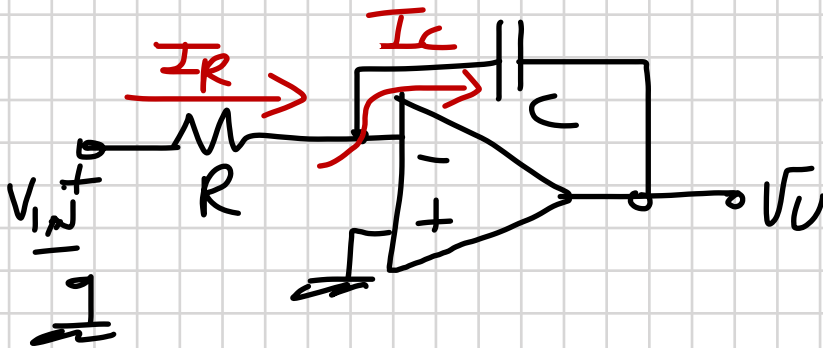
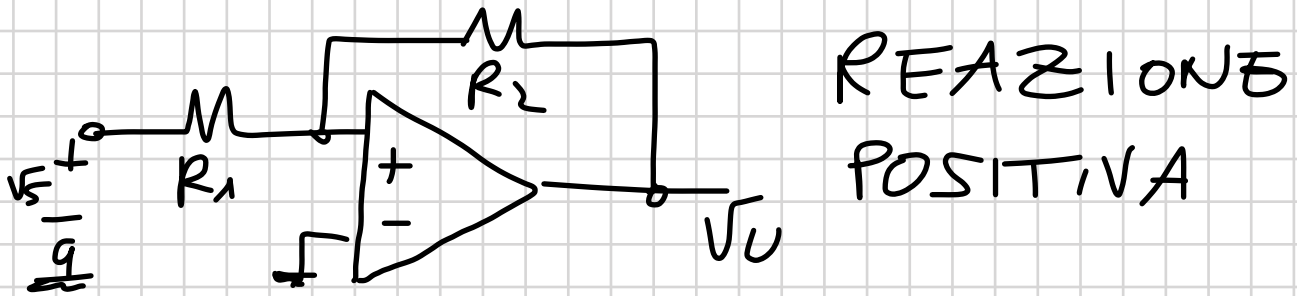


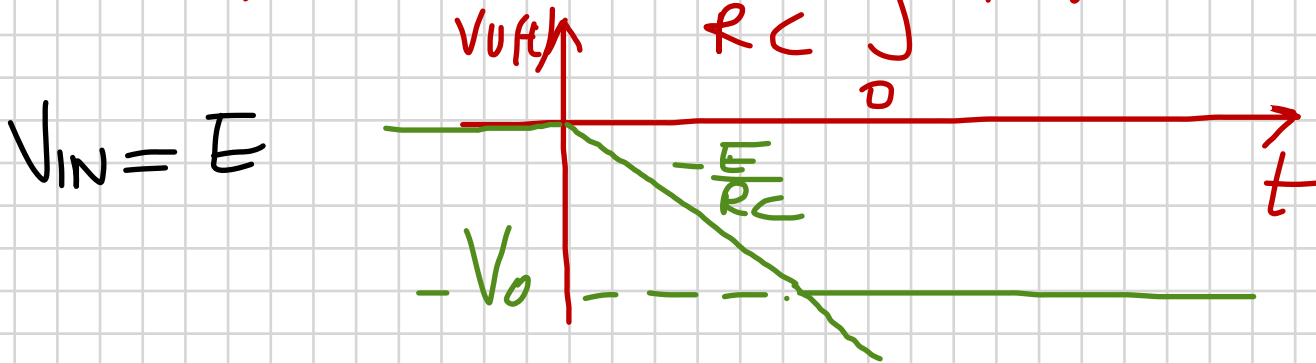
$$V_p = I_p R_1 \Rightarrow R_v = \frac{V_p}{I_p} = R_1$$

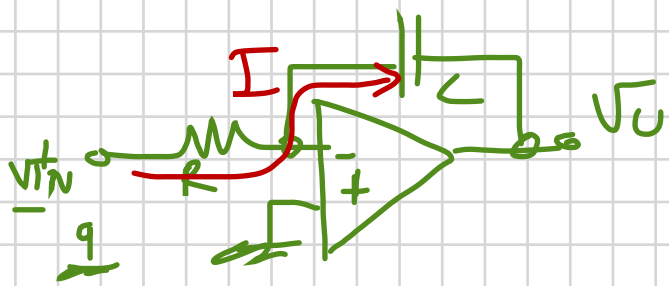


$$I_R = \frac{V_{IN}}{R} \quad I_C = I_R$$

$$V_U = -V_C = -\frac{1}{C} \int_0^t \frac{V_{IN}}{R} dt$$

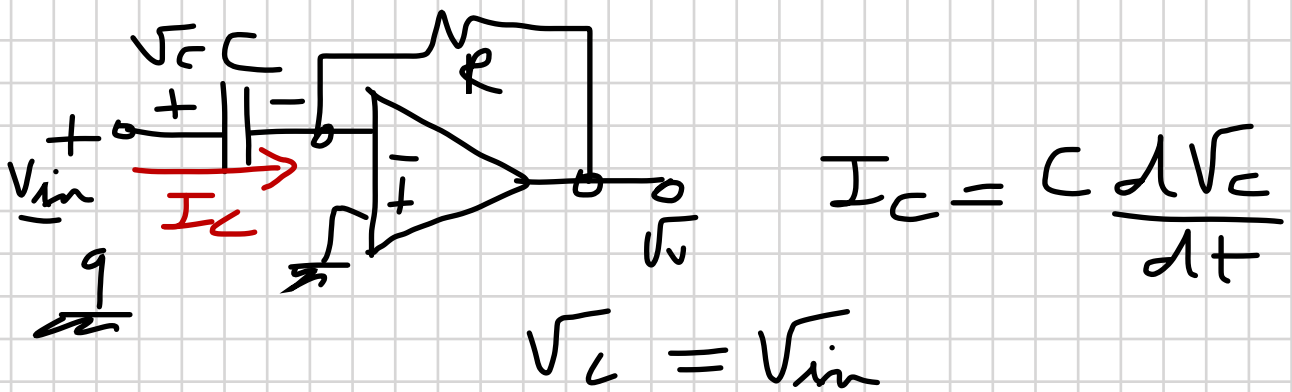
$$V_U(t) - V_U(0) = -\frac{1}{RC} \int_0^t V_{IN} dt$$





