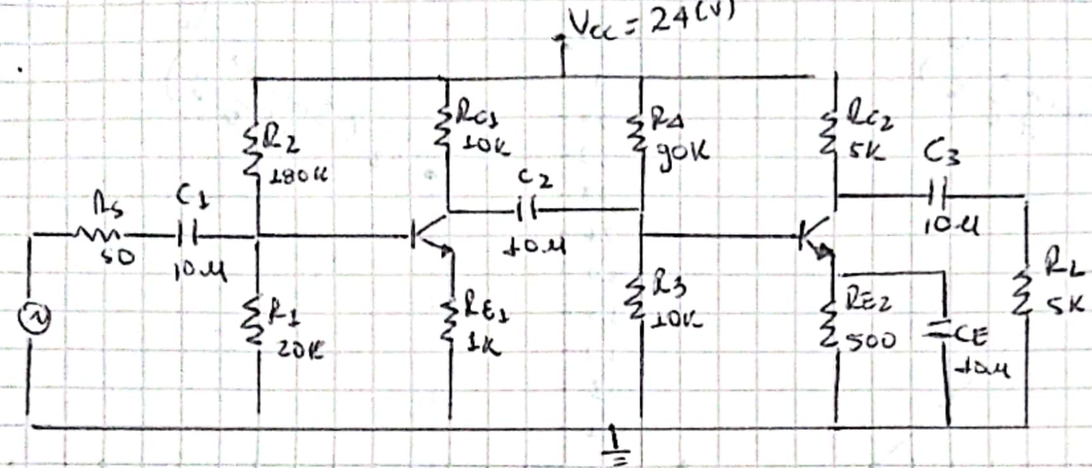
Parcial 2A.

1.



$\beta_1 = \beta_2 = 200$

$f_T : 500MHz$

$C_{bc} = 10pF$

C_o: despreciable

Análisis D.C

Etapa 1.

$R_{B_1} = R_1 // R_2 = 18K$

$V_{BB_1} = \dfrac{V_{cc} R_1}{R_1 + R_2} = 2.4(V)$

L.V.K malla de entrada:

$V_{BB_1} = \dfrac{I_{CQ_1} R_{B_1}}{\beta} + V_{BE} + I_{CQ_1} R_{E_1}$

$\Rightarrow I_{CQ_1} = \dfrac{V_{BB_1} - V_{BE}}{R_{B_1}/\beta + R_{E_1}} = 1.56mA$

L.V.K Malla de salida:

$V_{cc} = I_{CQ_1} R_{C_1} + V_{CE_1} + I_{CQ_1} R_{E_1}$

$\Rightarrow V_{CE_1} = V_{cc} - I_{CQ_1}(R_{C_1} + R_{E_1})$

$\Rightarrow V_{CE_1} = 6.84(V)$

$I_{cmax_1}(V_{CE_1}=0) = \dfrac{V_{cc}}{R_{C_1} + R_{E_1}} = 2.18mA$

$V_{CEmax_1} = V_{cc} = 24(V)$

Etapa 2.

$R_{B2} = R_3 // R_4 = 9K$

$V_{BB_2} = \dfrac{V_{cc} R_3}{R_3 + R_4} = 2.4(V)$

L.V.K malla de entrada:

$V_{BB2} = \dfrac{I_{CQ2} R_{B2}}{\beta} + V_{BE} + I_{CQ_2} R_{E2}$

$\Rightarrow I_{CQ_2} = \dfrac{V_{BB_2} - V_{BE}}{R_{B2}/\beta + R_{E_2}} = 3.12mA$

L.V.K malla de salida:

