eletronica_basica_exerc

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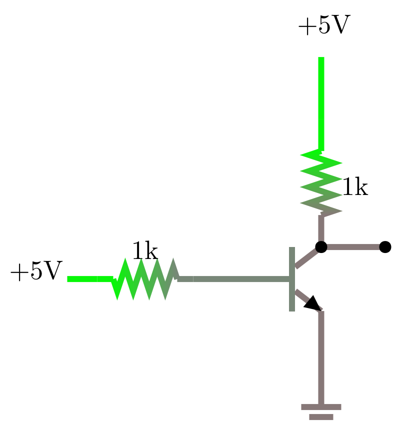
1 Principais Equações do BJT



$$I_E = I_B + I_C$$
$$\beta = \frac{I_C}{I_B}$$
$$I_C = \beta I_B$$
$$I_E = I_B + \beta I_B$$
$$I_E = (\beta + 1)\, I_B$$
$$V_{BE} = 0.7V$$

1.1 Região de Operação

Para $V_{CE=0}$

$$I_C = \frac{V_{CC_{ColletorEmissor}}}{R_C}$$

Para $I_C = 0$

$$V_{CC} = V_{CE}$$

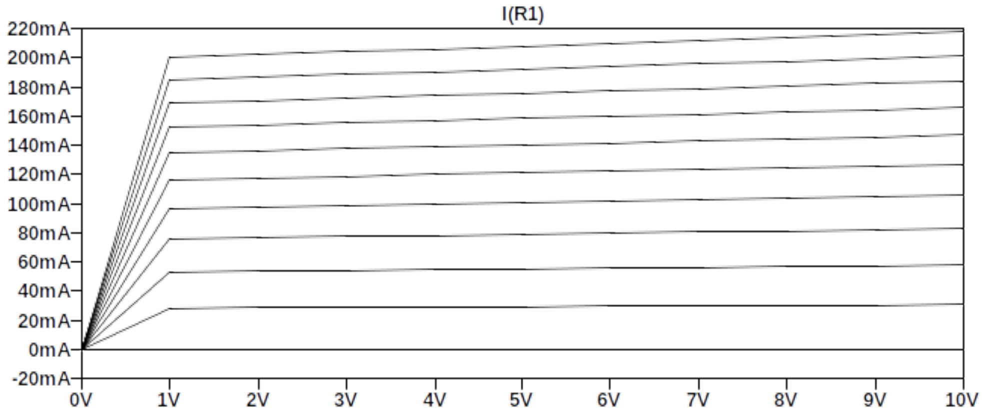
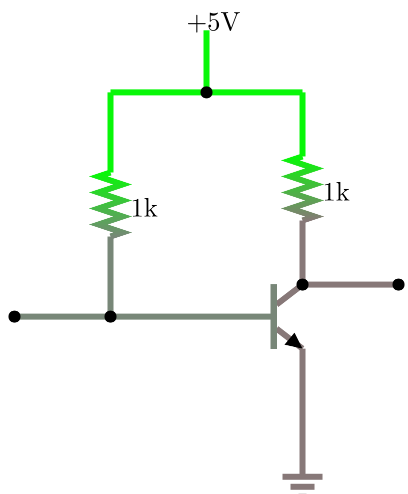


Figure 1: Eixo $Y = I_C$, eixo $X = V_{CE}$, I_B gera uma das linhas, encontrar a intecessão entre os pontos I_C e V_{CC} com a linha I_B

2 Polarização Fixa



$$V_{CC} - I_B R_B - VBE = 0$$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B}$$

