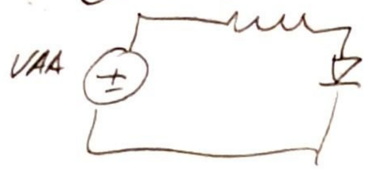
Ej diodos

1) Siendo VAA = 5 V y R = 1 KΩ

ⓐ Determinar la corriente en el diodo y la tensión entre sus extremos

ⓑ ¿Cuánta potencia disipa el diodo?

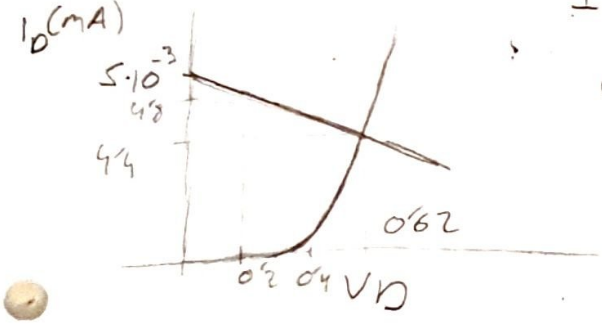
ⓒ ¿Cuál será la corriente del diodo si se cambia R a 2KΩ?



C.K.M

$I_D \cdot R + V_D - V_{AA} = 0$ $\qquad I = \frac{V_{AA} - V_D}{R}$

$I = \frac{5}{10^3} - 10^{-3} V_D$

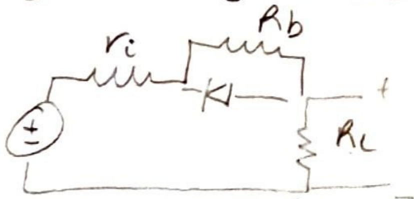


$4'4 \cdot 10^{-3}$ A y 0'62 V $\qquad P = V \cdot I = 2'73$ mW

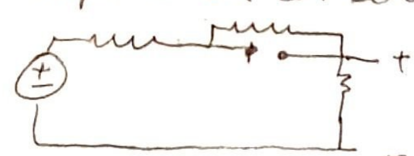
ⓒ Repetir el ⓐ cambiando la recta de carga

2) Considerando $V_\gamma = 0'6$ V y $R_d = 0$

ⓐ Dibujar $V_L(t)$ si $R_b = 100 K\Omega$, $r_i = R_L = 1 K\Omega$



Suponemos en corte



CKM

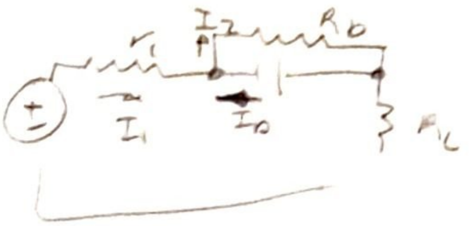
$I r_i + I r_b + I r_L - V_i = 0 \qquad I(r_i + r_b + r_r) = V_i$

$I = \frac{V_i}{r_i + r_b + r_r} \qquad I = \frac{V}{R} \qquad I \cdot R_L = V_s = \frac{1}{102} V_i$

Para que se cumpla la cond de corte $V_D < V_\gamma$

$I_1 = \frac{-V_D}{r_b} = I_L \qquad \frac{-V_D}{100 \cdot 10^3} = \frac{V_L}{R_L} \qquad V_D = \frac{V_L \cdot 100 \cdot \cancel{10^3}}{\cancel{10^3}}$

$V_D = \frac{-1}{102} V_i \cdot 100 < V_\gamma \qquad V_i > \frac{-V_\gamma}{100} \cdot 102 \qquad V_i > -6'1 \cdot 10^{-1} V$



C.K.N $\quad I_1 = I_2 + I_D$, $\quad I_2 = I_D + I_3$ $\quad \Big\} \; I_1 = I_3$

C.K.M $\quad I_1 r_i + I_1 R_L - V_i - V_\gamma = 0 \qquad I_1 (r_i + R_L) = V_i + V_\gamma \qquad I_1 = \dfrac{V_i + V_\gamma}{r_i + R_L}$

$$I_2 = \frac{V_i - x}{r_i} \qquad \frac{V_i - x}{r_i} = \frac{V_i + V_\gamma}{r_i + R_L} \qquad \frac{-V_i + x}{r_i} = \frac{-V_i - V_\gamma}{r_i + R_L}$$

$$x = \frac{-V_i - V_\gamma}{r_i + R_L} \cdot R_L + V_i \qquad x = \frac{V_i}{2} - \frac{V_\gamma}{2} = \frac{V_i - V_\gamma}{2}$$

$$I_1 = \frac{V_L}{R_L} \qquad \frac{V_L}{R_L} = \frac{V_i + V_\gamma}{r_i + R_L} \qquad V_L = \frac{V_i}{r_i + R_L} \cdot R_L + \frac{V_\gamma}{r_i + R_L} \cdot R_L = \frac{1}{2} V_i + \frac{1}{2} V_\gamma$$

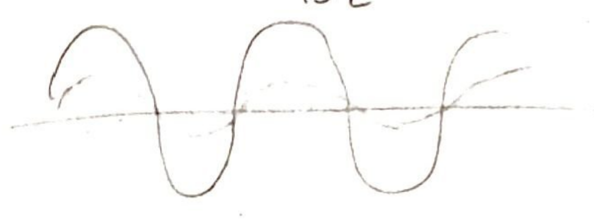
$I_D > 0 \qquad -I_D + I_2 = I_L \qquad I_D = -I_L + I_2 > 0$

$$-\frac{V_L}{R_L} + \frac{x - V_L}{R_B} > 0 \qquad -\frac{1}{2}\left[\frac{V_i + V_\gamma}{R_L}\right] + \frac{1}{2}\left[\frac{\cancel{V_i} - V_\gamma - \cancel{V_i} - V_\gamma}{R_B}\right] > 0$$

$$-\frac{V_i - V_\gamma}{R_L} + \frac{2V_\gamma}{R_B} > 0 \qquad -\frac{V_i}{R_L} > \frac{2V_\gamma}{R_B} + \frac{V_\gamma}{R_L} \qquad V_i < -\left(\frac{2V_\gamma}{R_B} + \frac{V_\gamma}{R_L}\right) R_L$$

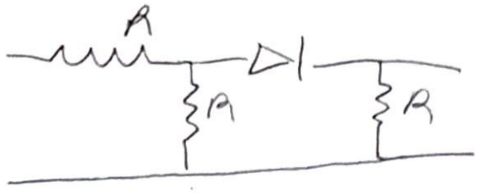
$V_i < -6'12 \cdot 10^{-1}$

$$V_o \begin{cases} \dfrac{V_i + V_\gamma}{2} & V_i < -6'12 \cdot 10^{-1} \\ \dfrac{V_i}{102} & V_i > -6'12 \cdot 10^{-1} \end{cases}$$