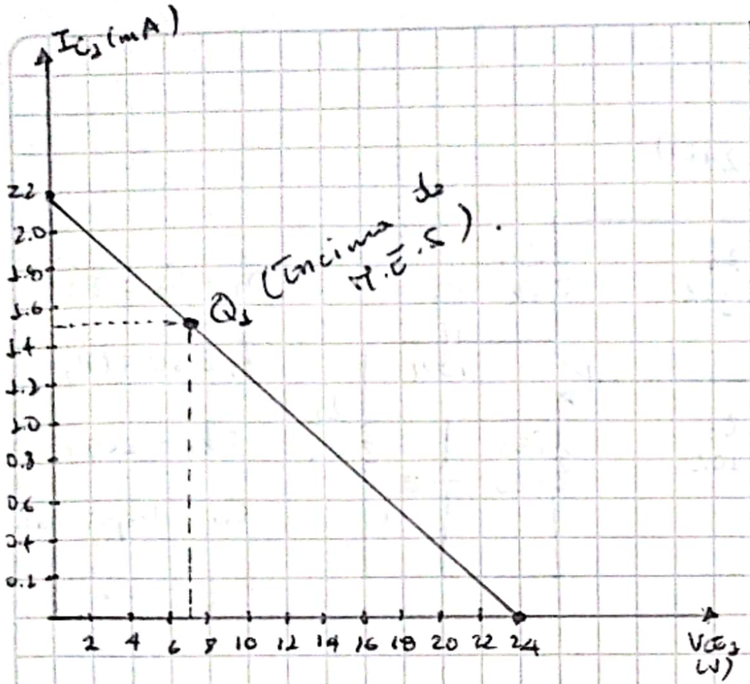
$V_{cc} = I_{CQ_2} R_{C2} + V_{CE2} + I_{CQ_2} R_{E2}$

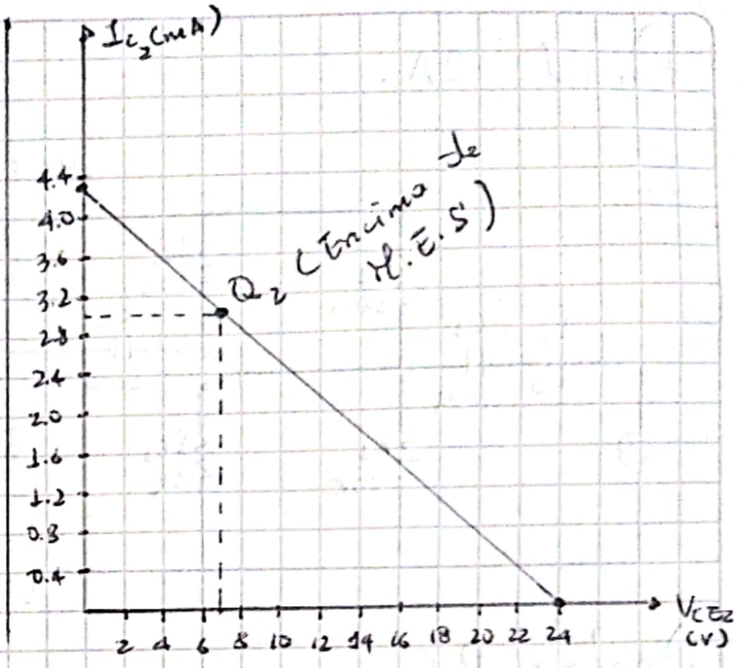
$\Rightarrow V_{CE_2} = V_{cc} - I_{CQ2}(R_{C2} + R_{E2})$

$\Rightarrow V_{CE_2} = 6.84(V)$

$I_{cmax_2}(V_{CE2}=0) = \dfrac{V_{cc}}{R_{C2} + R_{E2}} = 4.36mA$

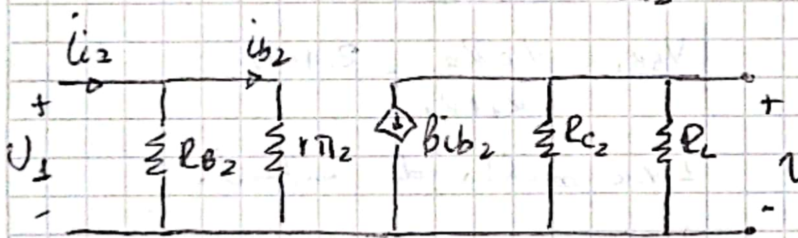
$V_{CEmax_2} = V_{cc} = 24(V)$





Análisis AC (Frecuencias medias).

