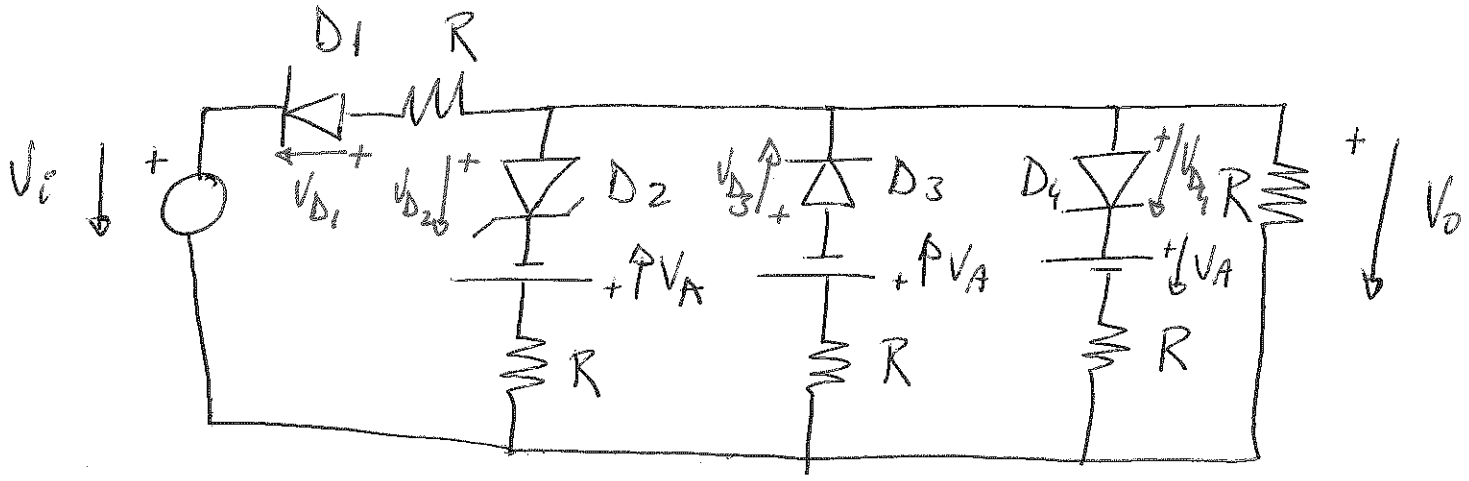
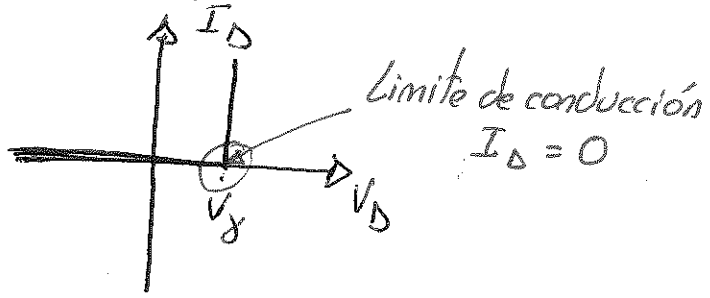
PROBLEMA REFUERZO DIODOS



CALCULO DE LIMITES DE CONDUCCIÓN DE CADA DIODO

En el límite de conducción de un diodo no pasa corriente por ese diodo ($I_D = 0$)



LIMITE DE CONDUCCIÓN DE D1

$$V_i = \cancel{I_D \cdot R}^{\,0} + V_o - V_{D1} \Rightarrow V_{D1} = V_o - V_i = V_\gamma \leftarrow \text{LÍMITE}$$

$V_D = V_o - V_i \geq V_\gamma \Rightarrow$ D1 on

$V_D = V_o - V_i < V_\gamma \Rightarrow$ D1 off

LÍMITE DE CONDUCCIÓN DEL D_2

$$V_{D_1} + \cancel{I_D R}^{\,0} = V_A + V_o \Rightarrow V_{D_1} = V_A + V_o \quad \text{LÍMITE}$$

