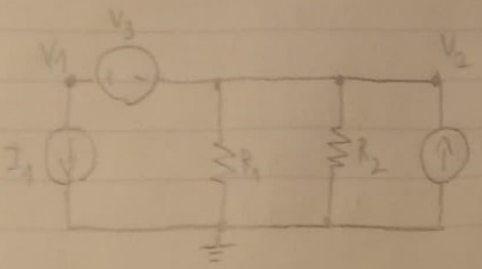


$I_1 = 750\,\mu A$
$R_1 = 30\,k\Omega$
$R_2 = 68\,k\Omega$
$I_2 = 460\,\mu A$
$V_3 = 1{,}2\,V$

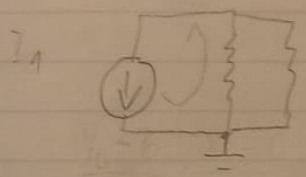
$V_1 - V_2 = 1{,}2\,V$
$I_1 + \frac{V_2}{R_1} + \frac{V_1}{R_2} - I_2 = 0$

$V_a = V_1 = -5{,}0449$
$V_b = V_2 = -6{,}2449$

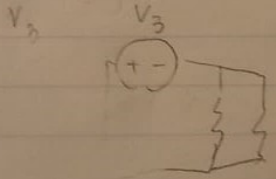
$I_1 \cdot V_a = P_{I_1} = -5{,}0449 \cdot 0{,}750 = -3{,}78\,mW$

b) I_2:

$V' = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1} \cdot I_2 = 9{,}36735\,V$



$V'' = -15{,}61224\,V$

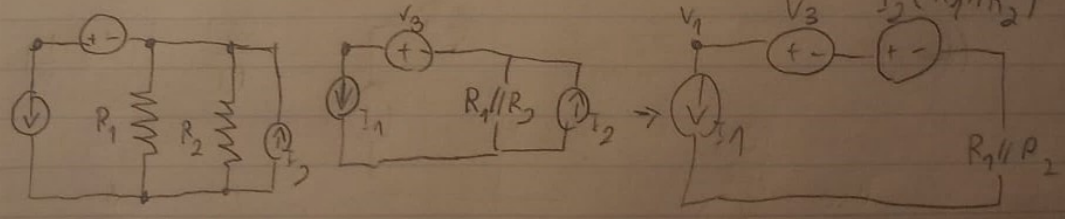


$V''' = 0\,V$

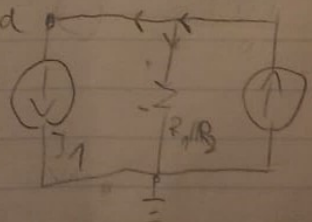
$V' + V'' + V''' = -6{,}2449\,V$ //

$V_3 + I_2(R_1 // R_2)$

c)

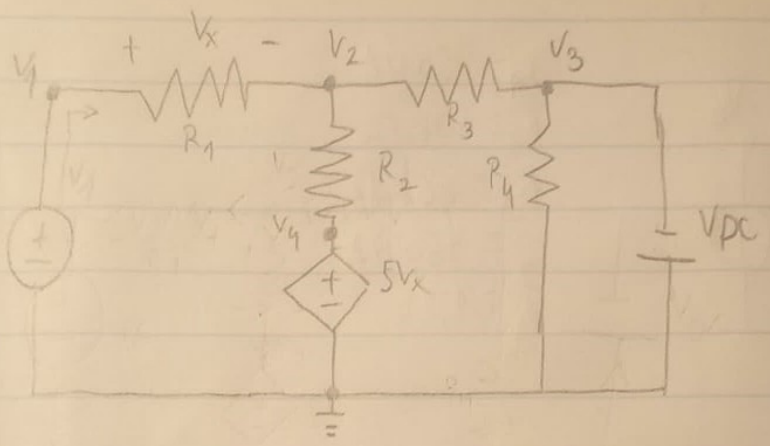


d



$\frac{V_3 + I_2(R_1 // R_2)}{R_1 // R_2} = I_1 + \frac{V_a}{R_1 // R_2}$

$\hookrightarrow V_a = 5{,}04\,V$



$R_1 = 1\,\Omega$
$R_2 = 2\,\Omega$
$R_3 = 3\,\Omega$
$R_4 = 4\,\Omega$
$V_{DC} = 8\,V$