Etapa 2. $\Rightarrow r_{\pi 2} = \dfrac{\beta\, 26\,mV}{I_{CQ_2}} = 1.66\,K\Omega$. $\quad R_{B2} = 9\,K\Omega$.



$A_{V2} = \dfrac{V_o}{V_1}$

$V_o = -\beta i_{b2} R_{C2} \| R_L \quad ; \quad V_1 = i_{b_2} r_{\pi 2}$

$$\Rightarrow A_{V2} = \frac{V_o}{V_1} = \frac{-\beta \cancel{i_{b2}} R_{C2} \| R_L}{\cancel{i_{b2}}\, r_{\pi 2}} = \frac{-\beta R_{C2} \| R_L}{r_{\pi 2}} = -301.2$$

$A_{i2} = \dfrac{i_o}{i_{i2}} \quad ; \quad i_o = \dfrac{-\beta i_{b2} R_{C2}}{R_{C2} + R_L}$, pero $i_{b_2} = \dfrac{i_{i2} R_{B2}}{r_{\pi 2} + R_{B2}}$

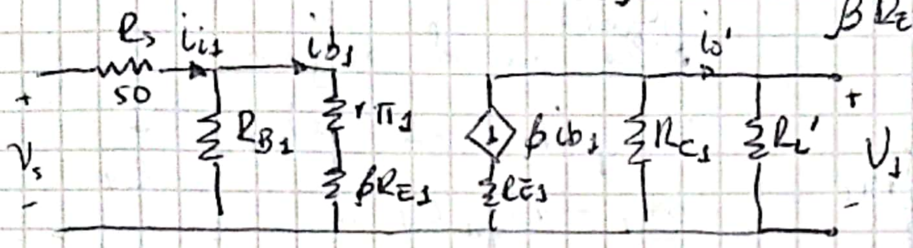
$$\Rightarrow \frac{i_o}{i_{i2}} = A_{i_2} = \frac{-\beta R_{B_2} R_{C2}}{(R_{C2} + R_L)(r_{\pi 2} + R_{B_2})} = -84.4$$

$Z_{out2} = Z_{out} = R_{C_2} = 5\,K\Omega$.

$Z_{in_2} = R_L' = r_{\pi 2} \| R_{B_2} = 1.4\,K\Omega$.

Etapa 1 $\Rightarrow r\pi_1 = \dfrac{\beta 26mV}{I_{CQ1}} \approx$ 3.33kΩ ; $R_{B1} = 18k\Omega$.

$\beta R_{E1} = 200k\Omega$; $R_L' = 1.4k\Omega$



Calculamos $(r\pi_1 + \beta R_{E1}) \parallel R_{B1} = 16.5k\Omega >>> R_s$

$\Rightarrow$ Se puede despreciar R_s de Av_1 y Zin_1

$$Av_1 = \frac{V_1}{V_s}$$

$V_1 = -\beta i_{b1} R_{C1} \parallel R_L'$; $V_s = i_{b1}(r\pi_1 + \beta R_{E1})$

$$\Rightarrow Av_1 = \frac{V_1}{V_s} = \frac{-\beta \cancel{i_{b1}} R_{C1} \parallel R_L'}{\cancel{i_{b1}}(r\pi_1 + \beta R_{E1})} = \frac{-\beta R_{C1} \parallel R_L'}{(r\pi_1 + \beta R_{E1})} = \frac{-(200)(1.23k)}{(203.3k)}$$

