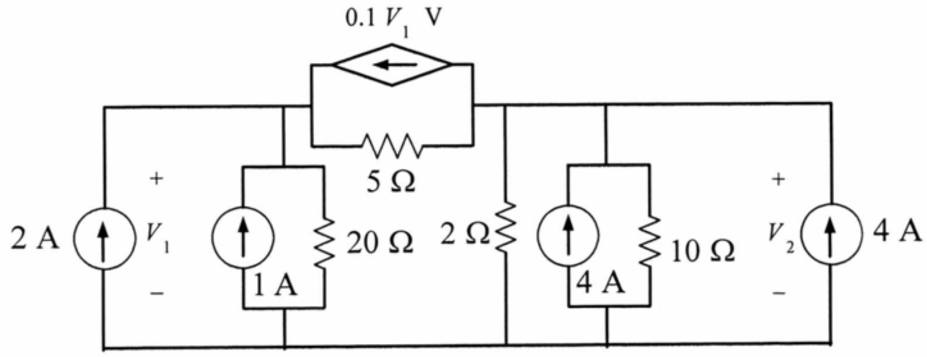
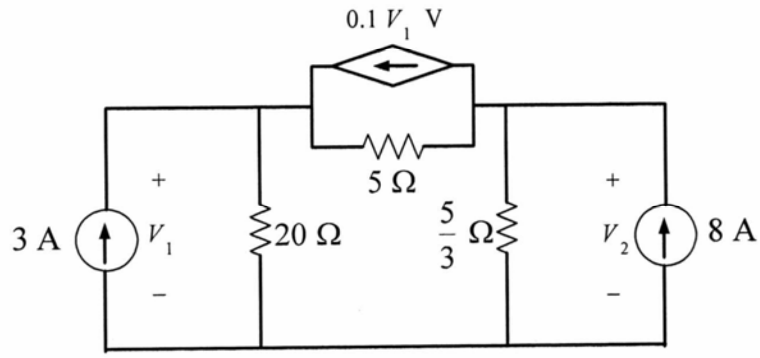
Q1
Step 1: Source Transform the voltage sources

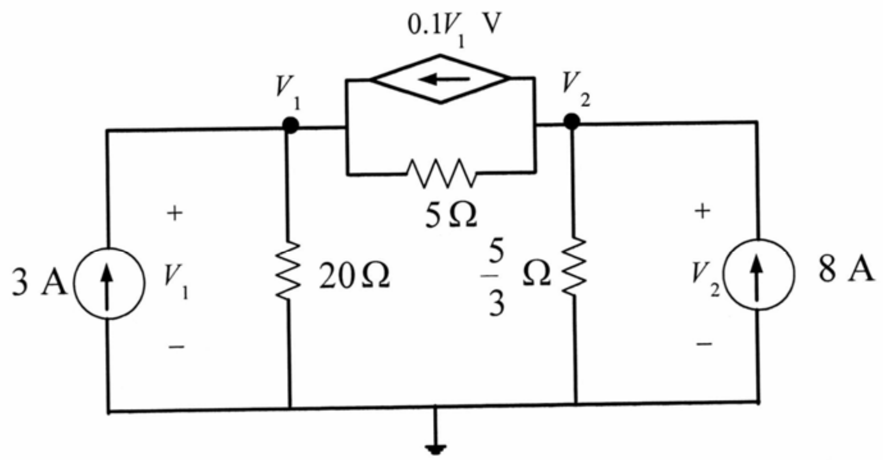


Step 2: Combine the currents sources and parallel resistors



Note : Do not transform the currents sources because that will destroy the required voltages namely V_1 V_2