$$I_C = \beta I_B$$

$$V_C E + I_C R_C - V_{CC} = 0$$

$$V_{CE} = V_{CC} - I_C R_C$$

3 Operando como chave

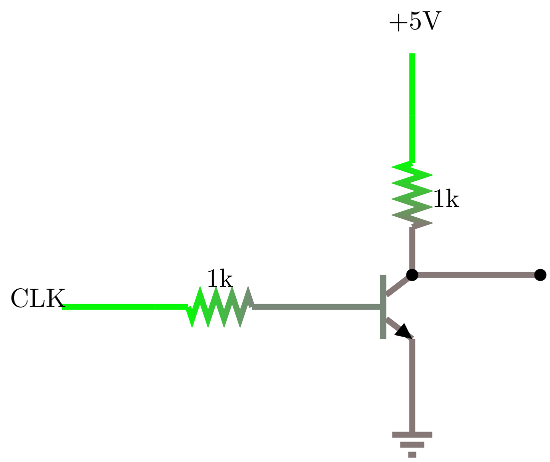
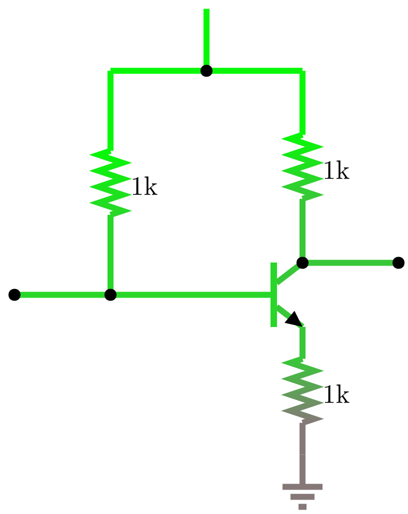


Figure 2: $V_I = CLK$

$$V_I = I_B R_B + V_{BE}$$
$$I_B = \frac{V_I - V_{BE}}{R_B}$$
$$V_B = V_I - I_B R_B$$
$$V_C = V_{CC} - I_C R_C$$

4 Polarização de Emissor



$$V_{CC} - I_B R_B - V_{BE} - (\beta + 1)\, I_B R_E = 0$$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B + (\beta + 1)\, R_E}$$

$$V_{CC} - I_C R_C - V_{CE} - I_E R_E = 0$$

Para $hFe100$:

$$I_C \approx I_E$$

$$V_{CE} = V_{CC} - I_C\,(R_C + R_E)$$

$$V_B = V_{CC} - I_B R_B$$

$$V_E = V_B - V_{BE}$$

$$V_C = V_{CC} - I_C R_C$$

5 Polarização por Divisor de Tensão

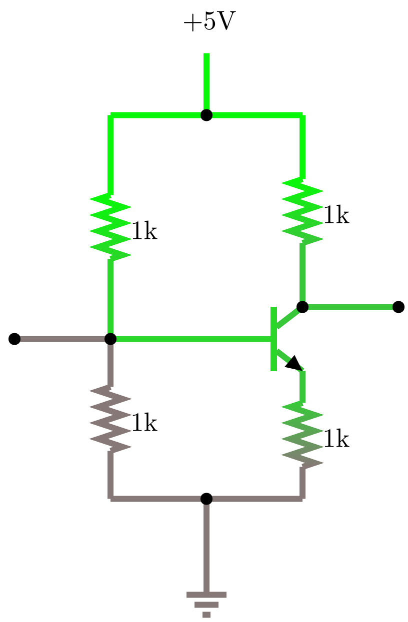


Figure 3: R_1 and R_2 are connected to the base of the transistor

5.1 Thevenim Theorem

$$R_{Th} = R_1 | R_2$$

$$E_{Th} = \frac{R_2}{R_1 + R_2} V_{CC}$$

5.2 Standard Equations

$$E_{Th} - I_B R_{Th} - V_{BE} - (\beta + 1) I_B R_E = 0$$

$$I_B = \frac{E_{Th} - V_{BE}}{R_{Th} + (\beta + 1) R_E}$$

$$V_{CC} - I_C R_C - V_{CE} - I_E R_E = 0$$

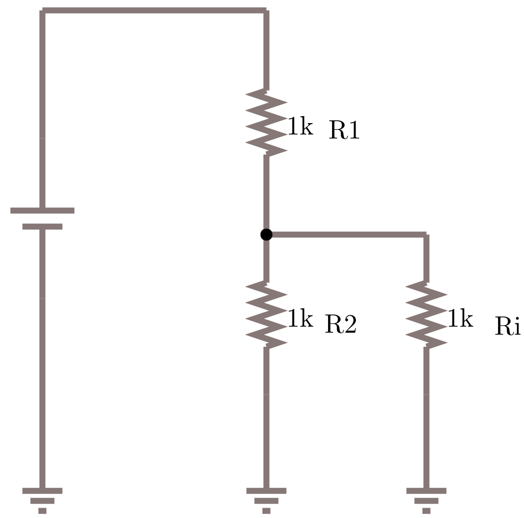
Para $hFe \geq 100$:

$$I_C \approx I_E$$

$$V_{CE} = V_{CC} - I_C (R_C + R_E)$$

$$V_B = V_{CC} - I_B R_B$$
$$V_E = V_B - V_{BE}$$
$$V_C = V_{CC} - I_C R_C$$

6 Polarização por Divisor de Tensão Simplificado



$$R_i = (\beta + 1)\, R_E \approx \beta R_E$$

Se $\beta R_E \geq 10 R_2$:

$$V_B = \frac{R_2 V_{CC}}{R_1 + R_2}$$

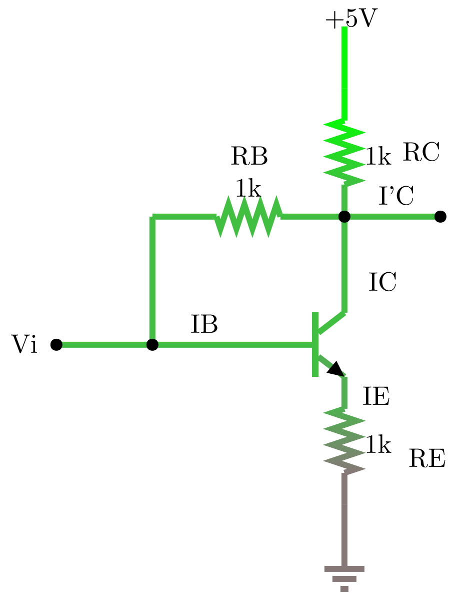
$$V_E = V_B - V_{BE}$$

$$I_E = \frac{V_E}{R_E}$$

$$I_{C_Q} \approx I_E$$

$$V_{CE_Q} = V_{CC} - I_C\, (R_C + R_E)$$

7 Realimantação de Tensão



$$V_{CC} - V_{BE} - \beta I_B \left(R_C + R_E\right) - I_B R_B = 0$$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B + \beta \left(R_C + R_E\right)}$$

$$I'_C \approx I_C | I_E \approx I_C$$

$$I_C \left(R_C + R_E\right) + V_{CE} - V_{CC} = 0$$

$$V_{CE} = V_{CC} - I_C \left(R_C + R_E\right)$$

8 Primeiro Circuito

8.1 Constantes

$$V_{BE} = V_B = 0.7V$$
$$R_B = 470k$$
$$R_C = 2.7k$$
$$\beta = 90$$
$$V_{CC} = 16V$$

8.2 Base Emissor

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{16 - 0.7}{470 \times 1000} = 3.25 \times 10^{-5} = 32.5\mu A$$

8.3 Coletor Emissor

$$I_C = \beta \times I_B = 90 \times 32.5\mu A = 2925.0\mu A = 2.92mA$$

$$V_{CE} = V_C = V_{CC} - I_C \times R_C = 16 - \left(\frac{2.92}{1000}\right) \times (2.7 \times 1000) = 8.116V$$

$$V_{BC} = V_B - V_C = V_{BE} - V_{CE} = 0.7 - 8.116 = -7.416V$$

9 Segundo Circuito

9.1 Constantes

$$V_{CC} = 12V$$
$$I_C = 2mA = 0.002A$$
$$V_C = V_{CE} = 7.6V$$
$$V_E = V_{BE} = 2.4V$$
$$V_{BE} = V_B = 0.7V$$
$$B = 50$$

9.2 O que da pra calcular

$$V_{CE} = V_C - V_E = 7.6 - 2.4 = 5.2V$$

$$V_C = V_{CC} - I_C R_C$$
$$R_C = -\frac{V_C - V_{CC}}{I_C} = -\frac{7.6 - 12}{2m} = 2200\Omega$$
$$I_B = \frac{I_C}{\beta} = \frac{2mA}{50} = 40\mu A$$
$$V_B = V_{BE} + V_E = 0.7 + 2.4 = 3.01V$$

$$V_B = V_{CC} - I_B R_B$$
$$R_B = -\frac{V_B - V_{CC}}{I_B} = -\frac{3.01 - 12}{40\mu} = 224.75k\Omega$$
$$V_{CE} = V_{CC} - I_C\left(R_C + R_E\right)$$
$$R_E = -\frac{V_{CE} - V_{CC}}{I_C} - R_C = -\frac{5.2 - 12}{2m} - 2200 = 1200\Omega$$

