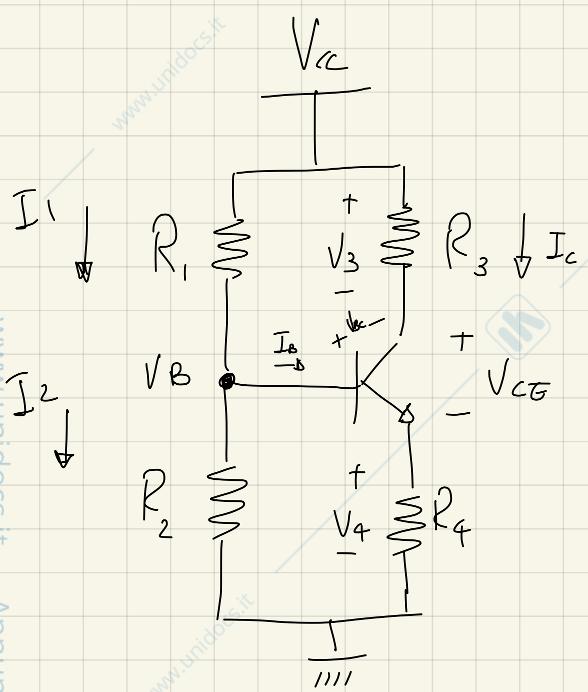
# CIRCUITO AMPLIFICATORE

# Dimensionamento circuito




$\beta_F = 75$  $P = (V_{CE}, I_c) = (6V, 10$

$V_{CC} = 18V$

$V_3 + V_4 = V_{CC} - V_{CE} = 18-6 = 12V$

$V_3 = V_4 = \frac{V_3 + V_4}{2} = \frac{12}{2} = 6V$

$R_3 = \frac{V_3}{I_c} = \frac{6}{10 \cdot 10^{-6}} = 600\ K\Omega$

Assumiamo Regione ATTIVA e Pol. diretta $\Rightarrow I_E = \Big(\frac{1}{\beta_F}$

$R_4 = \frac{V_4}{I_E} = \frac{6}{10,73 \cdot 10^{-6}} = 592,11\ K\Omega$

Tenie: $V_{BE} = 0,7\ V$

$V_B = V_{BE} + V_4 = 6,7\ V$

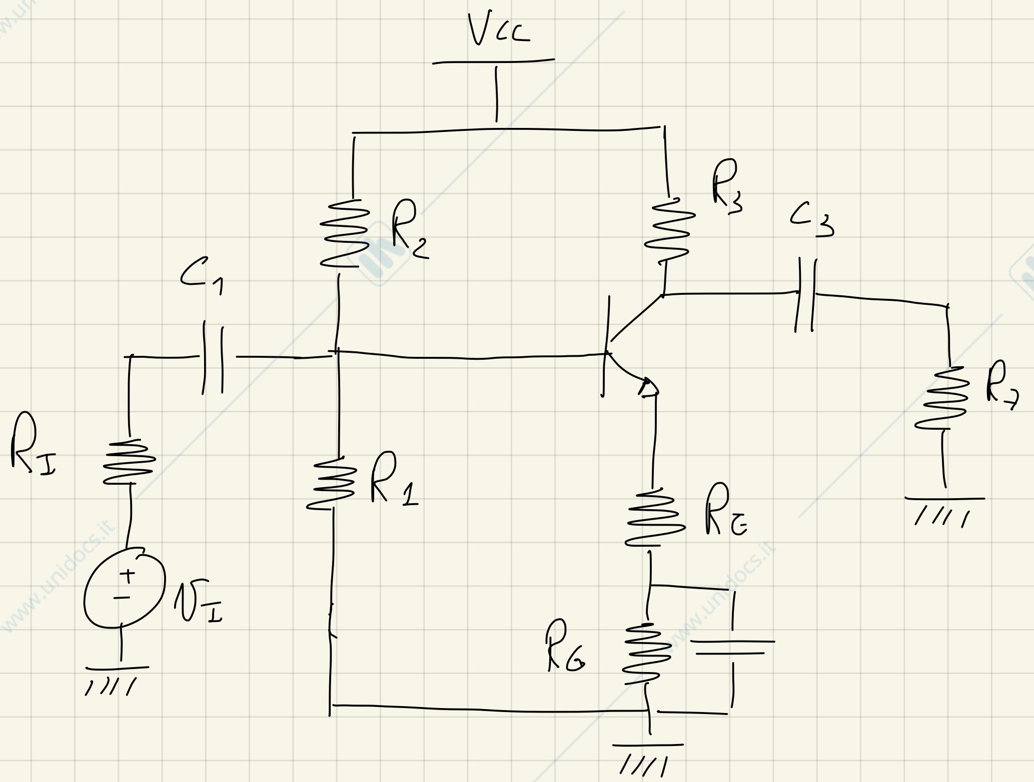
$I_B = \frac{I_c}{\beta_F} = \frac{10 \cdot 10^{-6}}{75} = 133,33\ mA$