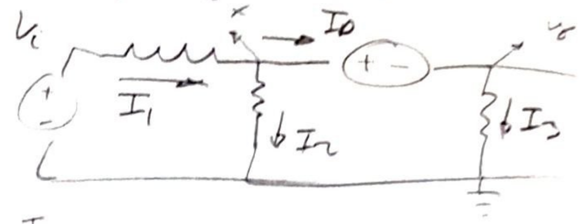


Expresar la característica de transferencia

a)



Supongamos en conducción



LKN $I_1 = I_2 + I_D$ $\qquad I_D = I_3$

LKM $I_1 R_1 + I_2 R_2 - V_i = 0$ $\qquad I_D R - I_2 R_2 + V_\gamma = 0$

$$\left(\begin{array}{ccc|c} 1 & -1 & -1 & 0 \\ R & R & & V_i \\ 0 & -R & R & -V_\gamma \end{array}\right) \to \left(\begin{array}{ccc|c} 1 & -1 & -1 & 0 \\ 10 & 10 & & V_i \\ 0 & -10 & 10 & -V_\gamma \end{array}\right) \to \left(\begin{array}{ccc|c} 1 & -1 & -1 & 0 \\ 0 & 20 & 10 & V_i \\ 0 & -10 & 10 & -V_\gamma \end{array}\right) \to$$

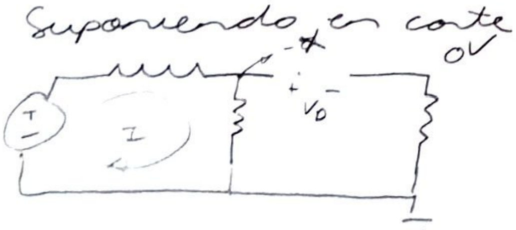
$$\left(\begin{array}{ccc|c} 1 & -1 & -1 & 0 \\ 0 & 20 & 10 & V_i \\ 0 & 0 & 15 & \frac{V_i}{2} - V_\gamma \end{array}\right)$$

$15 I_D = \frac{V_i}{2} - V_\gamma$ $\qquad I_D = \frac{V_i}{30} - \frac{V_\gamma}{15}$

$I_D = \frac{V_i - 2V_\gamma}{30} > 0 \to V_i > 2V_\gamma = 1'2$

$I_3 = I_D = \frac{y}{R}$ $\qquad I_D \cdot R = y$ $\qquad y = \frac{V_i - 2V_\gamma}{3}$

Suponiendo en corte



$V_i = 0$ $\qquad I_1 = I_2$

C.K.M $\qquad IR + IR - V_i = 0$ $\qquad 2I = \frac{V_i}{R}$

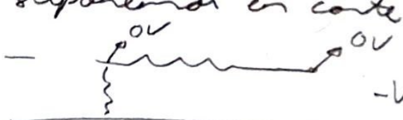
$I = \frac{V_i}{2R}$ $\qquad I = \frac{x}{R}$

$\frac{V_i}{2R} = \frac{x}{R}$ $\qquad \frac{V_i \cdot \cancel{R}}{2\cancel{R}} = x < V_\gamma$ $\qquad V_i < 2V_\gamma$

$$V_0 = \begin{cases} \frac{V_i - 2V_\gamma}{3} & V_i > 1'2 \\ 0 & V_i < 1'2 \end{cases}$$

b)

1- Suponemos en corte

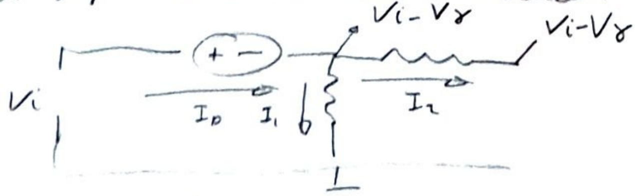


$V_0 = 0V$

$-V_Z < V_D < V_\gamma$

$-V_Z < V_i - 0 < V_\gamma$

2- Suponemos en conducción



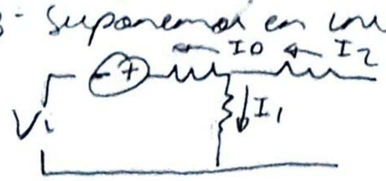
L.K.N

$I_D = I_1 + I_2$ $\qquad I_2 = 0$

$I_1 = \frac{V_i - V_\gamma}{R}$ $\qquad I_D = I_1 > 0$

$I_1 = \frac{V_i - V_\gamma}{R} > 0$ $\qquad V_i > V_\gamma$ $\qquad V_0 = V_i - V_\gamma$

3- Suponemos en inversa

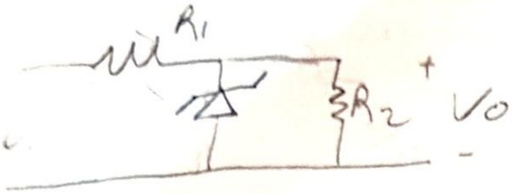


$I_2 = 0 \to I_D + I_1 = 0$ $\qquad I_D = -I_1$ $\qquad I_D > 0 \to -I_1 > 0$

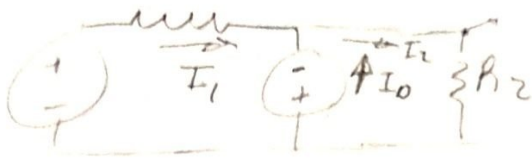
$-\frac{V_0}{R} > 0$ $\qquad V_0 < 0$ $\qquad$ L.K.M $\qquad IR + IR_Z + V_Z + V_i = 0$

$V_0\left(-1 - \frac{R_Z}{R}\right) = -V_i - V_\gamma \to V_0 = \frac{-V_i - V_\gamma}{\left(-1 - \frac{R_Z}{R}\right)} = \frac{3}{2}(V_i + V_Z)$

$\frac{3}{2}(V_i + V_Z) < 0$ $\qquad V_i < -V_Z$



1- Suponemos en conducción



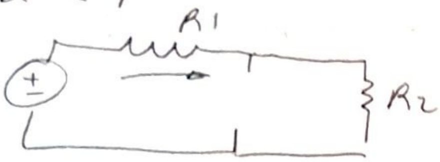
CKN $I_1 + I_D = I_2$ $\quad$ $I_1 - I_2 = -I_D$

$I_D = I_2 - I_1 > 0$ $\quad$ $\frac{-0'6}{R} - \frac{V_i + 0'6}{R} > 0$ $\quad$ $-\frac{V_i}{R} - \frac{1'2}{R} > 0$ $\quad$ $V_i < -1'2$

