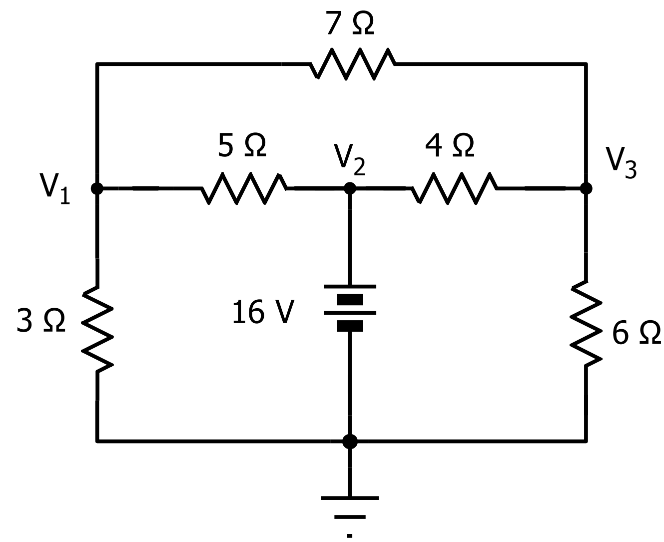
EE3 Fall 2020
Practice Problems 5

1. More NVA practice. Find V_1 & V_3.



$$\frac{V_1-16}{5}+\frac{V_1}{3}+\frac{V_1-V_3}{7}=0$$
$$\frac{V_3-V_1}{7}+\frac{V_3-16}{4}+\frac{V_3}{6}=0$$

$$71V_1-15V_3=336$$
$$-24V_1+94V_3=672$$

$$V_1=6.6\ \text{V};\ V_3=8.83\ \text{V}$$

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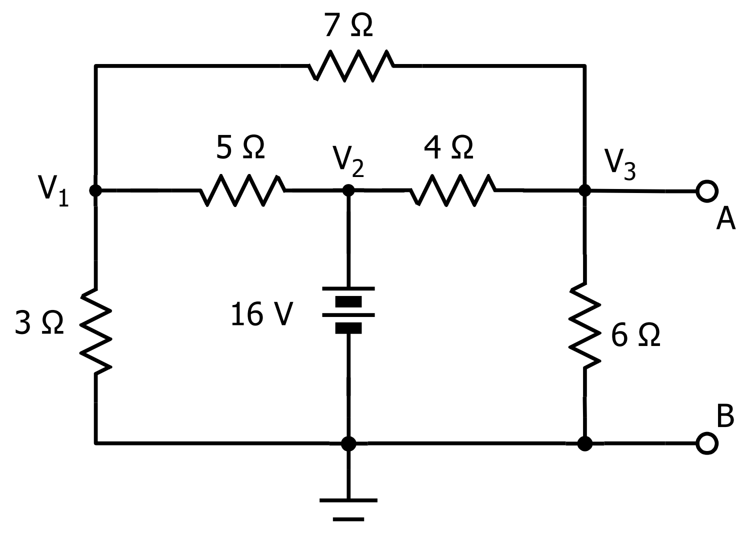
2. In this circuit, V_3=8.8 V.. You will be using Method (a.) to find the Thévenin Equivalent circuit.

   Use the V_{OC}-I_{SC} method to find the Thévenin Equivalent circuit, looking in through Port A-B.



From Problem 1, $V_3 = 8.8 \text{ V}$

$V_{OC} = V_3 = 8.8 \text{ V}$

Shorting Terminals A and B,

$$\frac{V_1 - 16}{5} + \frac{V_1}{3} + \frac{V_1}{7} = 0$$

$$\frac{0-16}{4} + \frac{0 - V_1}{7} + I_{SC} = 0$$

$$V_1 = \frac{336}{71} = 4.7324$$

$$I_{SC} = \frac{V_1 + 112}{28} = 4.6761$$

$$R_{th} = \frac{V_{OC}}{I_{SC}} = \frac{8.8}{4.6761} = 1.88 \ \Omega$$

NOTE: This problem shows Method (a.) to finding the Thévenin Equivalent circuit.

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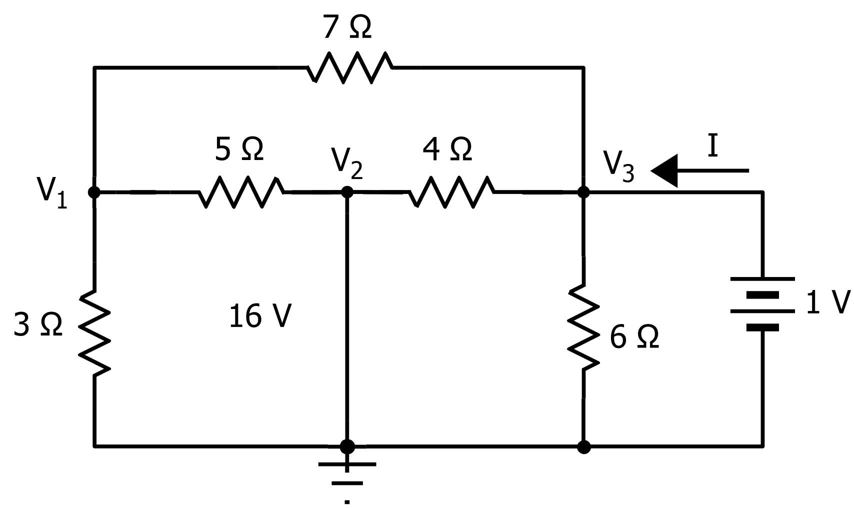
3. This time, you will find the Thévenin Equivalent circuit by using Method (b.). We zeroed out the 16 V battery and attached a test battery to the circuit as shown.
   a. Find an expression for the current I_T.
   b. Compute V_T / I_T. Units are ohms.
   c. Compare your answer to Problem 2.