Step 3 :
Solve the remaining circuit using nodal analysis



KCl on the two nodes V_1, V_2 , we have

$$\frac{V_1}{20}+\frac{V_1-V_2}{5}-0.1V_1-3=0$$

$$\Rightarrow\ 0.15V_1-0.2V_2=3 \text{ --------(1)}$$

$$\frac{V_2}{5/3}+\frac{V_2-V_1}{5}+0.1V_1-8=0$$

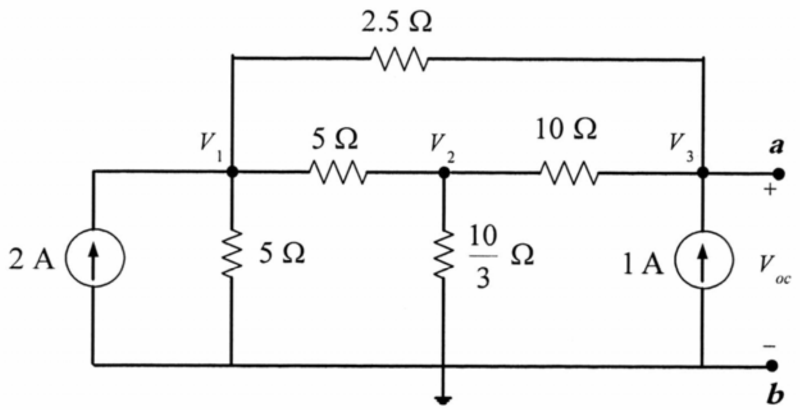
$$\Rightarrow\ -0.1V_1+0.8V_2=8 \text{ --------(2)}$$

$$\Rightarrow \begin{bmatrix}0.15 & -0.2\\ -0.1 & 0.8\end{bmatrix}\begin{bmatrix}V_1\\ V_2\end{bmatrix}=\begin{bmatrix}3\\ 8\end{bmatrix}$$

Solving $\Rightarrow$ $V_1 =$ 40 V $V_2 =$ 15 V

Q2

(a) **Using Nodal Analysis were** $V_{oc} = V_3$



KCl on the three nodes V_1, V_2, V_3

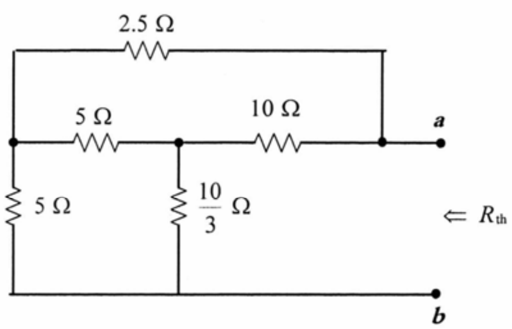
$$\frac{V_1}{5}+\frac{V_1-V_2}{5}+\frac{V_1-V_3}{2.5}-2=0 \Rightarrow \quad 0.8V_1-0.2V_2-0.4V_3=2 \text{ ----(1)}$$

$$\frac{V_2-V_1}{5}+\frac{V_2-V_3}{10}+\frac{V_2}{10/3}=0 \Rightarrow \quad -0.2V_1+0.6V_2-0.1V_3=0 \text{ ----(2)}$$

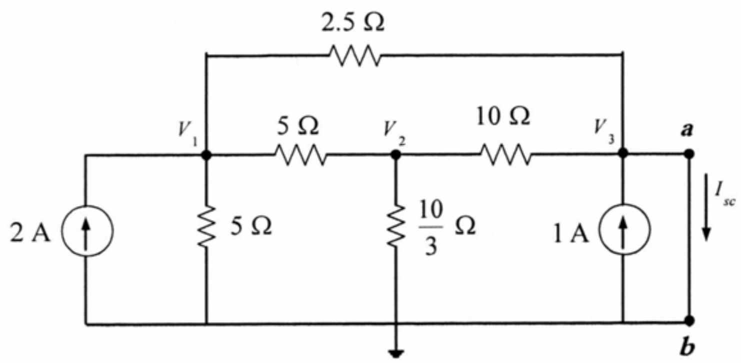
$$\frac{V_3-V_2}{10}+\frac{V_3-V_1}{2.5}-1=0 \quad \Rightarrow \quad -0.4V_1-0.1V_2+0.5V_3=1 \text{ ----(3)}$$

$$\begin{bmatrix} 0.8 & -0.2 & -0.4 \\ -0.2 & 0.6 & -0.1 \\ -0.4 & -0.1 & 0.5 \end{bmatrix}\begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}=\begin{bmatrix} 2 \\ 0 \\ 1 \end{bmatrix} \quad \text{Solving } \Rightarrow V_{oc}=V_3=9.6 \text{ V}$$

To find R_{th} , we deactivate all independent sources



then find R_{th} , $R_{th} = V_{oc}/I_{sc}$.



