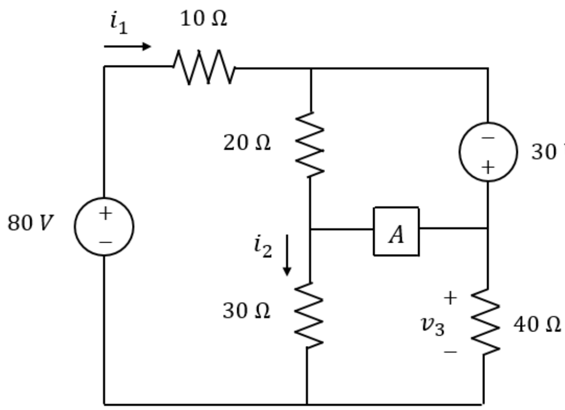
Name: ________________________________Roll No.: _____________________ Section: _________

A

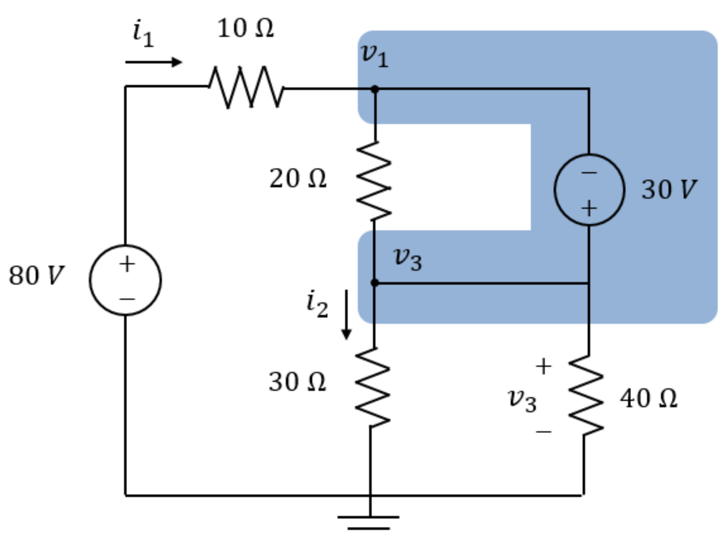
ESC201A: Introduction to Electronics
Quiz -1

Date: 01.09.2016

1. Find v_3 in the circuit shown below if element A is (a) a short circuit; (b) a $9V$ independent voltage source, with positive reference on the left; (c) a dependent current source, arrow head on the left, whose magnitude is $5i_1$.



Sol. 1 (a) A is a short circuit



Applying nodal analysis at super-node

$$\frac{v_1-80}{10}+\frac{v_1-v_3}{20}+\frac{v_3-v_1}{20}+\frac{v_3}{30}+\frac{v_3}{40}=0 \tag{1}$$

$$12v_1-960+7v_3=0 \tag{2}$$

$$12v_1+7v_3=960 \tag{3}$$

Also,

$$v_3 - v_1 = 30 \tag{4}$$

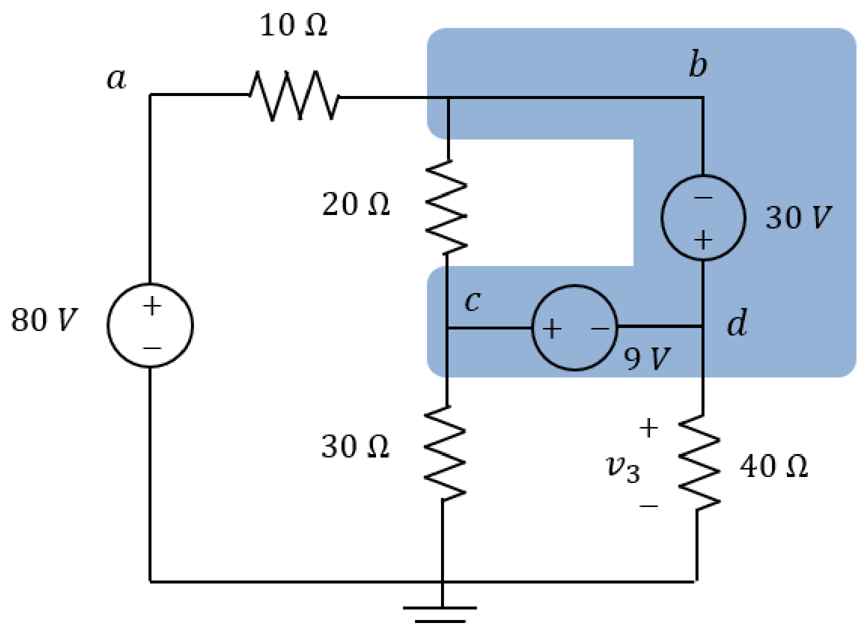
Which implies,

$$12 \cdot (v_3 - 30) + 7v_3 = 960 \tag{5}$$

$$19v_3 = 360 + 960 = 1320 \tag{6}$$

$$v_3 = 69.47\ V$$

(b) A is a $9V$ independent voltage source, with positive reference on the left



At the super-node b d c:

$$\frac{v_b - 80}{10} + \frac{v_d}{40} + \frac{v_c}{30} = 0 \tag{1}$$

$$12v_b - 960 + 3v_d + 4v_c = 0 \tag{2}$$

Also,

$$v_d - v_b = 30 \text{ and } v_c - v_d = 9 \tag{3}$$

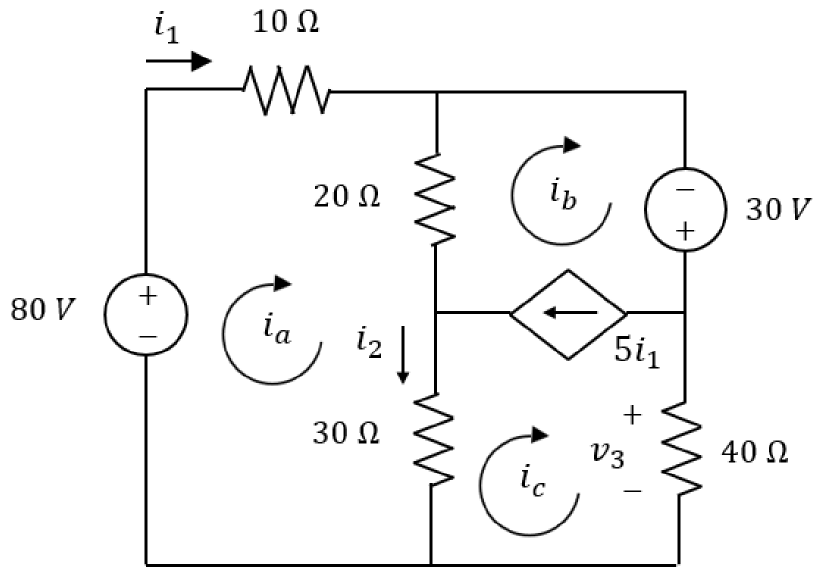
Which implies,

$$12(v_d - 30) + 3v_d + 4(v_d + 9) = 960 \tag{4}$$

$$19v_d = 960 + 360 + 36 = 1356 \tag{5}$$

$$v_d = v_3 = 71.37\ V$$

(c) A is a dependent current source, arrow head on the left, labelled $5i_1$



Define the left mesh as 1, the top right mesh as 2 and the bottom right mesh as 3.