a) $V_3 = -8\,V$
$V_1 = 6V$
$V_4 = 5V_x = (V_1 - V_2)5$

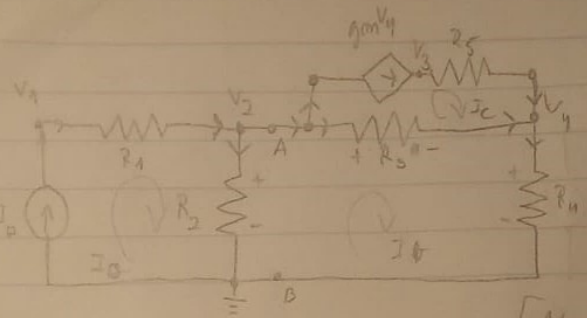
$V_3 = -8V$
$V_1 = 6V$

$V_2 = 7.23V$
$V_4 = 8.8V$

$$\frac{(V_2 - V_1)}{R_1} + \frac{V_2 - V_4}{R_2} + \frac{V_2 - V_3}{R_3} = 0$$

c) $P_{V_6} = 6 \cdot (-1.77) = -10.62\,W$

6



$R_1 = 2\Omega$
$R_2 = 5\Omega$
$R_3 = R_4 = 2\Omega$
$R_5 = 10\Omega$
$I_0 = 1A$
$g_m = 2S$

$* - \left(\frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}\right)$

$V_1 = -18V \quad V_3 = 21V$
$V_2 = -20V \quad V_4 = 10$

a) $I_0 = \frac{1}{R_1}(V_1 - V_2)$

$\frac{1}{R_1}(V_1 - V_2) = \frac{1}{R_2}V_2 + g_m V_4 + \frac{1}{R_3}(V_2 - V_4)$

$g_m V_4 = \frac{1}{R_5}(V_3 - V_4)$

$\frac{1}{R_5}(V_3 - V_4) + \frac{1}{R_4}(V_3 - V_4) = \frac{1}{R_4}(V_4)$

$$\begin{bmatrix} 1/R_1 & -1/R_1 & 0 & 0 \\ 1/R_1 & -\left(\frac{1}{R_1}\frac{1}{R_2}\frac{1}{R_3}\right) & 0 & 1/R_3 - g_m \\ 0 & 0 & 1/R_5 & -1/R_5 - g_m \\ 0 & 1/R_3 & 1/R_5 & * \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \end{bmatrix} = \begin{bmatrix} I_0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

b) $I_0 = I_a$

$-R_2(I_a - I_b) + R_3(I_b - I_c) + R_4 I_b = 0$

$I_c = g_m V_4 \Rightarrow I_c - g_m I_b \cdot R_4 = 0$

$$\begin{bmatrix} 1 & 0 & 0 \\ -R_2 & R_2 + R_3 + R_4 & -R_3 \\ 0 & -g_m R_4 & 1 \end{bmatrix} \begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} = \begin{bmatrix} I_0 \\ 0 \\ 0 \end{bmatrix}$$

c) $I_a = 1A \quad V_{R_5} = R_5 \cdot I_c \Leftrightarrow V_{R_5} = 10 \cdot 10 = 100V$

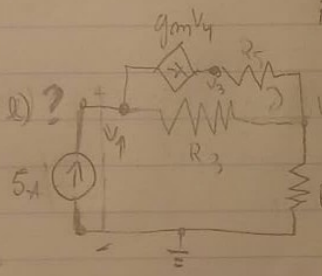
$I_b = 6A$

$I_c = 20A$

$R = \frac{-20}{-5} = 4\Omega$

d) $R_{Th} = 5\Omega$

$V_{Th} = 5V$



$V_{Th} = 0V$

f) $V_{Th} + V_{Th} = 5 + 0 = 5 = V_{ab}$

$-g_m V_4 + \frac{V_3 - V_4}{R_5} = 0$

$-5 + g_m V_4 + \frac{V_1 - V_4}{R_3} = 0$

$\frac{V_4}{R_4} + \frac{V_4 - V_1}{R_3} + \frac{V_4 - V_3}{R_5}$

1º fontes ind + RS (R_{Th}, I_N, R_{eq} escolhe 2)