$$I = \frac{V_{IN}}{R} \quad V_U = -\frac{1}{CS} I$$

$$V_U = -\frac{V_{IN}}{RCS}$$

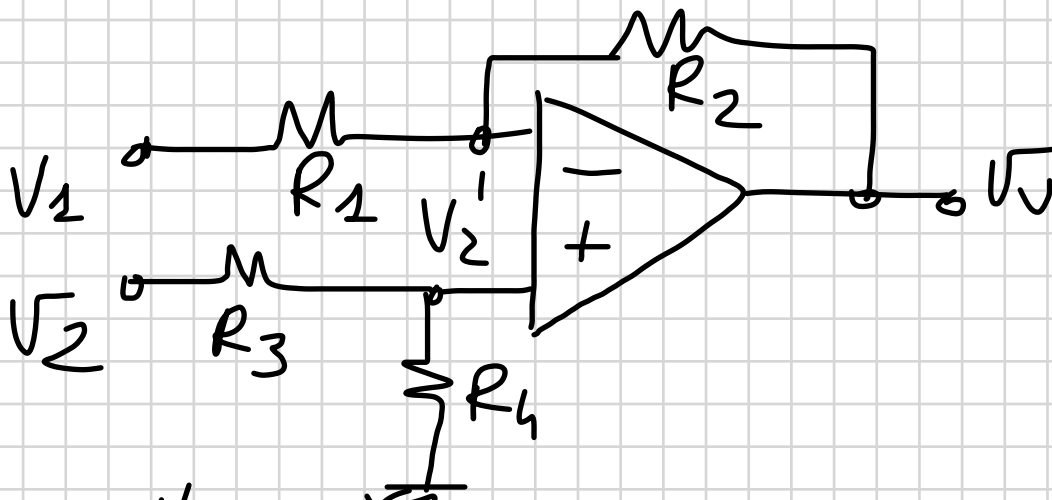


$$I_C = C \frac{dV_C}{dt}$$

$$V_C = V_{in}$$

$$I_C = C \frac{dV_{in}}{dt}$$

$$V_U = -RI_C \Rightarrow V_U = -RC \frac{dV_{in}}{dt}$$



$$V_U = V_2' \left(1 + \frac{R_2}{R_1} \right)$$

$$V_2' = \frac{R_4}{R_3 + R_4} V_2$$

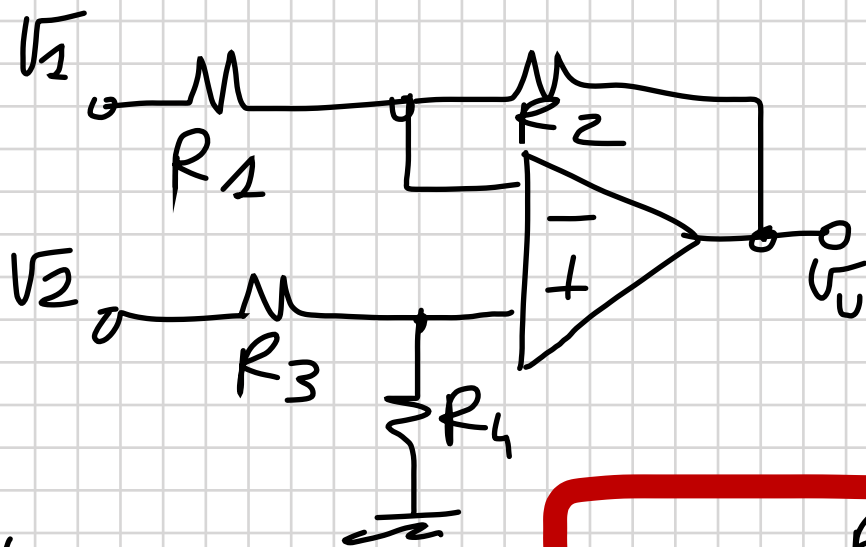
$$V_U = \left(1 + \frac{R_2}{R_1} \right) \frac{R_4}{R_3 + R_4} V_2; \quad V_{U1} = -\frac{R_2}{R_1} V_1$$

$$V_U = V_{U1} + V_{U2} = \left(1 + \frac{R_2}{R_1}\right) \frac{R_4}{R_4 + R_3} V_2 - \frac{R_2}{R_1} V_1$$

$$V_U = A(V_1 - V_2)$$

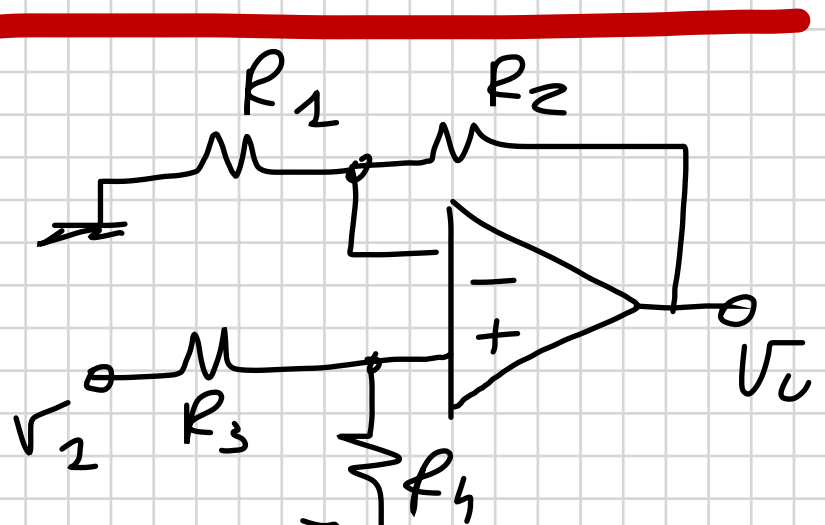
$$V_U = \cancel{\left(1 + \frac{R_2}{R_1}\right)} \frac{R_4}{R_3} \frac{\cancel{R_4 + 1}}{R_3} V_2 - \frac{R_2}{R_1} V_1$$

$$\frac{R_4}{R_3} = \frac{R_2}{R_1} \Rightarrow V_U = \frac{R_2}{R_1} (V_2 - V_1)$$