scelta $\Rightarrow$ il caso (di progetto)  $I_1 = 10 I_B = 1,33\ \mu A$  $R_1 = \frac{V_{CC} - V_B}{I_1} =$

$I_2 = I_1 - I_B = 10 I_B - I_B = 9 I_B$

$R_2 = \frac{V_B}{\dots} = \frac{6,7}{\dots}$

# Circuito con componenti lineari e

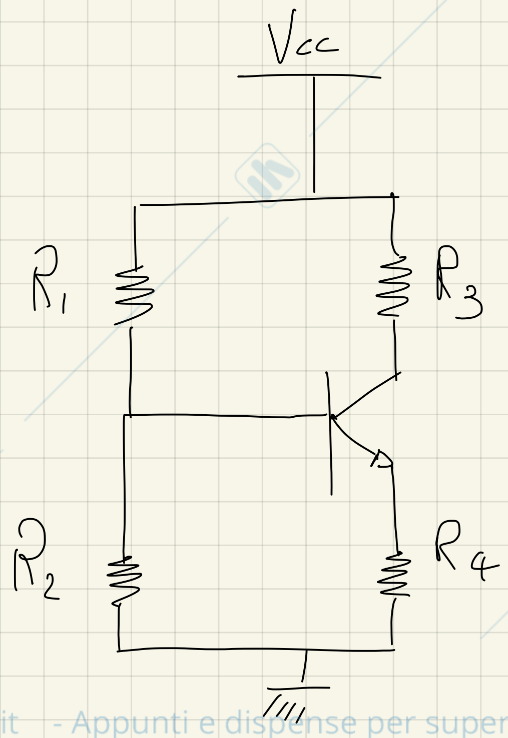



$V_{CC} = 12$ V
$R_I = 2$
$R_1 = 1$
$R_2 = 3$
$R_3 = 22$
$R_E = 3K$
$R_G = 10$
$R_7 = 100$

1) Analisi in continua $f = 0 \rightarrow$

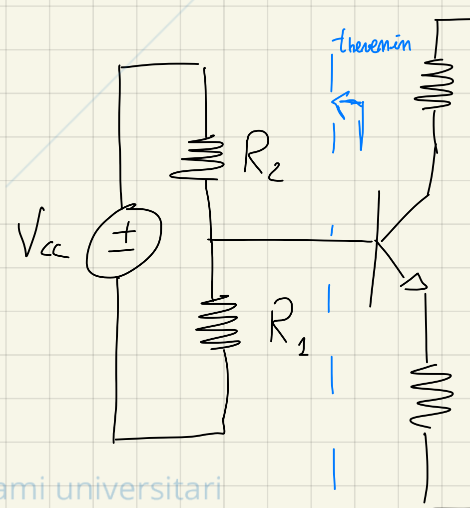
$$Z_C = \frac{1}{j\omega C} = \frac{1}{0} = \infty$$

circuito in continua




$R_4 = R_E + R_G = 13\ K$

$\rightarrow$



considerazione $\rightarrow$ Regione ATTIVA

$$\begin{cases} I_C = \beta_F \cdot I_B = 100\, I_B = 245\,\mu A \\ V_{BE} = 0,7\,V \\ I_E = I_B + I_C = 101\, I_B = 247,45\,\mu A \end{cases}$$