2º fontes ind + dep + RS (R_{Th} e I_N) ↓ ou transformar em 3

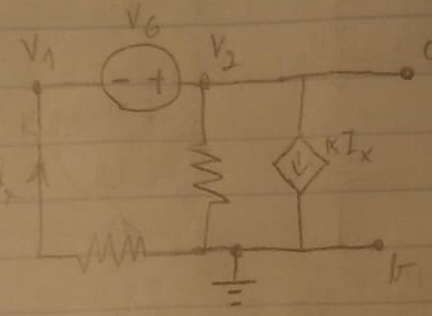
3º fontes ind + RS (usar uma fonte de teste) $\rightarrow V_{Th}$ e $I_N = 0$

4º RS ($V_{Th} = 0$ e $I_N = 0$)

$V_G = 30V$

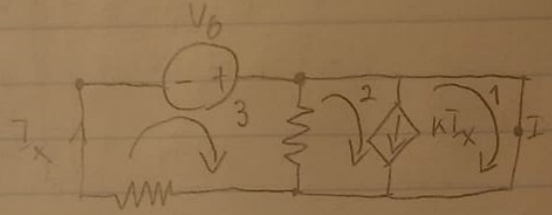
$R = 6k\Omega$

$k = \frac{1}{2}$



a)

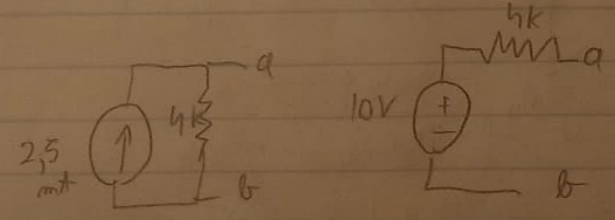
$$\begin{cases} V_2 - V_1 = 30V \\ \frac{V_1}{R} + \frac{V_2}{R} + \left(-\frac{1}{2}\frac{V_1}{R}\right) = 0 \end{cases} \qquad V_2 = 10V = V_{Th} = V_{ab} \qquad V_1 = -20V$$



$$\begin{cases} I_2 = I_1 + kI_x \\ R(I_2 - I_3) = 0 \\ I_3 = I_x \end{cases} \Leftrightarrow \begin{cases} I_2 = I_1 + \frac{1}{2}I_x \\ I_2 = I_3 \\ I_3 = I_x \end{cases} \Rightarrow \begin{cases} \frac{1}{2}I_3 = I_1 \\ -V_G + R(I_3 - I_2) + RI_3 = 0 \end{cases}$$

$$I_1 = I = I_{ab} = I_{cc} = 2{,}5\,mA$$

b)



