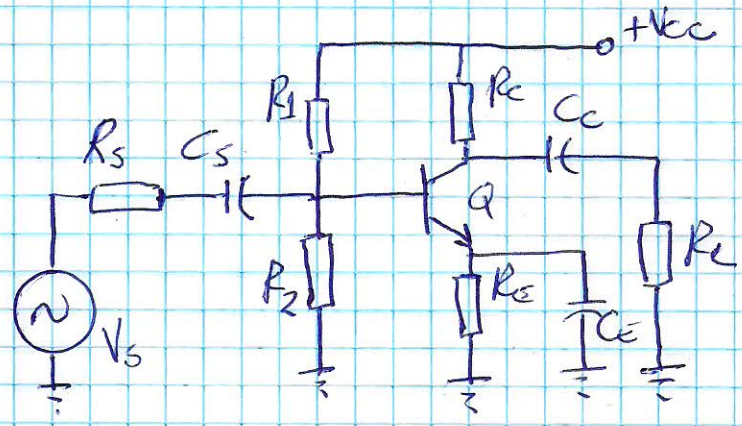
Análise Completa do Amplificador Emissor Comum com Polarização por Divisor de Tensão

1. Topologia



2. Dados

$R_S = 1K\Omega$; $R1 = 40K\Omega$; $R2 = 10K\Omega$; $R_E = 2K\Omega$

$R_C = 4K\Omega$; $R_L = 2K2$; $C_S = 10\mu F$; $C_E = 20\mu F$

$h_{fe} = \beta = 100$; $V_{CC} = 20V$; $C_C = 1\mu F$; $V_{BE} = 0,7V$

$V_S = 100mV$; $C_{be} = 36pF$; $C_{bc} = 4pF$; $C_{ce} = 1pF$;

$C_{wi} = 6pF$; $C_{wo} = 8pF$

3. ANÁLISE DC

$$V_{R2} = \frac{R2}{R1+R2} \cdot Vcc = \frac{10K}{40K+10K} \cdot 20 = 4V$$

$$V_E = V_{R2} - V_{BE} = 4 - 0,7 = 3,3\,V$$

$$I_E = \frac{V_E}{R_E} = \frac{3,3}{2K} \cong 1,6mA$$

$$V_{RC} = I_E \cdot R_C = 1,6m \cdot 4K = 6,4V$$

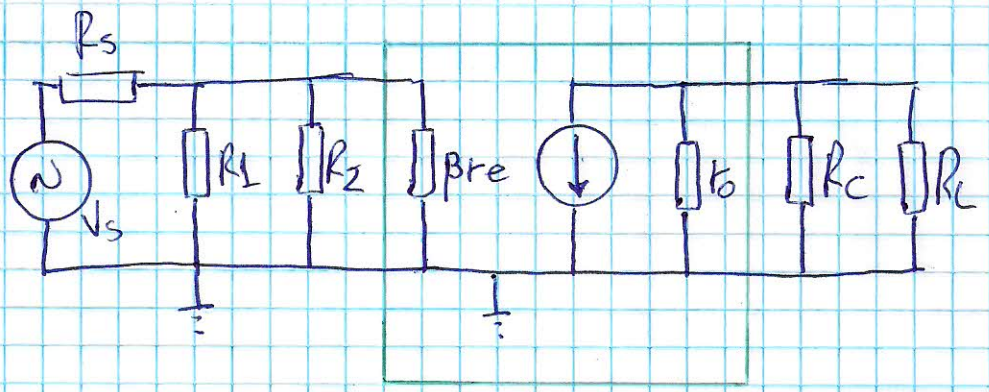
$$V_C = Vcc - V_{RC} = 20 - 6,4 = 13,6V$$

$$V_{CE} = V_C - V_E = 13,6 - 3,3 = 10,3V$$

$$P_Q = V_{CE} \cdot I_E = 10,3 \cdot 1,6m \cong 16mW$$

$$re = \frac{26mV}{I_E} = \frac{26mV}{1,6mA} = 16,25\Omega$$

4. Análise AC



$\beta \cdot re = 100 \cdot 16{,}25 = 1625\,\Omega$

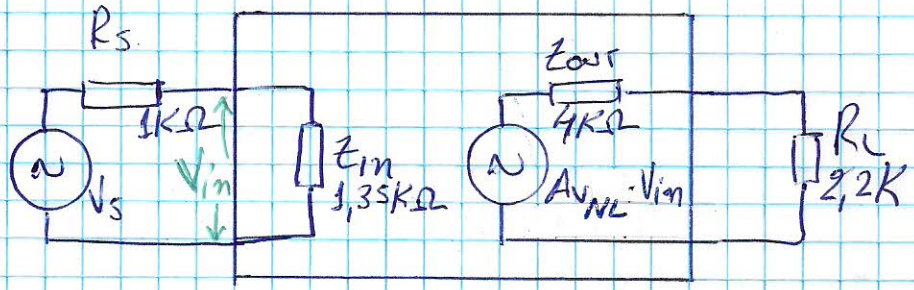
$Z_{in} = R1 // R2 // \beta re = 40K // 10K // 1625 \cong 1{,}35K\Omega$

