ECE 2001
Fall 2019
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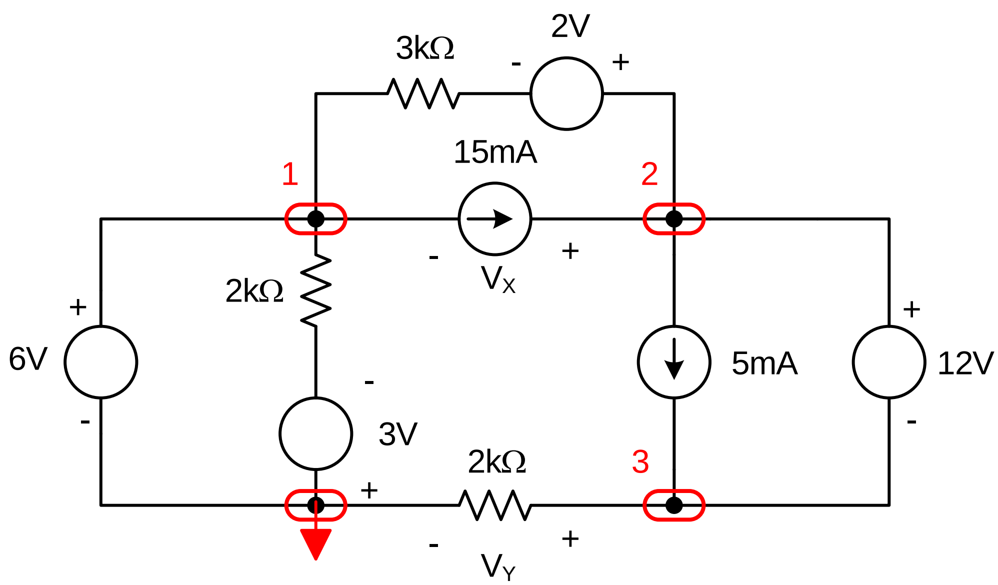
Homework Assignment 3 **SOLUTION**
Due: Friday, Sept. 20, 2019

1. (20) For the network below find, V_X, V_Y, and the power in the 15 mA source.



Solution. Node voltage method using V, kΩ, and mA.

