - e^{-T_1/\tau}\right)$$

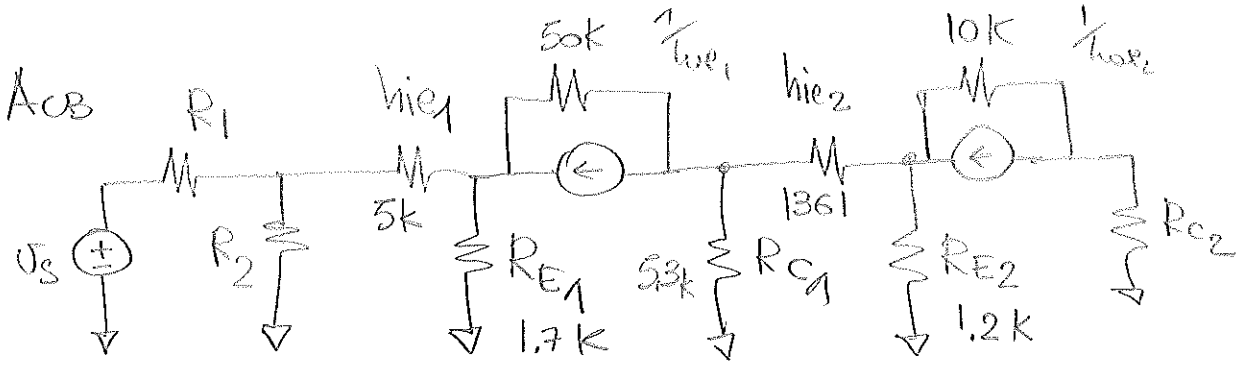
$$V_1 - \beta V_0 = (V_1 + \beta V_0)e^{-T_1/\tau} \rightarrow T_1 = \tau \ln\left(\frac{V_1 + \beta V_0}{V_1 - \beta V_0}\right) =$$

$$= 0{,}91 \cdot 10^{-3} \ln\left[\frac{4.7 + 0.49}{4.7 - 0{,}49}\right] =$$

$$\underline{T_1 = 0{,}19\ ms}$$

Analogamente $T_2 = \tau \ln\left(\frac{V_2 + \beta V_0}{V_1 - \beta V_0}\right) =$

$$= 0{,}91 \cdot 10^{-3} \ln\left[\frac{0{,}7 + 0{,}49}{97 - 0{,}49}\right] = \underline{1.58\ ms}$$



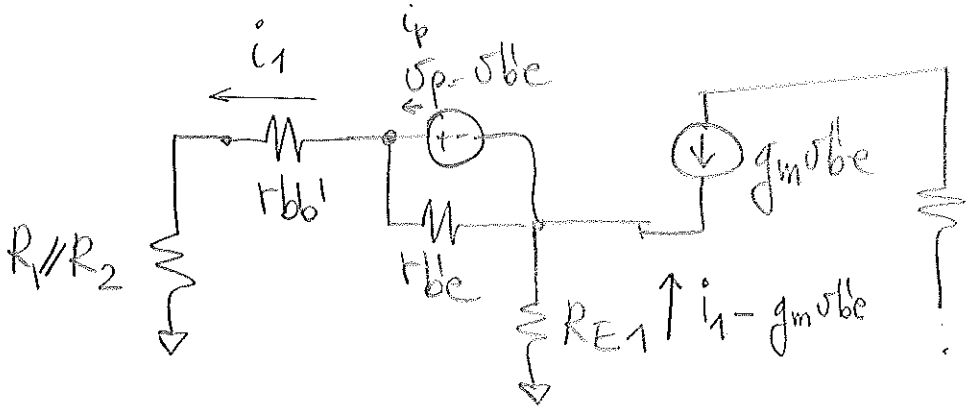
$\frac{1}{h_{oe1}}$ e $\frac{1}{h_{oe2}}$ possono essere trascurati

$$A_{CB} = \frac{R_2}{R_1+R_2} \cdot \frac{h_{fe1} R_{C1}}{R_1 /\!/ R_2 + h_{ie1} + (h_{fe1}+1) R_{E1}} \cdot \frac{h_{fe2} R_{C2}}{R_{C1} + h_{ie2} + R_{E2}(h_{fe2}+1)}$$

