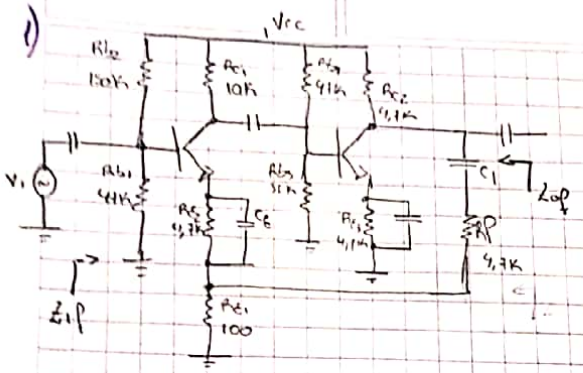
Realimentación negativa

HOJA N°

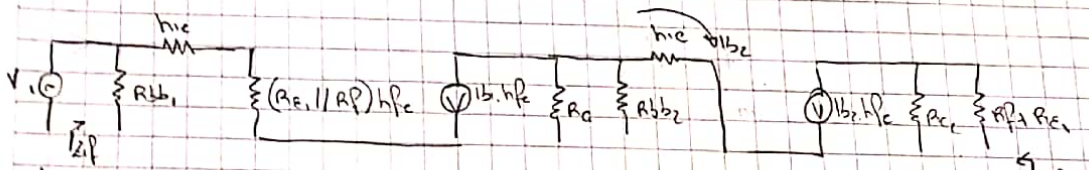
FECHA

1)



$R_s = 0$
$h_{fe} = 50$
$h_{ie} = 1,1k$

muestra tensión, mezcla serie

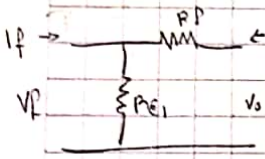


$$A_v = \frac{V_o}{V_1} = \frac{V_o}{I_{b2}} \cdot \frac{I_{b2}}{I_{b1}} \cdot \frac{I_{b1}}{V_i}$$

$$-I_{b2} h_{fe} \cdot [R_{c2} // (R_{f1} + R_{e1})] = V_o \rightarrow \frac{V_o}{I_{b2}} = -h_{fe} [R_{c2} // (R_{f1} + R_{e1})]$$

$$-I_{b1} h_{fe} [R_c // R_{bb2} // h_{ie}] \cdot \frac{1}{h_{ie}} = I_{b2} \rightarrow \frac{I_{b2}}{I_{b1}} = \frac{-h_{fe} [R_c // R_{bb2} // h_{ie}]}{h_{ie}}$$

$$I_{b1} \cdot [h_{ie} + (R_{e1} // R_f) h_{fe}] = V_1 \rightarrow \frac{I_{b1}}{V_1} = \frac{1}{h_{ie} + (R_{e1} // R_f) h_{fe}}$$



$$\beta = \frac{V_f}{V_o} = \frac{V_f}{V_{bf}}\Big|_{I_f = 0} = \frac{R_{e1}}{R_{f1} + R_{e1}}$$

$$V_{bf} = I_{bf}(R_f + R_{e1}) \qquad V_f = I_{bf} R_{e1}$$

$$\frac{V_{bf}}{R_{f1} + R_{e1}} = \frac{V_f}{R_{e1}} \rightarrow \frac{V_f}{V_{bf}} = \frac{R_{e1}}{R_{f1} + R_{e1}}$$

$$A_{vf} = \frac{A_v}{1 + A_v \beta} = \frac{A_v}{D}$$

$$Z_i = R_{bb1} // [h_{ie} + (R_{e1} // R_f) h_{fe}] \qquad Z_{if} = Z_i \cdot D$$

$$Z_o = R_{c2} // (R_{f1} + R_{e1}) \qquad Z_{of} = \frac{Z_o}{D}$$

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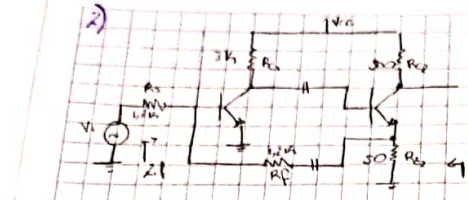
2)

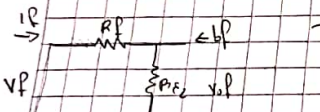


$A_1 = \frac{V_o}{V_i} = \frac{V_o}{I_{b2}} \frac{I_{b2}}{I_{b1}} \frac{I_{b1}}{I_i}$

$-I_{b2} h_{fe} = V_o \rightarrow \frac{V_o}{I_{b2}} = -h_{fe}$

$-I_{b1} h_{fe} \left\{ R_{c1} // \left[h_{ie} + (R_f // R_{E2}) h_{fe} \right] \right\} \frac{1}{h_{ie} + (R_f // R_{E2}) h_{fe}} = I_{b2} \rightarrow \frac{I_{b2}}{I_{b1}} = \frac{-h_{fe} \; R_{c1} // \left[h_{ie} + (R_f // R_{E2}) h_{fe} \right]}{h_{ie} + (R_f // R_{E2}) h_{fe}}$

$I_i \left\{ \left[R_S // (R_f + R_{E2}) // h_{ie} \right] \frac{1}{h_{ie}} \right\} = I_{b1} \rightarrow \frac{I_{b1}}{I_i} = \frac{R_S // (R_f + R_{E2}) // h_{ie}}{h_{ie}}$



$\beta = \frac{I_i}{I_f} = \frac{I_f}{I_{of}} \Big|_{V_f = 0}$

$V_{of} = I_{of} (R_{c2} // R_f)$

$V_{of} = I_f \cdot R_f$

$I_{of} (R_{c2} // R_f) = I_f R_f \rightarrow \frac{I_f}{I_{of}} = \frac{R_{c2} // R_f}{R_f} = \frac{R_{c2} \; R_f}{R_{c2} + R_f} \frac{1}{R_f}$

$A_f \quad \frac{A}{1 + \beta A} = \frac{A}{D}$

$Z_i = R_S // (R_f + R_{E2}) // h_{ie}$

$Z_{if} = \frac{Z_i}{D}$

$Z_o = R_{c2}$

$Z_{of} = Z_o \cdot D$

NOTA

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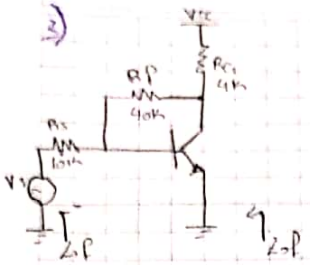
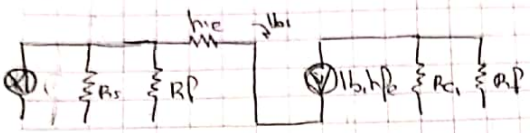
2)



hie: 1,1k
hfe: 50



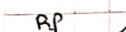
$S = \frac{V_s}{R_s}$

$$R_m = \frac{V_o}{I_s} = \frac{V_o}{I_{b1}} \cdot \frac{I_{b1}}{I_s}$$

$$-I_{b1}\, h_{fe}\, (R_c \parallel R_f) = V_o \rightarrow \frac{V_o}{I_{b1}} = -h_{fe}\,(R_c \parallel R_f)$$

$$I_s \cdot (R_s \parallel R_f \parallel h_{ie}) \cdot \frac{1}{h_{ie}} = I_{b1} \rightarrow \frac{I_{b1}}{I_s} = \frac{R_s \parallel R_f \parallel h_{ie}}{h_{ie}}$$

If



Vf

$$\beta = \frac{I_s}{V_o} = \frac{I_f}{V_{of}} = \frac{-1}{R_f} \qquad V_{of} = I_f R_f \rightarrow \frac{I_f}{V_{of}} = \frac{-1}{R_f}$$

$$R_{mf} = \frac{R_m}{1 + \beta R_m} = \frac{R_m}{D}$$

$Z_i = R_s \parallel R_f \parallel h_{ie}$ $\qquad Z_{if} = Z_i / D$

$Z_o = R_f \parallel R_{c1}$ $\qquad Z_{of} = Z_o / D$

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4)