Mesh 1:

$$-80 + 10i_a + 20i_a - 20i_b + 30i_a - 30i_c = 0 \quad (1)$$

For 2, 3 super-mesh

$$20i_b - 20i_a - 30 + 40i_c + 30i_c - 30i_a = 0 \quad (2)$$

And

$$i_b - i_c = 5i_1 = 5i_a \quad (3)$$

Rewriting eq. (1) as,

$$60i_a - 20i_b - 30i_c = 80 \quad (4)$$

Rewriting eq. (2) as,

$$-50i_a + 20i_b + 70i_c = 30 \quad (5)$$

Rewriting eq. (3) as,

$$5i_a - i_b + i_c = 0 \quad (6)$$

We can solve for $i_c = 4.73A$ and $v_3 = 40i_c = 189\ V$

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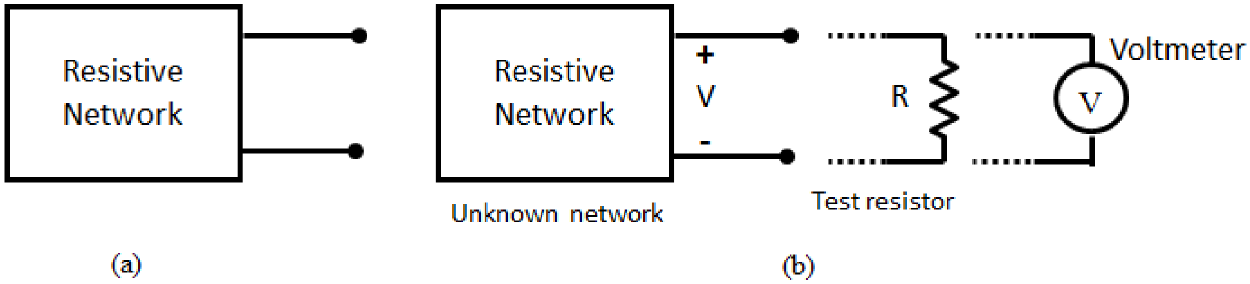


2. A student is given an unknown resistive network as shown in the figure above. She wishes to determine whether the network is linear, and if it is, what its Thevenin equivalent is. The only equipment available to student is a voltmeter (assume ideal), 100 kΩ and 1 MΩ test resistors that can be placed across the terminals during the measurements (see figure 2(b)).

The following data were recorded:

Test resistor	Voltmeter Reading
Absent	1.5 V
100 kΩ	0.25 V
1 MΩ	1.0 V

What should the student conclude about the network from these results? Support your conclusions with plot of the unknown resistive network's I-V characteristics.

Solution: Let us assume that the network is linear and Thevenin's equivalent Voltage of the network be denoted by V_{TH} and the resistance by R_{TH}. Open circuit voltage, V_{oc} is given by

$$V_{oc} = V_{TH} = 1.5 \text{ V} \tag{i}$$

With 100 kΩ test resistor, voltage across the test resistor is

$$0.25 = \frac{100 \text{ k}}{100 \text{ k} + R_{TH}} \times 1.5 \text{ V} \tag{ii}$$

$$\Rightarrow R_{TH} = 500 \text{ k}\Omega \tag{iii}$$

With 1 MΩ test resistor, the voltage across the test resistor should have been

$$\frac{1 \text{ M}}{1 \text{ M} + 500 \text{ k}} \times 1.5 \text{ V} = 1 \text{ V} \tag{iv}$$

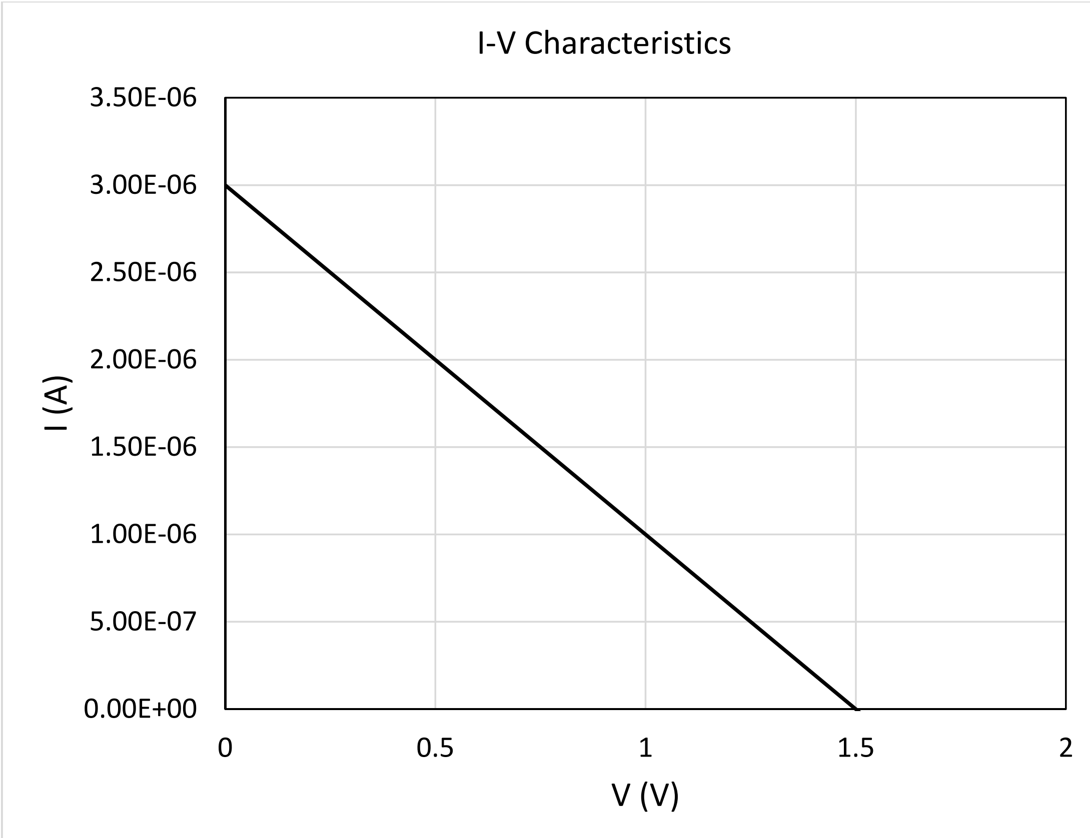
which is the observed voltage, hence the circuit is linear.