3.4

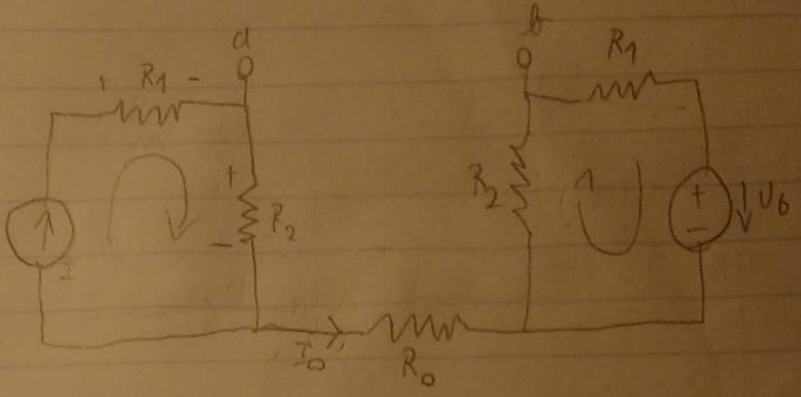
$V_G = 20V$

$I = 20\,mA$

$R_0 = 125\,\Omega$

$R_1 = 1{,}5\,k\Omega$

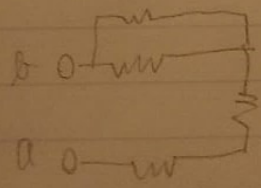
$R_2 = 600\,\Omega$



a) $I - I = I_0 \Rightarrow I_0 = 0\,A$

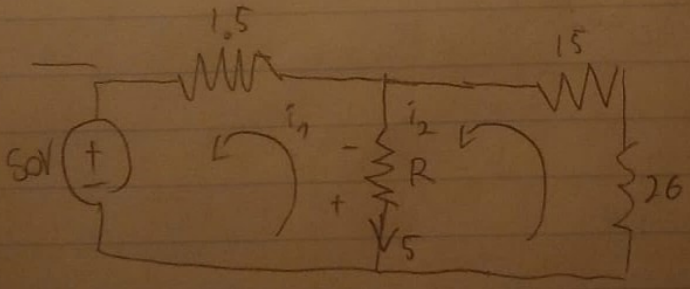
b) $-V_{ab} + R_2(I + 0) - V_0 \frac{R_2}{R_1 + R_2} = 0 \Rightarrow V_{ab} = 5V$

c) $V_{Th} = 5V$



$\Rightarrow R_2 + R_0 + (R_1 // R_2) \Rightarrow R_{Th} = 1000\,\Omega = 1k\,\Omega$

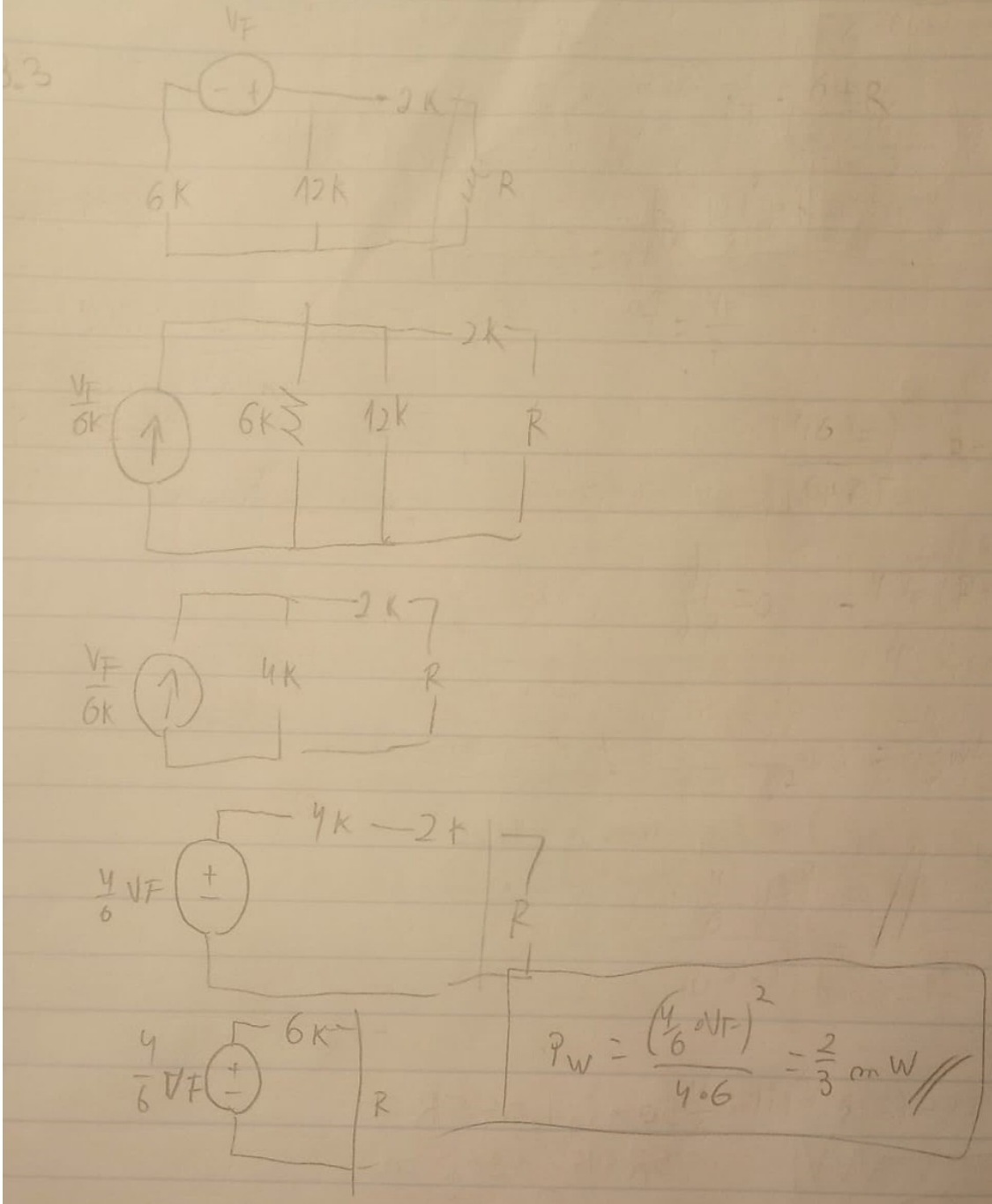
d) $i_{CC} = i_{ab} = \frac{V_{OC}}{R_{Th}} = \frac{V_{Th}}{R_{Th}} = \frac{5}{1} = 5\,mA$