Diseño

$G_{mf} = -1\ mA/V$

$A_{vf} = -4$

$D = 50$

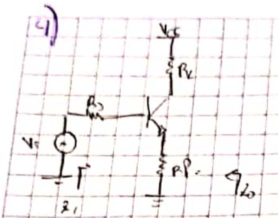
$h_{fe} = 150$

$R_s = 1k$

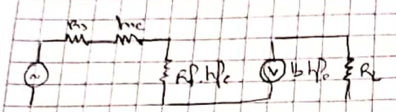
Muestra corriente realimentación

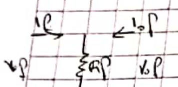
Calcular: R_L, R_{ie} = RP, R_f, I_{co}

Dudas: $P = h_{ie}$? ...



$$G_{mf} = \frac{G_m}{D} \rightarrow G_m = G_{mf} \cdot D = -50\ mA/V$$





$$\beta = \frac{V_f}{I_L} = \frac{V_f}{I_f} = -R_f$$

$$V_f = I_f \cdot R_f \quad V_f = -I_f \cdot R_f \rightarrow \frac{V_f}{I_f} = -R_f$$

$$\beta = -R_f \quad G_{mf} = \frac{G_m}{D} = \frac{G_m}{1+G_m\beta} \rightarrow 1+G_m\beta = \frac{G_m}{G_{mf}} \rightarrow \beta = \frac{G_m}{G_{mf}\,G_m} - \frac{1}{G_m} = \frac{1}{G_{mf}} - \frac{1}{G_m}$$

$$\beta = \frac{1}{G_{mf}} - \frac{1}{G_m} = -980 \quad \therefore \boxed{R_f = 980 \approx 1k}$$

$$G_m = \frac{I_L}{V_s} = \frac{I_L}{I_{b1}} \cdot \frac{I_{b1}}{V_s}$$

$$-I_{b1} \cdot h_{fe} = I_L \rightarrow \frac{I_L}{I_{b1}} = -h_{fe}$$

$$(R_s + h_{ie} + R_f \cdot h_{fe})\, I_{b1} = V_s \rightarrow \frac{I_b}{V_s} = \frac{1}{R_s + h_{ie} + R_f h_{fe}}$$

$$\therefore G_m = -h_{fe} \cdot \frac{1}{R_s + h_{ie} + R_f \cdot h_{fe}} \rightarrow R_s + h_{ie} + R_f\, h_{fe} = \frac{-h_{fe}}{G_m} \rightarrow h_{ie} = \frac{-h_{fe}}{G_m} - R_s - R_f\, h_{fe}$$

Porque no multiplica por hfe??

$$G_m = -h_{fe} \cdot \frac{1}{R_s + h_{ie} + R_f} \quad \therefore \boxed{h_{ie} = 1k}$$

$$A_{vf} = G_{mf} \cdot R_L \rightarrow R_L = \frac{A_{vf}}{G_{mf}} = 4k \rightarrow \boxed{R_L = 4k}$$

$$Z_i = R_s + h_{ie} + R_f = 3k$$

$$\boxed{Z_{if} = Z_i \cdot D = 150k}$$

$$h_{ie} = \frac{h_{fe} \cdot 25mV}{I_{co}} \rightarrow \boxed{I_{co} = \frac{h_{fe} \cdot 25mV}{h_{ie}} = 3{,}9mA}$$

NOTA

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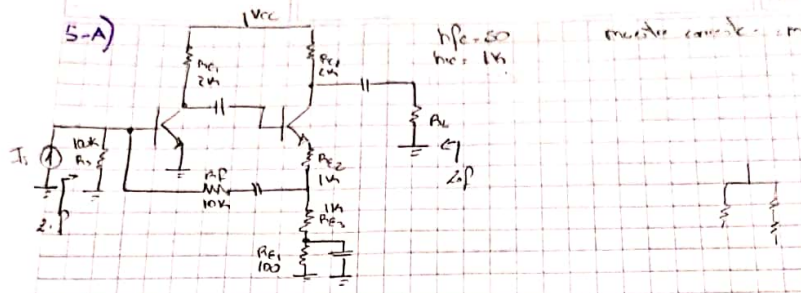
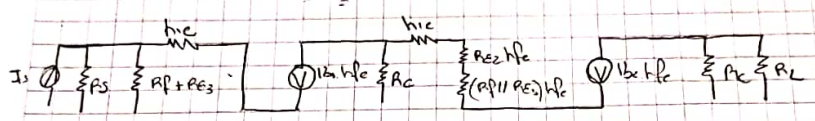
Anclars

5-A)



$h_{fe} = 50$
$h_{ie} = 1k\Omega$

muestra cómo se hace el modelo

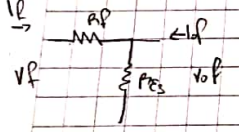


$$A_1 = \frac{I_L}{I_S} = \frac{I_L}{I_{b2}} \cdot \frac{I_{b2}}{I_{b1}} \cdot \frac{I_{b1}}{I_S}$$

$$-I_{b2} h_{fe} \cdot (R_C // R_L) \frac{1}{R_L} = I_L \rightarrow \frac{I_L}{I_{b2}} = -h_{fe} \frac{(R_C // R_L)}{R_L}$$

$$-I_{b1} h_{fe} \; R_C // \left[h_{ie} + R_{E2} h_{fe} + (R_F // R_{E1}) h_{fe} \right] \frac{1}{h_{ie} + R_{E2} h_{fe} + (R_F // R_{E1}) h_{fe}} = I_{b2}$$

$$I_S \cdot \left[R_S // (R_F + R_{E1}) // h_{ie} \right] \frac{1}{h_{ie}} = I_{b1} \rightarrow \frac{I_{b1}}{I_S} = \frac{R_S // R_F + R_{E1} // h_{ie}}{h_{ie}}$$



$$D = \frac{I_b}{I_i} = \frac{I_f}{I_{bf}} \Big|_{If=0}$$

$$V_{of} = (R_{E1} // R_F)\, I_{bf}$$

$$V_{of} = I_f \cdot R_f$$

$$I_{bf}(R_{E1} // R_F) = I_f R_F$$

$$\frac{I_f}{I_{bf}} = \frac{R_{E1} // R_F}{R_F} = \frac{R_{E1} \cdot R_F}{R_F + R_{E1} \cdot R_F}$$

$$A_{1f} = \frac{A_1}{1 + A_1 \beta} = \frac{A_1}{D}$$

$$Z_i = R_S // R_F + R_{E1} // h_{ie}$$

$$Z_{if} = Z_i / D$$

$$Z_o = R_C // R_C$$

$$Z_{of} = Z_o \cdot D$$

NOTA

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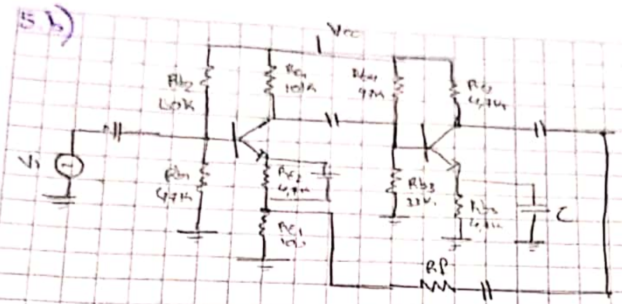
5 b)



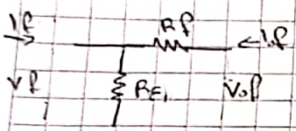
Muestra tensión - mezcla serie

$A_{vf} = 4,55$

$\Delta A_{vf} = 0,27\%$

$\Delta A_v = 5\%$

$A_{vf} = \frac{A_v}{D}$ $\therefore$ $\Delta A_{vf} = \frac{\Delta A_v}{D} \rightarrow D = \frac{\Delta A_v}{\Delta A_{vf}} = 184$ $\therefore$ $A_v = A_{vf} \cdot D = 837,63$



$\beta = \frac{V_f}{V_L} = \frac{V_f}{V_{of}} \bigg|_{I_f = 0}$

$V_{of} = (R_f + R_{E1})\, I_f$

$V_f = R_{E1}\, I_f$

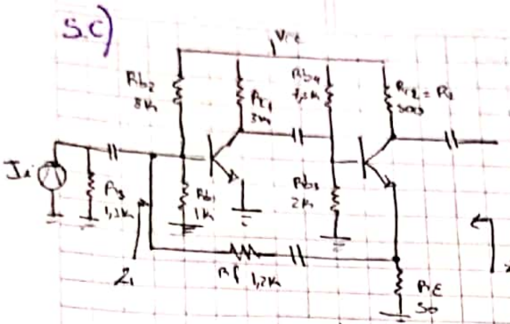
$\frac{V_{of}}{R_f + R_{E1}} = \frac{V_f}{R_{E1}} \rightarrow \frac{V_f}{V_{of}} = \frac{R_{E1}}{R_f + R_{E1}}$