The voltage V across the terminals of the given network is obtained as

$$V = V_{TH} - IR_{TH} = (1.5 - 5 \times 10^5 I) \text{ V}$$

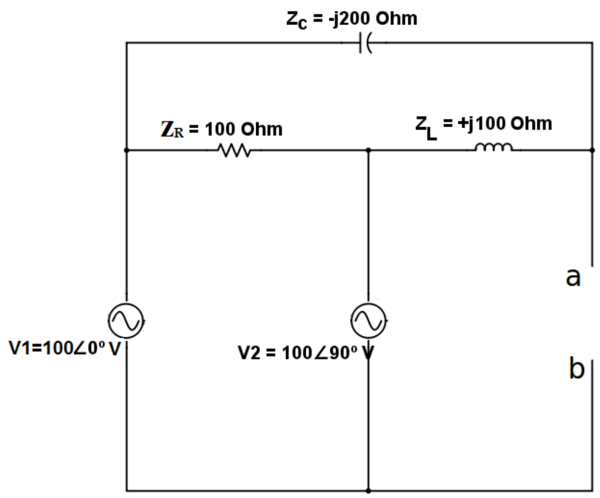
The I-V characteristics is shown below.

Name: ________________________________Roll No.: _____________________ Section: __________

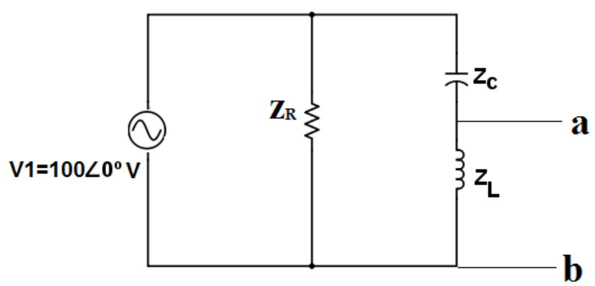


Name: ______________________________ Roll No.: ____________________ Section: _________

3 (a). Find the Thevenin equivalent of the circuit given below:

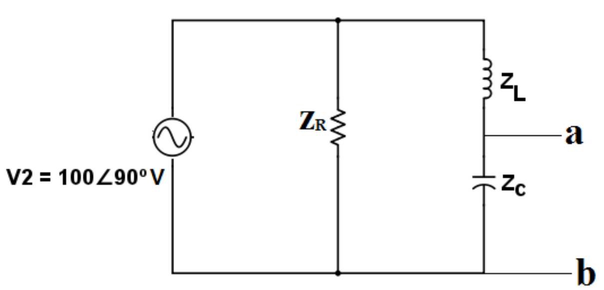


Solution: We could determine the v_{oc} across **a** and **b** by superposition of the two voltage sources.



$$V_{ab1} = \frac{V_1 Z_L}{Z_C + Z_L} = \frac{100\angle 0^o \cdot (j100)}{(j100 - j200)}$$

$$= -100V = 100\angle 180^o V$$

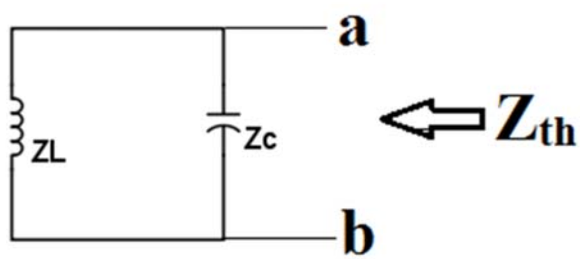


$$V_{ab2} = \frac{V_2 Z_C}{Z_C + Z_L} = \frac{100\angle 90^o \cdot (-j200)}{(j100 - j200)}$$

$$= 200\angle 90^o V$$

Therefore, $V_{Thevenin} = V_{ab1} + V_{ab2} = (-100 + j200)V = 223.61\angle 116.56^o V$

The Thevenin impedance may be determined by making the sources zero and finding the equivalent impedance across **a** and **b** which is



$$Z_{Thevenin} = Z_C || Z_L = \frac{-j200 \cdot j100}{j100 - j200} = 200j = 200\angle 90^o \Omega$$

(b). Express the Thevenin equivalent voltage in the canonical form and the Thevenin impedance as resistance and inductance/capacitance. The frequency of the voltage sources are both 50Hz.

Here $\omega = 2\pi f = 2 \times 3.14 \times 50 \approx 314\, rad/s$

$$V_{Thevenin}(t) = 223.61 \cos(314t + 116.56^o)\, V$$

$Z_{Thevenin}$ is an inductor with $L = \frac{200}{314} = 0.64H$. There is no resistive component in this impedance.

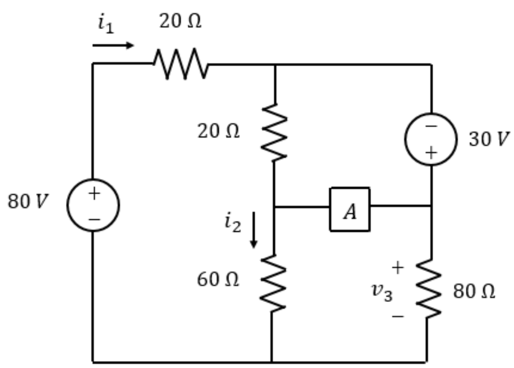
Name: ________________________________Roll No.: ____________________ Section: _________

B

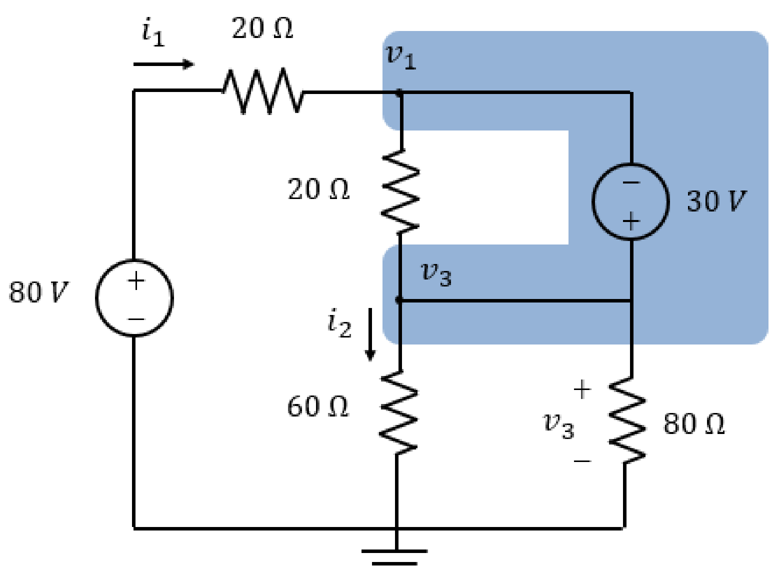
ESC201A: Introduction to Electronics
Quiz -1

Date: 01.09.2016

1. Find v_3 in the circuit shown below if element A is (a) a short circuit; (b) a $9V$ independent voltage source, with positive reference on the left; (c) a dependent current source, arrow head on the left, labelled $5i_1$.