Si $V_{D1} = V_A + V_o \geq V_\gamma \Rightarrow V_o \geq V_\gamma - V_A = -6{,}3V$ D_2 on

Si $V_{D1} = V_A + V_o \leq -|V_z| \Rightarrow V_o \leq -(V_z + V_A) = -10{,}3V$ D_2 ruptura

$$-10{,}3V < V_o < -6{,}3V \Rightarrow D_2 \text{ off}$$

LÍMITE DE CONDUCCIÓN DEL D_3

$$V_o + V_A + V_{D_3} + \cancel{I_D R}^{\,0} = 0 \Rightarrow V_{D_3} = -(V_o + V_A) \quad \text{LÍMITE}$$

Si $V_{D_3} = -(V_o + V_A) \geq V_\gamma \Rightarrow V_o \leq -V_A - V_\gamma = -7{,}7V \Rightarrow D_3$ on

Si $V_o > -7{,}7V \Rightarrow D_3$ off

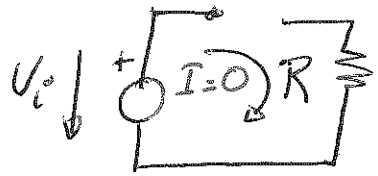
LÍMITE DE CONDUCCIÓN DEL D_4

$$V_A + V_{D_4} + \cancel{I_D R} = V_o \Rightarrow V_{D_4} = V_o - V_A \quad \text{LÍMITE}$$

Si $V_{D_4} = V_o - V_A \geq V_\gamma \Rightarrow V_o \geq V_\gamma + V_A = 7{,}7V \Rightarrow D_4$ on

Si $V_o < 7{,}7V \Rightarrow D_4$ off

1.- Suponemos todos los diodos off. El circuito que queda es:



$\Rightarrow I = 0A \Rightarrow V_o = 0V$

Comprobamos límites

D1 $\Rightarrow$ $V_o - V_i < V_\gamma \Rightarrow -V_i < V_\gamma \Rightarrow$ Si $V_i > -V_\gamma$ el D1 off

D2 $\Rightarrow$ $-10,3V < V_o < -6,3V$ off. No se cumple pues $V_o = 0V$

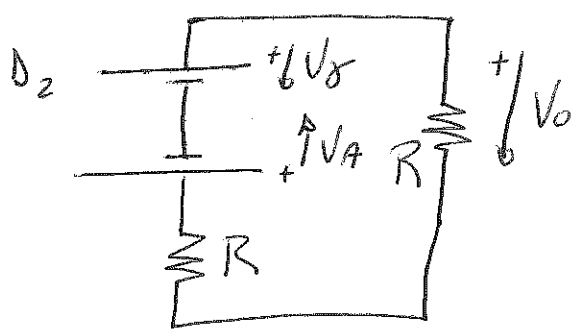
EL DIODO D2 NO ESTÁ OFF

D3 $\Rightarrow$ $V_o = 0V > -7,7V \Rightarrow$ D3 off o.k.

D4 $\Rightarrow$ $V_o = 0V < 7,7V \Rightarrow$ D4 off o.k.

LA SUPOSICIÓN ES INCORRECTA, CON $V_o = 0V \Rightarrow$ **D2 on**

2.- Suponemos D1, D3, D4 off y D2 on. El circuito que nos queda es:



$$I \cdot R + V_A + V_o = V_\gamma \Rightarrow I = \frac{V_\gamma - V_A - V_o}{R}$$

$$V_o = IR = \frac{V_\gamma - V_A - V_o}{R} \cdot R$$

$$V_o = \frac{V_\gamma - V_A}{2} = -3,15V$$

Comprobamos: ($V_o = -3{,}15\,V$)

D_1 off $\Rightarrow$ $V_o - V_i < V_\gamma \Rightarrow -V_i < 3{,}15 + 0{,}7 = 3{,}85V$

$V_i > -7V \Rightarrow D_1$ off

D_2 on $\Rightarrow$ $V_o = -3{,}15V \geq -6{,}3V \Rightarrow$ o.k.