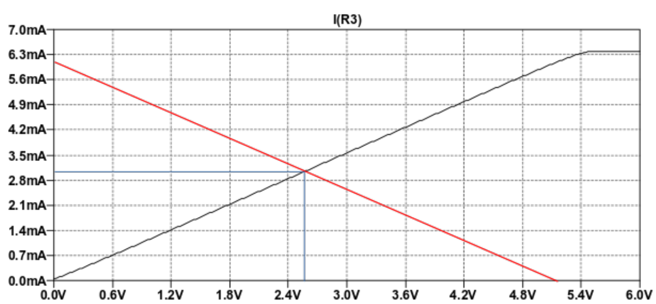
10 Terceiro Circuito

10.1 Constantes

$$V_{CC_{coletor}} = 5V$$
$$V_{CC_{base}} = V_I = 5V|3V|0V$$
$$R_C = 820\Omega$$
$$R_B = 68k\Omega$$
$$\beta = 100$$
$$V_{BE} = V_B = 0.7V$$

10.2 $V_I = 5V$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{5 - 0.7}{68 \times 1000} = 6.32 \times 10^{-5} = 63.23\mu A$$
$$I_C = \frac{V_{CC_{ColletorEmissor}}}{R_C} = \frac{5}{820} = 0.0061A = 6.1mA$$
$$V_{CC} = V_{CE} = 5V$$



Reta de carga para esse transistor (aproximado)

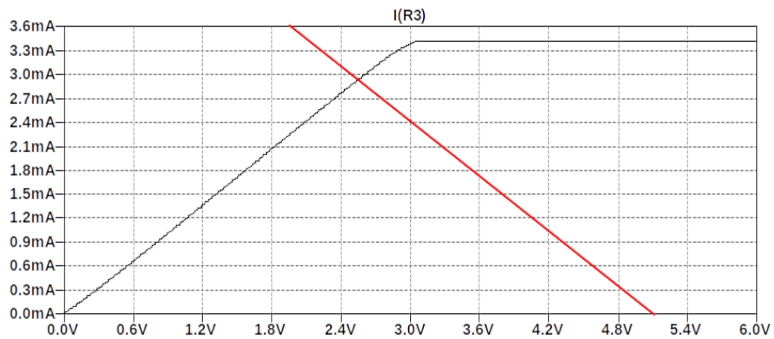
$$I_Q \approx 3mA$$
$$V_Q \approx 2.5V$$

10.3 $V_I = 3V$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{3 - 0.7}{68 \times 1000} = 3.38 \times 10^{-5} = 33.82\mu A$$

$$I_C = \frac{V_{CC_{ColletorEmissor}}}{R_C} = \frac{5}{820} = 0.0061A = 6.1mA$$

$$V_{CC} = V_{CE} = 5V$$



Reta de carga para esse transistor (aproximado)

$$I_Q \approx 2.8mA$$

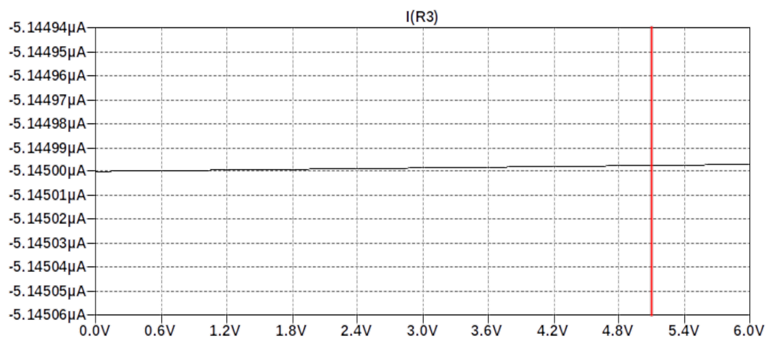
$$V_Q \approx 2.5V$$

10.4 $V_I = 0V$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{0 - 0.7}{68 \times 1000} = -1.029 \times 10^{-5} = -10.29\mu A$$