Sol.1 (a) A is a short circuit



Applying nodal analysis at super-node

$$\frac{v_1 - 80}{20} + \frac{v_1 - v_3}{20} + \frac{v_3 - v_1}{20} + \frac{v_3}{60} + \frac{v_3}{80} = 0 \quad (1)$$

$$12v_1 - 960 + 7v_3 = 0 \quad (2)$$

$$12v_1 + 7v_3 = 960 \quad (3)$$

Also,

$$v_3 - v_1 = 30 \tag{4}$$

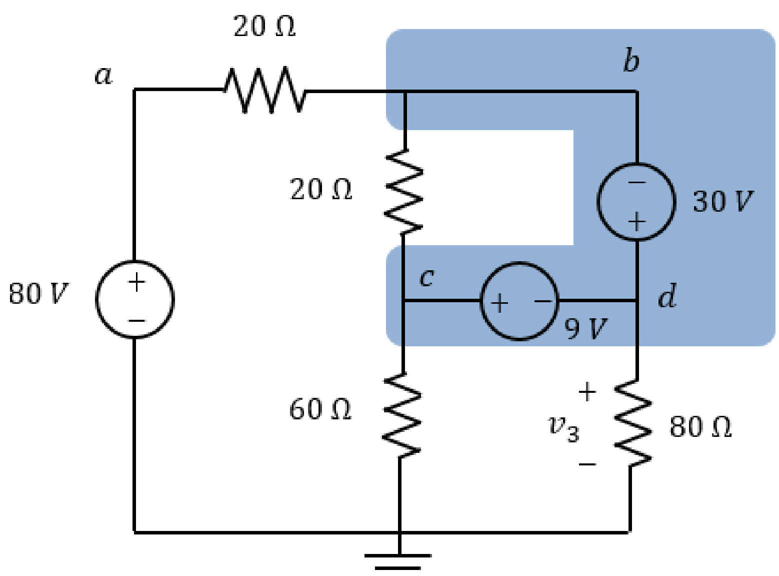
Which implies,

$$12 \cdot (v_3 - 30) + 7v_3 = 960 \tag{5}$$

$$19v_3 = 360 + 960 = 1320 \tag{6}$$

$$v_3 = 69.47\ V$$

(b) A is a $9V$ independent voltage source, with positive reference on the left



At the super-node bd c:

$$\frac{v_b - 80}{20} + \frac{v_d}{80} + \frac{v_c}{60} = 0 \tag{1}$$

$$12v_b - 960 + 3v_d + 4v_c = 0 \tag{2}$$

Also,

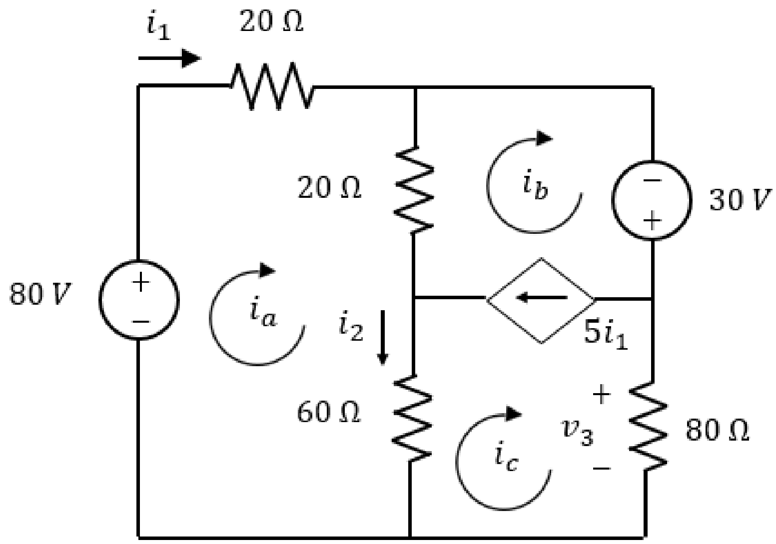
$$v_d - v_b = 30 \text{ and } v_c - v_d = 9 \tag{3}$$

Which implies,

$$12(v_d - 30) + 3v_d + 4(v_d + 9) = 960 \tag{4}$$
$$19v_d = 960 + 360 + 36 = 1356 \tag{5}$$

$$v_d = v_3 = 71.37\ V$$

(c) A is a dependent current source, arrow head on the left, labelled $5i_1$



Define the left mesh as 1, the top right mesh as 2 and the bottom mesh as 3.

Mesh 1:

$$-80 + 20i_a + 20i_a - 20i_b + 60i_a - 60i_c = 0 \tag{1}$$

For 2, 3 super-mesh

$$20i_b - 20i_a - 30 + 80i_c + 60i_c - 60i_a = 0 \tag{2}$$

And

$$i_b - i_c = 5i_1 = 5i_a \tag{3}$$

Rewriting eq. (1) as,

$$100i_a - 20i_b - 60i_c = 80 \tag{4}$$

Rewriting eq. (2) as,

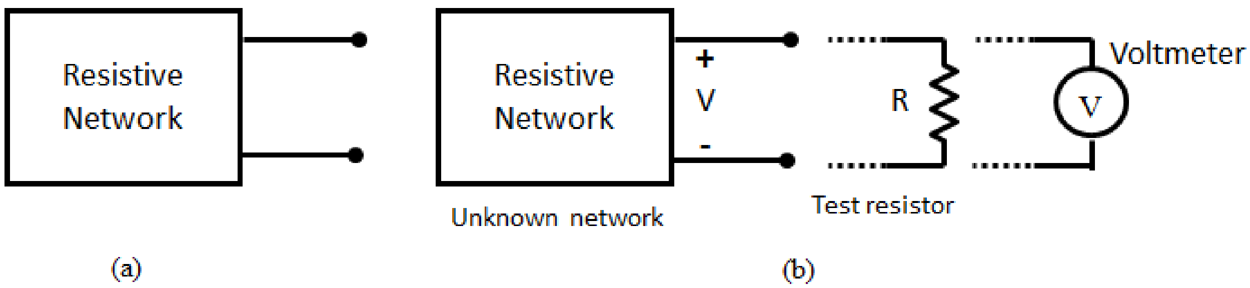
$$-80i_a + 20i_b + 140i_c = 30 \tag{5}$$

Rewriting eq. (3) as,

$$5i_a - i_b + i_c = 0 \tag{6}$$

We can solve for $i_c = -1A$ and $v_3 = 40i_c = -40\ V$

Name: ________________________________Roll No.: _____________________ Section: _________



2. A student is given an unknown resistive network as shown in the figure above. She wishes to determine whether the network is linear, and if it is, what its Thevenin equivalent is. The only equipment available to student is a voltmeter (assume ideal), 200 kΩ and 1 MΩ test resistors that can be placed across the terminals during the measurements (see Figure 2(b)).