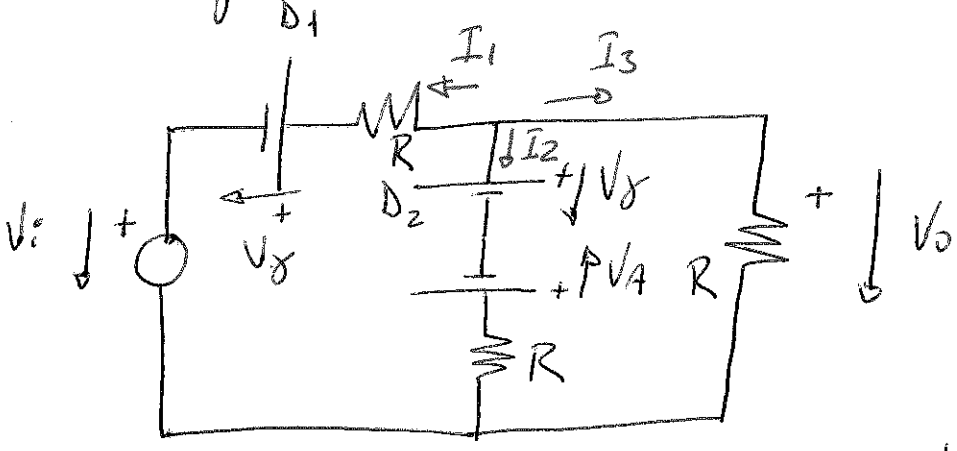
D_3 off $\Rightarrow$ $V_o = -3{,}15V \geq -7{,}7V \Rightarrow$ o.k.

D_4 off $\Rightarrow$ $V_o = -3{,}15V < 7{,}7V \Rightarrow$ o.k

D_1, D_3, D_4 off y D_2 on se cumple mientras $V_i > -3{,}85V$

Si $V_i \leq -3{,}85V \Rightarrow D_1$ on.

3.- Suponemos D_1, D_2 on y D_3, D_4 off para $V_i \leq -3{,}85V$



$I_1 + I_2 + I_3 = 0$

I_1: $V_i = -V_\gamma - I_1 R + V_o \Rightarrow I_1 = \dfrac{-V_i + V_o - V_\gamma}{R}$

I_2: $V_o + V_A = V_\gamma + I_2 R \Rightarrow I_2 = \dfrac{V_o + V_A - V_\gamma}{R}$

I_3: $V_o = I_3 R \Rightarrow I_3 = \dfrac{V_o}{R}$

$$\frac{-V_i + V_o - V_\gamma}{R} + \frac{V_o + V_A - V_\gamma}{R} + \frac{V_o}{R} = 0 \Rightarrow V_o = \frac{2V_\gamma + V_i - V_A}{3} \Rightarrow$$

