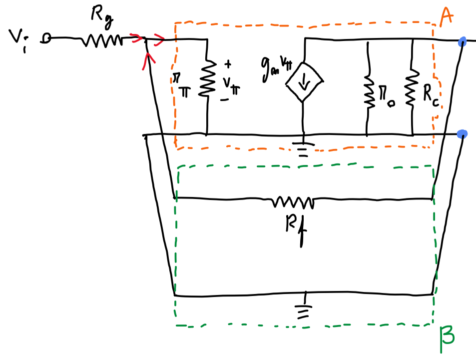
a)

AC em banda passante ⇒ Condensadores em c.c.



Como comparamos a corrente na entrada e "somos" a tensão na saída.

⇓

Corrente − Tensão (Paralelo − Paralelo)

$V_{BE} = 0{,}7\,V \qquad \beta_F = 200$

$r_o = \infty \qquad \beta = 200$

Calculo de gm:

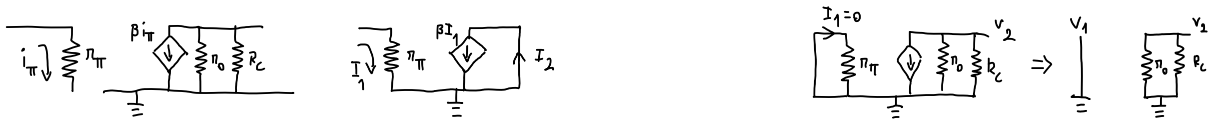
$g_m = \frac{I_C}{V_T} \qquad I_C + I_B = I_E \qquad I_B = \frac{I_E}{\beta+1}$

$10 = R_c(I_C + I_B) + R_f I_B + V_{BE} + R_E I_E$

$9{,}3 = \left(R_c + \frac{R_f}{\beta+1} + R_E\right) I_E \Rightarrow I_C = 14.26\,mA$

$g_m = \frac{14.26\,mA}{25\,mV} = 570.4\,mS$

b) A



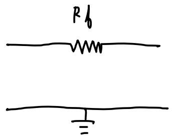
Corrente − Tensão ⇒ Y

$$Y_A = \begin{bmatrix} \frac{1}{r_\pi} & 0 \\ g_m & \frac{1}{R_c} \end{bmatrix} = 57 \begin{bmatrix} 2.85 & 0 \\ 0.4 & 3.3 \end{bmatrix} \mu S$$

$$y_{11A} = \left.\frac{I_1}{V_1}\right|_{V_2=0} = \frac{1}{r_\pi} = \frac{g_m}{\beta} = 2.85\,mS \qquad y_{12A} = \left.\frac{I_1}{V_2}\right|_{V_1=0} = 0$$

$$y_{21A} = \left.\frac{I_2}{V_1}\right|_{V_2=0} = \frac{\beta I_1}{r_\pi I_1} = \frac{\beta}{r_\pi} = g_m = 570.4\,mS \qquad y_{22A} = \left.\frac{I_2}{V_2}\right|_{V_1=0} = \frac{1}{r_o // R_c} \rightarrow \frac{1}{R_c} = 3.3\,mS$$

B

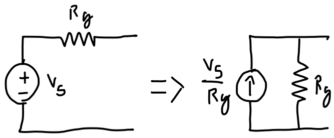


$$y_{11B} = \left.\frac{I_1}{V_1}\right|_{V_2=0} = \frac{1}{R_f} \qquad y_{12B} = \left.\frac{I_1}{V_2}\right|_{V_1=0} = -\frac{1}{R_f}$$

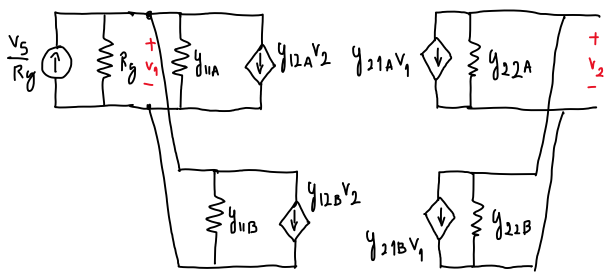
$$y_{21B} = \left.\frac{I_2}{V_1}\right|_{V_2=0} = -\frac{1}{R_f} \qquad y_{22B} = \left.\frac{I_2}{V_2}\right|_{V_1=0} = \frac{1}{R_f}$$

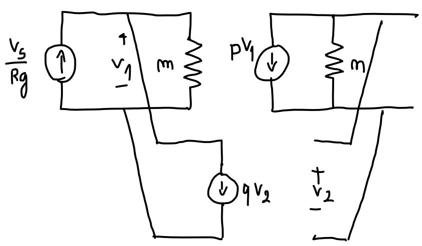
$$Y_B = \begin{bmatrix} \frac{1}{R_f} & -\frac{1}{R_f} \\ -\frac{1}{R_f} & \frac{1}{R_f} \end{bmatrix} = \begin{bmatrix} 20 & -20 \\ -20 & 20 \end{bmatrix} \mu S$$

Para obter A' e β' →



Unidirecional!