$V_O = -V_\gamma$ $\quad$ $V_O = -0'6$

$-V_Z < V_D < V_\gamma$

2- Suponemos en corte



CKM

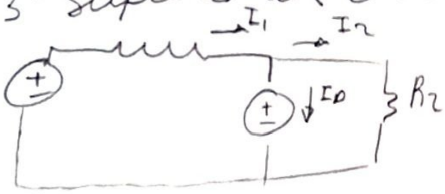
$IR_1 + IR_2 - V_i = 0$

$(R_1 + R_2)I = V_i$ $\quad$ $I = \frac{V_i}{R_1 + R_2}$

$IR_2 = V_S$ $\quad$ $\frac{V_i}{R_1 + R_2} \cdot R_2 = V_S$ $\quad$ $\frac{V_i}{2\cancel{R}}\cancel{R} = V_S$

$V_D = -V_S$ $\quad$ $-V_S < V_\gamma$ $\quad$ $V_S > -V_\gamma$ $\quad$ $\frac{V_i}{2} > V_\gamma$ $\quad$ $V_i > -2V_\gamma$

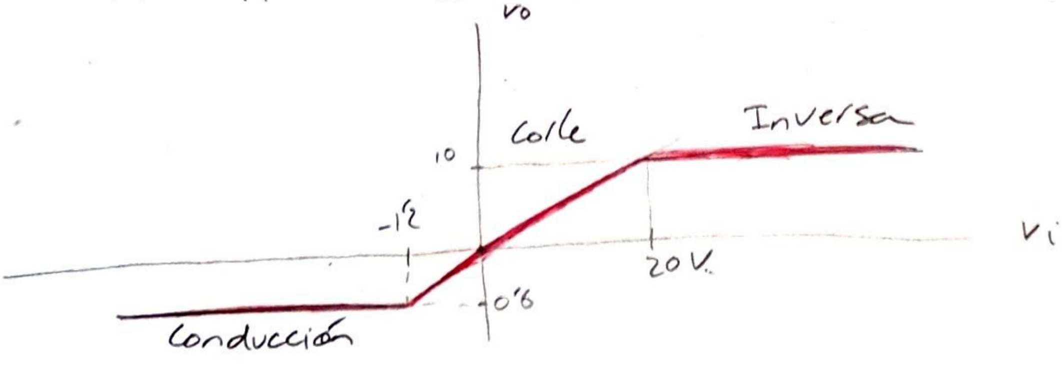
3- Suponemos en inversa



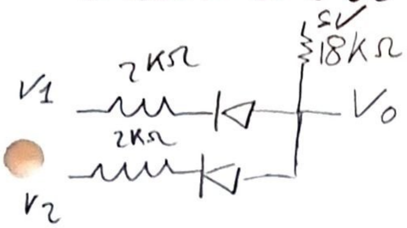
$I_D + I_2 = I_1$ $\quad$ $I_D = I_1 - I_2$

$I_1 = \frac{V_i - V_Z}{R}$ $\quad$ $I_2 = \frac{V_Z}{R_2}$

$\frac{V_i - V_Z}{R} - \frac{V_Z}{R} > 0$ $\quad$ $\frac{V_i}{\cancel{R}} > \frac{2V_Z}{\cancel{R}}$ $\quad$ $V_i > 2 \cdot 10 = 20V$ $\quad$ $V_S = V_Z$



Encontrar V_0 $V_\gamma = 0'65$

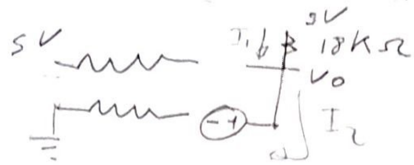


ⓐ $V_1 = V_2 = 5V$ corte

$I = 0 \rightarrow \frac{5 - V_0}{18} = 0 \rightarrow V_0 = 5V$

$V_0 < V_\gamma$ así que tá bien :)

① $V_1 = 5V$ y $V_2 = 0V$



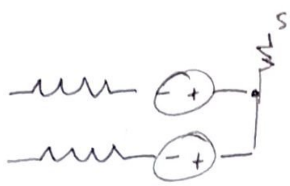
$I_1 = I_2$

$\frac{5 - V_0}{18} = \frac{V_0 - V_\gamma - 0}{2}$

$\frac{5}{18} - \frac{V_0}{18} - \frac{V_0}{2} = -\frac{V_\gamma}{2}$ $\quad -\frac{5}{9} V_0 = -\frac{V_\gamma}{2} - \frac{5}{18}$ $\quad V_0 = -\frac{9}{5}\left(-\frac{V_\gamma}{2} - \frac{5}{18}\right) = 1'085V$

$V_0 < V_\gamma$ por tanto D_1 está en corte y la $I_2 > 0$ así que todo en orden :)

② $V_1 = 0 = V_2$



$I_1 = I_2 + I_3$

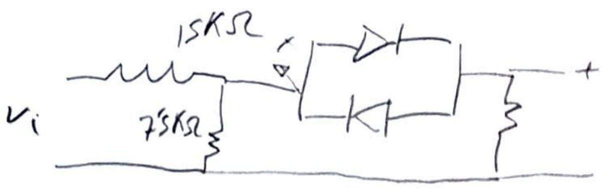
$\frac{5 - V_0}{R} = \frac{V_0 - V_\gamma}{R} + \frac{V_0 - V_\gamma}{R}$

$\frac{5 - V_0}{R} = 2\left(\frac{V_0 - V_\gamma}{R}\right)$ $\quad \frac{5 - V_0}{2 \cdot 18} = \frac{V_0 - 0'65}{2}$ $\quad \frac{5}{36} - \frac{V_0}{36} = \frac{V_0}{2} - \frac{31}{100}$

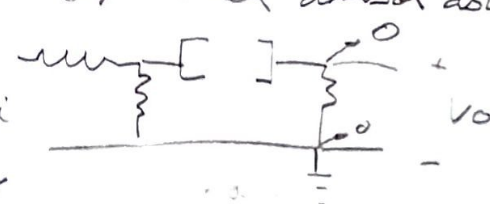
$\frac{5}{36} + \frac{31}{100} = \frac{V_0}{2} + \frac{V_0}{36}$ $\quad 0'44\overline{8} = 0'52\overline{7} V_0$ $\quad V_0 = 8'505387 \cdot 10^{-1} V$

$I_1, I_2 > 0$ por tanto es correcto.