1. $V_1 = 6V$ **(known node voltage)**

23. $-15 + \frac{V_2-2-6}{3} + \frac{V_3}{2} = 0$ **(supernode)**

VS. $V_3 = V_2 - 12$ **(voltage source)**

23VS. $-15 + \frac{V_2-8}{3} + \frac{V_2-12}{2} = 0$

23VS. $-90 + 2V_2 - 16 + 3V_2 - 36 = 0$

$5V_2 - 142 = 0$ $\qquad$ $V_2 = 28.4V$

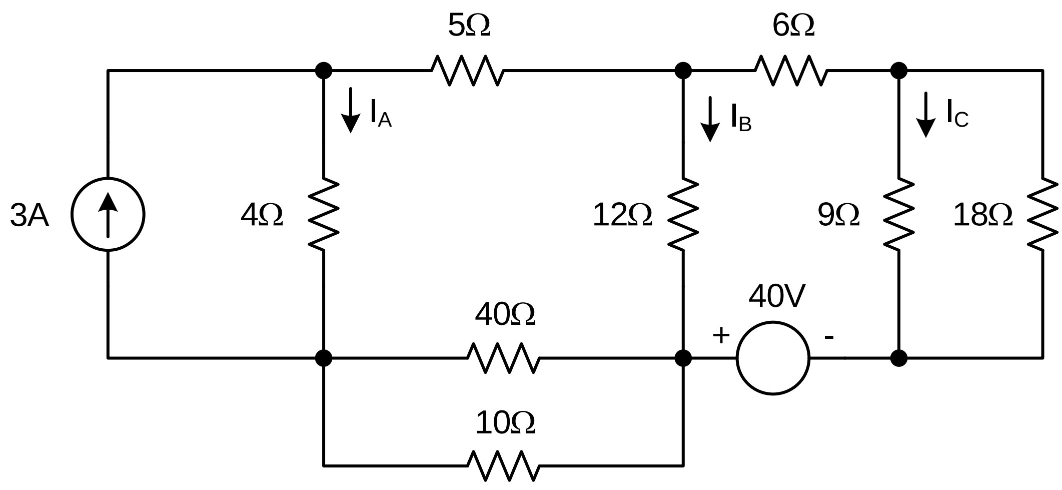
$V_3 = V_2 - 12V = 16.4V$

$V_X = V_2 - V_1 = 22.4V$

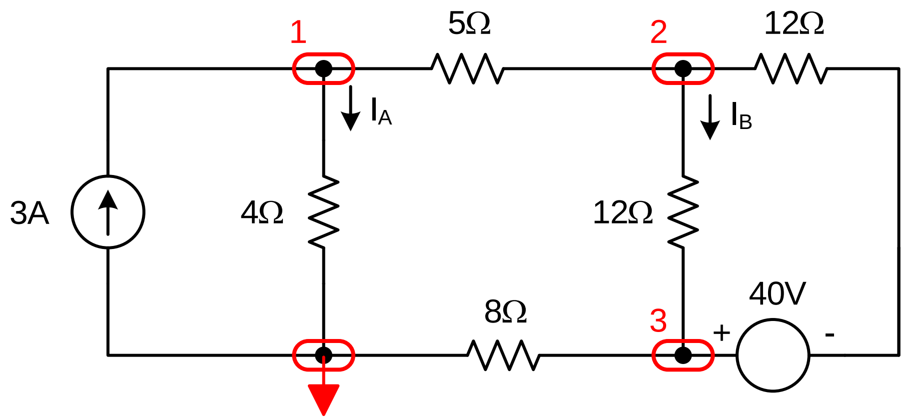
$V_Y = V_3 = 16.4V$

$P_{15mA} = (15mA)(V_1 - V_2) = -336mW$

2. (20) Find I_A, I_B, and I_C in the network below. Find the power for the 3 A source.



Solution. We can start by simplifying the circuit. (We can combine parallel and series resistances to reduce the number of essential nodes from six to four.)



Node voltage method using V, Ω, and A.

1. $-3+\frac{V_1}{4}+\frac{V_1-V_2}{5}=0$

2. $\frac{V_2-V_1}{5}+\frac{V_2-V_3}{12}+\frac{V_2+40-V_3}{12}=0$

3. $\frac{V_3}{8}+\frac{V_3-V_2}{12}+\frac{V_3-40-V_2}{12}=0$

1. $-60+5V_1+4V_1-4V_2=0$

2. $12V_2-12V_1+5V_2-5V_3+5V_2+200-5V_3=0$

3. $3V_3+2V_3-2V_2+2V_3-80-2V_2=0$

$$\begin{bmatrix} 9 & -4 & 0 \\ -12 & 22 & -10 \\ 0 & -4 & 7 \end{bmatrix}\begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}=\begin{bmatrix} 60 \\ -200 \\ 80 \end{bmatrix} \qquad \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}=\begin{bmatrix} 6.43V \\ -0.522V \\ 11.13V \end{bmatrix}$$

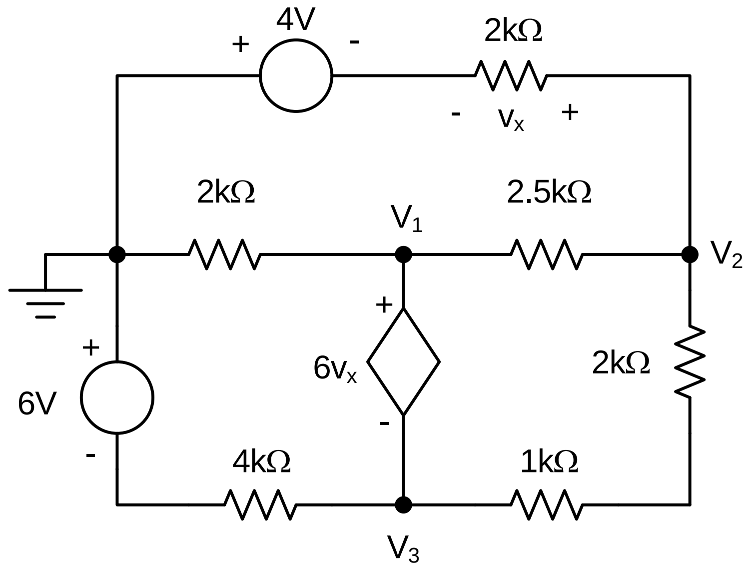
$$I_A = \frac{V_1}{4\Omega} = 1.61A$$

$$I_B = \left(\frac{V_2 - V_3}{12\Omega}\right) = -0.971A$$

$$I_C = \left(\frac{V_2 + 40 - V_3}{12\Omega}\right)\left(\frac{18\Omega}{9\Omega + 18\Omega}\right) = 1.575A$$

$$P_{3A} = -(3A)V_1 = -19.29\,W$$

3. (20) Determine V_1, V_2, and V_3 with respect to ground. Find v_x and the power for the dependent source.