The following data were recorded:

Test resistor	Voltmeter Reading
Absent	2.0 V
200 kΩ	0.5 V
1 MΩ	1.25 V

What should the student conclude about the network from these results? Support your conclusions with plot of the unknown resistive network's I-V characteristics.

Solution: Let us assume that the network is linear and Thevenin's equivalent Voltage of the network be denoted by V_{TH} and the resistance by R_{TH}. Open circuit voltage, V_{oc} is given by

$$V_{oc} = V_{TH} = 2\text{ V} \tag{1}$$

With 200 kΩ test resistor, voltage across the test resistor is

$$0.5 = \frac{200\text{ k}}{200\text{ k} + R_{TH}} \times 2\text{ V} \tag{2}$$

$$\Rightarrow\ R_{TH} = 600\text{ k}\Omega \tag{3}$$

With 1 MΩ test resistor, the voltage across the test resistor should have bee

$$\frac{1\text{ M}}{1\text{ M}+600\text{ k}} \times 2.0\text{ V} = 1.25\text{ V} \tag{4}$$

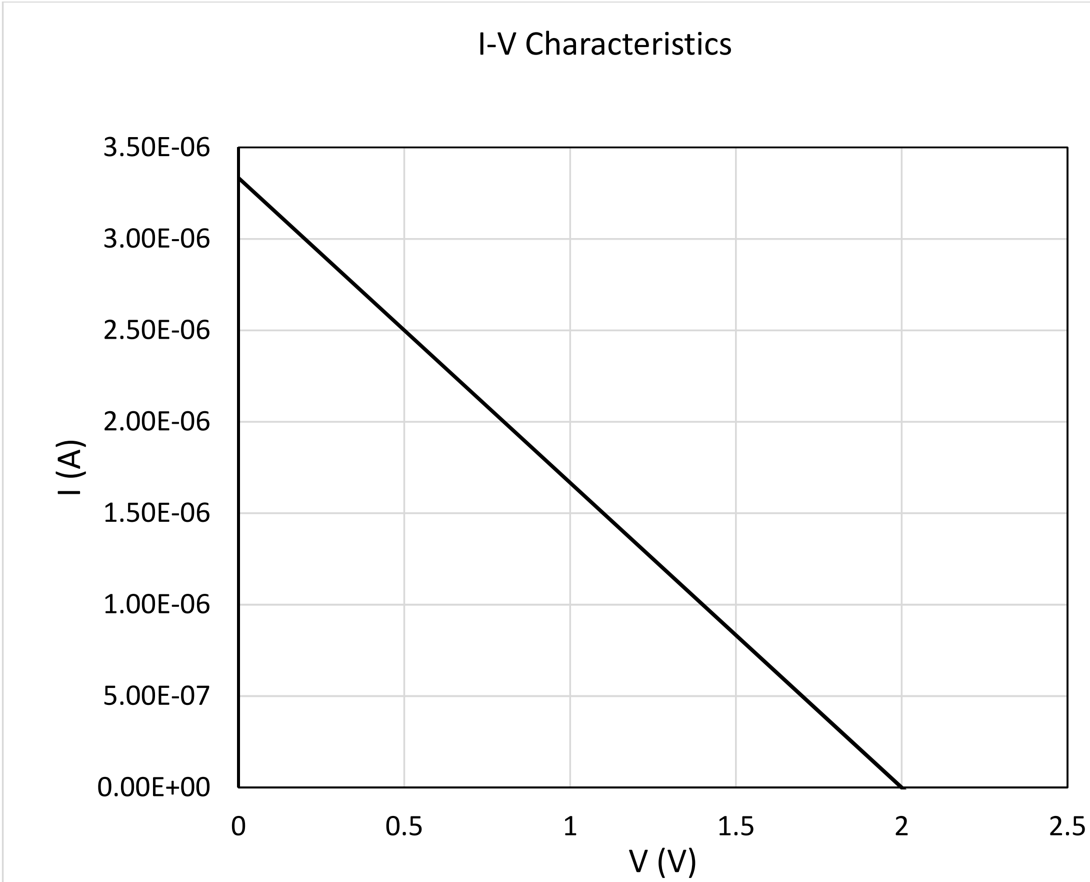
which is the observed voltage, hence the circuit is linear.

The voltage V across the terminals of the given network is obtained as

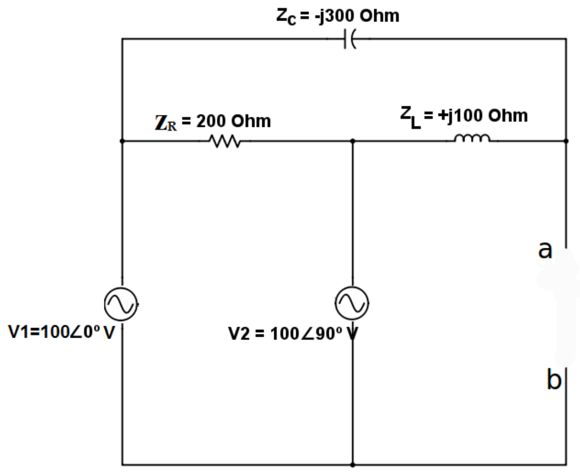
$$V = V_{TH} - IR_{TH} = (2.0\ - 6 \times 10^5 I)\text{ V}$$

The I-V characteristics is shown below.

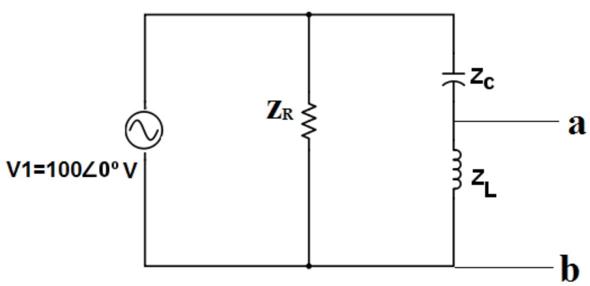
Name: _______________________________Roll No.: ____________________ Section: _________



3 (a). Find the Thevenin equivalent of the circuit given below:

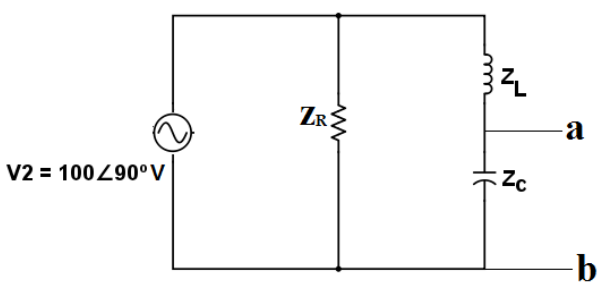


Solution: We could determine the v_{oc} across **a** and **b** by superposition of the two voltage sources.