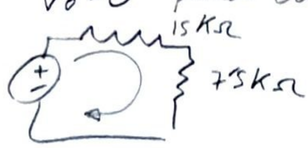
③ Característica de transferencia de tensión del circuito, suponiendo ambos diodos idénticos $V_\gamma = 0'6V$ y $r_d = 0$



1º Suponemos ambos abiertos



$V_0 = 0$ para ello, $V_D < V_\gamma$ $\quad x - 0 < V_\gamma$



$I \cdot 15K\Omega + I \cdot 7'5K\Omega - V_i = 0$

$I(15K\Omega + 7'5K\Omega) = V_i$ $\quad I_1 = \frac{V_i}{2'25 \cdot 10^4 \Omega}$

$I = \frac{x}{R}$ $\quad \frac{V_i}{2'25 \cdot 10^4} \cdot 7'5 \cdot 10^3 = x = \frac{1}{3} V_i$

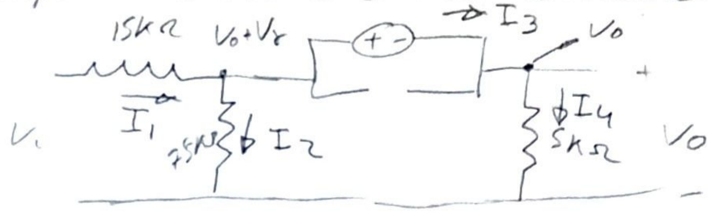
$x = IR$

$V_0 = 0 \rightarrow V_i < 3V_\gamma$ $\quad V_i > -3V_\gamma$

$V_D = x - 0$ $\quad x = V_D$ $\quad x < V_\gamma$ para que diodo 1 en corte

$V_{D_2} = 0 - x$ $\quad -x = V_D$ $\quad -x < V_\gamma$ para diodo 2 en corte

Suponemos uno en conducción y uno en corte



L.K.N

$I_1 = I_2 + I_3 \qquad I_3 = I_4$

$I_1 = \frac{V_i - V_o - V_\gamma}{R}$

$I_2 = \frac{V_o + V_\gamma}{R_2} \qquad I_3 = \frac{V_o}{R_3}$

$\frac{V_i - V_o - V_\gamma}{R} = \frac{V_o + V_\gamma}{R_2} + \frac{V_o}{R_3}$

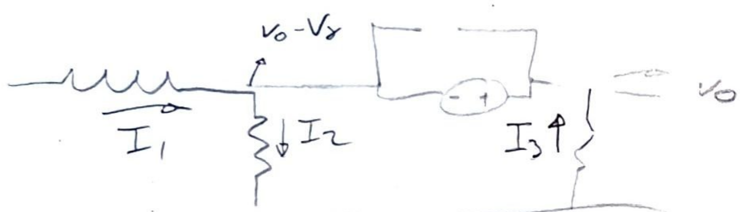
$\frac{V_i}{R_1} - \frac{V_\gamma}{R_1} - \frac{V_\gamma}{R_2} = \frac{V_o}{R_2} + \frac{V_o}{R_3} + \frac{V_o}{R} \rightarrow \frac{V_i}{R} - 1'2 \cdot 10^{-4} = 4 \cdot 10^{-4} (V_o)$

$4 \cdot 10^{-4} V_o = 6'67 \cdot 10^{-5} V_i - 1'2 \cdot 10^{-4}, \qquad V_o = 1'6675 \cdot 10^{-1} V_i - 3 \cdot 10^{-1}$

Para que esto ocurra diodo 1 en conducción

$I_3 > 0 \qquad \frac{V_o}{R_3} > 0 \qquad 3'335 \cdot 10^{-5} V_i - 6 \cdot 10^{-5} > 0 \qquad V_i > \frac{6 \cdot 10^{-5}}{3'35 \cdot 10^{-5}} = 1'8$

$V_{D2} = V_o - V_o - V_\gamma = -V_\gamma$ por tanto está en corte



$I_1 = \frac{V_i - V_o + V_\gamma}{R_1}$

$I_2 = \frac{V_o - V_\gamma}{R_2}$

$I_3 = \frac{V_o}{R_3}$

L.K.N $I_1 = I_2 + I_3$

$\frac{V_i - V_o + V_\gamma}{R_1} = \frac{V_o - V_\gamma}{R_2} + \frac{V_o}{R_3}$

$\frac{V_i}{R_1} + \frac{V_\gamma}{R_1} + \frac{V_\gamma}{R_2} = \frac{V_o}{R_2} + \frac{V_o}{R_1} + \frac{V_o}{R_3}$

$10^{-5} \cdot 6'\bar{6}\, V_i + 1'2 \cdot 10^{-4} = 4 \cdot 10^{-4} V_o$

$V_o = 0'1\bar{6}\, V_i + 3 \cdot 10^{-1}$

Esto ocurre cuando $I_3 < 0$

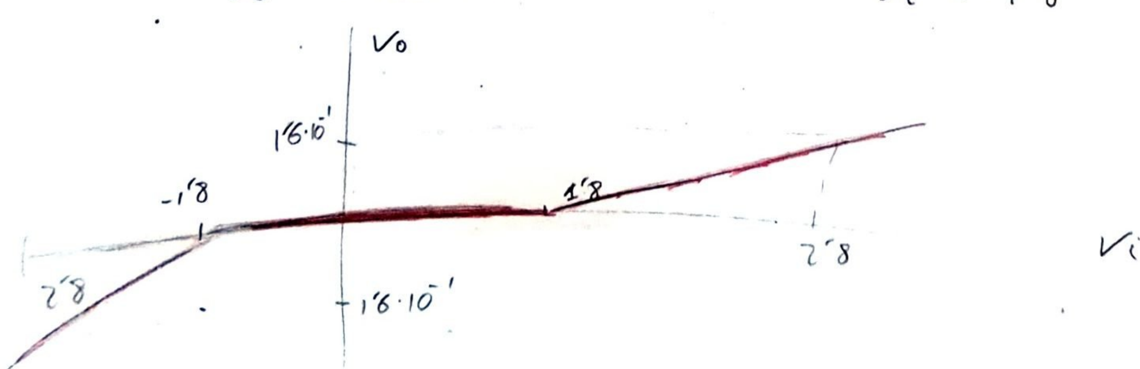
$\frac{V_o}{R_3} < 0 \qquad \frac{0'1\bar{6} V_i + 0'3}{R_3} < 0$

$0'1\bar{6} V_i < -0'3 \qquad V_i < -1'8\ V.$

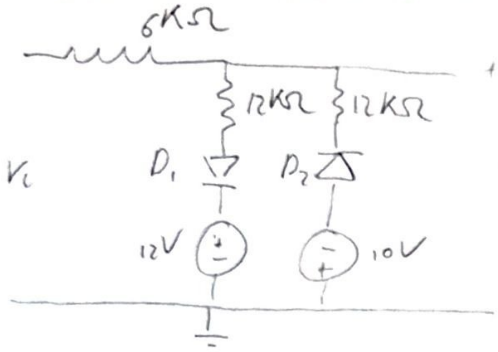
$V_o = 1'66675 \cdot 10^{-1} V_i - 0'3 \qquad V_i > 1'8$