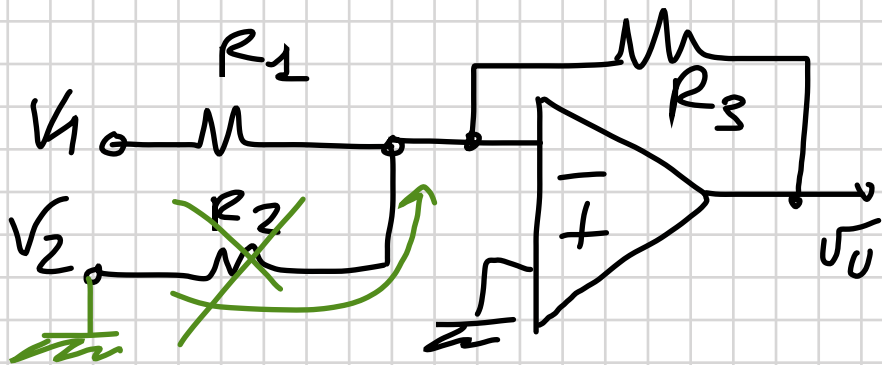


$$R V_1 = R_2$$

$$R V_2 = R_3 + R_4$$



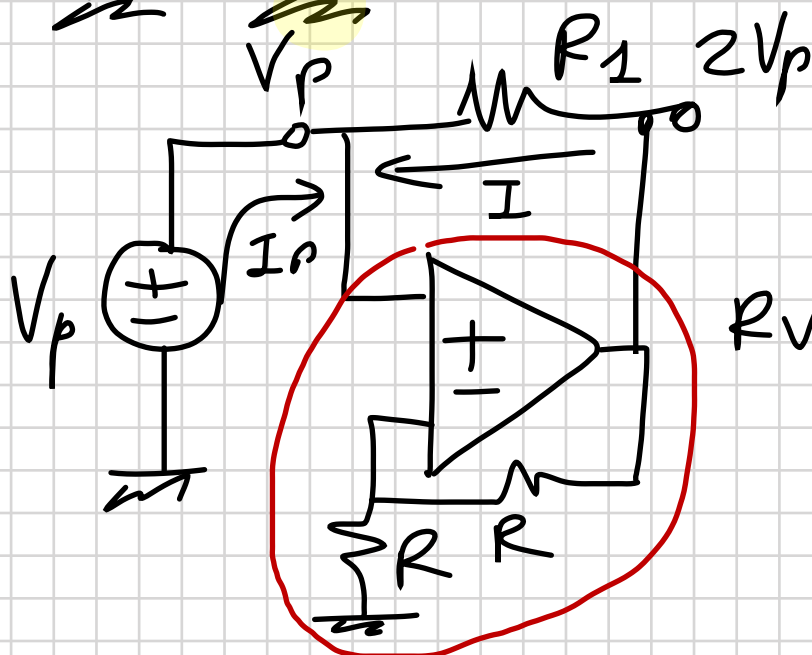
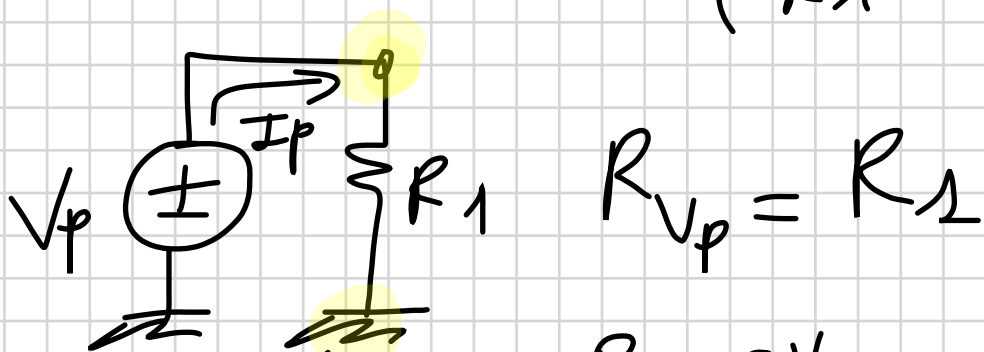
$$V_U = \left(1 + \frac{R_2}{R_1}\right) \left[\frac{R_4}{R_3 + R_4} V_2 + \frac{R_3 V_2}{R_3 + R_4} \right]$$