$$Av_1 = -1.20$$

$Ai_1 = \dfrac{i_o'}{i_{i1}}$, $i_o' = -\dfrac{\beta i_{b1} R_{C1}}{R_{C1} + R_L'}$, pero $i_{b1} = \dfrac{i_{i1} R_{B1}}{(R_{B1} + r\pi_1 + \beta R_{E1})}$

$$\Rightarrow Ai_1 = \frac{i_o'}{i_{i1}} = \frac{-\beta R_{C1} R_{B1}}{(R_{C1} + R_L')(R_{B1} + r\pi_1 + \beta R_{E1})} = -14.3$$

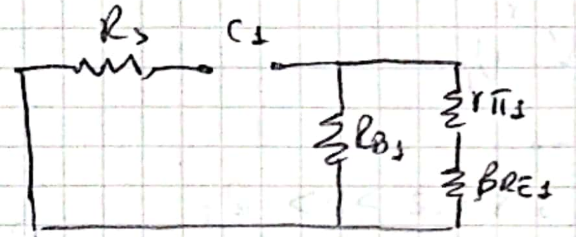
$$Zin = (r\pi_1 + \beta R_{E1}) \parallel R_{B1} = 16.5k\Omega.$$

$$\Rightarrow Av_T = Av_1 * Av_2 = (-1.20)(-301.2) = 361.4$$

$$\Rightarrow Ai_T = Ai_1 * Ai_2 = (-14.3)(84.4) = 1206.9$$

Análisis AC (frecuencias bajas).

Para C_1:



~~Polo~~ Cero en el origen

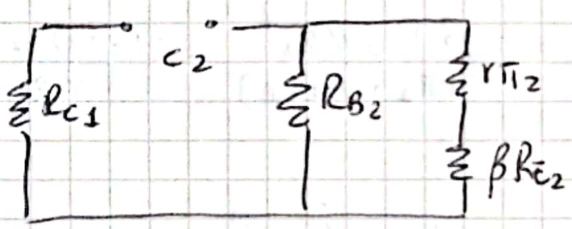
~~Cero~~ polo en $\omega_{p1} = \dfrac{1}{\tau_1}$

$\tau_1 = R_{eq_1} C_1$

$R_{eq_1} = \left[(r\pi_1 + \beta R_{E_1}) // R_{B_1} \right] + R_s$

$R_{eq_1} = 16.55 k\Omega \Rightarrow \omega_{p_1} = \dfrac{1}{16.55k * 10\mu F} = 6.04\ rad/s.$

Para C_2



Cero en el origen

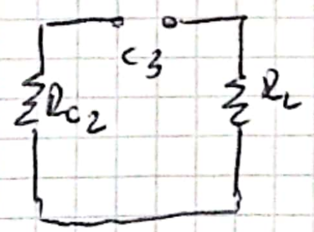
polo en $\omega_{p_2} = \dfrac{1}{\tau_2}$

$\tau_2 = R_{eq_2} C_2$

$R_{eq_2}\ [(\beta R_{E_2} + r\pi_2) // R_{B_2}] + R_{C_1}$

$R_{eq_2} = 18.27 k\Omega. \Rightarrow \omega_{p2} = \dfrac{1}{18.27k\Omega \times 10\mu} = 5.47\ rad/s.$

Para C_3



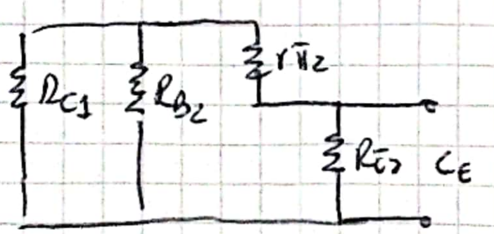
Cero en el origen

polo en $\omega_{p3} = \dfrac{1}{\tau_3}$

$\tau_3 = R_{eq_3} C_3$; $R_{eq_3} = R_{C2} + R_L = 10k\Omega.$

$\Rightarrow \omega_{p_3} = \dfrac{1}{10K * 10\mu} = 10\ rad/s.$

Para C_E.