$$V_o = -1{,}8 + \frac{V_i}{3}$$

Comprobamos $\left(V_o = -1,8 + \frac{V_i}{3}\right)$ Para $V_i \leq -3,85V$

D_1 on $\Rightarrow$ $V_o - V_i \geq V_\gamma$

$$-1,8 - V_i + \frac{V_i}{3} \geq V_\gamma$$

$$-V_i \geq \frac{3}{2}(V_\gamma + 1,8) = -3,75V$$

$$V_\gamma = 0,7$$

$$V_i \leq 3,75V \quad \text{o.k.}$$

D_2 on $\Rightarrow$ $V_o \geq -6,3V$

$$-1,8 + \frac{V_i}{3} \geq -6,3V$$

$$V_i \geq -(6,3 - 1,8) \cdot 3 = -13,5V$$

D_3 off $\Rightarrow$ $V_o > -7,7V$

$$-1,8 + \frac{V_i}{3} > -7,7V$$

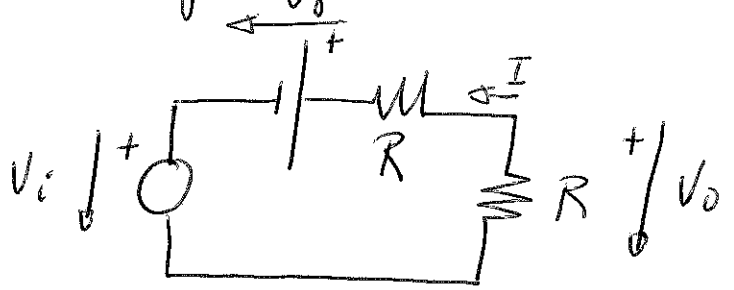
$$V_i > -(7,7 - 1,8) \cdot 3 = -17,7V$$

D_4 off $\Rightarrow$ $V_o < 7,7V$

$$V_i < (7,7 + 1,8) \cdot 3 = 28,5V \quad \text{o.k.}$$

D_2 pasa a estar off cuando $V_i < -13,5V$
D_3 pasa a estar on cuando $V_i \leq -17,7V$
$\Rightarrow$ Primero pasa D_2 a estar off

4.- Suponemos D_1 on, D_2, D_3, D_4 off $(V_i \leq -13,5V)$



$$V_i + V_\gamma + IR = V_o$$

$$V_o = -IR$$

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

$$V_o = \frac{V_i + V_\gamma}{2}$$

Comprobamos:

D_1 on $\Rightarrow$ $V_o - V_i \geq V_\gamma$

$$\frac{V_i}{2} + \frac{V_\gamma}{2} - V_i \geq V_\gamma$$

$$-V_i \geq \frac{V_\gamma}{2} \Rightarrow V_i \leq -V_\gamma \text{ o.k.}$$

D_2 off $\Rightarrow$ $-10,3V < V_o < -6,3V$

$$-10,3V < \frac{V_i + V_\gamma}{2} < -6,3V$$

$$-21,3V = -V_\gamma - (10,3 \cdot 2) < V_i < -(6,3 \cdot 2) - V_\gamma = -13,3V$$

D_3 off $\Rightarrow$ $V_o > -7,7V$

$$\frac{V_i + V_\gamma}{2} > -7,7 \Rightarrow V_i > (-7,7) \cdot 2 - V_\gamma = -16,1V$$

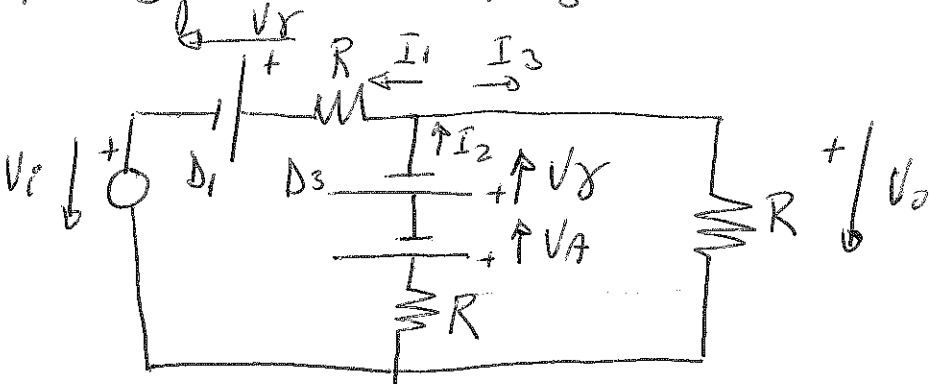
D_4 off $\Rightarrow$ $V_o < 7,7V$

$$\frac{V_i + V_\gamma}{2} < 7,7V \Rightarrow V_i < 7,7 \cdot 2 - 0,7 = 14,7$$

o.k.