Here $V_3 = 0$, KCl on the two nodes V_1, V_2

$$\frac{V_1}{5} + \frac{V_1 - V_2}{5} + \frac{V_1 - V_3}{2.5} - 2 = 0 \Rightarrow \quad 0.8V_1 - 0.2V_2 = 2 \text{ ----(1)}$$

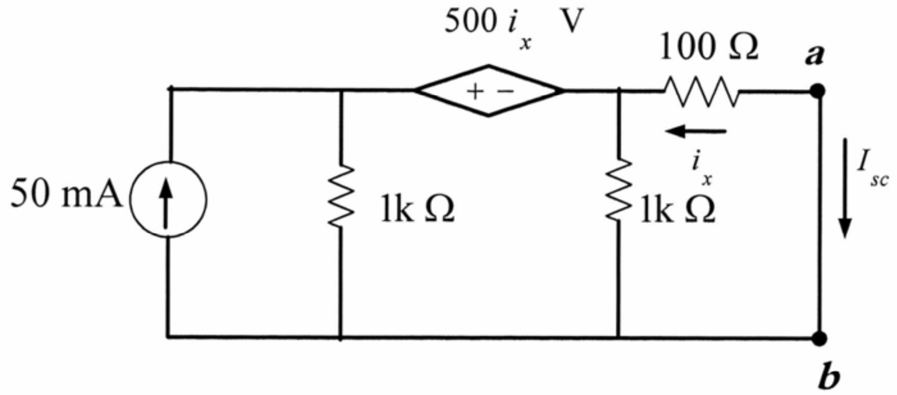
$$\frac{V_2 - V_1}{5} + \frac{V_2 - V_3}{10} + \frac{V_2}{10/3} = 0 \Rightarrow \quad -0.2V_1 + 0.6V_2 = 0 \text{ ----(2)}$$

$$\begin{bmatrix} 0.8 & -0.2 \\ -0.2 & 0.6 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 2 \\ 0 \end{bmatrix} \text{ Solving } \Rightarrow V_1 = 2.73 \text{ V} \quad V_2 = 0.91 \text{ V}$$

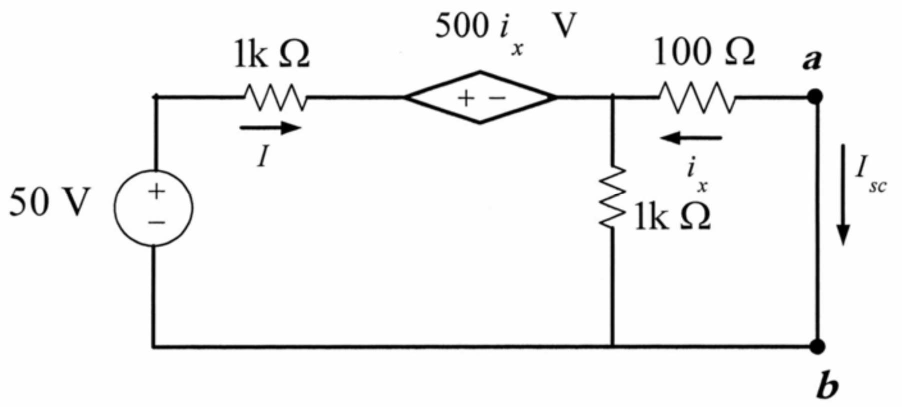
$$\frac{V_1 - V_3}{2.5} + \frac{V_2 - V_3}{10} + 1 = I_{sc} \quad \Rightarrow \frac{2.73}{2.5} + \frac{0.91}{10} + 1 = I_{sc} \Rightarrow I_{sc} = 2.183 \quad \Rightarrow R_{\text{th}} = \frac{V_{oc}}{I_{sc}} = \frac{9.6}{2.183} = 4.4\ \Omega$$

(b) $R_L = R_{TH} = 4.4\ \Omega$ (c) $P_{\max} = \frac{V_{oc}^{\ 2}}{4R_{TH}} = \frac{9.6^2}{4(4.4\ )} = 5.24 \text{ W}$