$$V_{ab1} = \frac{V_1 Z_L}{Z_C + Z_L} = \frac{100\angle 0^o \cdot (j100)}{(j100 - j300)}$$

$$= -50V = 50\angle 180^o V$$

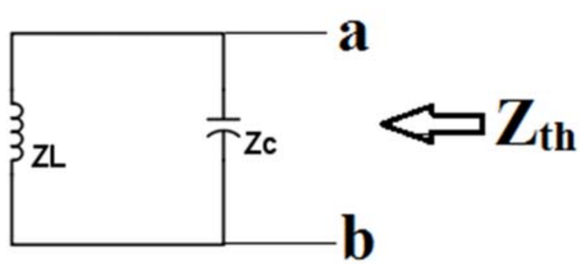


$$V_{ab2} = \frac{V_2 Z_C}{Z_C + Z_L} = \frac{100\angle 90^o \cdot (-j300)}{(j100 - j300)}$$

$$= 150\angle 90^o V$$

Therefore, $V_{Thevenin} = V_{ab1} + V_{ab2} = (-50 + j150)V = 158.11\angle 108.43^o V$

The Thevenin impedance may be determined by making the sources zero and finding the equivalent impedance across **a** and **b** which is



$$Z_{Thevenin} = Z_C||Z_L = \frac{-j100 \cdot j300}{j100 - j300} = 150j = 150\angle 90^o \Omega$$

(b). Express the Thevenin equivalent voltage in the canonical form and the Thevenin impedance as resistance and inductance/capacitance. The frequency of the voltage sources are both 50Hz.

Here $\omega = 2\pi f = 2 \times 3.14 \times 50 \approx 314\, rad/s$

$$V_{Thevenin}(t) = 158.11\cos(314t + 108.43^o)\, V$$

$Z_{Thevenin}$ is an inductor with $L = \frac{150}{314} = 0.48H$. There is no resistive component in this impedance.

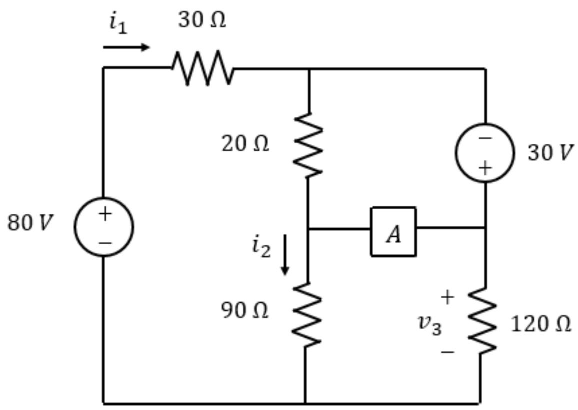
Name: ______________________________ Roll No.: ____________________ Section: _________

C

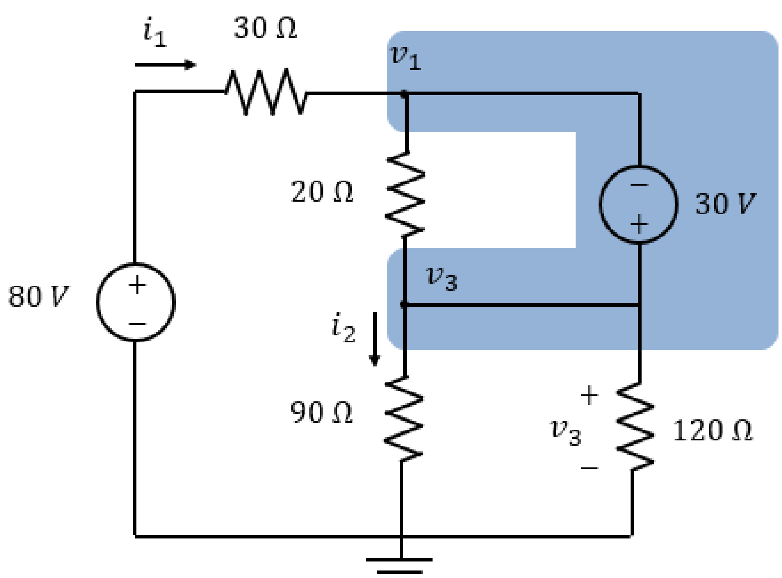
ESC201A: Introduction to Electronics
Quiz -1

Date: 01.09.2016

1. Find v_3 in the circuit shown below if element A is (a) a short circuit; (b) a $9V$ independent voltage source, with positive reference on the left; (c) a dependent current source, arrow head on the left, labelled $5i_1$.



Sol. (a) A is a short circuit



Applying nodal analysis at super-node

$$\frac{v_1 - 80}{30} + \frac{v_1 - v_3}{20} + \frac{v_3 - v_1}{20} + \frac{v_3}{90} + \frac{v_3}{120} = 0 \qquad (1)$$

$$12v_1 - 960 + 7v_3 = 0 \qquad (2)$$

$$12v_1 + 7v_3 = 960 \qquad (3)$$

Also,

$$v_3 - v_1 = 30 \tag{4}$$

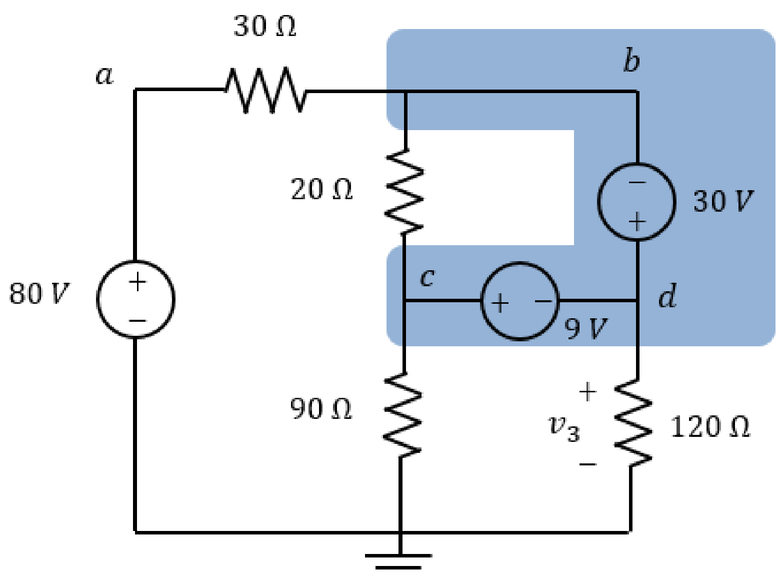
Which implies,

$$12 \cdot (v_3 - 30) + 7v_3 = 960 \tag{5}$$

$$19v_3 = 360 + 960 = 1320 \tag{6}$$

$$v_3 = 69.47\ V$$

(b) A is a $9V$ independent voltage source, with positive reference on the left



At the super-node b d c:

$$\frac{v_b - 80}{30} + \frac{v_d}{120} + \frac{v_c}{90} = 0$$

$$12v_b - 960 + 3v_d + 4v_c = 0 \tag{2}$$

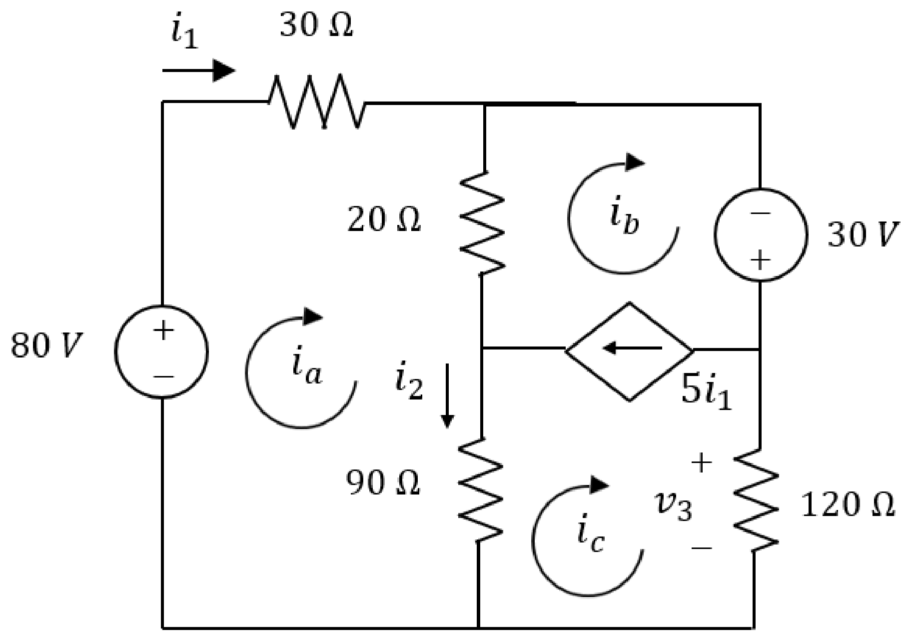
Also,

$$v_d - v_b = 30 \text{ and } v_c - v_d = 9 \tag{3}$$

Which implies,

$$12(v_d - 30) + 3v_d + 4(v_d + 9) = 960 \tag{4}$$
$$19v_d = 960 + 360 + 36 = 1356 \tag{5}$$
$$v_d = v_3 = 71.37\ V$$

(c) A is a dependent current source, arrow head on the left, labelled $5i_1$



Define the left mesh as 1, the top right mesh as 2 and the bottom mesh as 3.

Mesh 1:

$$-80 + 30i_a + 20i_a - 20i_b + 90i_a - 90i_c = 0 \tag{1}$$

For 2, 3 super-mesh

$$20i_b - 20i_a - 30 + 120i_c + 90i_c - 90i_a = 0 \tag{2}$$

And

$$i_b - i_c = 5i_1 = 5i_a \tag{3}$$

Rewriting eq. (1) as,

$$140i_a - 20i_b - 90i_c = 80 \tag{4}$$

Rewriting eq. (2) as,

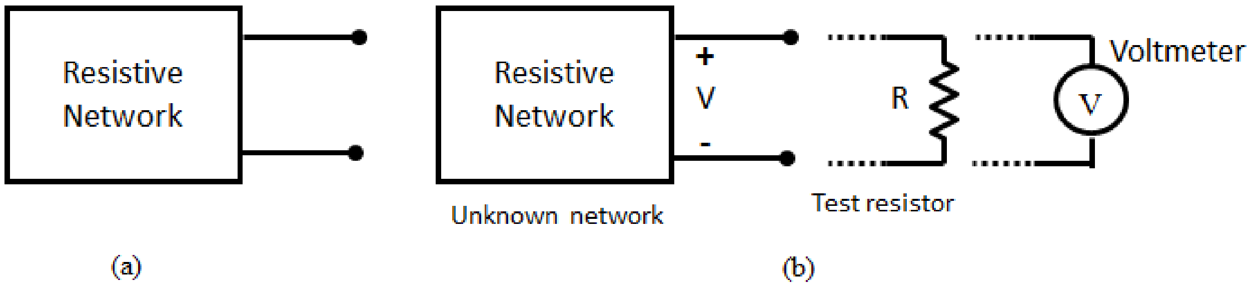
$$-110i_a + 20i_b + 210i_c = 30 \tag{5}$$

Rewriting eq. (3) as,

$$5i_a - i_b + i_c = 0 \tag{6}$$

We can solve for $i_c = 0.246A$ and $v_3 = 40i_c = 9.84\ V$

Name: ______________________________ Roll No.: ____________________ Section: _________



2. A student is given an unknown resistive network as shown in the figure above. She wishes to determine whether the network is linear, and if it is, what its Thevenin equivalent is. The only equipment available to student is a voltmeter (assume ideal), 100 kΩ and 400 kΩ test resistors that can be placed across the terminals during the measurements (see Figure 2(b)).
The following data were recorded:

Test resistor	Voltmeter Reading
Absent	2.5 V
100 kΩ	0.5 V
400 kΩ	1.25 V

What should the student conclude about the network from these results? Support your conclusions with plot of the unknown resistive network's I-V characteristics.

Solution: Let us assume that the network is linear and Thevenin's equivalent Voltage of the network be denoted by V_{TH} and the resistance by R_{TH}. Open circuit voltage, V_{oc} is given by

$$V_{oc} = V_{TH} = 2.5 \text{ V} \tag{1}$$

With 100 kΩ test resistor, voltage across the test resistor is

$$0.5 = \frac{100 \text{ k}}{100 \text{ k} + R_{TH}} \times 2.5 \text{ V} \tag{2}$$

$$\Rightarrow \; R_{TH} = 400 \text{ k}\Omega \tag{3}$$

With 400 kΩ test resistor, the voltage across the test resistor should have bee

$$\frac{400 \text{ k}}{400 \text{ k} + 400 \text{ k}} \times 2.5 \text{ V} = 1.25 \text{ V} \tag{4}$$