$A_{vf} = \frac{A_v}{1 + A_v \beta} \rightarrow 1 + A_v\beta = \frac{A_v}{A_{vf}} \rightarrow \beta = \left(\frac{A_v}{A_{vf}} - 1\right)\frac{1}{A_v} = \frac{1}{A_{vf}} - \frac{1}{A_v}$

$\beta = \frac{R_{E1}}{R_f + R_{E1}}$ $\therefore$ $\left(\frac{1}{A_{vf}} - \frac{1}{A_v}\right) = \frac{R_{E1}}{R_f + R_{E1}} \rightarrow R_f + R_{E1} = \frac{R_{E1}}{\left(\frac{1}{A_{vf}} - \frac{1}{A_v}\right)} \rightarrow R_f = \frac{R_{E1}}{\left(\frac{1}{A_{vf}} - \frac{1}{A_v}\right)} - R_{E1} = 4700$

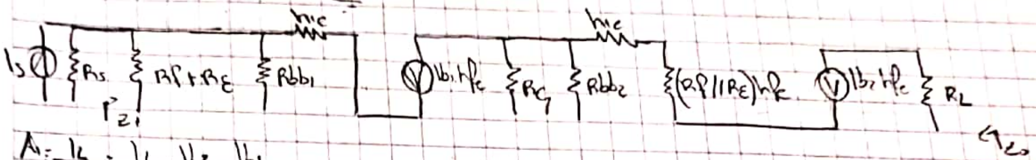
$\therefore$ $\boxed{R_f = 4700\,\Omega}$

5.c)



hfe = 50
hie = 1,1k

muestra corriente - realimentación paralelo



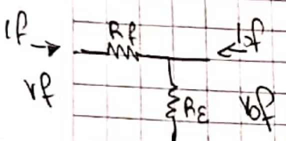
$A_i = \frac{I_L}{I_s} = \frac{I_L}{I_{b2}} \cdot \frac{I_{b2}}{I_{b1}} \cdot \frac{I_{b1}}{I_s}$

$-I_{b2}\, h_{fe} = I_L \rightarrow \frac{I_L}{I_{b2}} = -h_{fe}$

$3k // 1578 // (1,1k + (48)50) = 798$ (3500)

$-I_{b1} h_{fe} \cdot \{ R_{C1} // R_{bb2} // [h_{ie} + (R_f // R_E) h_{fe}] \} \frac{1}{h_{ie} + (R_f // R_E) h_{fe}} = I_{b2} \quad \therefore \frac{I_{b2}}{I_{b1}} = -11{,}40$

$I_s \cdot [R_s // (R_f + R_E) // R_{bb1} // h_{ie}] \frac{1}{h_{ie}} = I_{b1}$



$\beta = \left.\frac{I_f}{I_L}\right|_{V_f = 0} = \frac{R_E}{R_E + R_f}$

$V_{of} = R_E // R_f \; I_{of}$
$V_f = R_f I_f$

$I_{of}\; R_E // R_f = I_f\; R_f$

$\frac{I_f}{I_{of}} = \frac{R_E // R_f}{R_f} = \frac{R_E}{R_E + R_f}$

$A_{if} = \frac{A_i}{1 + \beta A_i} = \frac{A_i}{\beta}$

$Z_i = (R_f + R_E) // R_{bb1} // h_{ie}$

$Z_{if} = Z_i / D$

$Z_o = R_L$

$Z_{of} = Z_o D$

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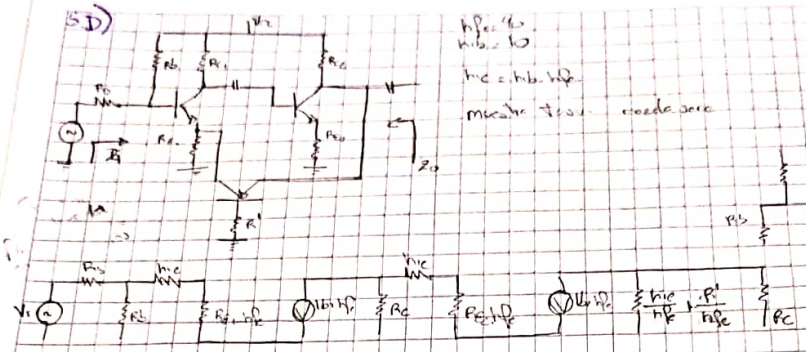
5D)



$h_{fe} = \beta$

$h_{ib} = h_b$

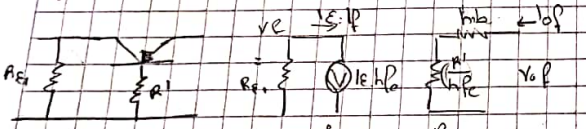
$h_{ie} = h_{ib} \cdot h_{fe}$

$$A_v = \frac{V_L}{V_S} = \frac{V_L}{I_{b2}} \cdot \frac{I_{b2}}{I_{b1}} \cdot \frac{I_{b1}}{V_S}$$

$$-I_{b2} \cdot h_{fe}\left[\left(\frac{h_{ie}}{h_{fe}} + \frac{R'}{h_{fe}}\right) /\!/ R_c\right] I_L \rightarrow \frac{V_L}{I_{b2}} = -h_{fe}\left[\left(\frac{h_{ie}}{h_{fe}} + \frac{R'}{h_{fe}}\right) /\!/ R_c\right]$$

$$-I_{b1} \cdot h_{fe} \; R_c /\!/ (h_{ie} + R_{e2} \cdot h_{fe}) \cdot \frac{1}{h_{ie} + R_{e2} \cdot h_{fe}} = I_{b2} \rightarrow \frac{I_{b2}}{I_{b1}} = -\frac{h_{fe}}{R_{e2} h_{fe} + h_{ie}} R_c /\!/ (h_{ie} + R_{e2} \cdot h_{fe})$$

$$\frac{V_i}{h_{ie} + R_{e1} \cdot h_{fe}} = I_{b1} \rightarrow \frac{I_{b1}}{V_i} = \frac{1}{h_{ie} + R_{e1} \cdot h_{fe}}$$



$$\beta = \frac{V_S}{V_L} = \frac{V_{of}}{V_o}\Big|_{I_f = 0} =$$

$$V_{of} = I_{of}\left(h_{ib} + R'/h_{fe}\right)$$

$$V_f = I_{of} \cdot R_{e1}$$

$$I_{of}\left(h_{ib} + R'/h_{fe}\right) = \frac{V_f}{R_{e1}}$$

$$\frac{V_f}{V_{of}} = \frac{R_{e1}}{\left(h_{ib} + \frac{R'}{h_{fe}}\right)}$$

$$A_{vf} = \frac{A_v}{1 + A_v \beta}$$

$$Z_i = \left[R_b /\!/ h_{ie} + R_{e1} \cdot h_{fe}\right] \cdot \; \rightarrow$$ [illegible]

$$Z_o = R_c /\!/ \left(h_{ib} + \frac{R'}{h_{fe}}\right)$$

$$Z_{if} = Z_i \cdot D$$

$$Z_{of} = Z_i / D$$

NOTA

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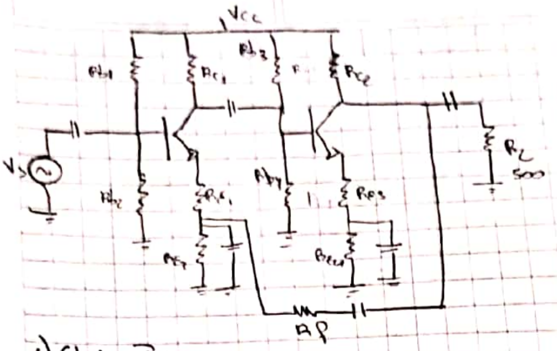
Diseño. (cambiar algo para MES)