Q3



Source Transformation



KVL on the outer loop

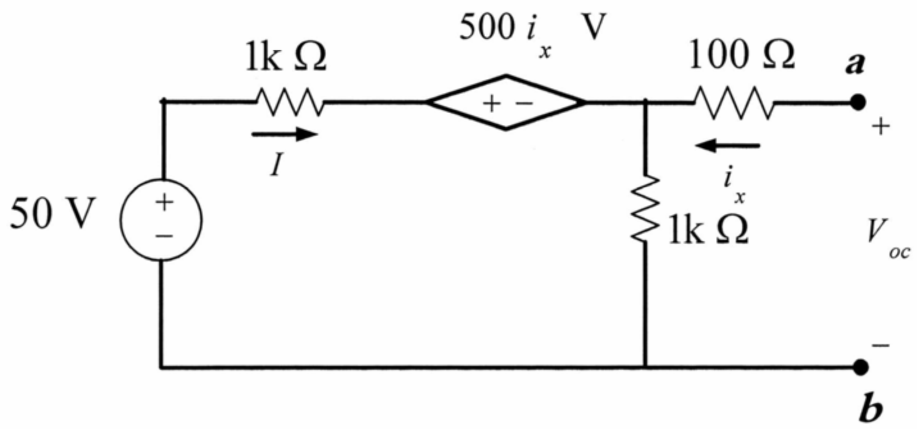
$$-50+1000I+500i_x-100i_x=0 \;\Rightarrow\; 1000I+400i_x=50 \quad ---(1)$$

KVL on the inner loop

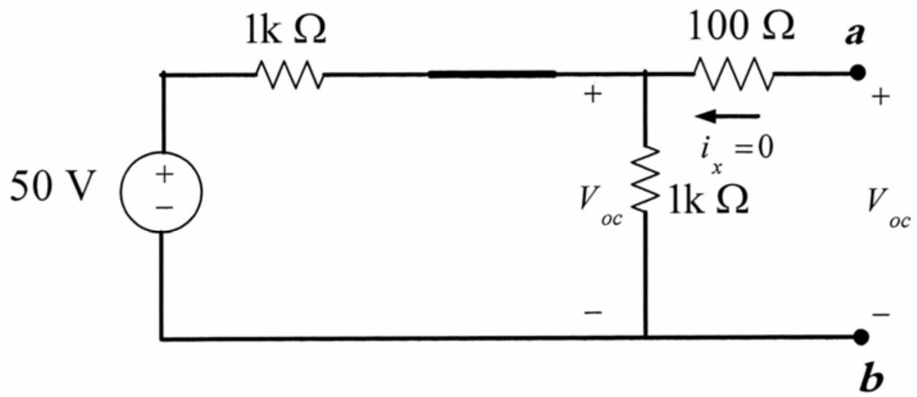
$$-1000(I+i_x)-100i_x=0 \;\Rightarrow\; 1000I+1100i_x=0 \quad ---(2)$$

Solving (1) and (2) for $i_x=-\frac{1}{14}\text{ A} \Rightarrow I_{sc}=-i_x=\frac{1}{14}\text{ A}$

Finding R_{th} : Since the circuit has a dependent source we cannot find R_{th} by combining resistors . We find R_{th} as $R_{\text{th}} = \frac{V_{oc}}{I_{sc}}$. Therefore we seek V_{oc} as follows :