$$\begin{cases} V_{eq} = \\ V_{CC} = \end{cases}$$

$$\begin{cases} V_{eq} = (R_{eq} \\ V_{CC} = (100 \end{cases}$$

$$I_B = \frac{V_{eq} - V_{BE}}{R_{eq} + 101 R_4} = 2,45\,\mu A$$

$$V_{CE} = V_{CC} - (100 R_3 + 101 R_4)\, I_B \rightarrow 3,39\,V$$

devo controllare che essere davvero

$$V_{BC} = V_B - V_C + V_E = V_{BE} - V_{CE} = -2,69 \quad < \cdot$$

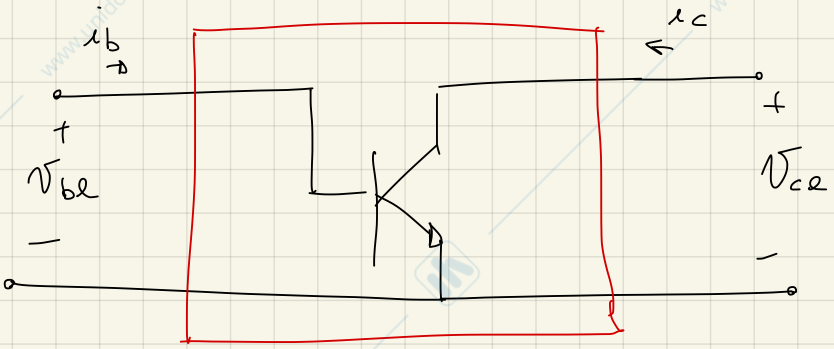
ti
tr

$$P(I_C, V_{CE}) = (245\,\mu A, 3,39\,V)$$

analisi in alternata ( $C \rightarrow$ c.c. , g

disegno

# BJT Piccoli segnali




$$\begin{cases} i_c = \left.\dfrac{\partial i_c}{\partial v_{be}}\right|_P v_{be} + \dfrac{\partial i_c}{\partial v_{ce}} \\ i_b = \left.\dfrac{\partial i_b}{\partial v_{be}}\right|_P v_{be} + \dfrac{\partial i_b}{\partial v_{ce}} \end{cases}$$

$$i_C = I_S \, e^{\frac{V_{BE}}{V_T}} \left(1 + \frac{V_{CE}}{V_A}\right) \qquad \beta_0 = \frac{\beta_F}{\left(1 + \frac{V_{CE}}{V_A}\right)}$$

$$i_B = \frac{I_S}{\beta_0} e^{\frac{V_{BE}}{V_T}}$$

$$g_r = 0$$

$\beta_0 \simeq \beta_F$ (semplif

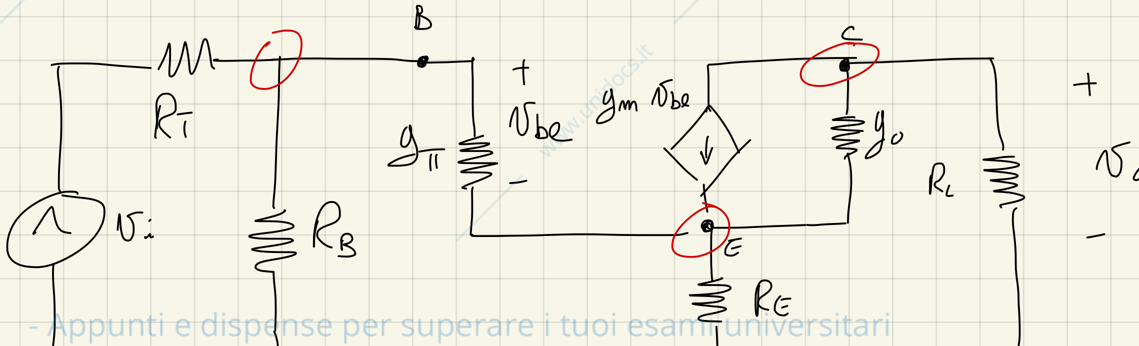
$V_T = 25\,mV$

$$g_m = \frac{I_S}{V_T} e^{\frac{V_{BE}}{V_T}} \left(1 + \frac{V_{CE}}{V_A}\right) = \frac{I_C}{V_T} = 9{,}8\ mS$$

$$g_o = \frac{I_S}{V_T} e^{\frac{V_{BE}}{V_T}} = \frac{I_C}{V_A + V_{CE}} = 4{,}59\ \mu S$$

