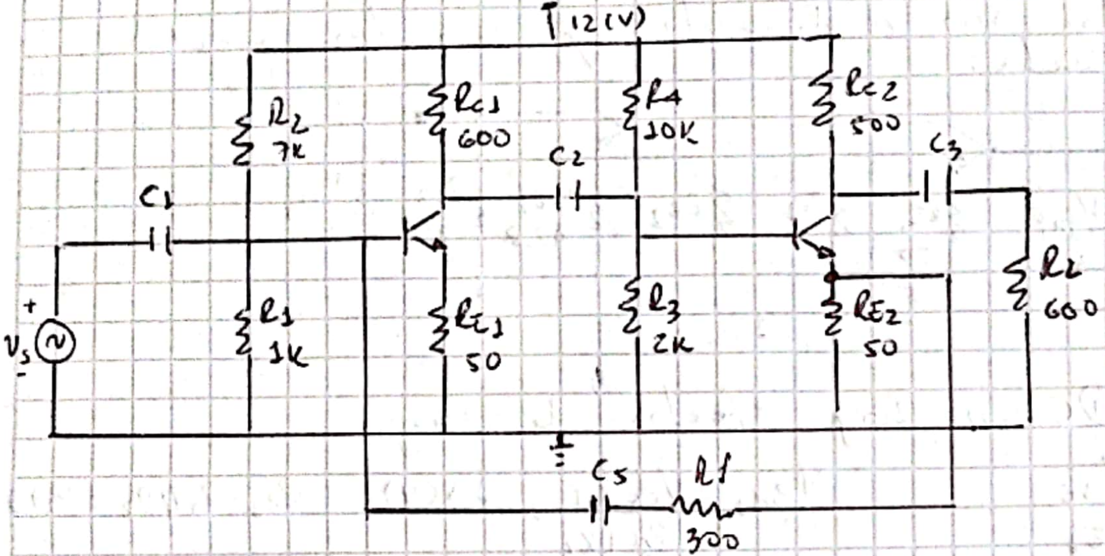
Solución Parcial 3.A - Electrónica Analógica.

1. Hallar β, A, A, Af, Rin, Rout, Zinf, Zoutf.



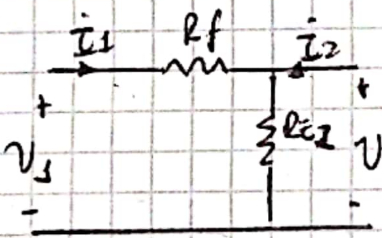
$\beta_T = 100$

→ Realimentación de corriente: i_o

→ Comparación de corriente: i_s

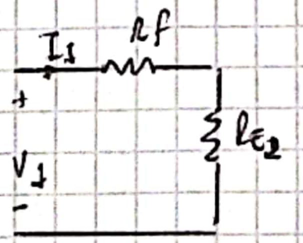
Se usan los parámetros "g".

→ La red de realimentación es:



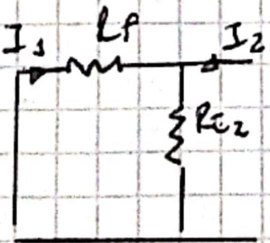
$$I_1 = g_{11f} V_1 + g_{12f} I_2$$
$$V_2 = g_{21f} V_1 + g_{22f} I_2$$

$$g_{11f} = \frac{I_1}{V_1}\Big|_{I_2=0}$$



$$\Rightarrow g_{11f} = \frac{1}{R_{E2}+R_f} = \frac{1}{300+50} = 2.86\,[℧]$$

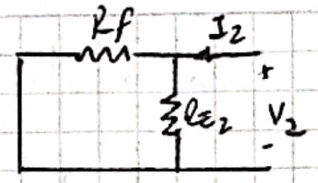
$$g_{12f} = \frac{I_1}{I_2}\Big|_{V_1=0}$$