$50 + i_1 1{,}5 - 5R = 0$

$5R + 15 i_2 + 26 i_2 = 0$

$i_2 = i_1 + 5$

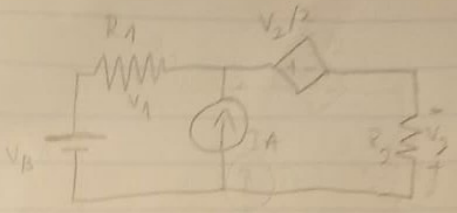

VF
2K
6K
12K
R
2K
VF/6K
6K
12K
R
2K
VF/6K
4K
R
4K — 2K
4/6 VF
R
6K
4/6 VF
R
$P_W = \frac{(\frac{4}{6} \cdot VF)^2}{4 \cdot 6} = \frac{2}{3}$ on W

3.2 $I_A = 4\,mA$

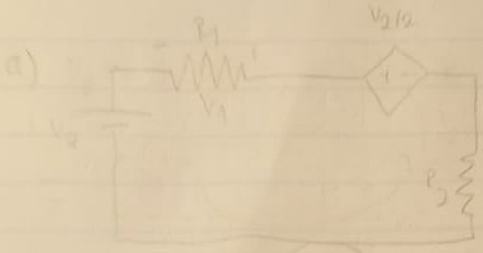
$V_B = 1V$

$R_1 = 1k\Omega$

$R_2 = 3k\Omega$



a)

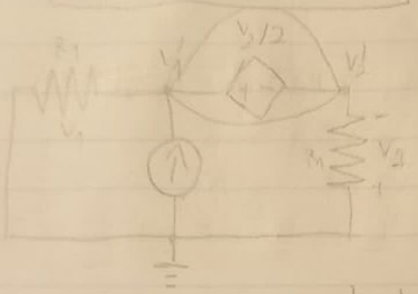


$\begin{cases} V_B + R_2 \cdot I_0 - \frac{R_2 V_2}{2} + R_1 \cdot I \\ V_2 = R_2 \cdot I \end{cases}$

$I = -0,4$

$V_2' = -1,2$

$V_1' = -0,4$



$\begin{cases} V_1' - V_2' = \frac{V_2}{2} \\ V_2 = -V_2' \\ \frac{V_1'}{1} - 4 + \frac{V_2'}{2} = 0 \end{cases}$

$V_1' = 2,4\,V$

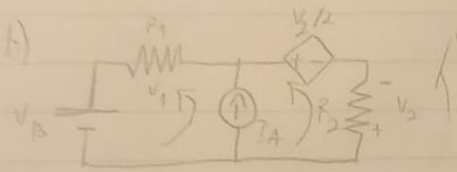
$V_2' = 4,8\,V$

$V_2 = -4,8\,V$

$V_2 = V_2' + V_2' = -6\,V$ ✓

$V_1 = V_1' + V_1' = 2,4 - 0,4 = 2V$

b)



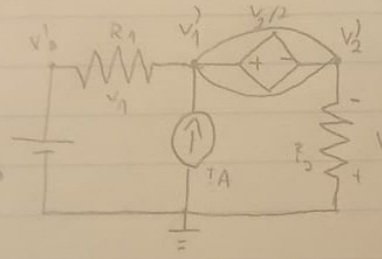
$\begin{cases} V_B + R_1 \cdot I_1 - \frac{R_2 I_2}{2} + R_2 I_3 = 0 \\ I_1 = I_2 + I_4 \end{cases}$