Polo en $\omega_{z_1} = \dfrac{1}{R_{E2} C_E} = 200\ rad/s$,

Polo en $\omega_{p4} = \dfrac{1}{\tau_4} = \dfrac{1}{R_{eq_4} C_E}$

$R_{eq_4} = \left[\dfrac{(R_{C1} // R_{B2}) + r\pi_2}{\beta} \right] // R_{E2}$

$R_{eq_4} \approx 30\Omega \Rightarrow \omega_{p4} = \dfrac{1}{(30)(10\mu)} = 3.33 k\Omega. \Rightarrow \omega_L = \omega_{p4}$

polo dominante $= 3.33 k\Omega$.

Análisis A.C (para alta frecuencia). $C_{bc1} = C_{bc2} = 10pF$

$\omega_T = 2\pi \times 500MHz$

$C_{be1} = \frac{g_{m1}}{\omega_T}$, $g_{m1} = \frac{1}{r_{e1}}$ $\Rightarrow g_{m1} = \frac{1}{26mV/I_{CQ1}} = 0.06$

$\Rightarrow C_{be1} = \frac{0.06}{(2\pi \times 500MHz)} = 19pF$

$C_{be2} = \frac{g_{m2}}{\omega_T}$, $g_{m2} = \frac{1}{r_{e2}}$ $\Rightarrow g_{m2} = \frac{1}{26mV/I_{CQ2}} = 0.12$

$\Rightarrow C_{be2} = \frac{0.12}{(2\pi \times 500MHz)} = 38pF.$

Aplicamos teorema de Miller para C_{bc1} y C_{bc2}

Para C_{bc1}:

$C_{M1} = C_{bc1}(1 - A_{v1}) = 10pF(1-(-1.20)) = 22pF$

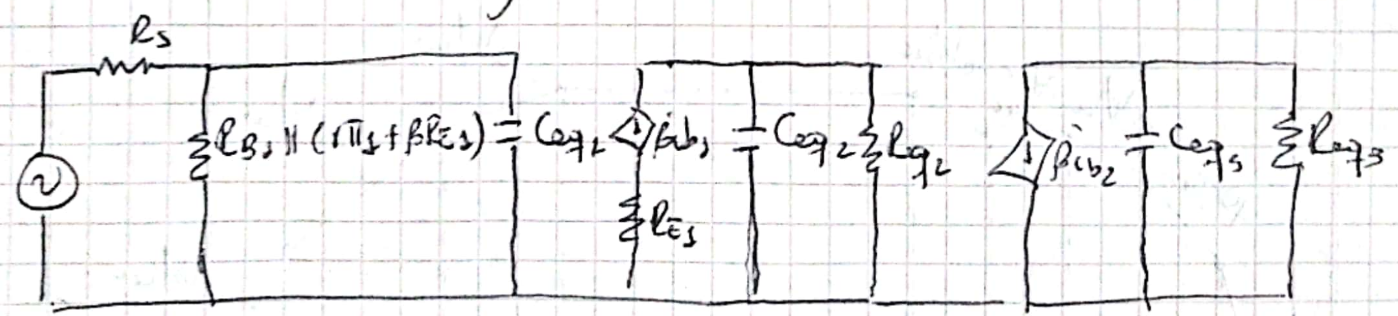
$C_{M2} = C_{bc1}(1 - 1/A_{v1}) = 10pF\left(1 - \left(-\frac{1}{1.2}\right)\right) = 18.3pF$

Para C_{bc2}:

$C_{M3} = C_{bc2}(1 - A_{v2}) = 10pF(1 - (-301.2)) \approx 3nF$

$C_{M4} = C_{bc2}(1 - 1/A_{v2}) = 10pF(1 - (-1/301.2)) \approx 10pF.$

Reduciendo los paralelos se obtiene:



Polo para C_{eq_1}: $\quad C_{eq_1} = C_{be_1} + C_{M_1} = 22pF + 19pF = 41pF$

$$\omega_{p1} = \frac{1}{C_{eq_1} R_{eq_1}} \qquad R_{eq_1} = R_S \parallel R_{B1} \parallel (r_{\pi_1} + \beta R_{E1}) = 49.8\Omega.$$

$$\Rightarrow \omega_{p1} = \frac{1}{49.8 \times 41pF} = 489.8\ Mrad/s$$

Polo para C_{eq_2}: $\quad C_{eq_2} = C_{M_2} + C_{be_2} + C_{M_3} = 18.3pF + 3nF + 38pF \approx 3nF$

$$\Rightarrow \omega_{p2} = \frac{1}{C_{eq_2} R_{eq_2}} \qquad R_{eq_2} = R_{C1} \parallel R_{B2} \parallel r_{\pi_2} = 1.23K$$

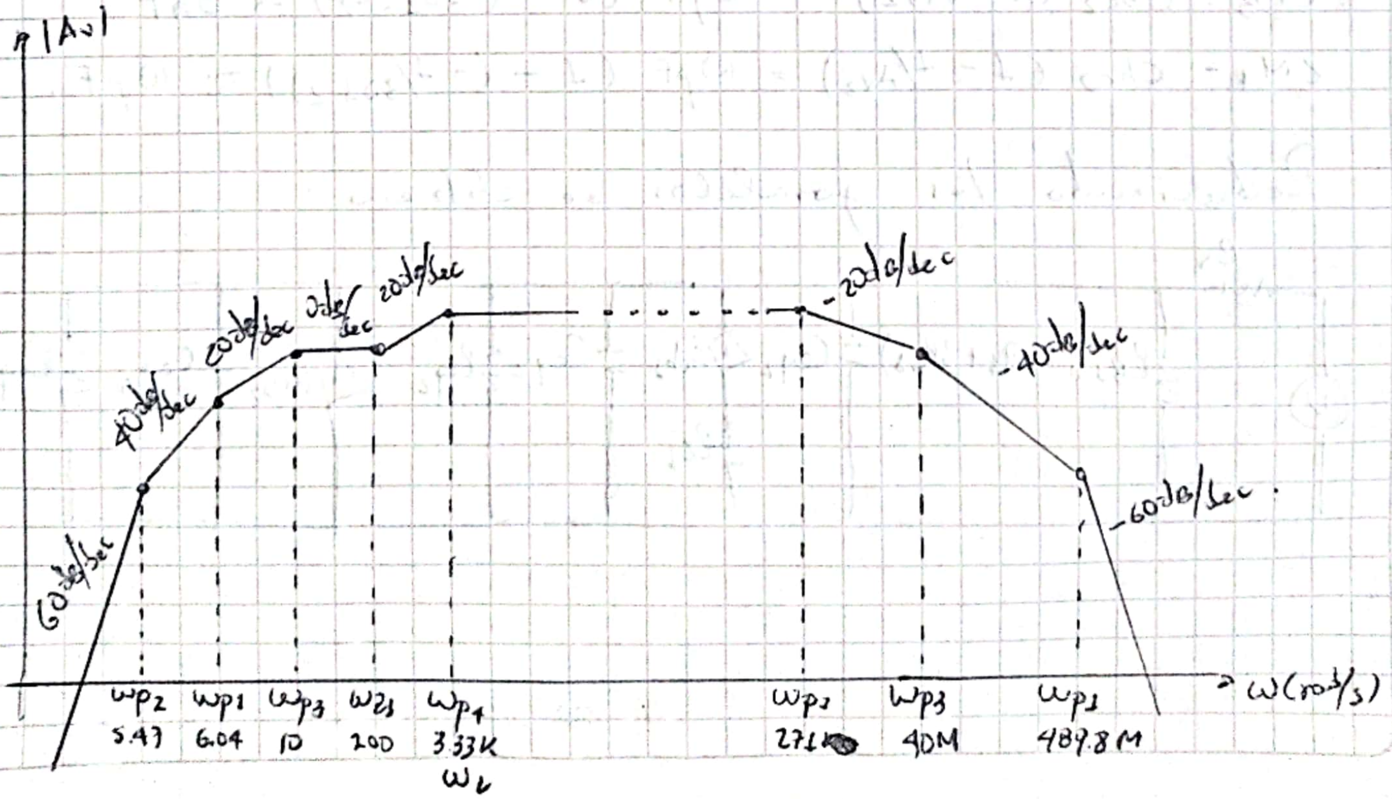
$$\omega_{p2} = \frac{1}{3nF \times 1.23K} = 271K\ rad/s. \quad \Rightarrow \boxed{\omega_H = 271 K rad/s.}$$