$V_o = 0 \qquad -1'8 < V_i < 1'8$

$V_o = 1'66675 \cdot 10^{-1} V_i + 0'3 \qquad V_i < -1'8$

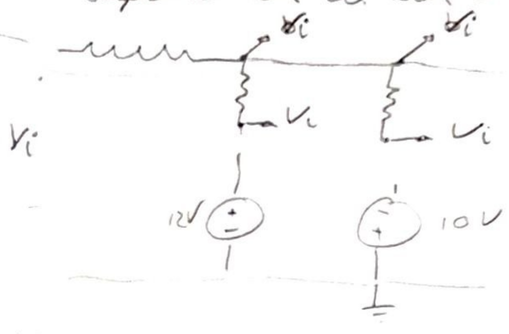


7 Obtener la característica de transferencia de tensión asumiendo el modelo umbral para diodos $V_\gamma = 0'6V$ $R_d = 0\Omega$



$I = 0$ $\quad \frac{V_i - x}{R} = 0$ $\quad x = V_i$

Suponemos ambos en corte



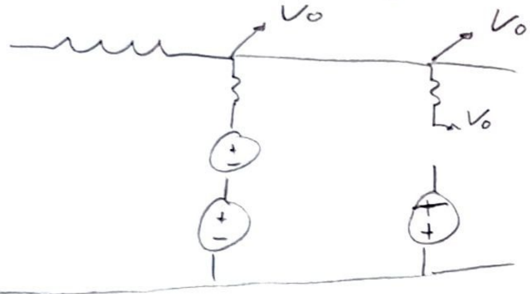
$V_o = V_i$

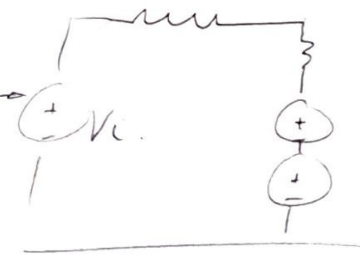
Estarán en corte cuando el voltaje del diodo no sea suficiente

$V_i - 12 < V_\gamma \qquad V_i < 12 + V_\gamma = 12'6 \qquad -10 - V_i < V_\gamma \qquad -V_i < V_\gamma + 10$

$12'6 > V_i > -V_\gamma - 10 = -10'6$

D_1 en conducción y D_2 en corte





L.K.M

$IR_1 + IR_2 + V_\gamma + 12 - V_i = 0$

$I(R_1 + R_2) + 12'6 - V_i = 0$

$V_i = I(R_1 + R_2) + 12'6$

$I = \frac{V_i - 12'6}{R_1 + R_2} \qquad I_{R_2} = \frac{V_o - 12'6}{R_2} \qquad \frac{V_i - 12'6}{R_1 + R_2} = \frac{V_o - 12'6}{R_2}$

$\left(\frac{V_i - 12'6}{R_1 + R_2}\right) R_2 + 12'6 = V_o \qquad \left(\frac{V_i}{18000} - 7 \cdot 10^{-4}\right) \cdot 12 \cdot 10^3 + 12'6 = V_o$

$V_o = \frac{2}{3} V_i + \frac{21}{5}$

$-10 - V_o < V_\gamma \qquad -V_o < 10 + V_\gamma \qquad V_o > -10'6$

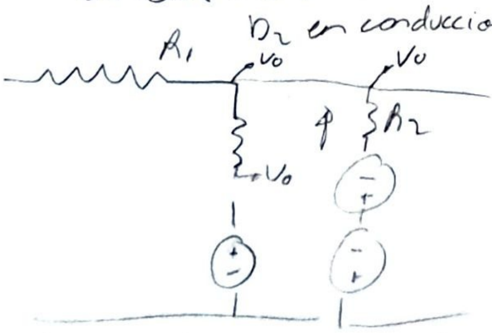
$V_i > -22'2V$

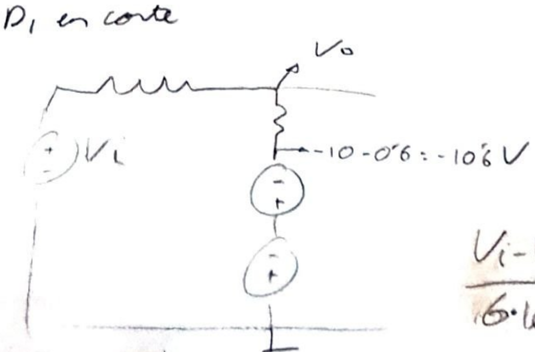
$I_D > 0 \qquad \frac{V_i - V_o}{R} > 0 \qquad V_i > V_o \qquad V_i > \frac{2}{3} V_i + \frac{21}{5}$

$V_i - \frac{2}{3} V_i > \frac{21}{5} \qquad \frac{1}{3} V_i > \frac{21}{5} \qquad V_i > 12'6$

De las dos condiciones las más restrictiva es $V_i > 12'6V$

D_2 en conducción y D_1 en corte





$I_{R_1} = -I_{R_2}$

$\frac{V_i - V_o}{R_1} = -\left(\frac{10'6 - V_o}{R_2}\right)$

$\frac{V_i - V_o}{6 \cdot 10^3} = \frac{10'6 + V_o}{12 \cdot 10^3}$

$2 \times \frac{V_i - V_o}{6} = \frac{10'6 + V_o}{12} \qquad 2V_i - 2V_o = 10'6 + V_o \qquad 2V_i - 10'6 = 3V_o$

$\frac{2V_i - 10'6}{3} = V_o$

Para ello $\frac{2V_i - 10'6}{3} - 12 < V_\gamma$

y $I_{R_2} > 0 \quad \frac{-10'6 - V_o}{R_2} > 0 \rightarrow V_i < -10'6$ + restrictiva

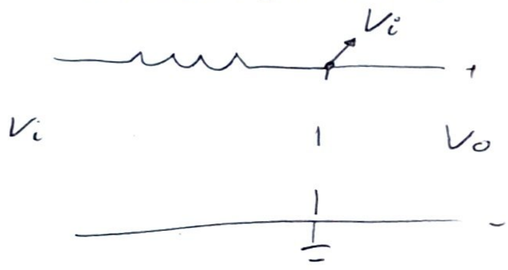
$V_i < \frac{12'6 + 10'6}{2} = 11'6V$

$$V_o(V)\begin{cases} \dfrac{2V_i-10'6}{3} & V_i<-10'6V \\ V_i & -10'6V<V_i<12'6V \\ \dfrac{2V_i+12'6}{3} & V_i>12'6V \end{cases}$$

8 Expresar la característica de transferencia del circuito suponiendo ambos Zener idénticos $V\gamma=0'6V$ y $rd=0$ en directa y $V_z=3V$ y $r_z=10\Omega$ en inversa