$rc = Rc // RL \;\Big|_{ro \geq 10\, Rc // RL}$

$rc = 4K // 2{,}2K \cong 1{,}4K\Omega$

$A_V = -\frac{rc}{re} = \frac{1{,}4K\Omega}{16{,}25\Omega} = -86 \cong -90$

$Z_{OUT} = Rc // ro \xrightarrow{ro \geq 10 \cdot Rc} Z_{OUT} = Rc = 4K\Omega$



$A_{V_{NL}} = -\frac{Rc}{re} \;\Big|_{RL \to \infty,\; ro \geq 10 \cdot Rc}$

$A_{V_{NL}} = -\frac{4K}{16{,}25} \cong -250$

$$V_{in} = \frac{Z_{in}}{Z_{in} + R_S} \cdot V_S$$

$$V_{in} = \frac{1,35K}{1,35K + 1K} \cdot 100mV = 57mV$$

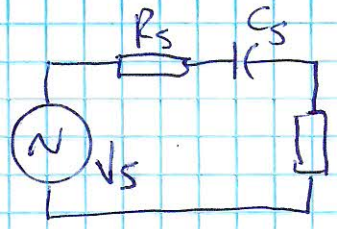
$$A_{V_{NL}} \cdot V_{in} = -250 \cdot 57mV = 14,25V$$

$$V_{OUT\ (AC)} = \frac{R_L}{Z_{OUT} + R_L} \cdot A_{V_{NL}} \cdot V_{in} =$$

$$V_{OUT\ (AC)} = \frac{2,2K}{4K + 2,2K} \cdot 14,25 \cong 5V$$

5. Resposta em Baixa Frequência

5.1 Capacitor de Acoplamento de Entrada



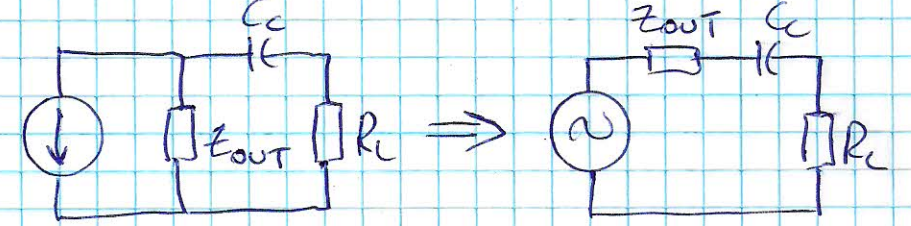
$$R = R_S + Z_{in}$$

$$f_C = \frac{1}{2\pi R C_S}$$

$$R = 1K + 1,35K = 2,35K\Omega$$

$$f_C = \frac{1}{2 \cdot \pi \cdot 2,35K \cdot 1\mu} \cong 7Hz$$

5.2 Capacitor de Acoplamento de Saída



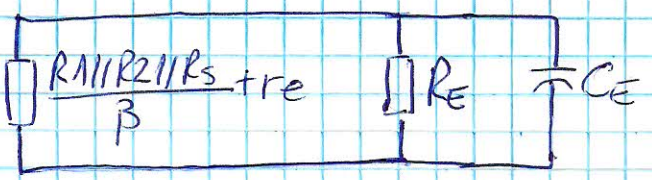
$$R = R_L + Z_{OUT}$$

$$f_C = \frac{1}{2\pi R C_C}$$

$$R = 2,2K + 4K = 6,2K$$

$$f_C = \frac{1}{2\pi \cdot 6,2K \cdot 1\mu} \cong 25Hz$$

5.3 Capacitor de desacoplamento de emissor



$$Z_E = R_E // \left(re + \frac{R1 // R2 // Rs}{\beta} \right)$$

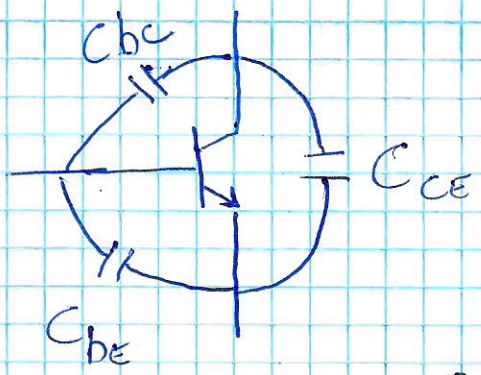
$$f_C = \frac{1}{2\pi \cdot Z_E \cdot C_E}$$

$$re + \frac{R1 // R2 // Rs}{\beta} = 16{,}25 + \frac{888}{100} = 25{,}13\,\Omega$$