Solution. Node voltage method using V, kΩ, and mA.

13. $\frac{V_1}{2}+\frac{V_1-V_2}{2.5}+\frac{V_3+6}{4}+\frac{V_3-V_2}{3}=0$

2. $\frac{V_2-V_1}{2.5}+\frac{V_2-V_3}{3}+\frac{V_2+4}{2}=0$

DS. $V_1-V_3=6V_x=6(V_2+4)$ $\qquad$ $V_1-6V_2-V_3=24$

13. $30V_1+24V_1-24V_2+15V_3+90+20V_3-20V_2=0$

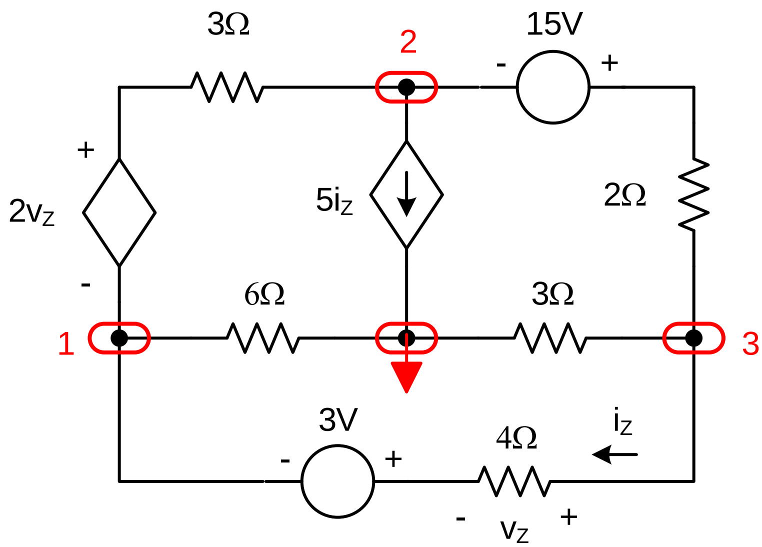
2. $12V_2-12V_1+10V_2-10V_3+15V_2+60=0$

$$\begin{bmatrix} 54 & -44 & 35 \\ 1 & -6 & -1 \\ -12 & 37 & -10 \end{bmatrix}\begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}=\begin{bmatrix} -90 \\ 24 \\ -60 \end{bmatrix} \qquad \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}=\begin{bmatrix} -1.133V \\ -3.35V \\ -5.03V \end{bmatrix}$$

$V_x=V_2+4V=0.65V$

$P_{6Vx}=6V_x\left(\frac{0-V_1}{2k\Omega}+\frac{V_2-V_1}{2.5k\Omega}\right)=-1.25mW$

4. (20) For the circuit shown, find i_Z and the power for each of the sources.



Solution. Node voltage method with V, Ω, and A.

1. $\frac{V_1+2v_Z-V_2}{3}+\frac{V_1}{6}+\frac{V_1+3-V_3}{4}=0$

2. $\frac{V_2-2v_Z-V_1}{3}+5i_z+\frac{V_2+15-V_3}{2}=0$

3. $\frac{V_3-3-V_1}{4}+\frac{V_3}{3}+\frac{V_3-15-V_2}{2}=0$

DS1. $i_z=\frac{V_3-3-V_1}{4}$

DS2. $v_z=V_3-3-V_1$

1DS2. $\frac{V_1+2(V_3-3-V_1)-V_2}{3}+\frac{V_1}{6}+\frac{V_1+3-V_3}{4}=0$

2DS1DS2. $\frac{V_2-2(V_3-3-V_1)-V_1}{3}+5\left(\frac{V_3-3-V_1}{4}\right)+\frac{V_2+15-V_3}{2}=0$

1DS2. $4V_1+8V_3-24-8V_1-4V_2+2V_1+3V_1+9-3V_3=0$

2DS1DS2. $4V_2-8V_3+24+8V_1-4V_1+15V_3-45-15V_1+6V_2+90-6V_3=0$

3. $3V_3-9-3V_1+4V_3+6V_3-90-6V_2=0$

$$\begin{bmatrix} 1 & -4 & 5 \\ -11 & 10 & 1 \\ -3 & -6 & 13 \end{bmatrix}\begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 15 \\ -69 \\ 99 \end{bmatrix} \qquad \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} -86.1V \\ -96.0V \\ -56.6V \end{bmatrix}$$