$$V_{U1} = -\frac{R_3}{R_1} V_1$$

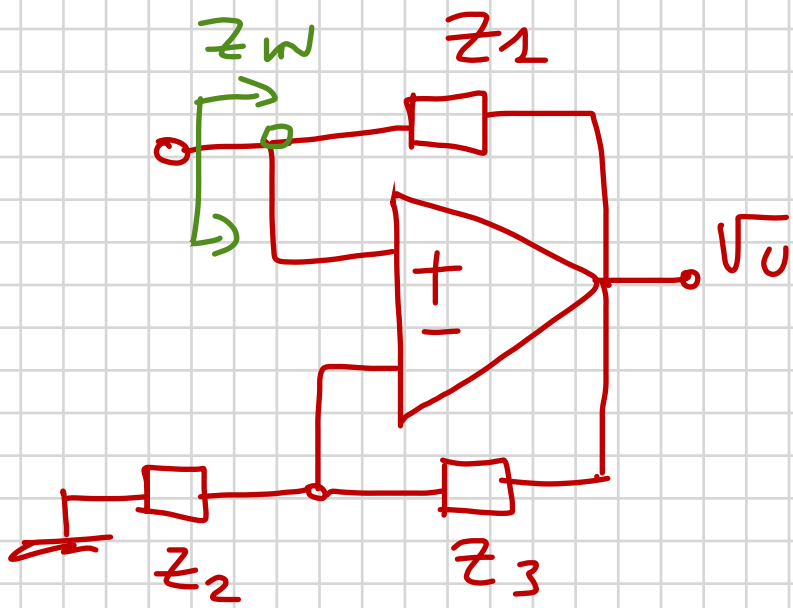
$$V_{U2} = -\frac{R_3}{R_2} V_2$$

$$V_U = V_{U1} + V_{U2} = -R_3 \left(\frac{V_1}{R_1} + \frac{V_2}{R_2} \right)$$



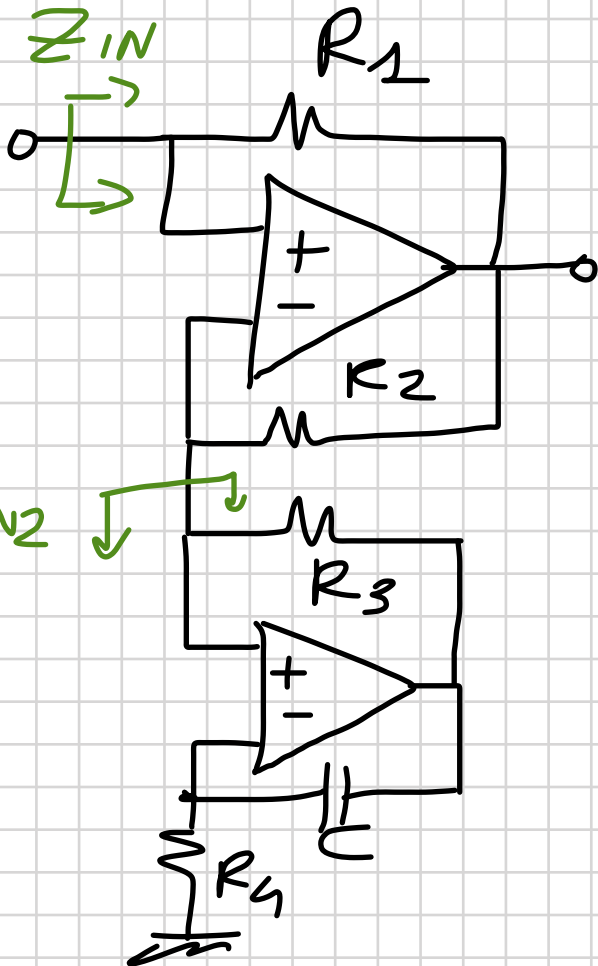
$$I = -I_p = +\frac{V_p}{R_1}$$

$$R_V = -R_1$$



$$Z_W = - \frac{Z_1 Z_2}{Z_3}$$

$$i_{in} = V_{in} \left[1 - \left(1 + \frac{Z_3}{Z_2} \right) \right] \frac{1}{Z_1}$$

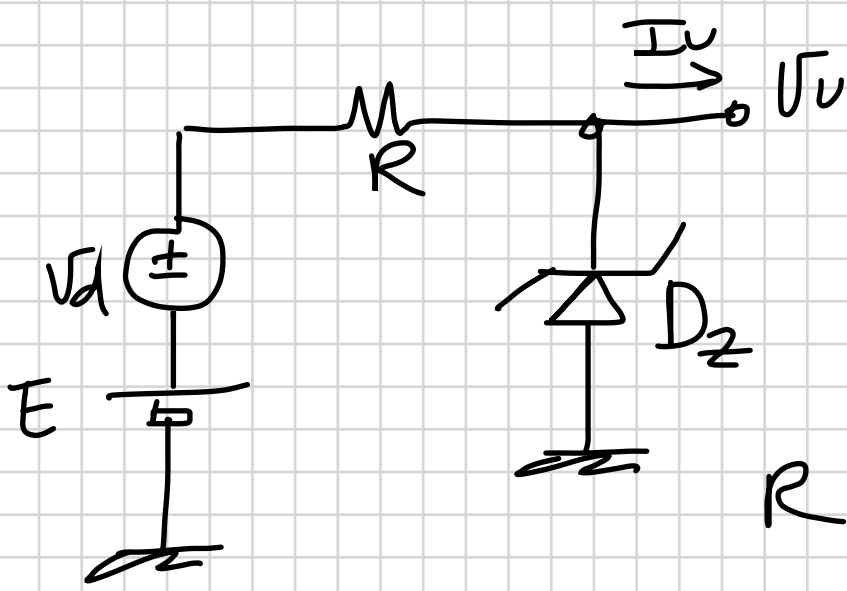


$$Z_{IN} = - \frac{R_1 Z_{IN2}}{R_2}$$

$$Z_{IN2} = - R_3 R_4 C S$$

⇓

$$Z_{IN} = \frac{R_1 R_3 R_4 C S}{R_2}$$

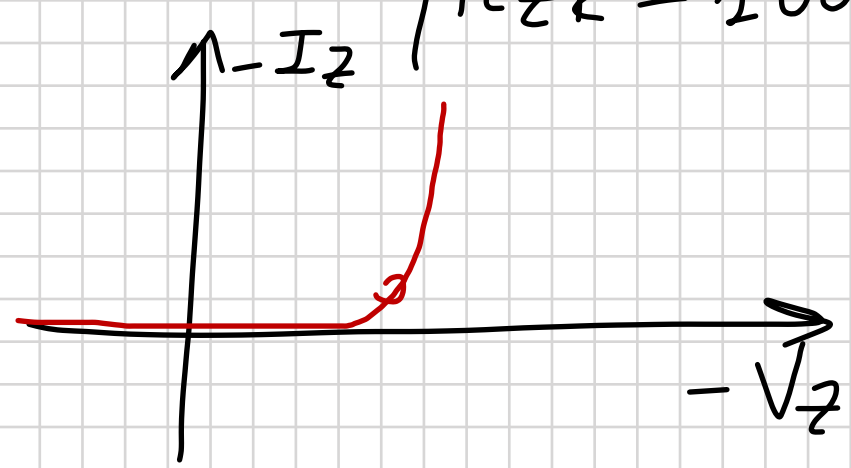


$$10V < E < 12V$$

$$I_U < 100mA$$

$$R : \min \{ P_{MAX E} \}$$

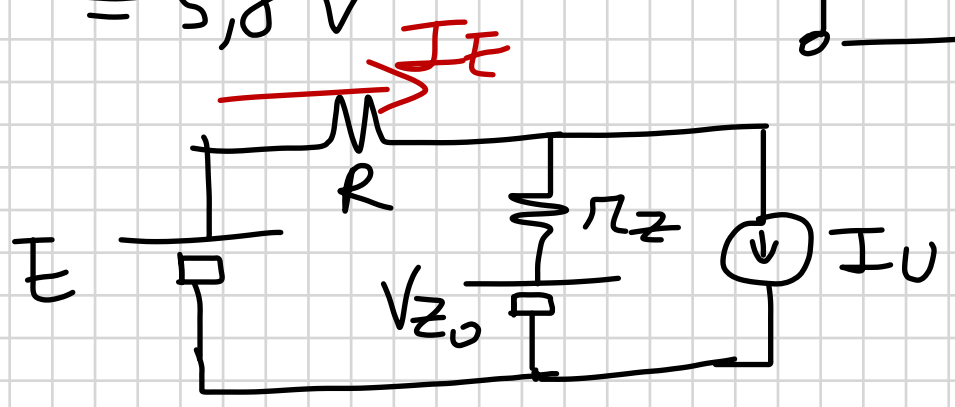
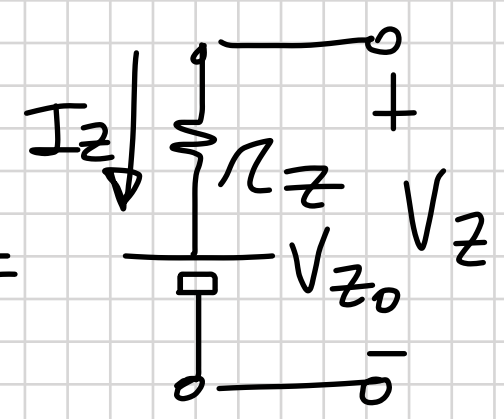
$$V_z = 6V \quad \left. \begin{array}{l} r_z = 4\Omega @ I_z = 50mA \\ r_{zk} = 100\Omega @ I_{zk} = 1mA \end{array} \right\}$$