$$V_2 = 0 \text{ V};\ V_3 = 1 \text{ V}$$

$$\frac{V_1 - 0}{3} + \frac{V_1 - 0}{5} + \frac{V_1 - 1}{7} = 0$$

$$V_1 = \frac{15}{71} = 0.2113 \text{ V}$$

$$-I + \frac{1 - 0 \text{ V}}{4\ \Omega} + \frac{1 \text{ V}}{6\ \Omega} + \frac{1 - 0.2113 \text{ V}}{7\ \Omega} = 0$$

$$I = 0.53 \text{ A}$$

$$\frac{1 \text{ V}}{I} = \frac{1}{0.53} = 1.89\ \Omega$$

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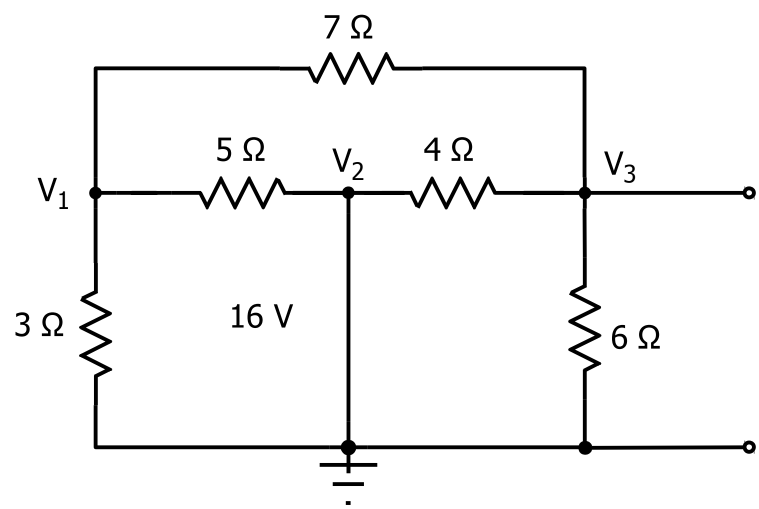
4. This time, you will find the Thévenin Equivalent circuit by using Method (c.). We replaced the 16 V battery with a short.
   a. Using your knowledge of series and parallel circuits, find the resistance of the circuit when looking in through the port.
   b. Compare your answer to Problem 3.



$$\left(7+5\|3\right)\ \|\ \left(4\|6\right)=1.89\ \Omega$$

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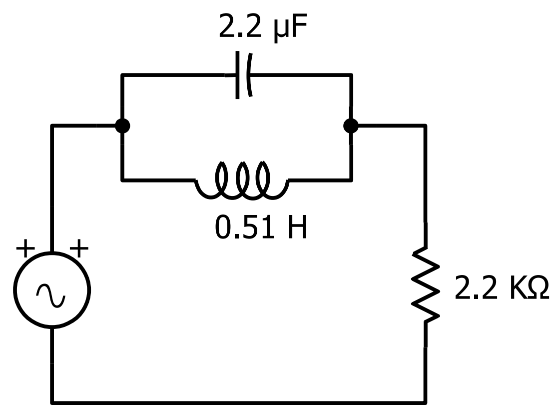

5a. Using the expressions for capacitive and inductive impedance, find the total impedance presented by the capacitor, inductor, and resistor to the voltage source. Set ω = 1000 rad/s.

$$Z_{tot} = Z_C \| Z_L + R$$

$$Z_C \| Z_L + R = \frac{Z_C Z_L}{Z_C + Z_L} + R = \frac{\frac{j\omega L}{j\omega C}}{\frac{1}{j\omega C} + j\omega L} + R = \frac{\frac{j\,1000 \cdot 0.51}{j\,1000 \cdot 2.2\text{e-}6}}{\frac{1}{j\,1000 \cdot 2.2\text{e-}6} + j\,1000 \cdot 0.51} + 2200$$

$$Z_{tot} = 2200 - j\,4180$$

b. Now find the current through the voltage source if v(t) = 10 cos(1000t). Express in both rectangular and polar forms.

$$i_V(t) = \frac{v(t)}{Z_{tot}} = \frac{10 \angle 0°}{2200 - j\,4180} = 0.99 + j\,1.87 \text{ mA} = 2.12 \measuredangle 62.1°$$

d. Find the current through the inductor i_L. Express in both rectangular and polar forms.

$$i_L(t) = i_V(t)\left(\frac{Z_C}{Z_C + Z_L}\right) = (0.99 + j\,1.87)\left(\frac{-j\,454}{-j\,454 + j\,510}\right) = -8.1 - j\,15.4 \text{ mA} = 17.4 \measuredangle -118°$$

e. Find the current through the capacitor i_C.

$$i_C(t) = i_V(t)\left(\frac{Z_L}{Z_L + Z_C}\right) = (0.99 + j\,1.87)\left(\frac{j\,510}{-j\,454 + j\,510}\right) = 9.1 + j\,17.2 \text{ mA} = 19.5 \measuredangle 62.1°$$

f. Add i_L and i_C. The sum should equal the current in #2.

$$i_L + i_C = -8.1 - j\,15.4 + 9.1 + j\,17.2 = 0.99 + j\,1.87 \text{ mA}$$

g. Compare the magnitudes of $i_L(t)$, $i_C(t)$, and $i_V(t)$. Can you explain the apparent anomaly?

NOTE: $|i_L(t)|$ and $|i_C(t)|$ are much larger than $|i_V(t)|$!