D_2 pasa a ruptura cuando $V_i \leq -21,3\,V$
D_3 pasa a on cuando $V_i \leq -16,1\,V$
] $\Rightarrow$ Primero pasa D_3 a estar on

5.- Suponemos D_1, D_3 on, D_2, D_4 off $\quad V_i \leq -16,1\,V$



$I_2 = I_1 + I_3$

I_1: $\quad V_i + V_\gamma + I_1 R = V_o \Rightarrow I_1 = \dfrac{V_o - V_i - V_\gamma}{R}$

I_2: $\quad V_o + V_\gamma + V_A + I_2 R = 0 \Rightarrow I_2 = -\dfrac{V_o + V_A + V_\gamma}{R}$

I_3: $\quad V_o = I_3 R \Rightarrow I_3 = \dfrac{V_o}{R}$

$$-V_o - V_A - V_\gamma = V_o - V_i - V_\gamma + V_o$$

$$V_o = -\frac{V_i - V_\gamma + V_A + V_\gamma}{3} = \frac{V_i - V_A}{3} = \frac{V_i}{3} - \frac{7}{3}$$

Comprobamos:

D_1 on $\Rightarrow \quad V_o - V_i \geq V_\gamma$

$$\frac{V_i}{3} - \frac{7}{3} - V_i \geq V_\gamma$$

$$-V_i \geq \frac{3}{2}\left(V_\gamma + \frac{7}{3}\right) = 4,55\,V$$

$$V_i \leq 4,55\,V \quad \text{o.k.}$$

D_2 off $\Rightarrow$ $-10,3V < V_o < -6,3V$

$$-10,3V < \frac{V_i}{3} - \frac{7}{3} < -6,3V$$

$$-23,9V = 3\cdot\left(-10,3+\frac{7}{3}\right) < V_i < \left(-6,3+\frac{7}{3}\right)\cdot 3 = -11,9V$$

D_3 on $\Rightarrow$ $V_o \leq -7,7V$

$$\frac{V_i}{3} - \frac{7}{3} \leq -7,7V$$

$$V_i \leq 3\left(-7,7+\frac{7}{3}\right) = -16,1V \quad \text{o.k.}$$

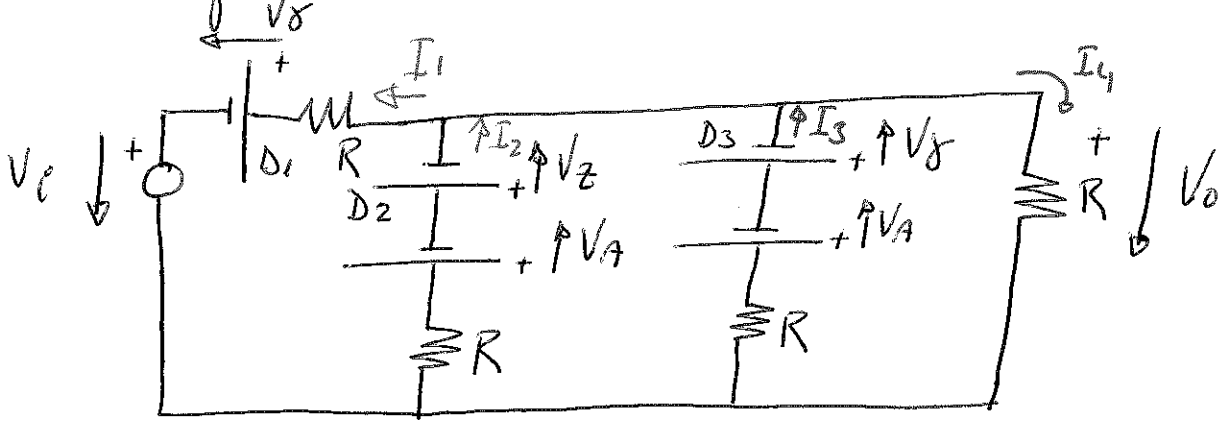
D_4 off $\Rightarrow$ $V_o < 7.7V$

$$\frac{V_i}{3} - \frac{7}{3} < 7.7$$

$$V_i < \left(7,7+\frac{7}{3}\right)\cdot 3 = 30,1V \quad \text{o.k.}$$

Para $V_i \leq -23,9V$ $\Rightarrow$ D_2 ruptura.