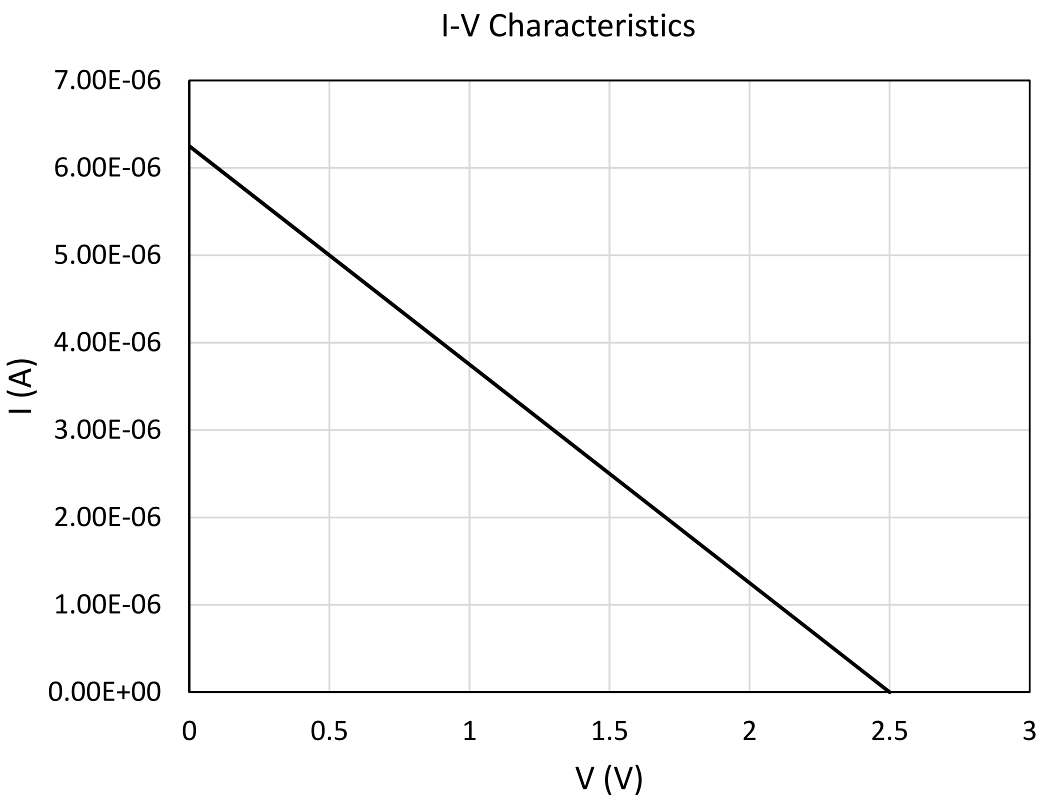
which is the observed voltage, hence the circuit is linear.

The voltage V across the terminals of the given network is obtained as

$$V = V_{TH} - IR_{TH} = (2.5 \; - 4 \times 10^5 I) \text{ V}$$

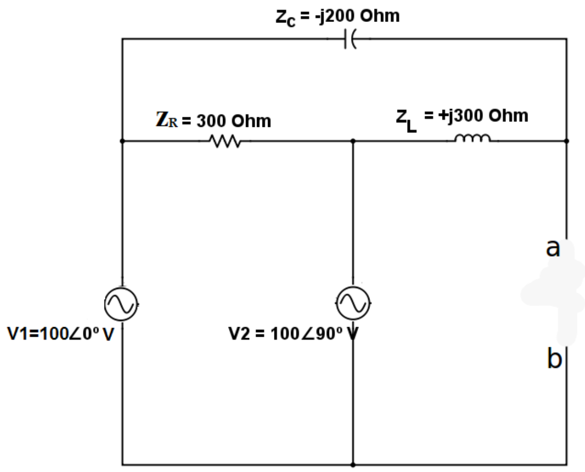
The I-V characteristics is shown below

Name: ________________________________Roll No.: _____________________ Section: __________

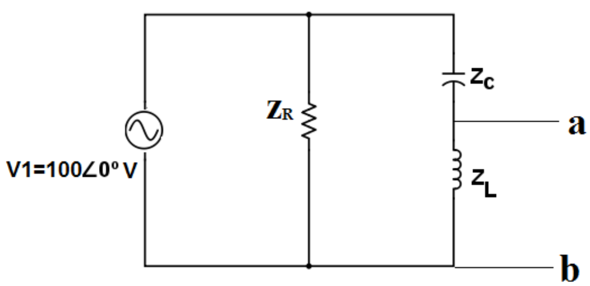


Name: ______________________________Roll No.: ____________________ Section: _________

3 (a). Find the Thevenin equivalent of the circuit given below:

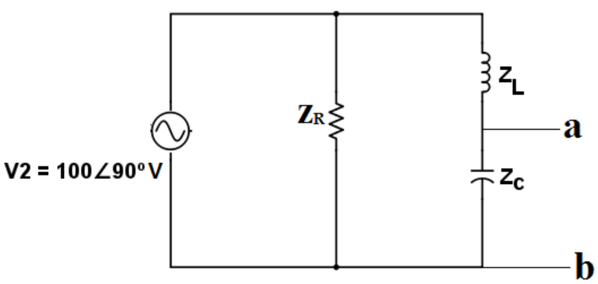


Solution: We could determine the v_{oc} across **a** and **b** by superposition of the two voltage sources.



$$V_{ab1} = \frac{V_1 Z_L}{Z_C + Z_L} = \frac{100\angle 0^o \cdot (j300)}{(j300 - j200)}$$

$$= 300V = 300\angle 0^o V$$

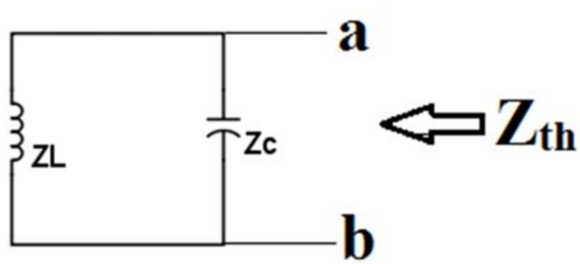


$$V_{ab2} = \frac{V_2 Z_C}{Z_C + Z_L} = \frac{100\angle 90^o \cdot (-j200)}{(j300 - j200)}$$

$$= 200\angle 180^o V$$

Therefore, $V_{Thevenin} = V_{ab1} + V_{ab2} = (300 - j200)V = 360.56\angle{-33.69^o}V$

The Thevenin impedance may be determined by making the sources zero and finding the equivalent impedance across **a** and **b** which is



$$Z_{Thevenin} = Z_C || Z_L = \frac{-j200 \cdot j300}{j300 - j200} = -600j = 600\angle 180^o \Omega$$

(b). Express the Thevenin equivalent voltage in the canonical form and the Thevenin impedance as resistance and inductance/capacitance. The frequency of the voltage sources are both 50Hz.

Here $\omega = 2\pi f = 2 \times 3.14 \times 50 \approx 314\, rad/s$

$$V_{Thevenin}(t) = 360.56\cos(314t - 33.69^o)\, V$$

$Z_{Thevenin}$ is a capacitor with $C = \frac{1}{314 \times 600} = 5.31\mu F$. There is no resistive component in this impedance.