$A_{vf} = 12$
$f = 1, 3k, 4k2$
$\Delta A_{vf} = 3\%$
$\Delta A_v = 45\%$
$V_{cc} = 23V$

muestra tensión - mezcla serie

1) Calculo B

$S = \frac{\Delta A_{vf}}{\Delta A_v}$ $D = \frac{1}{S} = \frac{\Delta A_v}{\Delta A_{vf}} = \frac{45}{3} = 15 \rightarrow \boxed{D = 15}$ $\therefore A_{vf} = \frac{A_v}{D} \rightarrow A_v = A_{vf} D = 180$ $\boxed{A_v = 180}$

$A_{vf} = \frac{A_v}{1 + A_v \beta} \rightarrow 1 + A_v\beta = \frac{A_v}{A_{vf}} \rightarrow \beta = \frac{A_v}{A_{vf} \cdot A_v} - \frac{1}{A_v} = 0{,}077 \rightarrow \boxed{\beta = 0{,}077}$

2) Análisis de EC para la segunda etapa amplificadora

Definimos $I_{cq_2} = 5mA$, $V_{ceq_2} = 10V$, $V_{cc} = 22V$

$V_E = \frac{V_{cc}}{10} = I_{cq}(R_{E_3} + R_{E_4}) \rightarrow R_{E_3} + R_{E_4} = \frac{V_{cc}}{10 \cdot I_{cq}} =$

$V_{cc} - I_{cq_2} R_{c_2} - V_{CEQ} - I_{cq}(R_{E_3} + R_{E_4}) = 0$

$R_{c_2} = \frac{V_{cc} - V_{CEQ} - I_{cq}(R_{E_3} + R_{E_4})}{I_{cq_2}}$

$R_{bb_2} = \frac{\beta (R_{E_3} + R_{E_4})}{10} =$

$V_{bb} = I_{cq_2}(R_{bb_2}) - V_{bE} - I_{cq}(R_{E_3} + R_{E_4}) \rightarrow R_{b_4} = \frac{R_{bb_2}}{1 - \frac{V_{bb}}{V_{cc}}} =$ $R_{b_3} = \frac{R_{bb_2}}{V_{bb}/V_{cc}} =$

P/ MES

Con $R_{E_3} = 0$ P/ RCA

$I_{cq_{2(MES)}} = \frac{V_{cc}}{R_{cc} + R_{CA}} = \frac{V_{cc}}{(R_{c_2} + R_{E_3}) + (R_{c_2} // R_L)}$

$V_{bb_{2(MES)}} = I_{cq_{2(MES)}}\left(R_{bb_2} - (R_{E_3} + R_{E_4})\right) - V_{bE}$ $\therefore R_{b_4} = \frac{R_{bb_2}}{1 - \frac{V_{bb_{2(MES)}}}{V_{cc}}} =$

$h_{ie_2} = \frac{25mV \, h_{fe}}{I_{cq_{2(MES)}}}$ $R_{b_3} = \frac{R_{bb_2}}{\frac{V_{bb_{2(MES)}}}{V_{cc}}} =$

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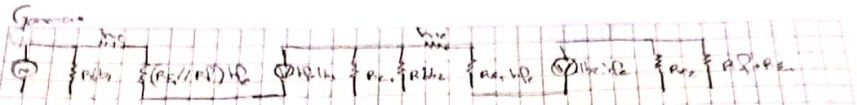

$$A_V = \frac{V_c}{V_s} = \frac{V_{b2}}{I_{b2}} \cdot \frac{I_{b2}}{I_{b1}} \cdot \frac{I_{b1}}{V_1}$$

$$-I_{b2} \cdot I_{b2} \cdot (R_{c2} // (R_2 + R_6)) = V_c \rightarrow \frac{V_c}{I_{b2}} = +I_{b2} \cdot [R_{c2} // (R_2 + R_6)]$$

$$-I_{b2} \cdot I_{b2} \{R_{c1} // R_{b2} // (h_{ie} + R_3 \cdot h_{fe})\} \frac{1}{h_{ie} + R_3 \cdot h_{fe}} = I_{b2}$$

$$\frac{V_2}{h_{ie} + (R_{c1} // R_2) \cdot h_{fe}} = I_{b1} \rightarrow \frac{I_{b1}}{V_s} = \frac{1}{h_{ie} + (R_{c1} // R_2) \cdot h_{fe}}$$

NOTA

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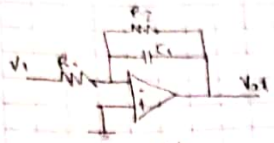
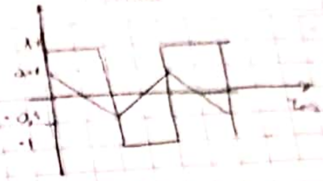
Integrador



$f = 1KHz$
$V_{ip} = 1V$
$V_{pp} = 1V$

Onda triangular



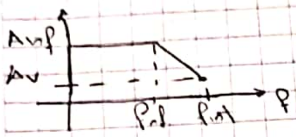
$V_{opp} = \frac{V_{ip}}{R_1C}\int_0^{T/2} dt = \frac{V_{ip}\cdot T}{2R_1C} \rightarrow A_v = \frac{V_{opp}}{V_{ip}} = \frac{T}{2R_1C} = 1$

Si $R_1 = 10K$

$C_1 = \frac{T}{A_v 2 R_1} = 0{,}05\mu F$

$f_{inf} = \frac{f}{10} = \frac{1k}{10} = 100Hz$

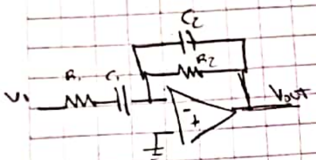
$A_v \cdot f = A_{vinf} \cdot f_{inf} \rightarrow A_{vinf} = \frac{A_v f}{f_{inf}} = \frac{R_2}{R_1} \rightarrow R_2 = A_{vinf} R_1 = 5K$



$f_{inf} = \frac{1}{2\pi R_2 C_1} = 31{,}8 Hz$

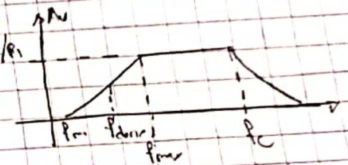
$f_{int} = \frac{1}{2\pi R_1 C_1} = 318 Hz$

Derivador



$R_1 = 10K$
$V_{op} = 5V$
$V_{ip} = 2V$
$f_{der} = 3KHz$

Onda seno



$f_{der} = \frac{f_{max}}{10}$ $\quad f_{max} = \frac{1}{2\pi R_1 C_1}$ $\quad f_{min} = \frac{1}{2\pi R_2 C_1}$ $\quad f_c = \frac{1}{2\pi R_2 C_2}$

$f_{max} = f_{der} \cdot 10 = 3K \cdot 10 = 30K$

$C_1 = \frac{1}{f_{max} \cdot R_1 \cdot 2\pi} = 0{,}56nF \rightarrow C_1 = 0{,}56nF$

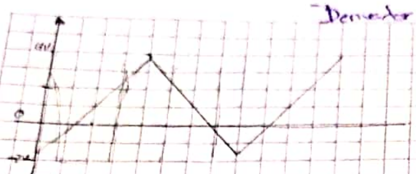
$V_o(t) = -R_2 C_1 \frac{d(v_1(t))}{dt} = -R_2 C_1 (V_{ip} \cdot \cos\omega t)\omega = 2\omega R_2 C_1 \rightarrow -5 = -2\omega R_2 C_1 \rightarrow R_2 = \frac{+5}{2\omega C_1} = 24{,}9K\Omega$

Si $f_c = 50K$

$f_c = \frac{1}{2\pi R_2 C_2} \rightarrow C_2 = \frac{1}{2\pi f_c R_2} = 13pF \rightarrow C_2 = 13pF$