$$I_1 = -\frac{I_2 R_{E2}}{R_{E2}+R_f}$$

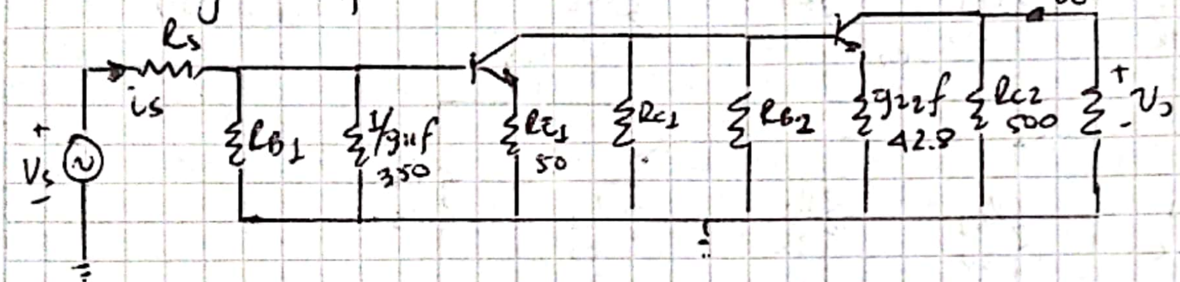
$$\Rightarrow g_{12f} = \beta = \frac{-R_{E2}}{R_{E2}+R_f} = -0.143$$

$$g_{22f} = \left.\frac{V_2}{I_2}\right|_{V_1=0}$$



$g_{22f} = R_f // R_{E2} = 42.8\,\Omega$.

El amplificador sin realimentar y con los efectos de carga queda:



Nota: En DC no hay efectos de carga

$$I_{CQ1} = \frac{V_{BB1} - V_{BE}}{\frac{R_{B1}}{\beta_T} + R_{E1}} \qquad V_{BB1} = \frac{V_{CC} R_1}{R_1 + R_2} = 1.5\,(V) \qquad R_{B1} = R_1 // R_2 = 875\,\Omega$$

$$I_{CQ1} = \frac{1.5 - 0.7}{\frac{875}{100} + 50} = 13.6\,mA$$

$$I_{CQ2} = \frac{V_{BB2} - V_{BE}}{\frac{R_{B2}}{\beta_T} + R_{E2}} \qquad V_{BB2} = \frac{V_{CC} R_3}{R_3 + R_4} = 2\,(V) \qquad R_{B2} = R_3 // R_4 = 1.6K\,\Omega$$

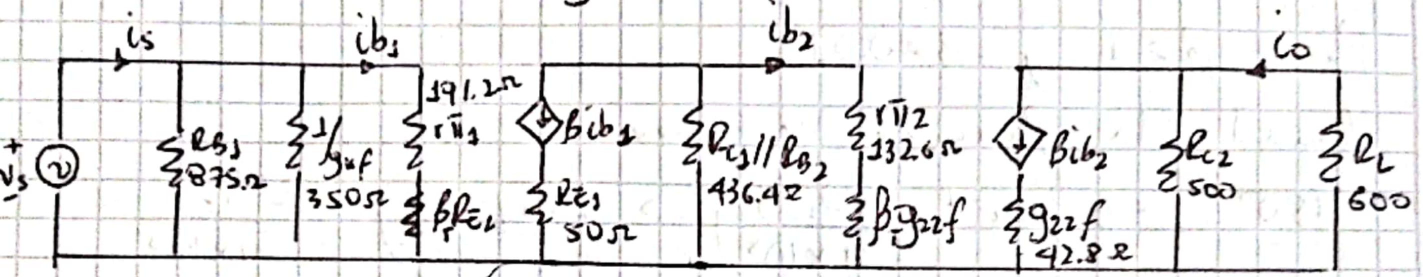
$$I_{CQ2} = \frac{2 - 0.7}{\frac{1.6K}{100} + 50} = 19.6\,mA$$

$$\therefore \quad r\pi_1 = \frac{\beta_T\, 26mV}{I_{CQ1}} = 191.2\,\Omega$$

$$r\pi_2 = \frac{\beta_T\, 26mV}{I_{CQ2}} = 132.6\,\Omega$$

$A = \frac{i_o}{i_s}$; $A_f = \frac{A}{1+\beta A}$; $Z_{inf} = \frac{R_{in}}{(1+\beta A)}$; $Z_{outf} = R_{out}(1+\beta A)$

