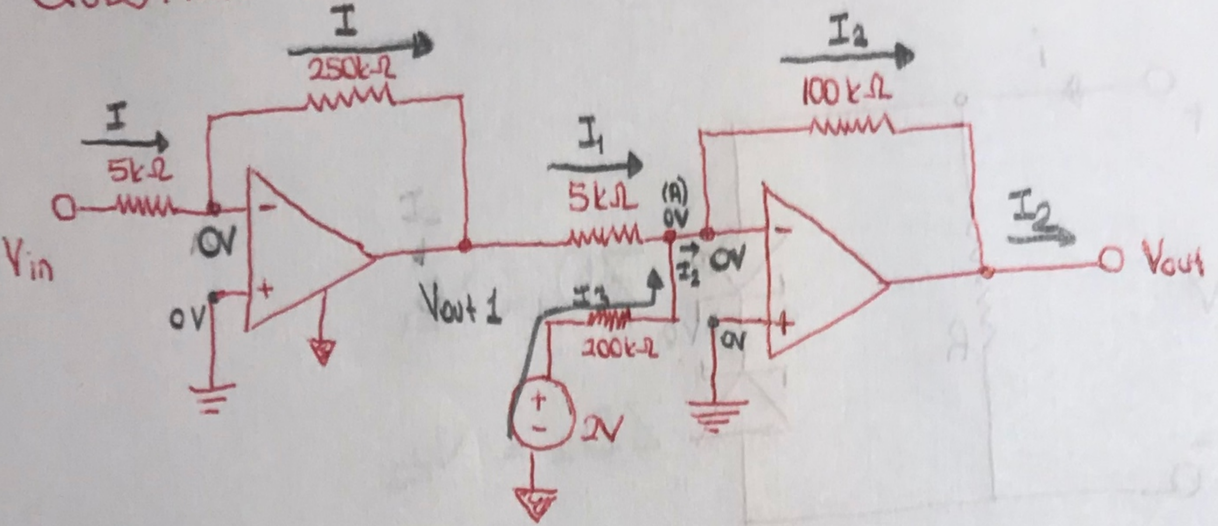
TEVFIK ÖZGU
150180082

QUESTION 1:



$V_{OUT} = ?$

$$V_{out_1} = -V_{in} \cdot \frac{250}{5} = -50 \cdot V_{in}$$

$I_1 + I_2 - I_3 = 0 \longrightarrow$ KCL at point A.

$$\frac{V_{out_1} - 0V}{5k\Omega} + \frac{2V - 0V}{200k\Omega} - \frac{0V - V_{out}}{100k\Omega} = 0$$

$$\frac{-50 V_{in}}{5k\Omega} + \frac{2V}{200k\Omega} + \frac{V_{out}}{100k\Omega} = 0 \Longrightarrow \frac{V_{out}}{100k\Omega} = \frac{10 V_{in}}{1k\Omega} - \frac{1V}{100k\Omega}$$

$$\boxed{\text{So } V_{out} = 1000 V_{in} - 1}$$

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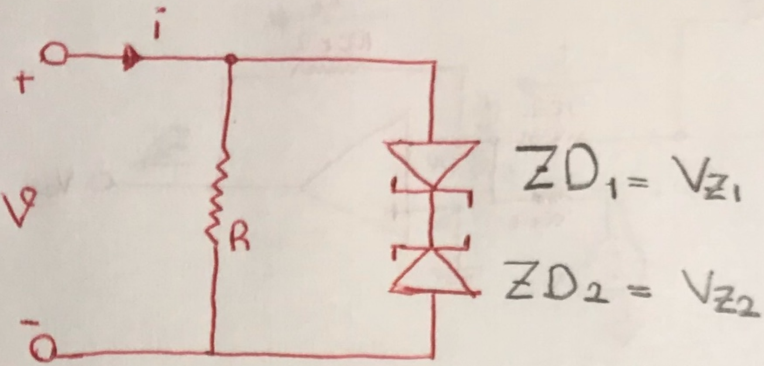
QUESTION 2:

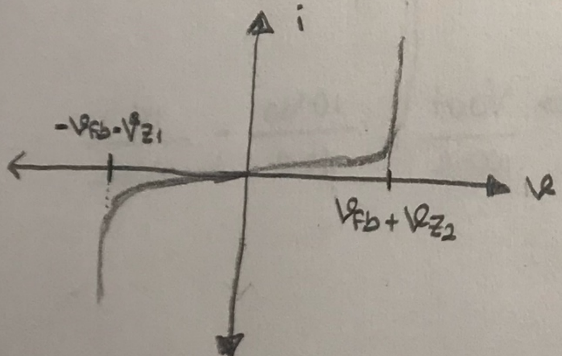


Find nonlinear i-v characteristic of circuit

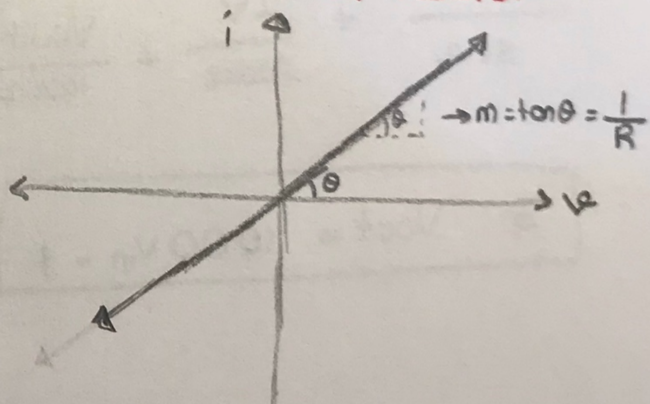
If $v > 0$, first zener diode is forward biased and second zener diode is reverse biased. So until $v < V_{fb} + V_{Z_2}$ there won't be current. And after that point zener diodes will act like voltage regulator.

If $v < 0$, first zener diode is reverse biased and second zener diode is forward biased. So until $v > -V_{fb} - V_{Z_1}$ there won't be current. After that point zener diodes will act like voltage regulator.

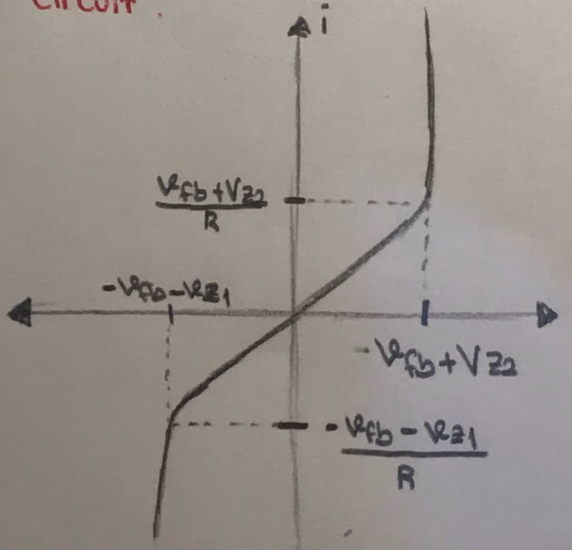
iv characteristic of zener diodes:



i-v characteristic of resistor



i-v characteristic of circuit:



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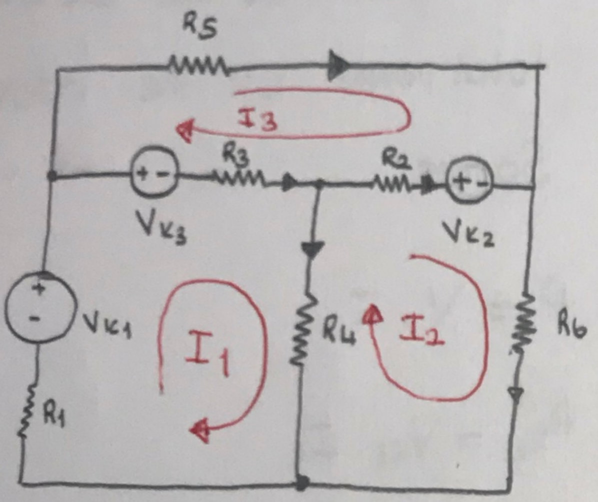
QUESTION 3:



KVL at MESH 1: $I_1 R_1 - V_{K1} + V_{K3} + (I_1 - I_3) R_3 + (I_1 - I_2) R_4 = 0$ (1)

KVL at MESH 2: $I_2 R_6 + (I_2 - I_1) R_4 + (I_2 - I_3) . R_2 + V_{K2} = 0$ (2)

KVL at MESH 3: $I_3 R_5 - V_{K2} + (I_3 - I_2) R_2 + (I_3 - I_1) . R_3 - V_{K3} = 0$ (3)

From Eq (1): $I_1 R_1 + I_1 R_3 - I_3 R_3 + I_1 R_4 - I_2 R_4 - V_{K1} + V_{K3} = 0$

So $(R_1 + R_3 + R_4) . I_1 - R_3 . I_3 - R_4 . I_2 = V_{K1} - V_{K3}$

From Eq (2): $I_2 R_6 + I_2 R_4 - I_1 R_4 + I_2 R_2 - I_3 R_2 + V_{K2} = 0$

So $-R_4 I_1 - (R_6 + R_4 + R_2) . I_2 + R_2 . I_3 = V_{K2}$

From Eq (3): $I_3 R_5 - V_{K2} + I_3 R_2 - I_2 R_2 + I_3 R_3 - I_1 R_3 - V_{K3} = 0$

So $-I_1 R_3 - I_2 R_2 + (R_3 + R_5 + R_2) I_3 = V_{K3} + V_{K2}$

$$\begin{bmatrix} R_1+R_3+R_4 & -R_4 & -R_3 \\ R_4 & -(R_6+R_4+R_2) & R_2 \\ -R_3 & -R_2 & R_3+R_5+R_2 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} V_{K1}-V_{K3} \\ V_{K2} \\ V_{K3}+V_{K2} \end{bmatrix}$$

$$I_1 = \frac{\begin{vmatrix} V_{K1}-V_{K3} & -R_4 & -R_3 \\ V_{K2} & -(R_6+R_4+R_2) & R_2 \\ V_{K3}+V_{K2} & -R_2 & R_3+R_5+R_2 \end{vmatrix}}{\begin{vmatrix} R_1+R_3+R_4 & -R_4 & -R_3 \\ R_4 & -(R_6+R_4+R_2) & R_2 \\ -R_3 & -R_2 & R_3+R_5+R_2 \end{vmatrix}}$$

$$I_2 = \frac{\begin{vmatrix} R_1+R_3+R_4 & V_{K1}-V_{K3} & -R_3 \\ R_4 & V_{K2} & R_2 \\ -R_3 & V_{K3}+V_{K2} & R_2+R_3+R_5 \end{vmatrix}}{\begin{vmatrix} R_1+R_3+R_4 & -R_4 & -R_3 \\ R_4 & -(R_6+R_4+R_2) & R_2 \\ -R_3 & -R_2 & R_3+R_5+R_2 \end{vmatrix}}$$

$$I_3 = \frac{\begin{vmatrix} R_1+R_3+R_4 & -R_4 & V_{K1}-V_{K3} \\ R_4 & -(R_6+R_4+R_2) & V_{K2} \\ -R_3 & -R_2 & V_{K3}+V_{K2} \end{vmatrix}}{\begin{vmatrix} R_1+R_3+R_4 & -R_4 & -R_3 \\ R_4 & -(R_6+R_4+R_2) & R_2 \\ -R_3 & -R_2 & R_3+R_5+R_2 \end{vmatrix}}$$

Since we know I_1, I_2 and I_3 volues we can determine total power of the independent Sources.

$$P = V \cdot I$$

$$P_{V_{K1}} = V_{K1} \cdot I_1$$

$$P_{V_{K2}} = V_{K2} \cdot (I_2 - I_3)$$

$$P_{V_{K3}} = V_{K3} \cdot (I_1 - I_3)$$

$$P_{total} = P_{V_{K1}} + P_{V_{K2}} + P_{V_{K3}}$$