$A_v = \frac{-R_2}{R_1} = -24{,}9$

Derivador onda triangular



$V_1 \rightarrow -1{,}5 \text{ a } 4 \rightarrow V_{ipp} = 5{,}5\,V$

$f_{deriv} = 4{,}3k$

$R_1 = 4{,}7k$

$V_0(t) = 3V$

$(0 ; -1{,}5)$

$(116\mu ; 4)$

$$f_{deriv} = \frac{f_{max}}{10} \rightarrow f_{max} = f_{deriv} \cdot 10 = 43k$$

$$f_{max} = \frac{1}{2\pi R_1 C_1} \rightarrow C_1 = \frac{1}{2\pi f_{max} R_1} = 1nF \rightarrow \boxed{C_1 = 1nF}$$

$$\frac{X - X_1}{X_2 - X_1} = \frac{Y - Y_1}{Y_2 - Y_1} \qquad \frac{X - 0}{116\mu - 0} = \frac{Y - (-1{,}5)}{4 + 1{,}5} \Rightarrow \frac{X}{116\mu} = \frac{Y + 1{,}5}{5{,}5} \rightarrow Y + 1{,}5 = \frac{X \cdot 5{,}5}{116\mu}$$

$$Y = \frac{5{,}5 X}{116\mu} - 1{,}5 \quad \therefore \quad V_1 = \frac{5{,}5}{116\mu} X - 1{,}5$$

$$V_0(t) = -R_2 C_1 \frac{d(V_1)}{dt} = -R_2 C_1 \frac{d(5{,}5/116\mu \; X - 1{,}5)}{dt} = -R_2 C_1 \left(\frac{5{,}5}{116\mu}\right) \rightarrow V_0(t) = -R_2 C_1 \, 47498$$

$$\therefore R_2 = \frac{V_0}{C_1 \cdot 47413{,}8} = 63k \quad \rightarrow \boxed{R_2 = 63k}$$

$$f_c = \frac{1}{2\pi R_2 C_2} \qquad \text{si } f_c = 50k \qquad C_2 = \frac{1}{f_c \, 2\pi \cdot R_2} = 56pF \quad \rightarrow \boxed{C_2 = 56pF}$$

NOTA

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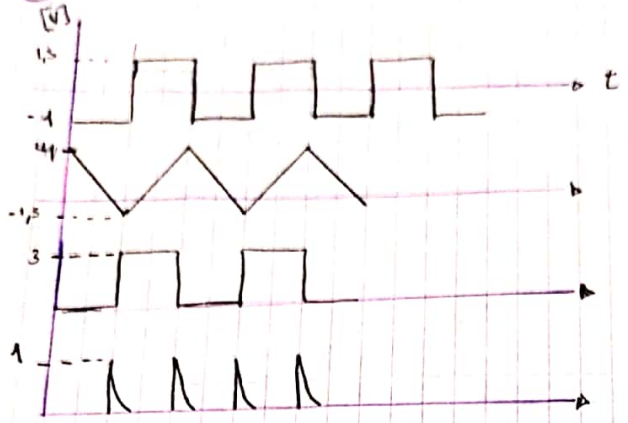
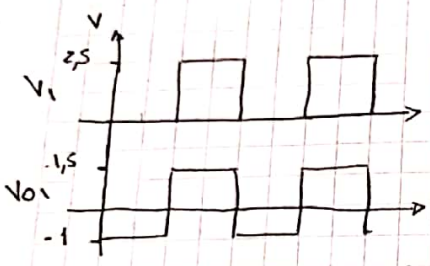
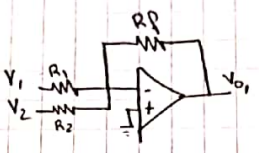
f = 4300 Hz $R_1 = 2_1 = 15\,k\Omega$

(3)





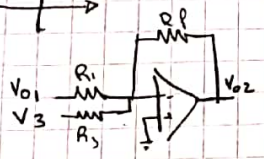


$V_1 = 2,5V$
$V_2 = -1,5V$

$R_1 = R_2 = RP = 1k$

$V_o = -RP\left(\frac{V_1}{R_1} + \frac{V_2}{R_2}\right) = -V_1 - V_2 = -2,5 + 1,5 = -1V$

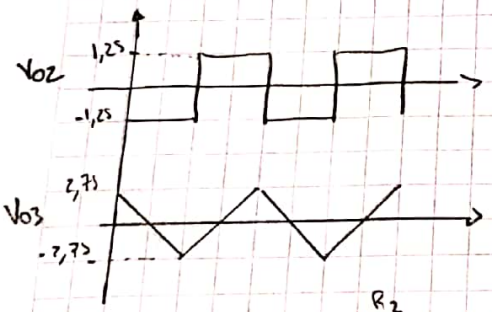
La hago Simetrica



V_{01}
$V_1 = 1,5$
$V_3 = -0,25$

$RP = R_1 = R_3$

$V_{02} = -RP\left(\frac{V_{01}}{R_1} + \frac{V_3}{R_3}\right) = -(1,5 - 0,25) = -1,25V$

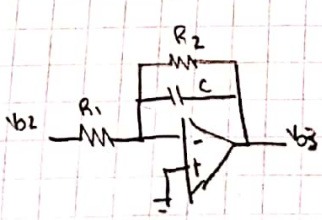


$V_{1p} = 1,25$; $f = 4,3k$
$V_{opp} = 5,5V$; $T = 0,232\,ms$

$A_V = \frac{V_{opp}}{V_{1p}} = 4,25$

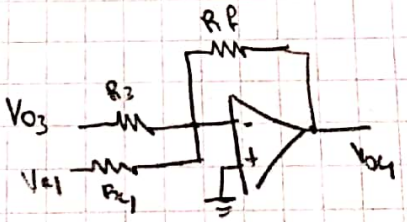
$C = 10\,n$

$A_V = \frac{1}{2 \cdot R_1 \cdot C} \rightarrow R_1 = \frac{1}{2 A_V \cdot C} = 2735,9\,\Omega \rightarrow$ **$R_1 = 2735,9\,\Omega$**



$f_{inf} = \frac{f}{10} = 430$ $A_V \cdot f = A_{inf} \cdot f_{inf} \rightarrow A_{inf} = \frac{A_V \cdot f}{f_{inf}} = 42,5$

$A_{V\,inf} = \frac{R_2}{R_1} \rightarrow R_2 = A_{V\,inf} \cdot R_1 = 116,27\,k\Omega \rightarrow$ **$R_2 = 116,27\,k\Omega$**



$V_1 = V_3 = 2,75$
$V_4 = -1,25$

$RP = R_3 = R_1$

$V_{04} = -RP\left(\frac{V_{03}}{R_3} + \frac{V_4}{R_4}\right)$

$V_{04} = -(2,75 - 1,25) = -1,5V$

NOTA

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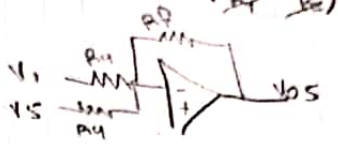
$V_1 = V_{o1} = 4V$

$V_5 = -1,25V$

$R_F = R$

$V_{o5} = -R_F\left(\frac{V_{o1}}{R_1} + \frac{V_5}{R_5}\right) = -(4 - 1,25) = -2,75V$



$V_1 = 2,75$

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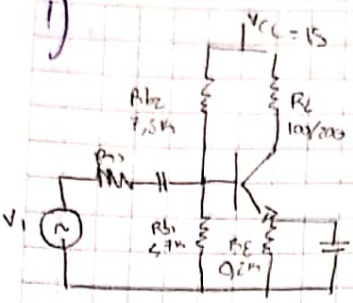
Repaso de Frec. R.f

1)

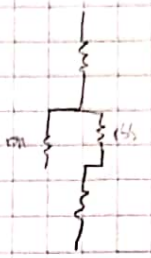


hfe: 80
rbb: 30
Rs: 50Ω
Cbc: 2,5 pF
fT: 150 mHz

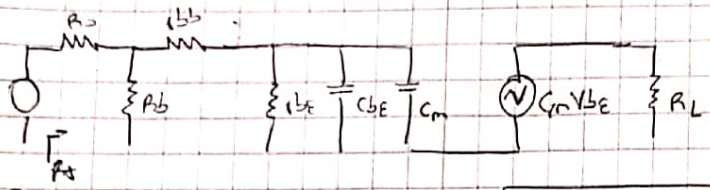
Calcular $f_{H_i}|_{R_L=100}$

Av. $|_{R_L=100}$

$R_b = R_{b1} // R_{b2} = 1,9K$



Alta Frec.