$$= \frac{20}{25} \cdot \frac{175 \cdot 5,3}{4+5+176 \cdot 1,7} \cdot \frac{175 \cdot 0,2}{5,3+1,36+1,2 \cdot 176} = 0,38$$

limite sup bande

R_{Vbe}

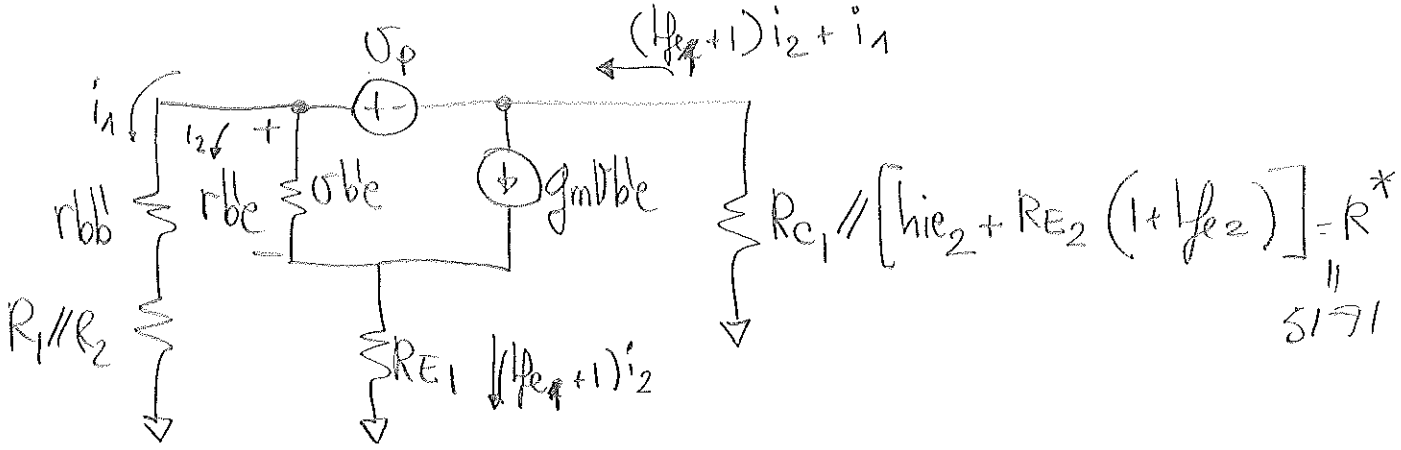


$$v_p = (r_{bb'} + R_1 /\!/ R_2) i_1 + R_{E1}(i_1 - g_m v_p)$$

$$i_1 = \frac{v_p (1 + g_m R_{E1})}{r_{bb'} + R_1 /\!/ R_2 + R_{E1}}$$

$$R_{Vb'e} = \left(\frac{r_{bb'} + R_1 /\!/ R_2 + R_{E1}}{1 + g_m R_{E1}} \right) /\!/ r_{b'e} = 93\,\Omega$$

R_{Vbc}'



$\therefore g_m v_{be} = g_m r_{be} i_2 = h_{fe_1} i_2$

$$i_1 (r_{bb}' + R_1 // R_2) = i_2 [r_{be}' + R_{E1}(1 + h_{fe_1})]$$

$$\frac{i_2}{i_1} = 0{,}0146$$

$$v_p = i_1 (r_{bb}' + R_1 // R_2) + R^* [i_1 + (h_{fe_1}+1) i_2]$$

$$v_p = i_1 \left[r_{bb}' + R_1 // R_2 + R^* + R^* (h_{fe_1}+1) \frac{i_2}{i_1} \right]$$

$$i_p = i_1 + i_2 = i_1 \left(1 + \frac{i_2}{i_1}\right) = i_1 \cdot 1{,}0146$$

$$\frac{v_p}{i_p} = \frac{r_{bb}' + R_1 // R_2 + R^* + R^* (h_{fe_1}+1) \frac{i_2}{i_1}}{1 + \frac{i_2}{i_1}} = 22578\,\Omega$$

$$f_H = \frac{1}{2\pi (R_{V_{be}} C_{be} + R_{Vbc} C_{bc})}$$

$$= \frac{1}{2\pi \left[43 \cdot 63 \cdot 10^{-12} + 22578 \cdot 5 \cdot 10^{-12} \right]} = 1{,}34\ MHz$$