$$I_z > 4 I_{zk} = 4mA$$

$$r_z = 4\Omega$$

$$V_{z0} = V_z - r_z I_z = 5,8V$$



$$P_E = E I_E$$

$$E = E_{MAX}$$

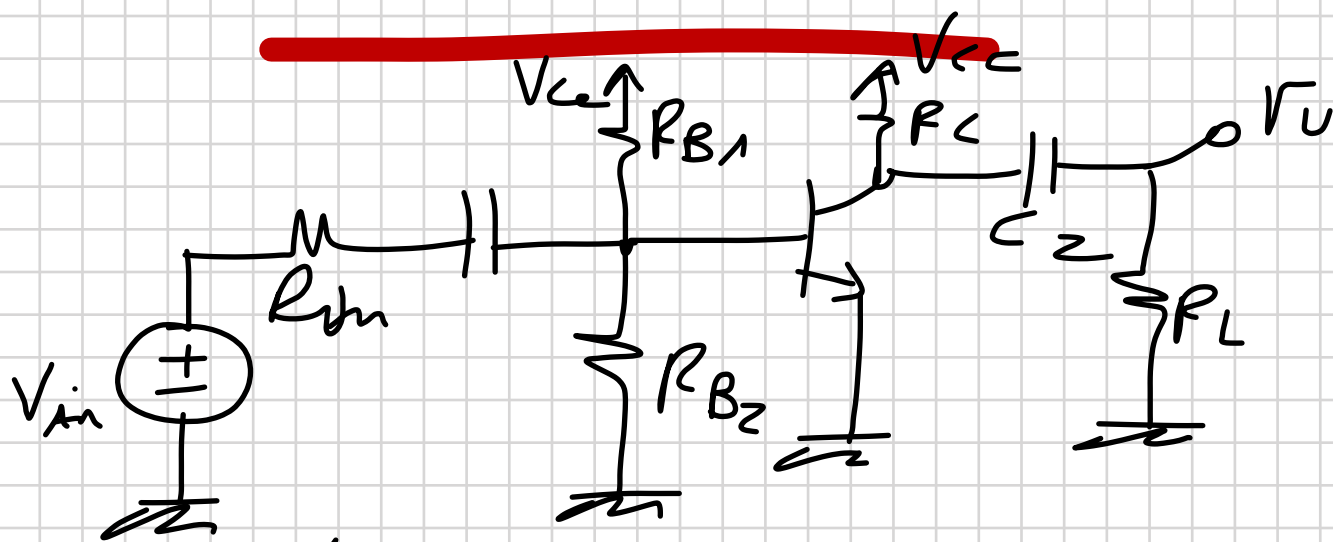
$$I_U = I_{UMAX}$$

$$P_F = E_{MAX} \left(\frac{E_{MAX} - V_{z0}}{R + r_z} + \frac{I_U r_z}{R + r_z} \right)$$

$$I_z = I_{zk}$$

$$E = E_{min}; I_U = I_{UMAX}$$

$$R = \frac{E_{min} (V_{z0} + 4r_z I_{zk})}{I_{UMAX} + 4I_{zk}} = 40,23 \Omega$$



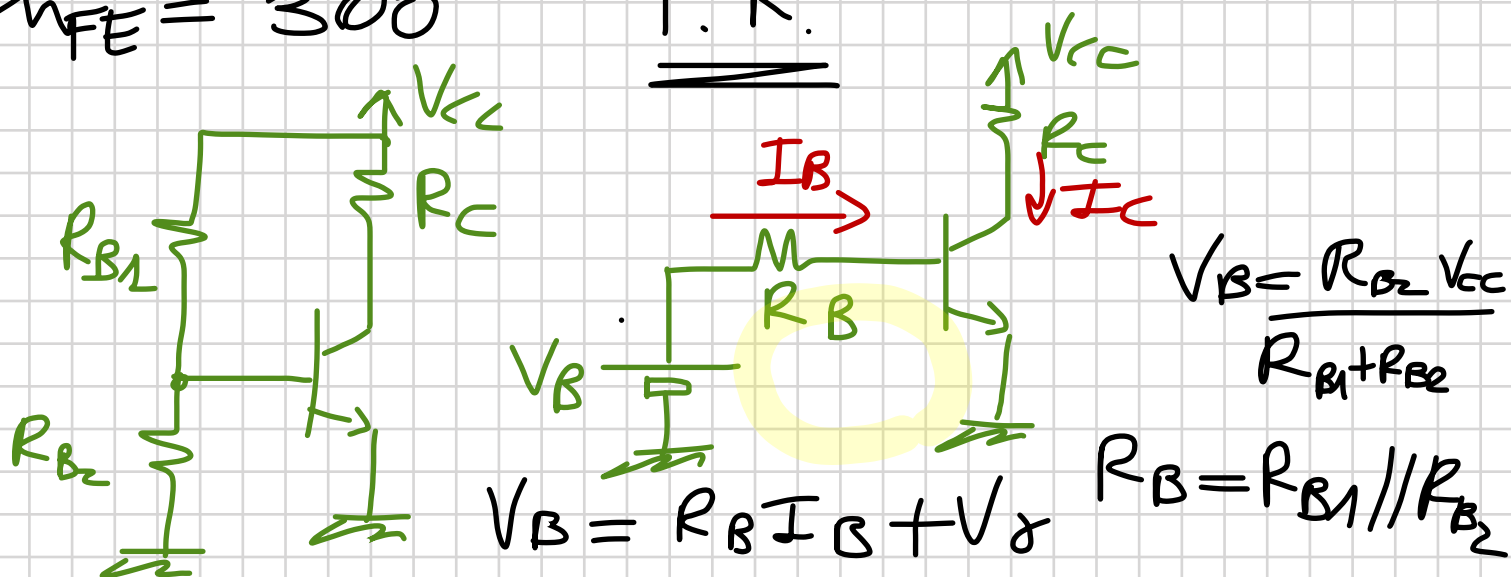
$$V_{cc} = 12V \quad C_1 = 10\mu F; \quad C_2 = 1\mu F$$

$$R_C = R_L = 5k\Omega \quad R_{B1} = 11R_{B2}$$

$$R_{B2} = 100k\Omega \quad R_{in} = 10k\Omega$$

$$h_{FE} = 300$$

P.R.