$f_h = \frac{1}{2\pi . R_T C_T} = 5,66\ mHz \rightarrow \boxed{f_h = 5,66\ mHz}$

$C_T = C_m + C_{be} = 148,62\ pF$

$C_m = C_{bc}(1 + g_m . R_L) = 442,5\ pF$

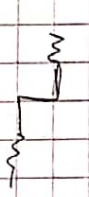
$R_T = [[(R_s // R_b) + r_{bb}] // r_{be}] = 104$

$g_m = \frac{I_{cQ}}{25mV} = 0,57$

$r_{be} = \frac{2mV . \beta}{I_{cQ}} = 138$

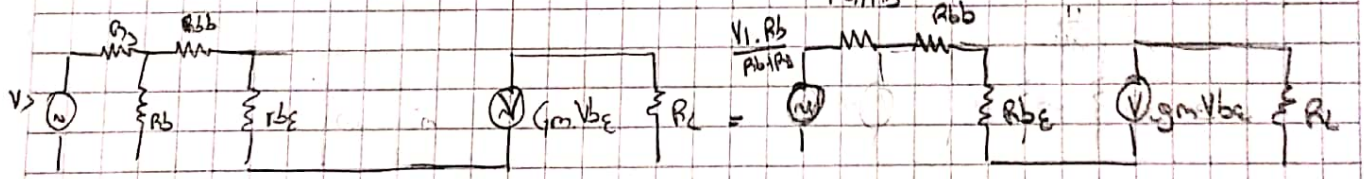
$I_{cQ} = \frac{V_{BB} - V_{be}}{R_b/\beta + R_E} = 14,48\ mA$

$V_{BB} = \frac{V_{cc} R_{b1}}{R_{b1} + R_{b2}} = 3,97\ V$



$C_{be} = \frac{g_m}{2\pi f_T} = 122,91\ nF$

Frecuencias medias



$A_V = \frac{V_L}{V_i} = \frac{V_L}{V_{be}} \frac{V_{be}}{V_s}$

$-G_L V_{be} R_E V_L \rightarrow \frac{V_L}{V_{be}} = g_m R_L$

$\frac{V_i R_b}{R_b + R_s} = \frac{1}{(R_s // R_b) + r_{bb} + r_{be}} . R_{be} = V_{be} \rightarrow \frac{V_{be}}{V_i} = \frac{R_b}{(R_b + R_s)} \frac{R_{be}}{[(R_s // R_b) + r_{bb} + r_{be}]} = 0,19$

395,8

NOTAS:

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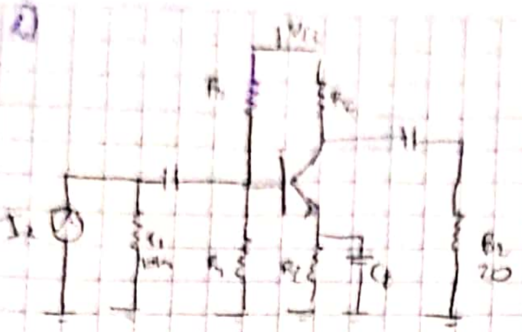
2)

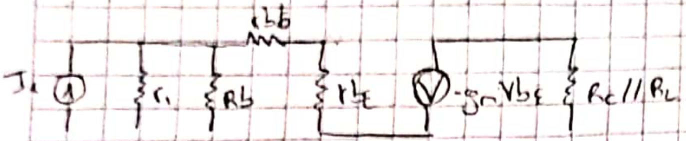


Rb = 2k
Cbe = 20 pF
rbb = 80
gm = 0,3 S
rbe = 100
Cbc = 2p
Rc >> RL

Rc ≈ RL

Calc la: Aim, fh

Frec medias

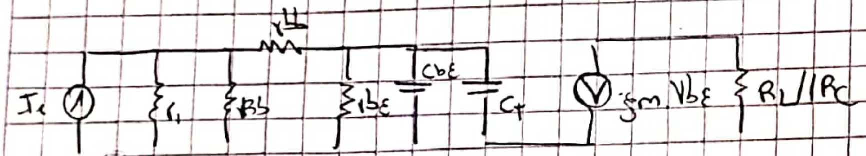


$A_{im} = \frac{I_L}{I_i} = \frac{I_L}{V_{bE}} \cdot \frac{V_{bE}}{I_i}$

$-gm\, V_{bE} = I_L \rightarrow \frac{I_L}{V_{bE}} = -gm$

$I_i \cdot r_1 // R_b // (r_{bb} + r_{bE}) \cdot \frac{1}{r_{bb} + r_{bE}} \cdot r_{bE} = V_{bE} \rightarrow \frac{V_{bE}}{I_i} = \frac{r_1 // r_b // r_{bb} + r_{bE}}{(r_{bb} + r_{bE})} \cdot r_{bE}$

Alta frec



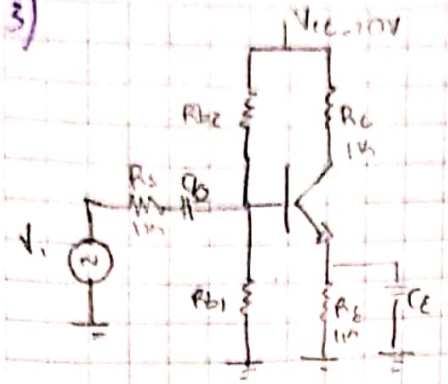
$f_h = \frac{1}{2\pi\, R_{eq}\, C_T} =$

$R_{eq} = \left[(r_1 // R_b) + r_{bb} \right] // r_{bE} = 158$

$C_T = C_m + C_{bE}$

$C_m = C_{bc}(1 + gm\, R_L) = 22p$

3)



Calcula Ce y Cb con $f_1 = 20\,Hz$

Rb: BK

rbb: 50

rbE: 150

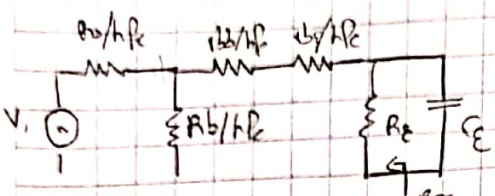
hfe: 110

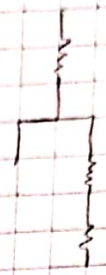
Cbc: 2pF

Cbe: 200p

gm: 0,5

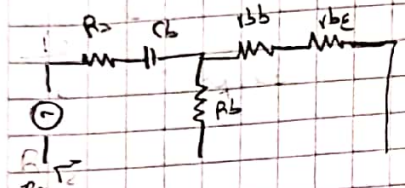
Polo dominante Ce





Cb orb $f_L = \frac{1}{2\pi \cdot Req \cdot Ce} \rightarrow Ce = \frac{1}{f_L \cdot 2\pi \cdot Req_1} = .307\,\mu F \rightarrow \boxed{Ce = 307\,\mu F}$

$Req_1 = \frac{(Rs // Rb) + (rbb + rbe)}{hfe} // Re = 26,5 \rightarrow \boxed{Req_1 = 26,5\,\Omega}$



Ce orb $f_L = \frac{1}{2\pi \cdot Req_2 \cdot Cb} \rightarrow Cb = \frac{1}{2\pi f_L Cb} = 66,58\,\mu F \rightarrow \boxed{Cb = 66,58\,\mu F}$

$Req_2 = (rbb + rbE) // Rb + Rs = 1195,12$

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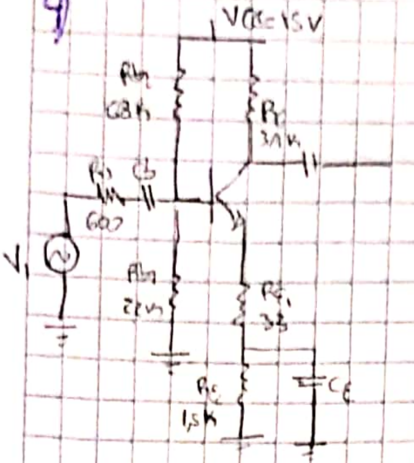
Analisis

4)



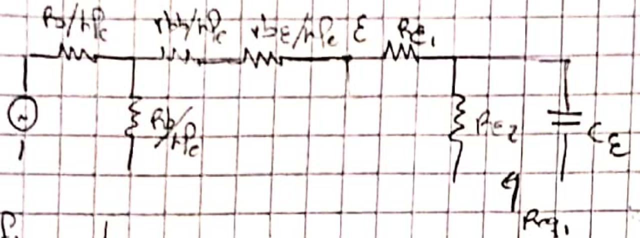
C_{e}, C_b = 100nF
C_f = 100 µF
C_{cc}, C_c = 330 nF