Modelo híbrido en lazo abierto:



$$i_o = \frac{\beta_T i_{b2} R_{C2}}{R_{C2}+R_L} = \frac{100(500)\, i_{b2}}{500+600} = 45.45\, i_{b2}$$

$$i_{b2} = -\frac{\beta i_{b1} (R_{C1} // R_{B2})}{(R_{C1} // R_{B2}) + r\pi_2 + \beta g_{22f}} = \frac{-(100)(436.4)\, i_{b1}}{436.4 + 132.6 + (100 * 428)} \approx -9\, i_{b1}$$

$$\Rightarrow i_o = -9(45.45)\, i_{b1} = -409.05\, i_{b1}$$

$$i_{b1} = \frac{i_s (R_{B1} // 1/g_{11f})}{(R_{B1} // 1/g_{11f}) + r\pi_1 + \beta_T R_{E1}} = \frac{i_s(250)}{250 + 191.2 + (100 * 50)} = 0.046\, i_s$$

$$\Rightarrow i_o = -409.05(0.046)\, i_s \Rightarrow A = \frac{i_o}{i_s} = -18.8$$

$$A_f = \frac{A}{1+\beta A} \quad \frac{-18.8}{1+(-0.143)(-18.8)} = -5.09$$

$$R_{in} = (r\pi_1 + \beta R_{E1}) // 1/g_{11f} // R_{B1} = 238.5\,\Omega$$

$$R_{out} = R_L // R_{C2} = 272.7\,\Omega.$$

$$Z_{inf} = \frac{R_{in}}{1+\beta A} = \frac{\cancel{272.7\,\Omega}\ 238.5\,\Omega}{1+(-0.143)(-18.8)} = 64.66\,\Omega.$$

$$Z_{outf} = R_{out}(1+\beta A) = 272.7(1+(-0.143)(-18.8)) \approx 1.003\,k\Omega$$

2.a) Determinar estabilidad de un amplificador con:

$$A(j\omega) = \frac{150}{\left(1 + \frac{j\omega}{4\times10^5}\right)^5}$$

Para $\beta = 1$ y $\beta = 0.01$.

Usando la función de fase:

$$-180^\circ = -5\tan^{-1}\left(\frac{\omega_{180}}{4\times10^5}\right) \Rightarrow \tan\left(\frac{180}{5}\right) = \frac{\omega_{180}}{4\times10^5}$$

$$\Rightarrow \omega_{180} = 4\times10^5 \tan\left(\frac{180}{5}\right) = 290.6\times10^3 \text{ Krad/s}.$$

$$|\beta A(\omega_{180})| = \frac{\beta 150}{\left[\sqrt{1+\left(\frac{290.6\times10^3}{4\times10^5}\right)^2}\right]^5}$$

Para $\beta = 1 \Rightarrow |\beta A(\omega_{180})| = \dfrac{150}{\left[\sqrt{1+\left(\frac{290.6\times10^3}{4\times10^5}\right)^2}\right]^5} = 52.17$ $\therefore$ Inestable

Para $\beta = 0.01 \Rightarrow |\beta A(\omega_{180})| = \dfrac{150\times 0.01}{\left[\sqrt{1+\left(\frac{290.6\times10^3}{4\times10^5}\right)^2}\right]^5} = 0.521$ $\therefore$ Estable

b) Margen de ganancia de $-20dB$; $\beta = ?$

$$\Rightarrow 20\log(A) = -20 \Rightarrow A = 10^{\frac{-20}{20}} = 0.1.$$

$$\Rightarrow |\beta A|_{\omega_{-180}} = 0.1 \Rightarrow \frac{\beta 150}{\left[\sqrt{1+\left(\frac{290.6\times10^3}{4\times10^5}\right)^2}\right]^5} = 0.1$$

$$\Rightarrow \beta = \frac{0.1\left[\sqrt{1+\left(\frac{290.6\times10^3}{4\times10^5}\right)^2}\right]^5}{150} = 0.00192$$

β debe valer 0.00192 para un margen de ~~fase~~ ganancia de $-20dB$.