$$g_\pi = \frac{g_m}{\beta_F} = 98\ \mu S$$

## disegno con modello Piccoli segnali



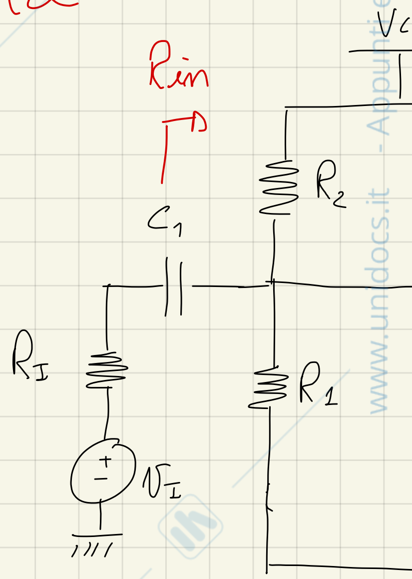
$$\begin{cases} \dfrac{v_i}{R_I} + g_\pi v_e = \left(\dfrac{1}{R_I} + \dfrac{1}{R_B} + g_\pi\right) v_b \\ (g_m + g_\pi) v_b + g_o v_o = \left(\dfrac{1}{R_E} + g_m + g_\pi + g_o\right) v_e \\ (g_m + g_o) v_e = g_m v_b + \left(\dfrac{1}{R_C} + g_o\right) v_o \end{cases} = \begin{cases} 5 \cdot 10^{-4}\, v_i \ldots \\ 9{,}8 \cdot 10^{-3}\, v_b + 9 \ldots \\ 9{,}8 \cdot 10^{-3}\, v_e = \ldots \end{cases}$$

$$\begin{cases} v_b = -1{,}92 \cdot 10^{-1}\, v_o \\ v_e = -1{,}86 \cdot 10^{-1}\, v_o \\ v_i = -\dfrac{v_o}{5{,}1} \end{cases} \qquad A_v = \frac{v_o}{v_i} = -5{,}1$$

## Resistenza ingresso-uscita

Resistenza in generale vista da $C_1$

in uscita da $C_3$

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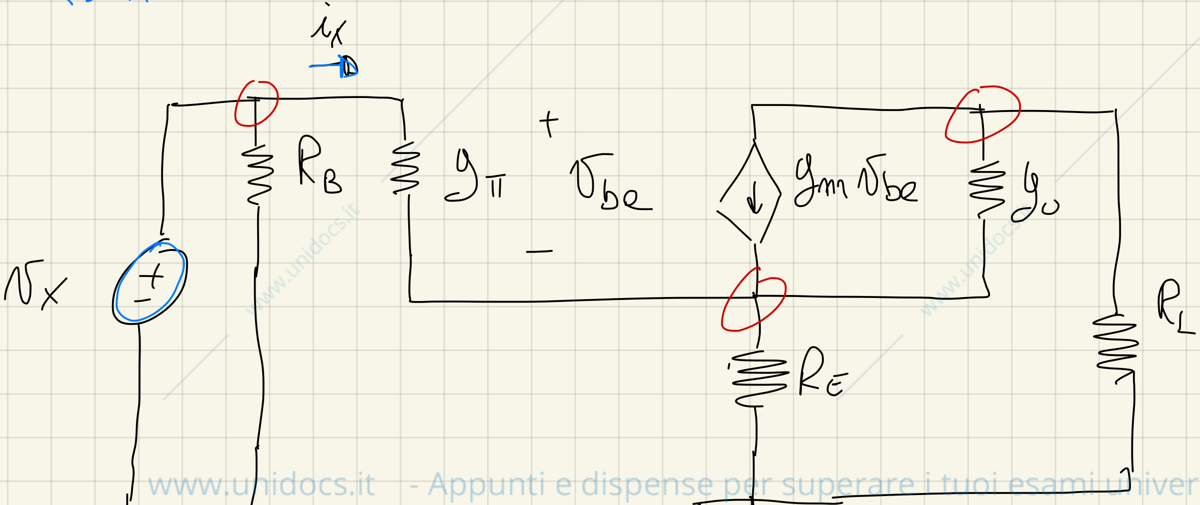
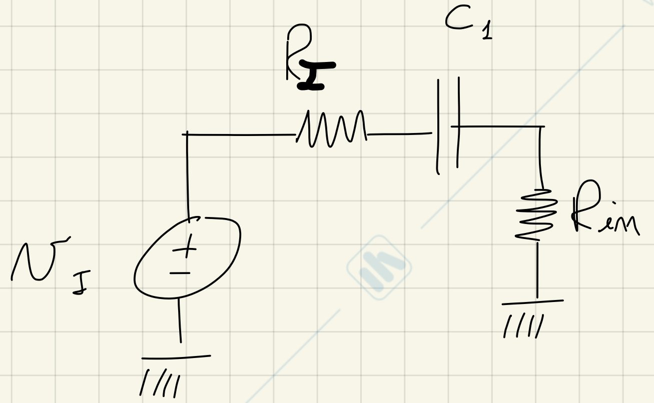