R_L 5,6k
h_{ie} = 1900
h_{fe} 200

$r_{bb'} + r_{b'e} = h_{ie}$

Calcular polo de frec. inferior
Dibujar diagrama de bode

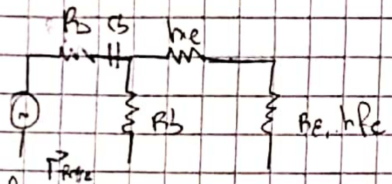
f_L debido C_E



$$f_{L_1} = \frac{1}{2\pi\, R_{eq_1}\, C_E} =$$

$$R_{eq_1} = \left[\frac{(R_s // R_b)}{h_{fe}} + \frac{h_{ie}}{h_{fe}} + R_{e_1}\right] // R_{e_2} = 44{,}09 \quad \therefore \rightarrow f_{L_1} = 39{,}09\ \text{Hz}$$

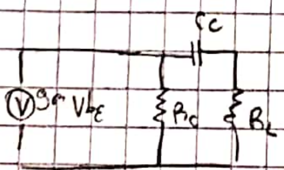
f_L debido Cb



$$f_L = \frac{1}{2\pi\, R_{eq_2}\, C_b} =$$

$$R_{eq_2} = \left[(R_{e_1} h_{fe} + h_{ie}) // R_b\right] + R_s = 6232{,}9\ \Omega \quad \therefore \rightarrow f_{L_2} = 255{,}38\ \text{Hz}$$

f_L debido C_c



$$f_L = \frac{1}{2\pi\, R_{eq}\, C_c}$$

$$R_{eq} = R_c // R_L = 9300 \quad \therefore \quad f_{L_3} = 50{,}8\ \text{Hz}$$

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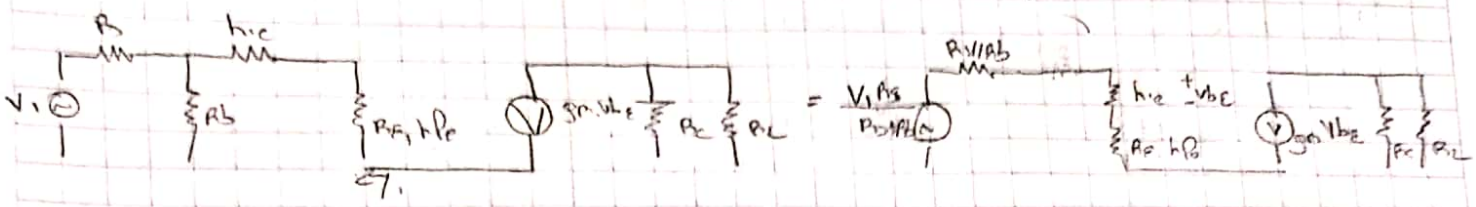
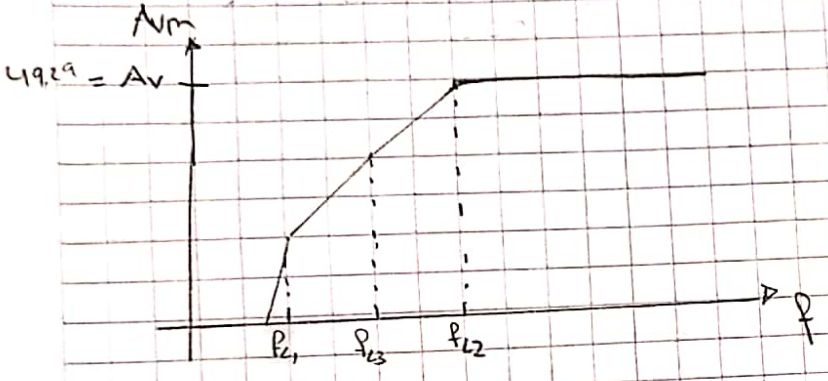
Diagrama de bode



$$Avm = \frac{V_L}{V_i} = \frac{V_L}{V_{be}} \cdot \frac{V_{be}}{V_i}$$

$$-g_m V_{be} R_c // R_L = V_L \rightarrow \frac{V_L}{V_{be}} = -g_m R_c // R_L$$

$$\frac{V_i}{R_s + R_b} \cdot \frac{R_s}{(R_s // R_b) + h_{ie} + R_E \cdot h_{fe}} \cdot h_{ie} = V_{be} \rightarrow \frac{V_{be}}{V_i} = \frac{R_s}{R_s + R_b} \cdot \frac{h_{ie}}{(R_s // R_b) + h_{ie} + R_E (h_{fe})}$$



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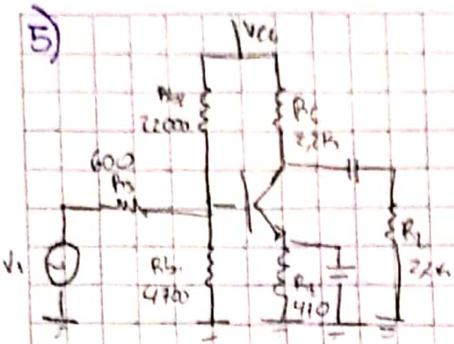
Analisis

5)

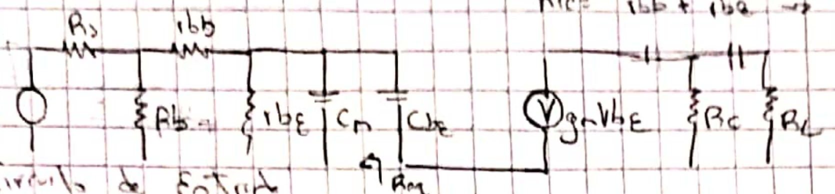


$h_{fe}: 125$
$C_{bc}: 2,4pF$
$C_{bE}: 20pF$
$r_{bb}: 30$
$h_{ie}: 1360$

Calcule f_h
Dibujar diagrama de bode

$R'_L: R_c // R_L = 1100$

$h_{ie}: r_{bb} + r_{be} \rightarrow r_{bE} = h_{ie} - r_{bb} = 1330$



Circuito de Entrada

$$f_{h_{Ent}} = \frac{1}{2\pi R_{eq} C_{Ent}} = 1,56 MHz \rightarrow \boxed{f_h = 1,56 MHz}$$

$$C_{Ent} = C_m + C_{bE} = 260pF \rightarrow \boxed{C_{Ent} = 260pF}$$

$$R_{eq} = [(R_s // R_b) + r_{bb}] // r_{bE} = 390,5$$

$$\boxed{R_{eq} = 390,5\Omega}$$

$$C_m = C_{bc}(1 + g_m R'_L) = 240 pF$$

$$g_m = \frac{I_{cQ}}{25mV} = 0,09$$

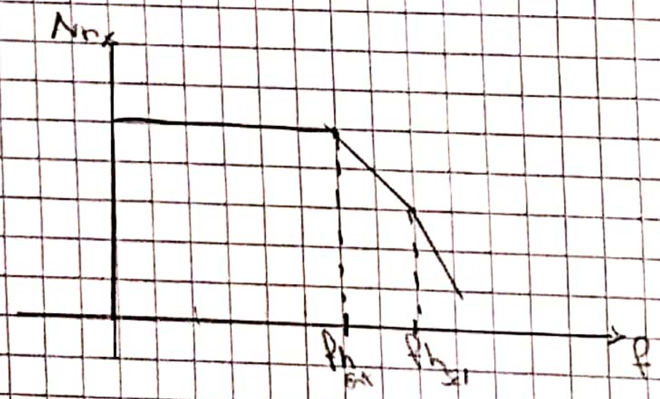
$$I_{cQ} = \frac{25mV\ h_{fe}}{h_{ie}} = 2,26mA$$

Circuito de salida

$$f_{h_{sal}} = \frac{1}{2\pi R_{eq} C_{t_{sal}}} = 60,28 MHz \rightarrow \boxed{f_{h_{sal}} = 60,28 MHz}$$

$$C_{t_{sal}} = C_{bc} = 2,4 pF$$

$$R_{eq} = R_c // R_L = 1100$$



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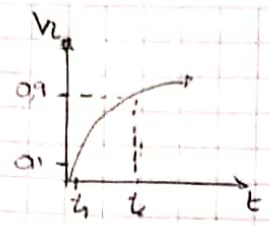
FECHA