3 casos posibles
- ambos conducen
- ambos en inversa
- ambos en corte

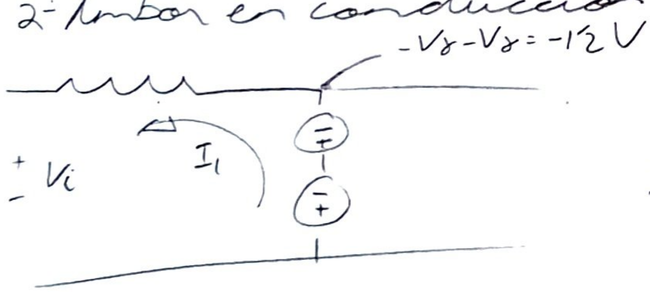
1º ambos en corte



No puede ocurrir uno conduciendo y otro en corte, si conduce la $I>0$

$2V\gamma > -V_o > -2V_z$ $\quad$ $6V > V_o > -1'2$

2º ambos en conducción

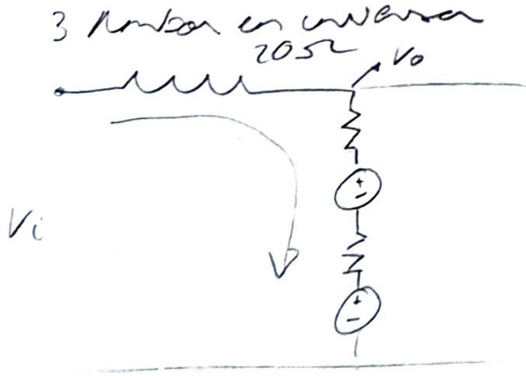


$V_o=-1'2V$

esto ocurre cuando $I_D>0$

$I_D=I_1=\dfrac{-1'2-V_i}{R}>0 \quad -1'2>V_i$

3 ambos en inversa



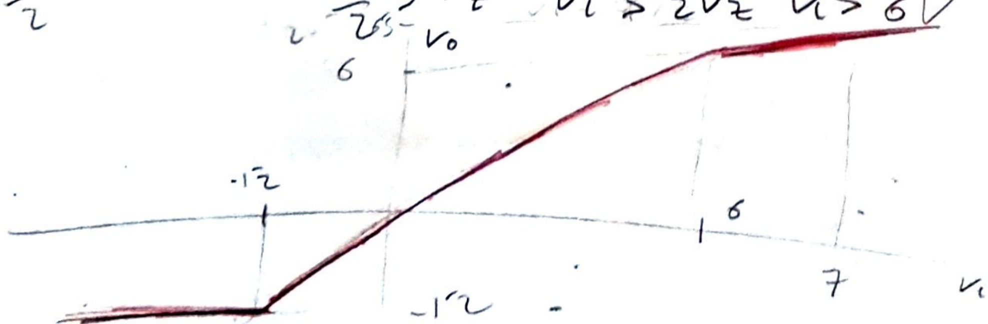
$I_1=I_D \quad \dfrac{V_i-V_o}{R_1}=\dfrac{V_o-V_z-V_z}{R_z+R_z}$

$V_i=2V_o-2V_z \quad \dfrac{V_i+2V_z}{2}=V_o$

$I_1>0 \rightarrow \dfrac{V_i-V_o}{R_1}>0 \quad V_i-V_o>0$

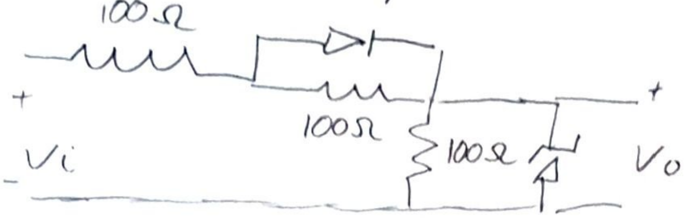
$V_i-\dfrac{(V_i+2V_z)}{2}>0 \quad V_i-\dfrac{V_i}{2}-\dfrac{2V_z}{2}>0$

$\dfrac{V_i}{2}-V_z>0 \quad \dfrac{V_i}{2}>V_z \quad V_i>2V_z \quad V_i>6V$



$$V_o\begin{cases} -1'2 & V_i<-1'2 \\ V_i & -1'2<V_i<6V \\ \dfrac{V_i+2V_z}{2} & V_i>6V \end{cases}$$

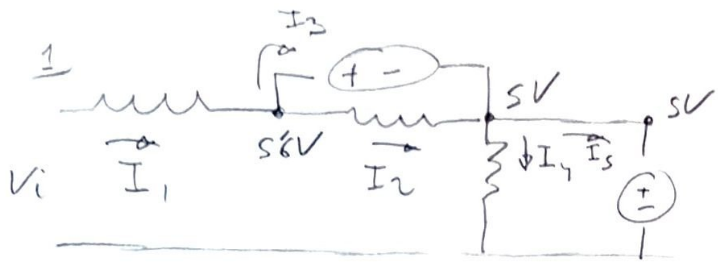
9) Dado el circuito de la figura, sabiendo que $V_Z = 5V$, $V_\gamma = 0'6V$ y considerando que las resistencias despreciables, hallar la característica de transferencia



Casos

1) D_1 conduce, D_2 inversa
2) D_1 conduce, D_2 corte
3) D_2 conduce, D_1 corte
4) D_1 corte, D_2 corte

1



$I_1 = I_3 + I_2$

$I_3 + I_2 = I_4 + I_5$

$I_1 = \frac{V_i - 5'6}{R}$ $\quad I_3 = I_D \quad I_2 = \frac{5'6 - 5}{R} \quad I_4 = \frac{5}{R} \quad I_5 = I_{D2}$

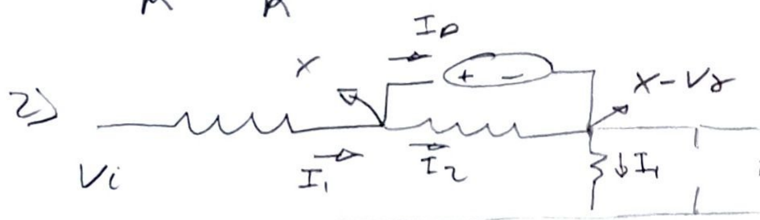
$V_o = 5V$ $\quad I_3 > 0 \quad I_1 - I_2 > 0 \quad \frac{V_i - 5'6}{R} - \frac{5'6-5}{R} > 0$

$\frac{V_i - 5'6}{R} > 6 \cdot 10^{-3} \quad V_i - 5'6 > 6 \cdot 10^{-1} \quad V_i > 5V$

$I_5 > 0 \rightarrow I_3 + I_2 - I_4 > 0 \quad I_1 - \cancel{I_2} + \cancel{I_2} - I_4 > 0$

$\frac{V_i - 5'6}{R} - \frac{5}{R} > 0 \quad V_i - 5'6 > 5 \quad \underline{V_i > 10'6V}$ cogemos esta que es la más restrictiva