$$V_B = \frac{R_{B2} V_{cc}}{R_{B1} + R_{B2}}$$

$$V_B = R_B I_B + V_{\gamma} \quad R_B = R_{B1} // R_{B2}$$

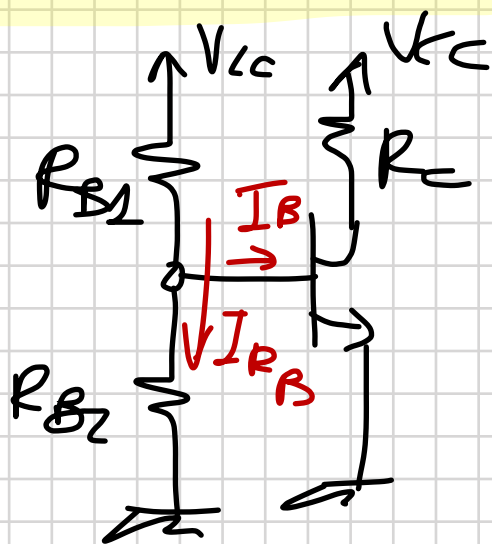
$$I_B = \frac{V_B - V_{BE}}{R_B} = 3,27 \mu A$$

$$I_C = h_{FE} I_B = 0,982 mA$$

$$V_{CE} = V_C - V_E$$

$$V_E = 0; \quad V_C = V_{CC} - R_C I_C = 7,091 V$$

$$V_{CE} = V_C = 7,091 V$$



$$I_{RB} \gg I_B$$

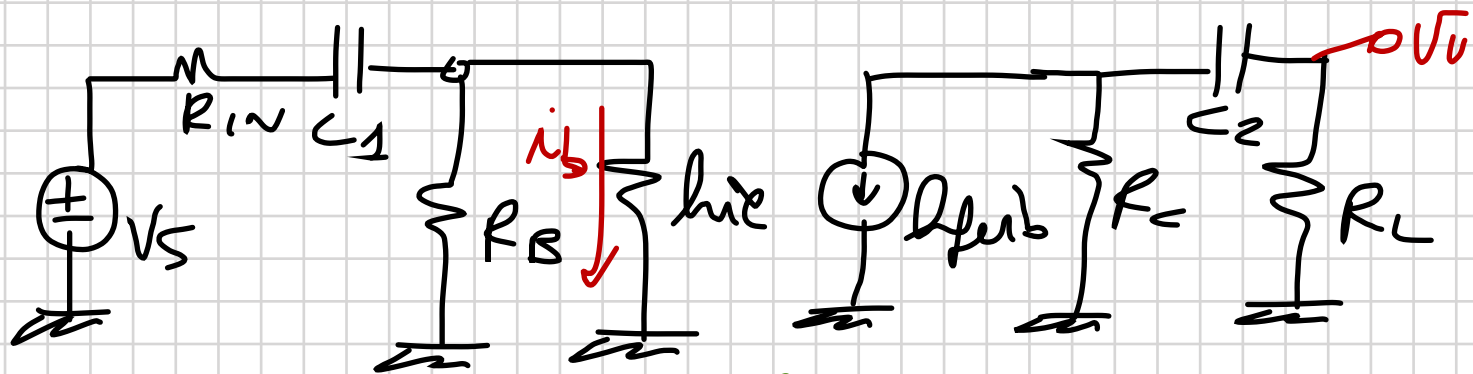
$$I_{RB} = \frac{V_{CC}}{R_{B1} + R_{B2}} = \underline{\underline{10 \mu A}}$$

$$h_{ie}^* = 800 \Omega @ I_C^* = 10 mA \quad h_{fe} = h_{FE}$$

$$h_{ie}^* = r_{bb'} + \frac{V_T}{I_C^*} h_{fe}$$

$$r_{bb'} = h_{ie}^* - \frac{V_T}{I_C^*} h_{fe} = 20 \Omega$$

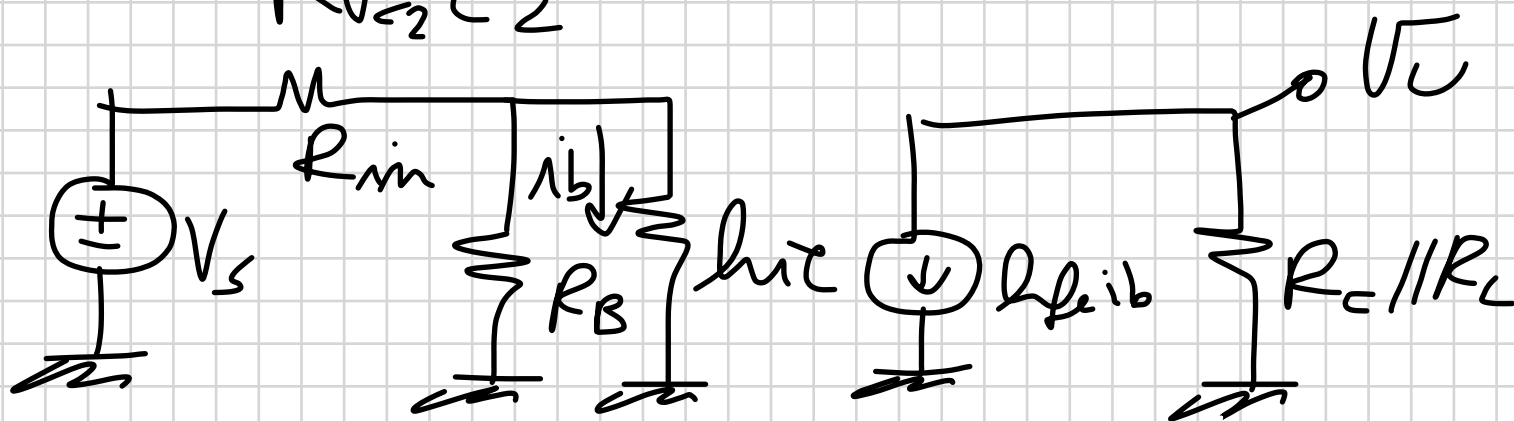
$$h_{ie} = r_{bb'} + \frac{V_T}{I_C} h_{fe} = 7,96 k\Omega$$