$I_1 = 2A$

$I_2 = -2\,mA$

$V_2 = R_2 \cdot I_2 = 3 \cdot 2 = -6\,V$ $V_1 = 2V$

c)



$\begin{cases} -I_4 + \frac{V_1' - V_3'}{R_1} + \frac{V_2'}{R_2} \\ V_3' = V_B \\ V_1' - V_2' = \frac{V_2}{2} \\ V_2 = -V_2' \end{cases}$

$V_1' = 3$

$V_2' = 6$

$V_3' = 1$

$V_2 = -6$

$V_1 = V_3' - V_1' = 2\,V$

$V_2 = -6\,V$

d) $P_{V_B} = 2 \cdot 1 = 2mW$

$P_{R_1} = 2 \cdot 2 = 4\,mW$

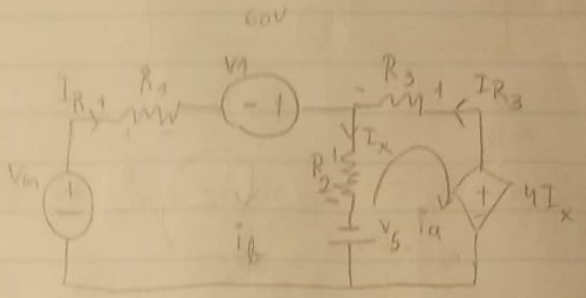
$P_{R_2} = -2 \cdot -6 = 12\,mW$

$P_{I_4} = -3 \cdot 4 = -12\,mW$

$P_{V_{2/2}} = -3 \cdot 2 = -6\,mW$

✓ 3.1

a) $V_1 = 60V$
$R_1 = 5\Omega$
$R_3 = 3\Omega$
$R_2 = 2\Omega$
$I_{R_1} = 2A$
$I_{R_3} = 8A$



$i_b = I_{R_1}$ $i_a = I_{R_3}$

$R_1 = 5\Omega$ $R_2 = 2\Omega$ $I_x = I_{R_1} + I_{R_3} = 10A$
$I_{R_1} = 2A$ $I_{R_3} = 8A$ $R_2 = 3\Omega$
$V_{R_1} = 10V$ $V_{R_3} = 16V$ $V_{R_2} = 30V$

$$\begin{cases} -V_{im} + V_{R_1} - V_1 + R_3(i_b - i_a) - V_S = 0 \\ V_S - 3(i_b - i_a) - V_{R_3} + 4I_x = 0 \end{cases}$$

$$\Leftrightarrow \begin{cases} -V_{im} + 10 - 60 + 3 \cdot 10 - V_S = 0 \\ V_S - 3(10) - 16 + 4 \cdot 10 = 0 \end{cases} \Leftrightarrow \begin{cases} V_{im} = -26 \\ V_S = 6 \end{cases}$$