$$\begin{cases} i_x = \dfrac{v_x}{R_B} + \ldots \\ g_\pi (v_x - v_e \ldots \\ g_o (v_e - v_c) \ldots \end{cases}$$

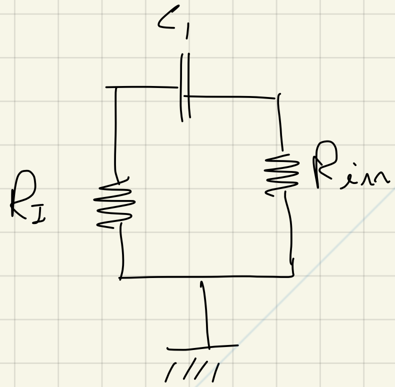
$$\begin{cases} i_x = \dfrac{v_x}{R_3} + g_o(v_x - v_e) + g_m(v_b - v_e) \\ g_m(v_b - v_e) + g_o(v_x - v_e) = \dfrac{v_e}{R_E} + g_\pi(v_e - v_b) \\ g_\pi(v_e - v_b) = \dfrac{v_b}{R_G} \end{cases}$$

$$R_{OUT} = \frac{v_x}{i_x} = 21{,}93\,K\Omega$$

dimensionamen



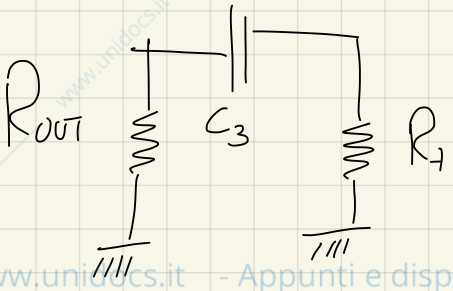

$$R_{eq} = R_I + R_{in}$$




$$\frac{1}{2\pi f_s C_1} \ll R_I + R_{in}$$

$$\frac{100}{2\pi f_s C_1} < (R_I + R_{in})$$

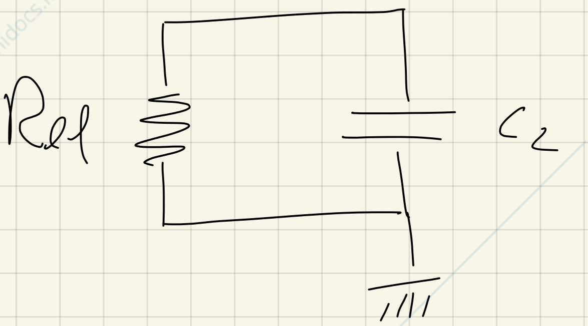
$$C_1 > \frac{100}{2\pi f_s (R_I + R_{in})} = 203\,nF$$




$$\frac{1}{2\pi f_s C_3} \ll R_7 + R_{OUT}$$

$$\begin{cases} i_x = \dfrac{v_x}{R_E} + \dfrac{v_x - v_e}{R_E} \\ \dfrac{v_x - v_e}{R_E} + g_m (v_b - v_e) = g_\pi (v_e - v_b) + g_o (v_e - v_c) \\ g_\pi (v_e - v_b) = \dfrac{v_b}{R_E} \end{cases}$$

$$R_{eq} = \frac{v_x}{i_x} = 2,$$




$$\frac{1}{2\pi f_s \cdot C_2} \ll R_{eq} \qquad C_2$$