9)



$t_h = \frac{t_2 - t_1}{\ln(0,9) - \ln(0,1)}$

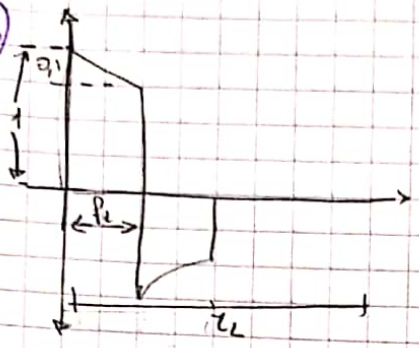
$\omega_h = \frac{1}{t_h}$

$V_L(t_1) = 0,1 = 1 \cdot e^{t_1/t_h}$

$V_L(t_2) = 0,9 = 1 \cdot e^{t_2/t_h}$

$t_c = (t_2 - t_1) = t_h(\ln 0,9 - \ln 0,1)$

10)



$f_L = 20\,Hz \quad t_L = \frac{1}{f_L} = 50\,ms$

$\frac{0,1}{1} = \frac{t_L}{t_L} \rightarrow t_L = \frac{t_L}{0,1} \cdot 1 =$ [s]

$\omega_L = \frac{1}{t_L}$

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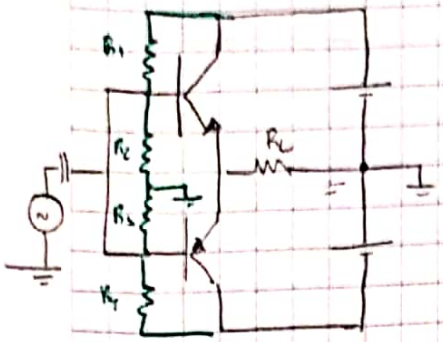
HOJA N°

FECHA

Amplificador de potencia

1) Clase B simétrica complementaria - Salida directa



$V_i = 12\ V_{rms}$
$V_{cc} = \pm 25V$
$R_L = 4\Omega$

$V_i = V_{rms}\cdot\sqrt{2} = 16,97 \simeq 17V$ $\quad I_{C_{max}} = \frac{V_{cc}}{R_L} = 6,25A$ $\quad I_L = I_{c_{max}}\cdot\frac{V_i}{V_{cc}} = 4,25A$

$P_L = \left(\frac{I_L}{\sqrt{2}}\right)^2 \cdot R_L = 36,125$ $\rightarrow$ **$P_L = 36,125W$**

$P_{cc} = V_{cc}\cdot I_L\cdot\frac{2}{\pi} = 67,6$ $\rightarrow$ **$P_{cc} = 67,6W$**

$2P_C = P_{cc} - P_L \rightarrow P_C = \frac{P_{cc} - P_L}{2} = 15,75 \rightarrow$ **$P_C = 15,75W$**

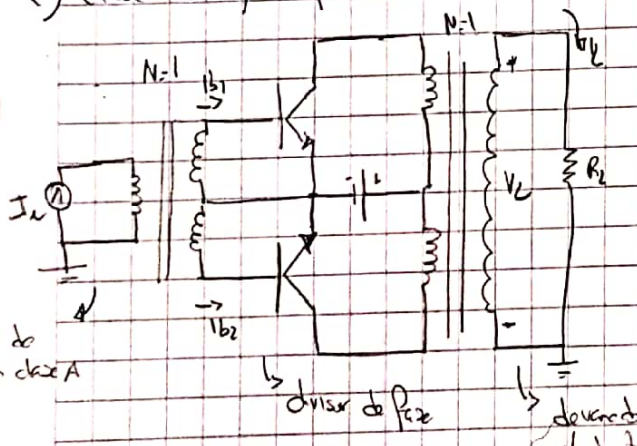
$\eta = \frac{P_L}{P_{cc}} = 0,53$

Red de polarización

$0,7 = \frac{V_{cc}\ R_2}{R_1 + R_2}$ $\quad R_2 = R_3$ $\quad R_1 = R_4 = 20K$

$R_3 = \frac{0,7\ R_1}{V_{cc} - 0,7} = 576,1$ $\rightarrow$ **$R_1 = R_4 = 20K\Omega$**, **$R_2 = R_3 = 576,1\Omega$**

2) Clase B "push-pull"



Etapa de excitación clase A

↳ divisor de P_{cc}

↳ devanado multiple p/adaptar impedancia

Datos
$P_L = 10W$
$R_L = 10$
$pV_{CEO} = 40V$

Calcular
β_{cc}
V_{cc}
N
P_{cc}

$V_{cc} = \frac{V_{CEO}}{2} = 20V \rightarrow$ **$V_{cc} = 20V$**

$P_{cc} = \frac{V_{cc}^2}{R_L'}\cdot\frac{2}{\pi} = 12,73W \rightarrow$ **$P_{cc} = 12,73W$**

$P_L = \frac{V_{cc}^2}{2\ N^2 R_L} \rightarrow N = \frac{V_{cc}^2}{2\ R_L\ P_L} = 1,41 \rightarrow$ **$N = 1,41$**

$P_{C_{max}} = \frac{V_{cc}^2}{\pi^2 R_L'} = 2,02 \rightarrow$ **$P_C = 2,02W$**

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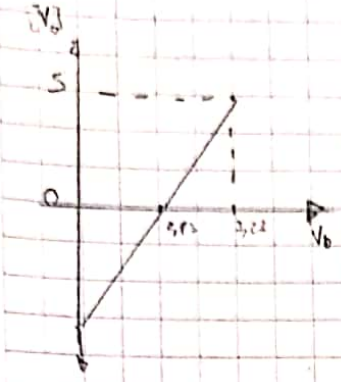
CAS

50°C ___ 5V

0°C ___ 0V

$V_{Tref} = \frac{10mV}{°C} \cdot t_{amb}[°C] + 2,73V \therefore V_T|_{0°C} = 2,73V$

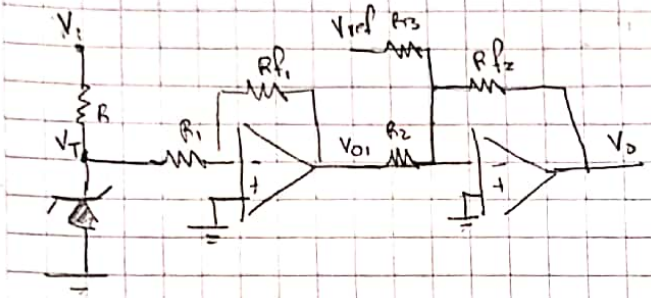
$V_T|_{50°C} = 3,23V$



$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{5-0}{3,23+2,73} = 10$

$y = mx + n$ Si $y=0 \therefore x = 2,73$ $\therefore 0 = 10 \cdot 2,73 + n \rightarrow n = -27,3$

$y = 10x - 27,3 \rightarrow \boxed{V_0 = 10 V_T - 27,3}$



$R_{f1} = 10K$
$R_1 = 1K$
$R_{f2} = 10K$
$R_2 = 10K$
$R_3 = 5500$

$V_{o1} = -\frac{R_f}{R_1} \cdot V_T$ Si $V_{o1} = 10 \cdot V_T \therefore R_f = 10K$, $R_1 = 1K$ $\therefore V_{o1} = -\frac{10K}{1K} \cdot V_T = -10 \cdot V_T$

$V_o = -R_{f2}\left(\frac{V_{o1}}{R_2} + \frac{V_{ref}}{R_3}\right) = \frac{-R_{f2}}{R_2} \cdot V_{o1} - \frac{R_{f2}}{R_3} V_{ref} = -V_{o1} - \frac{R_{f2}}{R_3} V_{ref}$

Si $V_{ref} = 15V$, $R_{f2} = 10K$: $-27,3 = -\frac{R_{f2}}{R_3} V_{ref} \rightarrow R_3 = \frac{R_{f2} V_{ref}}{-27,3} = 5500\Omega$

$$\boxed{V_o = \frac{R_2 R_f}{R_2 R_1} V_T - \frac{R_{f2}}{R_3} V_{ref}} \rightarrow$$

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