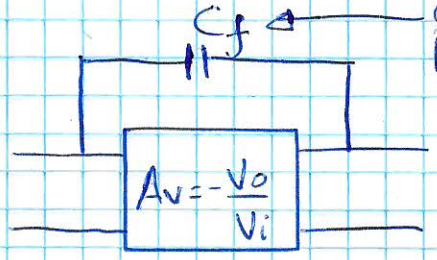
$$Z_E = R_E // 25{,}13\,\Omega = 2K // 25{,}13 \cong 25{,}13\,\Omega$$

$$f_C = \frac{1}{2\pi \cdot 25{,}13 \cdot 20\mu} \cong 317\,Hz$$

6. Resposta em alta frequência



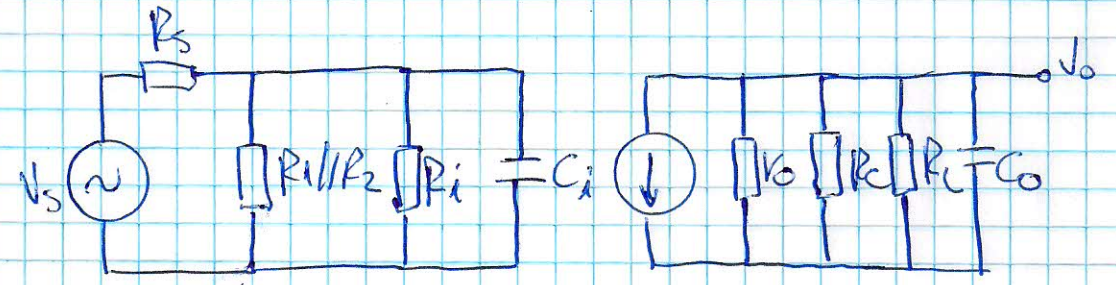
* Nas folhas de dados C_{bc} é representado por C_c e C_{BE} é representado por C_E.



Capacitância de realimentação. Para o emissor comum $C_f = C_{bc}$.

$$C_{Mi} = (1 - A_V) C_f$$

$$C_{Mo} = \left(1 - \frac{1}{A_V}\right) C_f$$



$$C_i = C_{wi} + C_{bE} + C_{Mi}$$

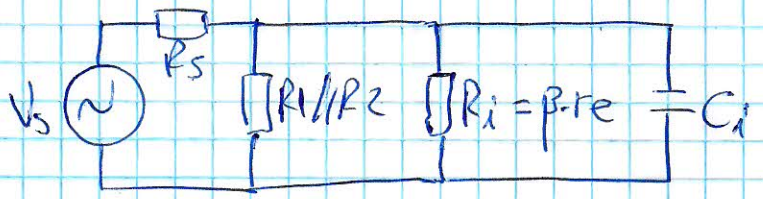
$$C_o = C_{wo} + C_{CE} + C_{Mo}$$

$$C_{Mi} = (1 - A_V) C_{bc} = (1 - (-90)) 4p = 364pF$$

$$C_{Mo} = \left(1 - \frac{1}{A_V}\right) C_{bc} = \left(1 - \frac{1}{-90}\right) 4p \cong 4pF$$

$C_i = 6p + 36p + 364p = 406\,pF$

$C_o = 8p + 1p + 4pF \cong 13pF$

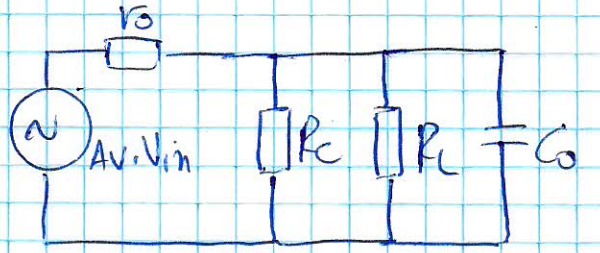


$R_{TH} = Rs // R_1 // R_2 // \beta.re$

$R_{TH} = 1K // 40K // 10K // 1625$

$R_{TH} = 574\,\Omega$

$$f_{Hi} = \frac{1}{2\pi . R_{TH} . C_i} = \frac{1}{2.\pi . 574 . 406p} = 683KHz$$



$$R_{TH} = Rc // R_L \quad \Big| \; r_o \geq 10.Rc // R_L$$

$R_{TH} = 4K // 2,2K \cong 1,4K\Omega$

$$f_{Ho} = \frac{1}{2\pi R_{TH} C_o} = \frac{1}{2\pi . 1,4K . 13p} \cong 8,7MHz$$

* EM ALGUNS CASOS C_E PODE SER APROXIMADO PARA

$$C_E = \frac{1}{2\pi . f_T . r'e}$$

L.T.S