Polo para C_{eq_3} $\quad C_{eq_3} = C_{M_4} = 10pF$

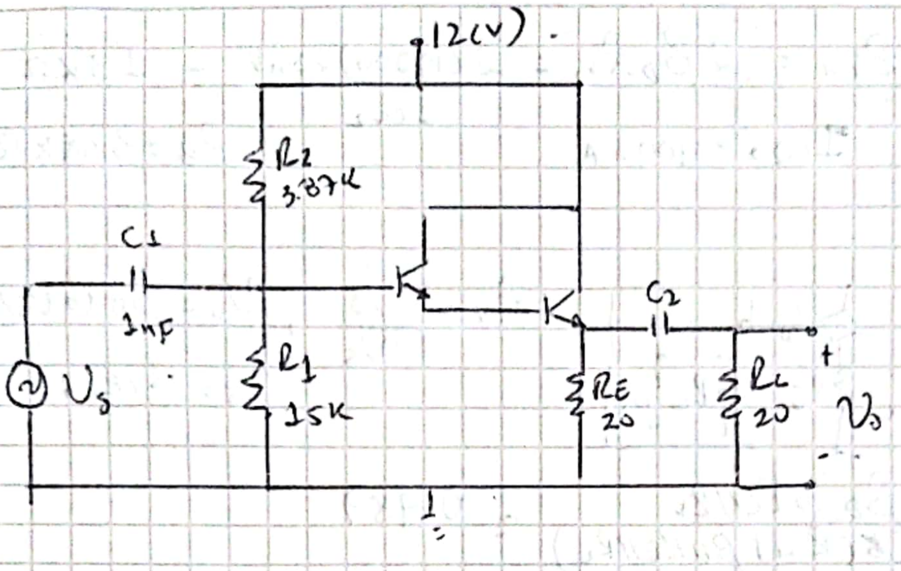
$$\omega_{p3} = \frac{1}{C_{eq_3} R_{eq_3}}, \quad R_{eq_3} = R_{C2} \parallel R_L = 2.5k\Omega.$$

$$\omega_{p3} = \frac{1}{10pF \times 2.5k\Omega} = 40\ M\ rad/s.$$

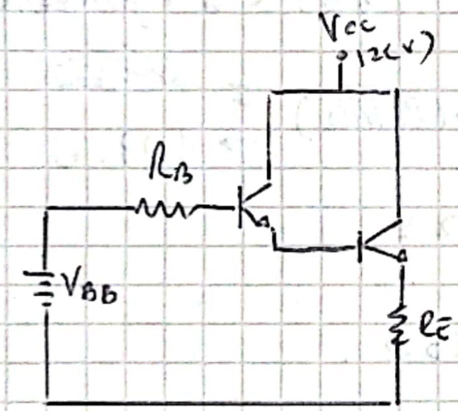
Respuesta en frecuencia.