$$I_C = \frac{V_{CC_{ColletorEmissor}}}{R_C} = \frac{5}{820} = 0.0061A = 6.1mA$$

$$V_{CC} = V_{CE} = 5V$$



Reta de carga para esse transistor (aproximado)

$$I_Q \approx -5.1499\mu A$$
$$V_Q \approx 5V$$

11 Quarto Circuito

11.1 Constantes

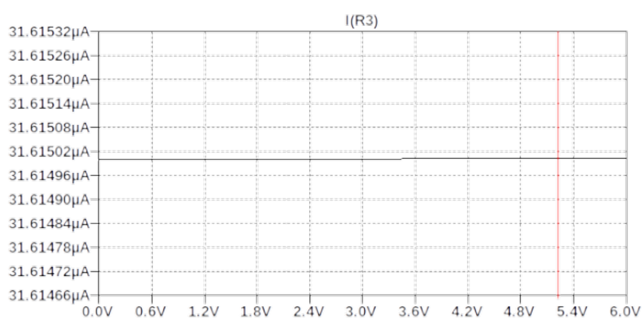
$$V_{CC_{coletor}} = 5V$$
$$V_{CC_{base}} = V_I = 5V|3V|0V$$
$$R_C = 820\Omega$$
$$R_B = 68k\Omega$$
$$\beta = 100$$
$$V_{BE} = V_B = 0.7V$$

11.2 $V_I = 5V$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{5 - 0.7}{68 \times 1000} = 6.32 \times 10^{-5} = 63.23\mu A$$

$$I_C = \frac{V_{CC_{ColletorEmissor}}}{R_C} = \frac{5}{820} = 0.0061A = 6.1mA$$

$$V_{CC} = V_{CE} = 5V$$



Reta de carga para esse transistor (aproximado)

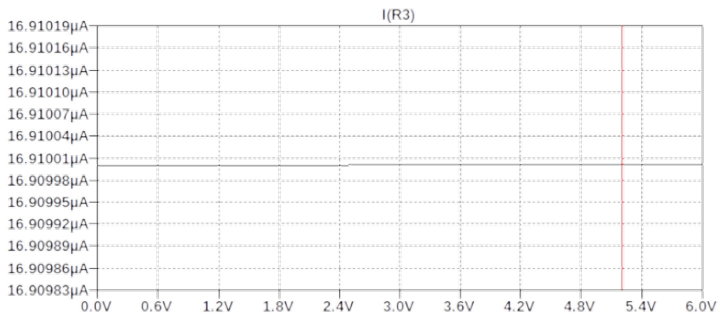
$$I_Q \approx 31.6150\mu A$$
$$V_Q \approx 5V$$

11.3 $V_I = 3V$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{3 - 0.7}{68 \times 1000} = 3.38 \times 10^{-5} = 33.82\mu A$$

$$I_C = \frac{V_{CC_{ColletorEmissor}}}{R_C} = \frac{5}{820} = 0.0061A = 6.1mA$$

$$V_{CC} = V_{CE} = 5V$$



Reta de carga para esse transistor (aproximado)

$$I_Q \approx 16.910\mu A$$

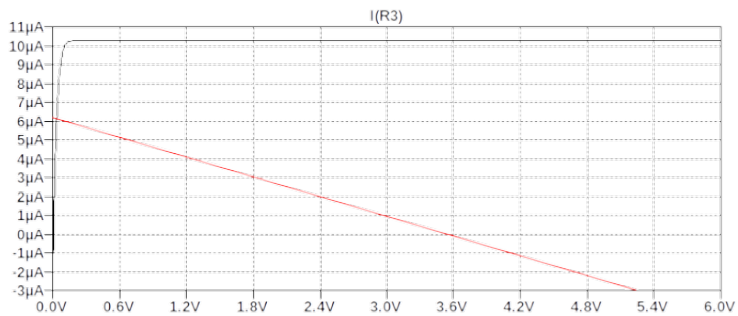
$$V_Q \approx 5V$$

11.4 $V_I = 0V$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{0 - 0.7}{68 \times 1000} = -1.029 \times 10^{-5} = -10.29\mu A$$

$$I_C = \frac{V_{CC_{ColletorEmissor}}}{R_C} = \frac{5}{820} = 0.0061A = 6.1mA$$

$$V_{CC} = V_{CE} = 5V$$



Reta de carga para esse transistor (aproximado)