b) $P = 4I_x \cdot -I_{R_3} = 4 \cdot 10 \cdot -8 = -320W$

c) Sobreposição

V_1: $\frac{60}{3} = 20A$
V_{im}: $-\frac{36}{3} = -12A$
V_S: $\frac{6}{3} = 2A$

$20 - 12 + 2 = 10A$ //

Nós: $I_x = I_{R_1} + I_{R_3} \Leftrightarrow I_x = 10A$ /

Malhas $V_S - 3(i_b - i_a) - V_{R_3} + 4I_x = 10A$ //

d) $V_{Th} = V_4$

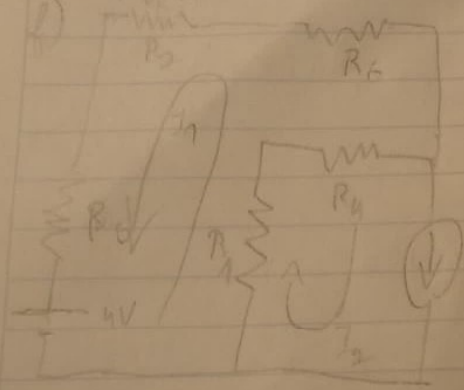
$R_{Th} = 1,3 // 1,4 \pm \Omega$

$I_N = \frac{V_4}{R_4}$

e) $I_N = I_E$

$V_{Th} = V_5$

$R_H = \frac{V_5}{I_E}$

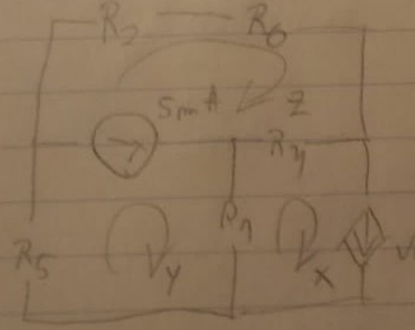


$I_2 = \frac{V_x}{400}$

$I_1:$ $R_1(I_1+I_2) + R_4(I_1+I_2) + R_6(I_1) + R_2(I_1) + R_5(I_1) + 4 = 0$

$I_1 \cdot R_2 = -V_x$

$V_x = \frac{2}{5}$



$I_x = \frac{V_x}{400}$

$I_y = 5mA + I_2$

$R_1(I_y - I_x) + R_5(I_y) + R_2(I_2) + R_6(I_2) + R_4(I_2 - I_x) = 0$

$V_x = R_2 \cdot I_2$

$V_x = -\frac{3}{4}$

$V_x = -\frac{3}{4} + \frac{2}{5} = -0.35V$

3.9 $V_x = 2000 \cdot I_T$

a)

b)

$I_D = \frac{V_x}{4000} \Rightarrow I_D = \frac{2000 \cdot I_T}{4000} \Rightarrow I_D = \frac{1}{2} I_T \Rightarrow I_D - \frac{1}{2} I_T = 0$

KVL:

$-4 + R_5 I_E + R_2 \cdot I_T + R_6 \cdot I_T + R_4 (I_T - I_D) + R_1 (I_E - I_D) = 0$

$I_E = I_T + 5$

$$\begin{bmatrix} 1 & 0 & -1 \\ 0 & 1 & -\frac{1}{2} \\ R_5 + R_1 & -R_1 - R_4 & R_2 + R_6 + R_4 \end{bmatrix} \cdot \begin{bmatrix} I_E \\ I_D \\ I_T \end{bmatrix} = \begin{bmatrix} 5 \\ 0 \\ 4 \end{bmatrix}$$

$I_E = \frac{13}{4000}$

$I_D = \frac{-7}{8000}$

$I_T = \frac{-7}{1000}$

b) $V_5 = 4V$

V_x

$\frac{(V_1 - V_5)}{R_5} + 5 + \frac{(V_1 - V_2)}{R_2} = 0$

$-5 + \frac{(V_3 - V_4)}{R_4} + \frac{V_3}{R_1}$ ↑ $V_4 - V_2$

$\frac{V_4 - V_2}{R_6} + \frac{V_4 - V_3}{R_4} + \frac{V_x}{400} = 0$

$\frac{V_2 - V_1}{R_2} + \frac{V_2 - V_4}{R_6} = 0$

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 1 \\ \frac{1}{R_5} + \frac{1}{R_2} & -\frac{1}{R_2} & 0 & 0 & -\frac{1}{R_5} \\ -\frac{1}{R_2} & \frac{1}{R_2} + \frac{1}{R_6} & 0 & -\frac{1}{R_6} & 0 \\ 0 & 0 & \frac{1}{R_4} + \frac{1}{R_1} & -\frac{1}{R_4} & 0 \\ -\frac{1}{400} & -\frac{1}{400} & -\frac{1}{R_6} & -\frac{1}{R_4} & \frac{1}{R_6} + \frac{1}{R_4} \end{bmatrix} \times \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \\ V_5 \end{bmatrix} = \begin{bmatrix} 4 \\ -5 \\ 0 \\ 5 \\ 0 \end{bmatrix}$$

$V_1 = \frac{19}{8} V$

$V_2 = \frac{109}{40} V$

$V_3 = -\frac{33}{6} V$

$V_4 = \frac{151}{40} V$

$V_5 = 4$

c) $I_D \cdot V_4 = \frac{151}{40} \cdot \frac{-7}{1000} = -0,00033\ W = -3,3\ mW$