6.- Suponemos D1. D3 on. D2 ruptura. D4 off



$$I_1 + I_4 = I_2 + I_3$$

I_1: $I_1 R + V_i + V_\gamma = V_o \Rightarrow I_1 = \dfrac{V_o - V_i - V_\gamma}{R}$

I_2: $V_A + V_Z + V_o + I_2 R = 0 \Rightarrow I_2 = -\dfrac{V_o + V_A + V_Z}{R}$

I_3: $V_A + V_\gamma + V_o + I_3 R = 0 \Rightarrow I_3 = -\dfrac{V_o + V_A + V_\gamma}{R}$

I_4: $V_o = I_4 R \Rightarrow I_4 = \dfrac{V_o}{R}$

$$V_o - V_i - V_\gamma + V_o = -(V_o + V_A + V_A + V_o + V_\gamma + V_Z)$$

$$V_o = \frac{V_i + V_\gamma - V_A - V_A - V_\gamma - V_Z}{4} = \frac{V_i - 2V_A - V_Z}{4}$$

$$V_o = \frac{V_i}{4} - 4{,}325$$

Comprobamos:

D_1 on $\Rightarrow$ $V_o - V_i \geq V_\gamma$

$$\frac{V_i}{4} - V_i - 4{,}325 \geq V_\gamma$$

$$-V_i \geq (V_\gamma + 4{,}325)\cdot\frac{4}{3} = 6{,}7$$

$$V_i \leq -6{,}7\,V \quad \text{o.k.}$$

D_2 captura $\Rightarrow$ $V_o \leq -10{,}3\,V$

$$\frac{V_i}{4} - 4{,}325 \leq -10{,}3\,V$$

$$V_i \leq (4{,}325 - 10{,}3)\cdot 4 = -23{,}9\,V \quad \text{o.k.}$$

D_3 on $\Rightarrow$ $V_o \leq -7{,}7\,V$

$$\frac{V_i}{4} - 4{,}325 \leq -7{,}7\,V$$

$$V_i \leq (4{,}325 - 7{,}7)\cdot 4 = -13{,}5 \quad \text{o.k.}$$

D_4 off $\Rightarrow$ $V_o < 7.7\,V$

$$\frac{V_i}{4} - 4{,}325 < 7.7\,V$$

$$V_i < (7.7 + 4{,}325)\cdot 3 = 36{,}075\,V$$

o. k.

RESUMEN

$-3{,}85V < V_i$ $D_1 . D_3 . D_4$ off D_2 on $\Rightarrow$ $V_o = -3{,}15\,V$

$-13{,}5V \leq V_i \leq -3{,}85V$ $D_1 . D_2$ on, $D_3 . D_4$ off $\Rightarrow$ $V_o = -1{,}8 + \frac{V_i}{3}$

$-16{,}1V < V_i < -13{,}5V$ D_1 on, $D_2 . D_3 . D_4$ off $\Rightarrow$ $V_o = 0{,}35 + \frac{V_i}{2}$

$-23{,}9V < V_i \leq -16{,}1V$ $D_1 . D_3$ on, $D_2 . D_4$ off $\Rightarrow$ $V_o = \frac{V_i}{3} - \frac{7}{3}$

$V_i \leq -23{,}9V$ $D_1 . D_3$ on, D_2 ruptura, D_4 off $\Rightarrow$ $V_o = \frac{V_i}{4} - 4{,}325$