$$i_z = \frac{V_3 - 3V - V_1}{4\Omega} = 6.62A$$

$$v_z = V_3 - 3V - V_1 = 26.5V$$

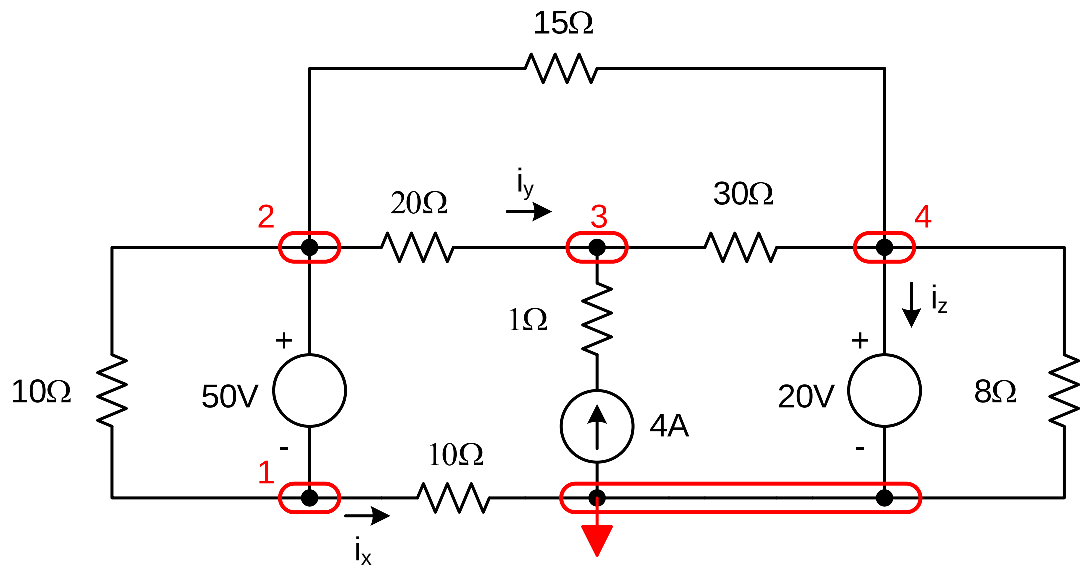
$$P_{2vz} = \left(\frac{V_2 - 2v_z - V_1}{3\Omega}\right)(2v_z) = -1111W$$

$$P_{5iz} = (V_2)(5i_z) = -3180W$$

$$P_{15V} = \left(\frac{V_3 - 15V - V_2}{2\Omega}\right)15V = 183W$$

$$P_{3V} = \left(\frac{V_3 - 3V - V_1}{4\Omega}\right)3V = 19.88W$$

5. (20) For the circuit shown, find i_x, i_y, and i_z. Find the power for the 50V source. Find the power for the 4A source.



Solution. Node voltage method using V, Ω, and A.

4. $V_4 = 20V$ **(known node voltage)**

12. $\frac{V_1}{10} + \frac{V_2 - 20}{15} + \frac{V_2 - V_3}{20} = 0$ **(supernode)**

3. $\frac{V_3 - V_2}{20} - 4 + \frac{V_3 - 20}{30} = 0$

VS. $V_2 - V_1 = 50 \qquad V_1 = V_2 - 50$

12VS. $\frac{V_2 - 50}{10} + \frac{V_2 - 20}{15} + \frac{V_2 - V_3}{20} = 0$

12VS. $6V_2 - 300 + 4V_2 - 80 + 3V_2 - 3V_3 = 0$

3. $3V_3 - 3V_2 - 240 + 2V_3 - 40 = 0$

$$\begin{bmatrix} 13 & -3 \\ -3 & 5 \end{bmatrix} \begin{bmatrix} V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 380 \\ 280 \end{bmatrix} \qquad \begin{bmatrix} V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 48.9V \\ 85.4V \end{bmatrix} \qquad V_1 = V_2 - 50V = -1.071V$$

$$i_x = \frac{V_1}{10\Omega} = -0.1071A \qquad i_y = \frac{V_2 - V_3}{20\Omega} = -1.821A$$

$$i_z = \frac{0 - V_4}{8\Omega} + \frac{V_3 - V_4}{30\Omega} + \frac{V_2 - V_4}{15\Omega} = 1.607A$$

$$P_{50V} = (50V)\left(\frac{V_1 - V_2}{10\Omega} + \frac{V_4 - V_2}{15\Omega} + \frac{V_3 - V_2}{20\Omega}\right) = -255W$$

$$P_{4A} = -(4A)\big(V_3 + (4A)(1\Omega)\big) = -357W$$