Here $i_x = 0$ which implies also that the dependent source $500i_x = 0$

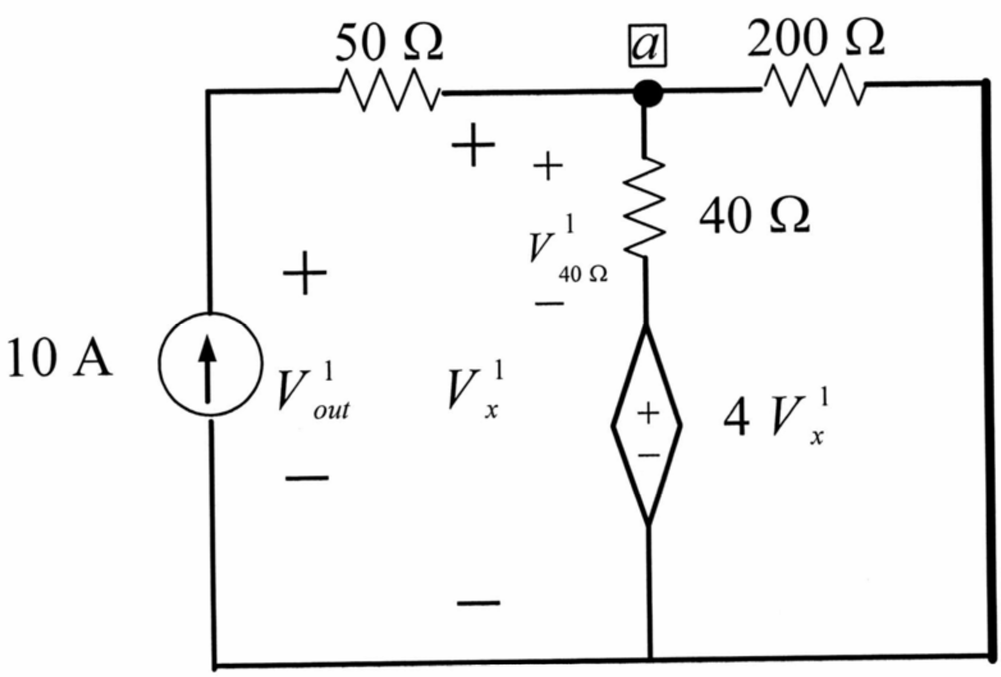


$$V_{oc} = \frac{1k}{1k + 1k}(50) = 25 \text{ V}$$

$$\Rightarrow R_{th} = \frac{V_{oc}}{I_{sc}} = \frac{25}{1/14} = 350\ \Omega$$

Q4

Step 1 : Deactivate the independent voltage source



Apply KCL at node a

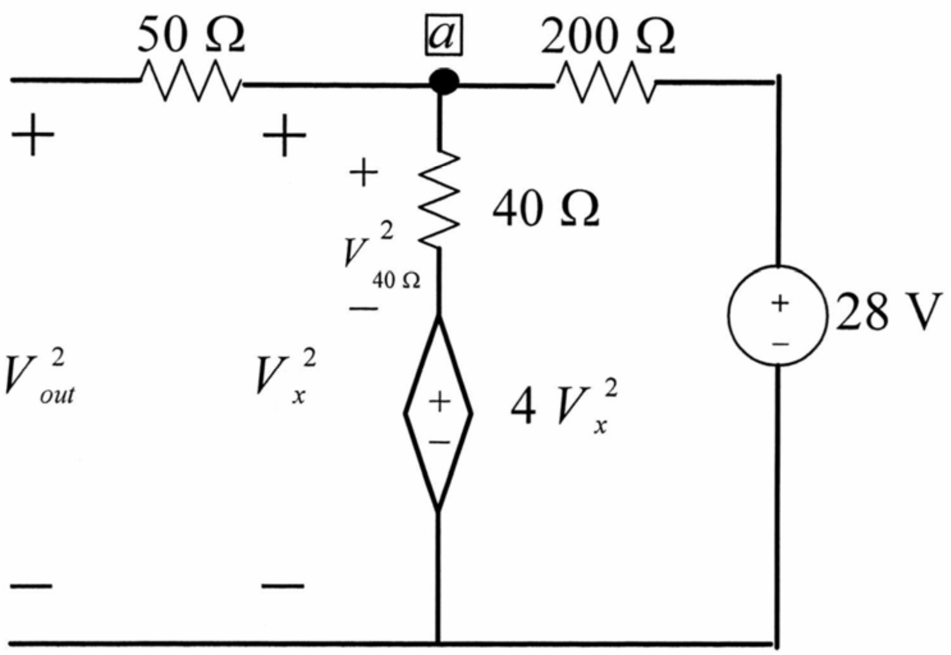
$$\frac{V_x^1}{200}+\frac{V_{40\,\Omega}^1}{40}-10=0 \quad ----(1)$$

Since $V_{40\,\Omega}^1 = V_x^1 - 4V_x^1 = -3V_x^1$

$$(1) \Rightarrow \quad \frac{V_x^1}{200}+\frac{-3V_x^1}{40}-10=0 \;\Rightarrow\; V_x^1 = -\frac{1000}{7} = -142.857\ \text{V}$$

$$\text{KVL} \Rightarrow \; -V_{out}^1 + 50(10) + V_x^1 = 0 \;\Rightarrow\; V_{out}^1 = \frac{2500}{7} = 357.143\ \text{V}$$

Step 2 : Deactivate the independent current source



Apply KCL at node a

$$\frac{V_x^2 - 28}{200} + \frac{V^2_{40\,\Omega}}{40} = 0 \quad \text{----(2)}$$

Since $V^2_{40\,\Omega} = V_x^2 - 4V_x^2 = -3V_x^2$

$$(2) \Rightarrow \quad \frac{V_x^2 - 28}{200} + \frac{-3V_x^2}{40} = 0 \quad \Rightarrow \quad V_x^2 = -2 \text{ V}$$

$$V^2_{out} = V_x^2 = -2 \text{ V}$$

Step 3 : Combine the results in step 1 and step 2

$$V_{out} = V^1_{out} + V^2_{out} = 357.143 + (-2) = 355.143 \text{ V}$$