$$I_Q \approx 6mA$$
$$V_Q \approx 0.1V$$

12 Quinto Circuito

12.1 Constantes

$$I_B = 10\mu A = 0.000001A$$
$$V_C = 8V$$
$$V_{CC} = 12V$$

$$\beta = 100$$
$$I_C \approx I_E$$

12.2 Analise

$$\beta = \frac{I_C}{I_B}$$
$$I_C = \beta I_B = 100 \times 10\mu = 100\mu A$$

$$I_E = (\beta + 1)\, I_B = (100 + 1)\, 10\mu = 101\mu A$$

$$V_C = V_{CC} - I_C R_C$$
$$R_C = -\frac{V_C - V_{CC}}{I_C} = -\frac{8 - 12}{100\mu} = 4000k\Omega$$

$$V_{CC} - I_C R_C - V_{CE} - I_E R_E = 0$$
$$R_E = \frac{V_{CC} - I_C R_C - V_{CE}}{I_E}$$

13 Sexto Circuito

14 Setimo Circuito

14.1 Constantes

$$\beta = 100$$
$$R_C = 2k\Omega$$
$$R_B = 270k\Omega$$
$$R_E = 220\Omega$$
$$V_{CC} = 10V$$
$$V_i = 0V|1V|5V$$

14.2 Analise

14.2.1 $V_i = 0V$

Nenhuma corrente passa por um transistor desativado, $V_o = 10V$.

14.2.2 $V_i = 1V$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B + (\beta + 1)\, R_E} = \frac{1 - 0.7}{270k + (100 + 1) \times 220} = 1.03\mu A$$

$$I_C = \beta I_B = 100 \times 1.03\mu = 103\mu A$$

$$V_C = V_{CC} - I_C R_C = 10 - 103\mu \times 2k = 9.794V$$

14.3 $V_i = 5V$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B + (\beta + 1)\, R_E} = \frac{5 - 0.7}{270k + (100 + 1) \times 220} = 14.71\mu A$$

$$I_C = \beta I_B = 100 \times 14.71\mu = 1.471mA$$

$$V_C = V_{CC} - I_C R_C = 10 - 1.471m \times 2k = 7.057V$$

14.4 Região de Operação

`Para` $V_{CE} = 0V$

$$I_C = \frac{V_{CC_{ColetorEmissor}}}{R_C + (\beta + 1)\, R_E} = \frac{10}{2k + (100 + 1) \times 220} = 0.4128mA$$

`Para` $I_C = 0A$

$$V_{CC} = V_{CE} = 10V$$

14.4.1 $V_i = 1V$

$$I_B = 1.03\mu A$$

`COLOCAR GRAFICO AQUI`

14.4.2 $V_i = 5V$

$$I_B = 14.71\mu A$$

`COLOCAR GRAFICO AQUI`

15 Oitavo Circuito

15.1 Constantes

$$\beta = 100 < x < 150 = 125$$
$$I_C = 10mA = 0.01A$$
$$V_{CE} = 10V$$
$$V_{CC} = 30V$$

15.2 Analise

$$I_C \approx I_E$$

$$V_{CE} = V_{CC} - I_C\left(R_C + R_E\right)$$
$$R_C + R_E = -\frac{V_{CE} - V_{CC}}{I_C}$$
$$R_C + R_E = 2000\Omega$$
$$R_C = R_E = 1000\Omega$$

$$I_C = \beta I_B$$
$$I_B = \frac{I_C}{\beta} = \frac{10m}{125} = 80\mu A$$

Corrente passando por R_1 e R_E tem que ser igual a $80\mu A$.
Se $R_2 = 10M\Omega$, corrente passará pelo R_1 indo para R_E.
Então $R_1 + R_E$ sobe $30V$ gerará $80\mu A$.

$$I_C = \frac{V_{CC}}{R_1 + R_E}$$
$$80\mu = \frac{30}{R_1 + 1000}$$
$$\left(R_1 + 1000\right) 80\mu = 30$$
$$R_{1_{SemGanho}} = \frac{30}{80\mu} - 1000 = 374k\Omega$$

O ganho do transistor tem que ser constado para calcular R_1.

$$R_1 = 374k - (125 + 1)\, R_E = 374k - (125 + 1)\, 1000 = 248k\Omega$$