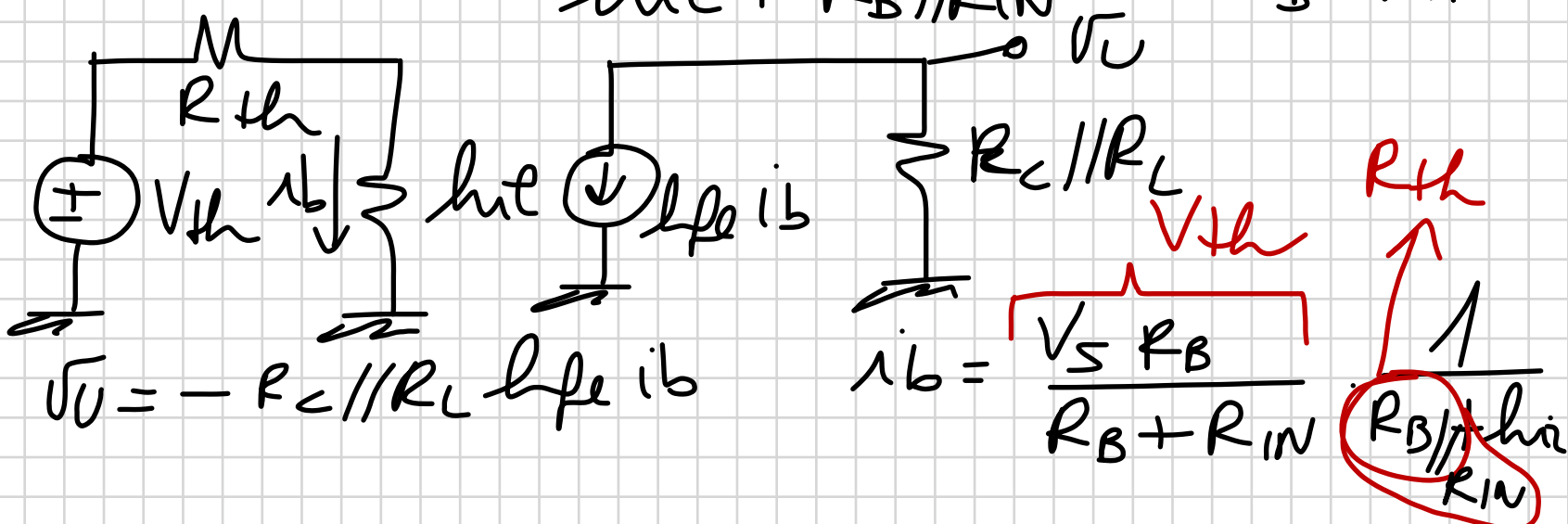
$$A(s) = \frac{V_U}{V_S} = \frac{K s^2}{\left(\frac{s}{\omega_{p1}} + 1\right) \left(\frac{s}{\omega_{p2}} + 1\right)}$$

$$\omega_{p1} = \frac{1}{R_{Vc1} C_1} ; R_{Vc1} = R_{in} + R_B // h_{ie}$$

$$\omega_{p2} = \frac{1}{R_{Vc2} C_2} ; R_{Vc2} = R_L + R_C$$

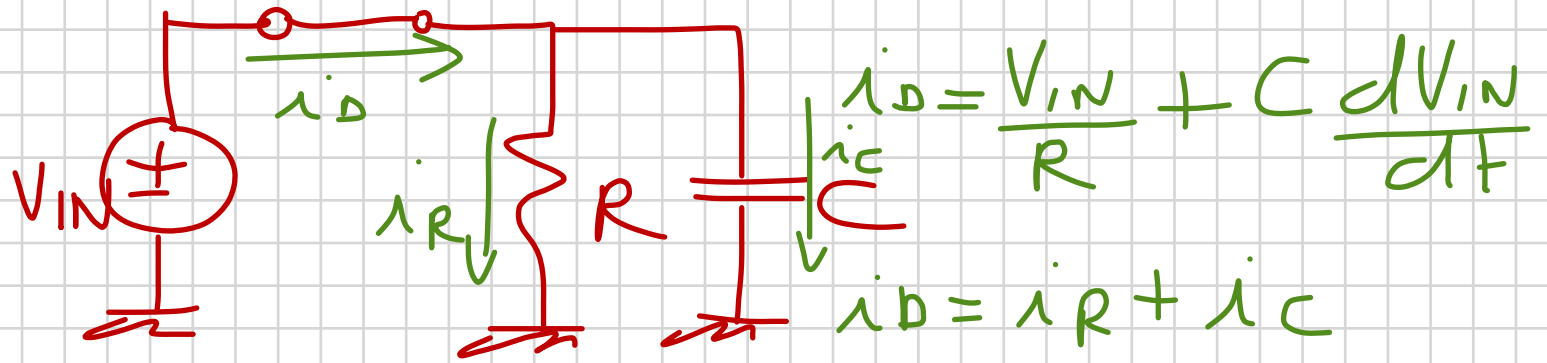
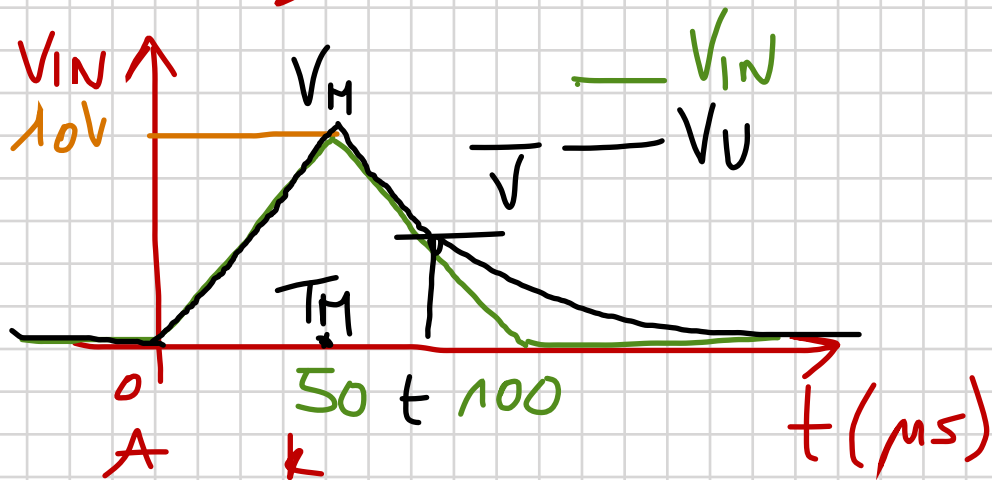
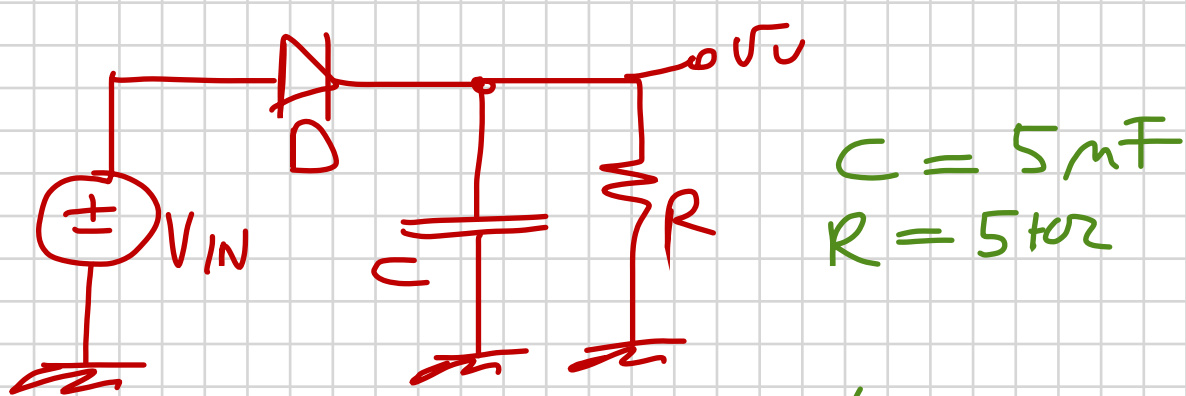