2)



L.K.N

$I_1 = I_D + I_2$

$\frac{V_i - x}{R} = I_D + \frac{x - (x - V_\gamma)}{R} \quad \frac{V_i - x}{R} = I_D + \frac{\cancel{x - x} + V_\gamma}{R}$

$\frac{V_i - x}{\cancel{R}} = \frac{x - V_\gamma}{\cancel{R}} \quad V_i = 2x - V_\gamma \quad \frac{V_i + V_\gamma}{2} = x$

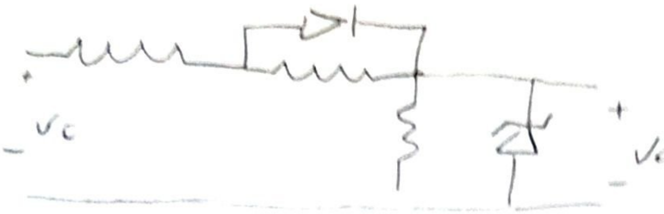
$I_D > 0 \quad I_1 - I_2 > 0 \quad \frac{V_i - x}{R} - \frac{V_\gamma}{R} > 0 \quad V_i - x > V_\gamma$

$V_i - \frac{V_i - V_\gamma}{2} > V_\gamma \quad \frac{V_i}{\cancel{2}} > \frac{3V_\gamma}{\cancel{2}} \quad V_i > 3V_\gamma \quad V_i > 1'8$

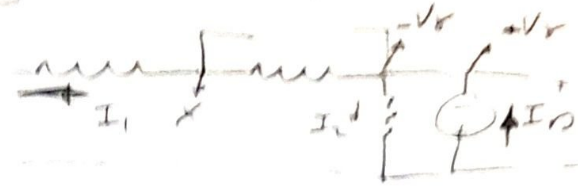
$\underset{V_d}{\rightarrow} V_D > -V_Z$

$x - V_\gamma < V_Z \quad \frac{V_i + V_\gamma}{2} - V_\gamma < V_Z \quad \frac{V_i - V_\gamma}{2} < V_Z \quad V_i < 2V_Z + V_\gamma$

$1'8 < V_i < 10'6$



3) D_2 conduce y D_1 en corte



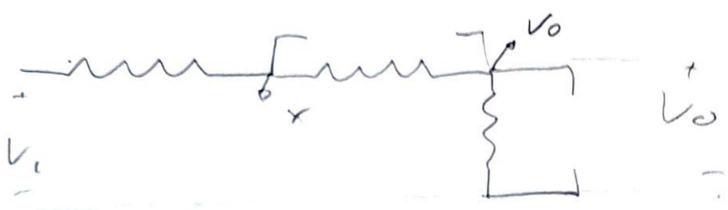
$I_D = I_1 + I_2 \qquad I_D > 0 \rightarrow \dfrac{-V_\gamma - V_i}{R_1 + R_2} + \dfrac{-V_\gamma}{R} > 0$

$\dfrac{-V_i}{R_1+R_2} > \dfrac{V_\gamma}{R} + \dfrac{V_\gamma}{R_1+R_2} \rightarrow \dfrac{-V_i}{R_1+R_2} > V_\gamma\left(\dfrac{1}{R} + \dfrac{1}{R_1+R_2}\right)$

$\dfrac{-V_i}{R+R} > 9\cdot10^{-3} \qquad -V_i > 200\cdot9\cdot10^{-3} \qquad V_i < -200\cdot9\cdot10^{-3} = -1'8V$

$\dfrac{V_i - X}{\cancel{R}} = \dfrac{X - V_\gamma}{\cancel{R}} \qquad \dfrac{V_i + V_\gamma}{2} = X \qquad X - V_\gamma < V_\gamma \qquad \dfrac{V_i + V_\gamma}{2} < V_\gamma$

$V_i < 2\left(V_\gamma + \dfrac{V_\gamma}{2}\right) \qquad V_i < -1'8V$ cogemos la más restrictiva



$I = \dfrac{V_i}{R_1+R_2+R_3}$

$I = \dfrac{V_o}{R} \qquad \dfrac{V_o}{R} = \dfrac{V_i}{R_1+R_2+R_3}$

$V_o = \frac{1}{3} V_i \qquad V_D < V_\gamma \qquad \dfrac{V_i - X}{R} = I \qquad X = IR - V_i$

$X = V_i - \underbrace{I\cancel{R}}_{\frac{V_o}{\cancel{R}}} \qquad X - V_o < V_\gamma \qquad V_i - V_o - V_o < V_\gamma \qquad V_i - 2V_o < V_\gamma$

$V_i - 2\left(\frac{1}{3}V_i\right) < V_\gamma \qquad \frac{1}{3}V_i < V_\gamma \qquad V_i < 1'8$

la + restrictiva

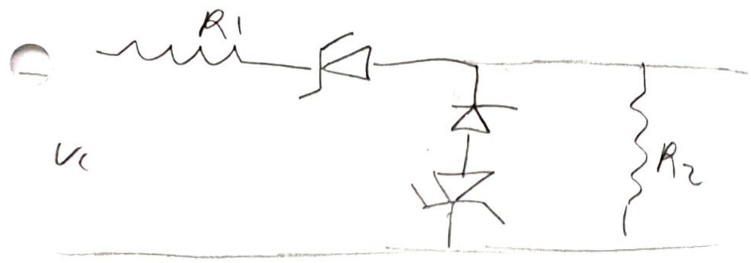
$-V_Z < -V_o < V_\gamma \qquad -V_Z < -\frac{1}{3}V_i < V_\gamma$

$-3V_Z < -V_i < 3V_\gamma \qquad 3V_Z > V_i > -3V_\gamma \qquad 15 > V_i > -1'8$

$1'8 > V_i > -1'8$

$$V_o \begin{cases} 5V & V_i > 10'8 \\ \dfrac{V_i - V_\gamma}{2} & 10'8 > V_i > 1'8 \\ \frac{1}{3}V_i & 1'8 > V_i > -1'8 \\ -V_\gamma & V_i < -1'8 \end{cases}$$

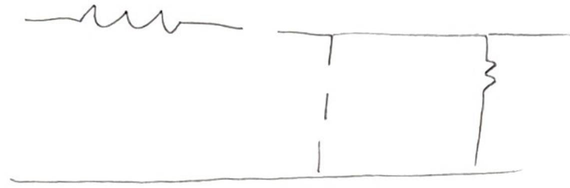
10) Calcular la característica de transferencia. Suponer despreciables las resistencias de los diodos