$m = Y_{11A} + Y_{11B} + \frac{1}{R_g}$

$m = Y_{22A} + Y_{22B}$

$p = Y_{21A} + Y_{21B}$

$q = Y_{12A} + Y_{12B}$

Logo

$$A' = \frac{V_2}{I_{1A}} = -\frac{p}{m \cdot m} = -\frac{Y_{21A}+Y_{21B}}{\left(Y_{11A}+Y_{11B}+\frac{1}{R_g}\right)\left(Y_{22A}+Y_{22B}\right)} = -\frac{g_m - \frac{1}{R_f}}{\left(\frac{1}{r_\pi}+\frac{1}{R_f}+\frac{1}{R_g}\right)\left(\frac{1}{r_o}+\frac{1}{R_c}+\frac{1}{R_f}\right)} = -44{,}3\,k\Omega$$

$$\beta' = \frac{I_{1B}}{V_2} = q = Y_{12A} + Y_{12B} = -\frac{1}{R_f} = -20\,\mu S$$

c)

$$A_f = \frac{V_2}{I_S} = \frac{A'}{1+A'\beta'} = -23{,}5K\,\Omega \qquad \frac{V_2}{V_S} = \frac{V_2}{R_g I_S} = \frac{A_f}{R_g} = -23{,}5$$

d) Impedância de entrada em malha aberta:

$$Z'_{iA} = \frac{1}{Y_{11A} + Y_{11\beta} + \frac{1}{R_g}} = 258.3\,\Omega$$

Impedância de saída em malha aberta:

$$Z'_{OA} = \frac{1}{Y_{22A} + Y_{22\beta}} = 301.2\,\Omega$$

Impedância de entrada realimentada:

$$Z_{if} = \frac{Z'_{iA}}{1+A'\beta'} = 136.8\,\Omega$$

Impedância de saída realimentada:

$$Z_{of} = \frac{Z'_{OA}}{1+A'\beta'} = 158.0\,\Omega$$

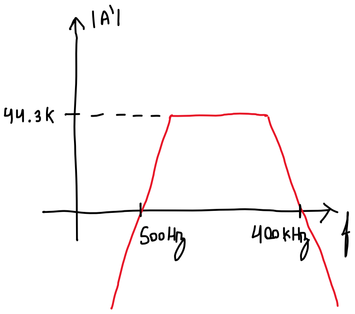
Impedancia real:

$$\frac{1}{Z_{if}} = \frac{1}{R_g} + \frac{1}{Z_i} \Leftrightarrow Z_i = \frac{1}{\frac{1}{Z_{if}} + \frac{1}{R_g}} = 158.6\,\Omega$$

Impedancia real:

$$\frac{1}{Z_{of}} = \frac{1}{Z_o} \Leftrightarrow Z_o = Z_{of} = 158.0\,\Omega$$

e) Amplificador básico carregado:



$s = j\omega$

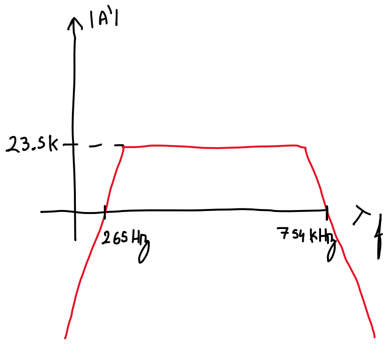
$\omega_L = 2\pi f_L \qquad f_L = 500\,Hz$

$\omega_H = 2\pi f_H \qquad f_H = 400\,kHz$

$$A'(s) = \frac{A'_0 \frac{s}{\omega_L}}{\left(1+\frac{s}{\omega_L}\right)\left(1+\frac{s}{\omega_H}\right)}$$

Com realimentação

$$A_f(s) = \frac{A'(s)}{1+A'(s)\beta'} = \frac{\dfrac{A'_0 \frac{s}{\omega_L}}{\left(1+\frac{s}{\omega_L}\right)\left(1+\frac{s}{\omega_H}\right)}}{1 + \dfrac{A'_0 \frac{s}{\omega_L}}{\left(1+\frac{s}{\omega_L}\right)\left(1+\frac{s}{\omega_H}\right)} \cdot \beta'} = \frac{A'_0 \frac{s}{\omega_L}}{\left(1+\frac{s}{\omega_L}\right)\left(1+\frac{s}{\omega_H}\right) + A'_0 \frac{s}{\omega_L}\beta'}$$



Para baixas freqs ($\omega \ll \omega_H$) → O polo de altas freqs não afecta $\left[\frac{s}{\omega_H} = 0\right]$

$$A_f(s) \approx \frac{A'_0 \frac{s}{\omega_L}}{1+\frac{s}{\omega_L} + A'_0 \frac{s}{\omega_L}\beta'} = \frac{A'_0 \frac{s}{\omega_L}}{1 + s\left(\frac{1+A'_0\beta'}{\omega_L}\right)}$$

→ Nova freq: $\omega_{Lf} = \frac{\omega_L}{1+A'_0\beta'} \Rightarrow f_{Lf} = 265\,Hz$

Produto Ganho - Largura de Banda

→ $GB = G \times B = 44.3K \cdot (400K - 500) =$

$= 17.7 \times 10^9$

→ $GB_f = G_f \times B_f = 23.5K \cdot (754K - 265) =$

$= 17.7 \times 10^9$

Para altas freqs ($\omega \gg \omega_L$) → O polo de baixas freqs não afecta $\left[\frac{s}{\omega_L} = \infty\right]$

$$A_f(s) \approx \frac{A'_0}{1+\frac{s}{\omega_H} + A'_0\beta'} = \frac{\dfrac{A'_0}{1+A'_0\beta'}}{1 + \dfrac{s}{\omega_H(1+A'_0\beta')}}$$

→ Nova freq: $\omega_{Hf} = \omega_H(1+A'_0\beta') \Rightarrow f_{Hf} = 754\,kHz$