$$A_{\infty} = \frac{V_U}{V_S} = - \frac{R_C // R_L h_{fe}}{h_{ie} + R_B // R_{in}} \cdot \frac{R_B}{R_B + R_{in}}$$



$$V_U = - R_C // R_L h_{fe} i_b$$

$$i_b = \frac{V_S R_B}{R_B + R_{in}} \cdot \frac{1}{R_B // h_{ie} + R_{in}}$$



$t > T_M$

$$V_{IN}(t) = -\sigma(t - T_M) + V_M \quad \sigma = 0,2 \text{ V}/\mu\text{s}$$

$$i_D = \frac{V_{IN}}{R} + C \frac{dV_{IN}}{dt} = \frac{-\sigma(t - T_M) + V_M}{R} +$$

$$- C\sigma = 0$$

$$\frac{\sigma}{R}(t - T_M) = C\sigma - \frac{V_M}{R}$$

$$t - T_M = RC - \frac{V_M}{\sigma}$$

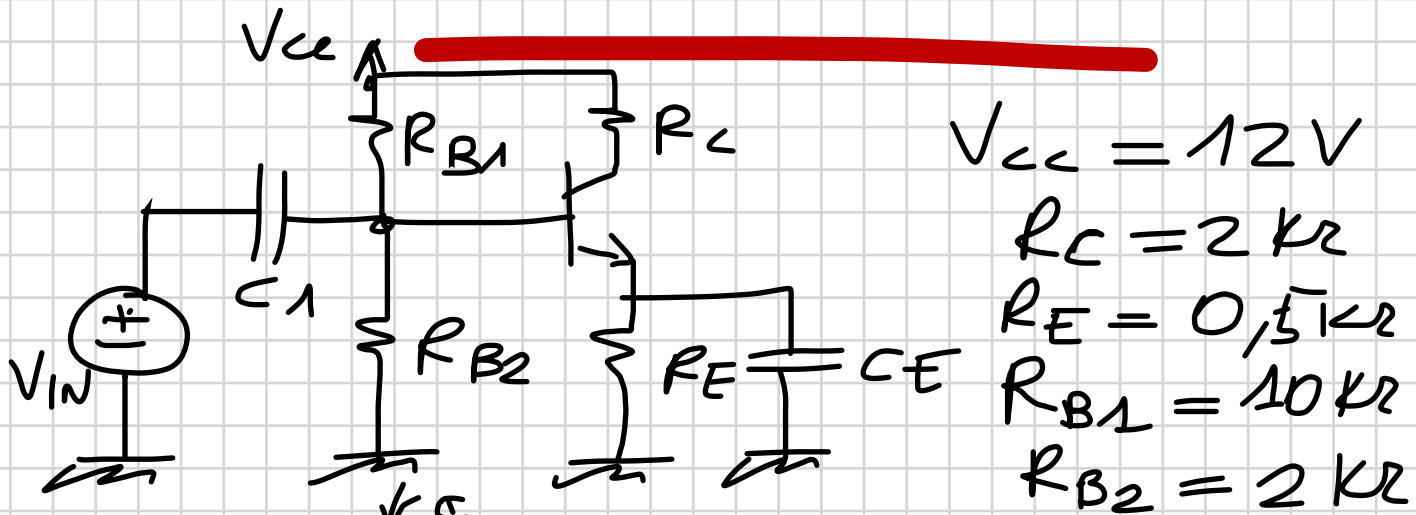
$$t = T_M + RC - \frac{V_M}{\sigma} = 75 \mu\text{s}$$

$$v_U(t) = \bar{V} e^{-\frac{t-t^*}{RC}} \quad \text{per } t > 75 \mu\text{s}$$

$$t^* = 75 \mu\text{s}$$

$$\bar{V} \Rightarrow v_U(t^*) = 5V$$

$$\bar{V} = -\sigma(t^* - T_M) + V_M = 5V$$



$$V_{CC} = 12V$$

$$R_C = 2k\Omega$$

$$R_E = 0,5k\Omega$$

$$R_{B1} = 10k\Omega$$

$$R_{B2} = 2k\Omega$$

$$h_{FE} = 100$$

$$V_B = \frac{V_{CC} R_{B2}}{R_{B1} + R_{B2}} = 2V$$

$$I_B = \frac{V_B - V_{BE}}{R_B + (h_{FE} + 1)R_E}$$

$$R_B = R_{B1} // R_{B2}$$

$$I_B = 24,92 \mu\text{A}$$

$$I_B \ll I_{R_{B1}} = \frac{V_{CC}}{R_{B1} + R_{B2}} = 1 \text{mA}$$

$$I_C = h_{FE} I_B = 2,492 \text{mA}$$

$$I_E = (h_{FE} + 1) I_B = 2,517 \text{mA}$$

$$V_{CE} = V_{CC} - R_C I_C - R_E I_E = 5,758V$$