Posibles casos

D1 Conduce | D1 Corte
D2 Conduce | D2 Corte
D3 Inversa | D3 Corte

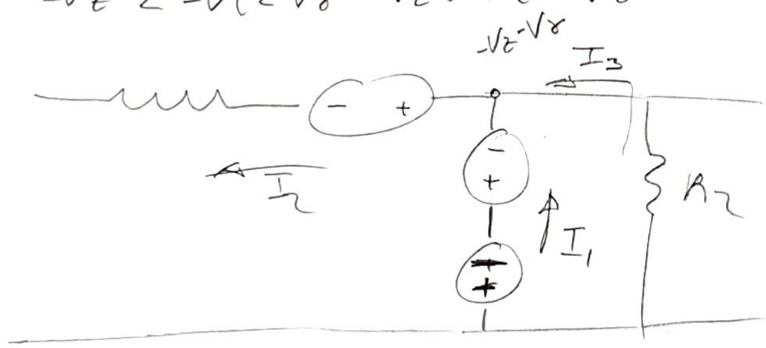
D1 conduce | D1 Inv
D2 Corte | D2 Corte
D3 Corte | D3 Corte



$V=0$ $V_o=0$

$-V_i=V_D$ $-V_z<V_D<V_\gamma$

$-V_z < -V_i < V_\gamma$ $V_z > V_i > -V_\gamma$



LKN

$I_2 = I_3 + I_1$

$\frac{-V_z-V_\gamma-V_\gamma-V_i}{R} = \frac{+V_z+V_\gamma}{R} + I_1$

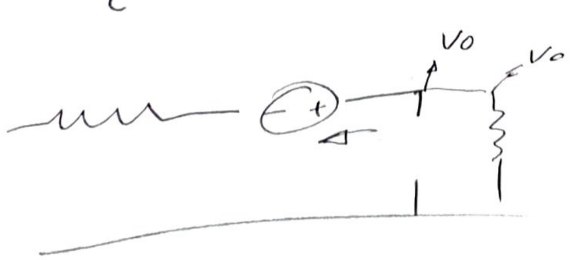
$I_2>0$ $\frac{-V_z-2V_\gamma-V_i}{R}>0$ $-V_z-2V_\gamma-V_i>0$ $-V_z-2V_\gamma>V_i$

$I_1>0$ $I_1=I_2-I_3$ $\frac{-V_z-V_\gamma-V_\gamma-V_i}{R_1}\ \frac{-V_z-V_\gamma}{R_2}>0$

$\frac{-V_z-V_\gamma}{R_2} > \frac{+V_z+2V_\gamma+V_i}{R_1}$ $\frac{R_1}{R_2}(-V_z-V_\gamma) > +V_z+2V_\gamma+V_i$

$-\frac{R_1}{R_2}V_z - V_z - \frac{R_1}{R_2}V_\gamma - 2V_\gamma > V_i$ $\frac{-R_2-R_1}{R_2}V_z\ \frac{-R_1-2R_2}{R_2}V_\gamma > V_i$

restrictiva



$I=\frac{-V_o}{R_2}$ $I=\frac{V_o-V_\gamma-V_i}{R_1}$

$\frac{-V_o}{R_2}=\frac{V_o-V_\gamma-V_i}{R_1}$ $\frac{R_1}{R_2}\cdot -V_o - V_o = -V_\gamma - V_i$

$\left(\frac{R_1}{R_2}-\frac{R_2}{R_2}\right)V_o = -V_\gamma - V_i$

$\left(\frac{-R_1-R_2}{R_2}\right)V_o = -V_\gamma - V_i$

$V_o = \frac{+R_2V_\gamma}{R_1+R_2} + \frac{R_2V_i}{R_1+R_2}$ $V_o=\left(\frac{R_2}{R_1+R_2}\right)(V_\gamma+V_i)$

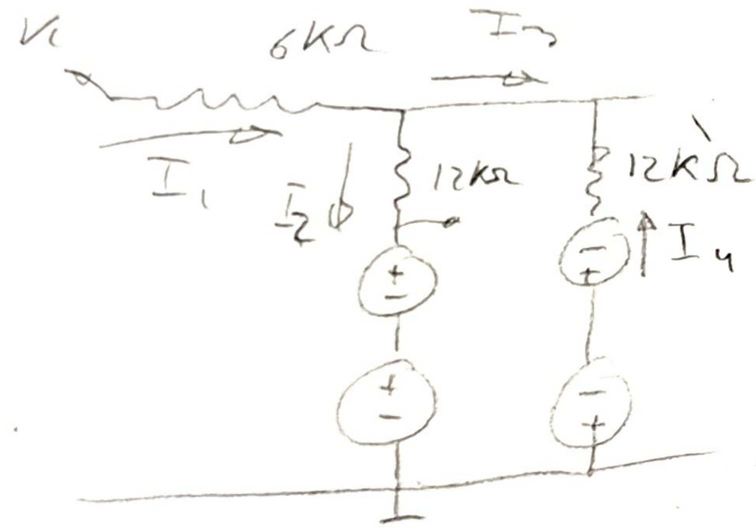
Para que ello ocurra

$I > 0 \quad \frac{-V_0}{R_2} > 0 \quad -V_0 > 0 \quad -V_\gamma - V_i > 0 \quad V_i < -V_\gamma$

$-V_0 < -V_Z + V_\gamma \quad \frac{R_2}{R_1+R_2}(-V_\gamma - V_i) < -V_Z + V_\gamma \quad -\frac{R_2}{R_1+R_2}V_\gamma + V_Z - V_\gamma > \frac{R_2}{R_1+R_2} V_i$

$\frac{R_1+R_2}{R_2}V_Z + -\frac{R_1-R_2}{R_2}V_\gamma - V_\gamma > V_i \to V_i > \frac{R_1+R_2}{R_2}V_Z + \frac{-R_1-R_2-R_2}{R_2}V_\gamma$

$V_i > \frac{R_1+R_2}{R_2}V_Z - \frac{R_1+2R_2}{R_2}V_\gamma$



$$I_1 = I_2 + I_3 \rightarrow I_1 = I_2 - I_4$$

$$I_3 = -I_4 \qquad \frac{V_i - V_o}{6K\Omega} = \frac{V_o - 12'6}{12K\Omega} - \frac{-10'6 - V_o}{12K\Omega}$$

$$2V_o - V_i = 1 \qquad V_o = \frac{1 + V_i}{2}$$

$$I_2 = \frac{V_o - 12'6}{12 \cdot 10^3} = \frac{\left(\frac{1+V_i}{2}\right) - 12'6}{12 \cdot 10^3} > 0 \rightarrow V_i > 24'2$$

$$I_3 = \frac{-10'6 - V_o}{12 \cdot 10^3} = \frac{-10'6 - \left(\frac{1+V_i}{2}\right)}{12 \cdot 10^3} > 0 \rightarrow V_i < -22'2$$

$\rightarrow$ Imposible

Anexo, los dos en conducción