2.



Análisis D.C



$R_B = R_1 // R_2 = 3.08 k\Omega$

$V_{BB} = \dfrac{V_{cc} R_1}{R_1 + R_2} = 9.53 (V)$

L.V.K malla de entrada

$V_{BB} = \dfrac{I_{CQ2}}{\beta_D} R_B + 2V_{BE} + I_{CQ2} R_E$

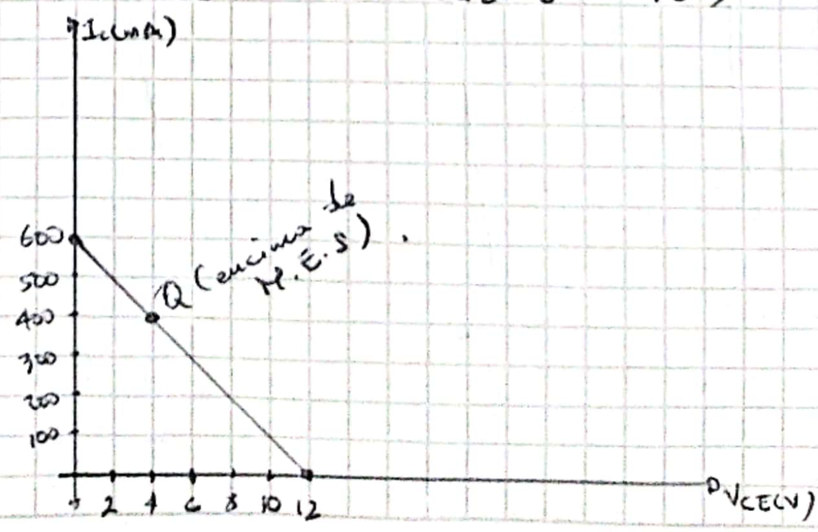
$\Rightarrow I_{CQ2} = \dfrac{V_{BB} - 2V_{BE}}{\dfrac{R_B}{\beta_D} + R_E} = 0.4 (A) = 400 mA$

L.V.K malla de salida:

$V_{cc} = V_{CE} + I_{CQ2} R_E \Rightarrow V_{CE} = V_{cc} - I_{CQ2} R_E = 4 (V)$

$I_{cmax} = \dfrac{V_{cc}}{R_E} = 600 mA$

$V_{CEmax} = V_{cc} = 12 (V)$



Escaneado con CamScanner

Análisis A.C $\quad R_{in} = 2\beta_D R_{e2} = \frac{2(10000)26mV}{I_{CQ2}} = 1.3k\Omega.$

$I_{CQ2} = 400mA \qquad R_B = 3.08k\Omega$

Modelo híbrido

$A_v = \frac{V_o}{V_s}$; $V_o = \beta_D i_b R_E \| R_L$

$V_s = i_b(R_{in} + \beta_D R_E \| R_L)$

$\Rightarrow A_v = \frac{V_o}{V_s} = \frac{\beta_D \cancel{i_b} R_E \| R_L}{\cancel{i_b}(R_{in} + \beta_D R_E \| R_L)} \approx 0.987$

$A_i = \frac{i_o}{i_i}$; $i_o = \frac{\beta_D i_b R_E}{R_E + R_L}$; pero $i_b = \frac{i_i R_B}{R_B + R_{in} + \beta_D(R_E \| R_L)}$

$\Rightarrow \frac{i_o}{i_i} = A_i = \frac{\beta_D R_E R_B}{(R_E + R_L)(R_B + R_{in} + \beta_D(R_E \| R_L))} = 147.6$

$Z_{in} = [R_{in} + \beta_D(R_E \| R_L)] \| R_B \approx 3k\Omega.$

$Z_{out} = \frac{R_{in}}{\beta_D} \| R_E = \frac{1.3k\Omega}{10000} \| 20 \approx 0.13\Omega.$