Desk Copy

ECE 300
Spring Semester, 2004
HW Set #7

March 23, 2004
wlg

Name Green
Print (last, first)

Use engineering paper. Work only on one side of the paper. Use this sheet as your cover sheet, placed on top of your work and stapled in the top left-hand corner. Number the problems at the top of the page, in the center of the sheet. **Do neat work. Underline your answers. Show how you got your equations.** **Be sure to show how you got your answers.** Each problem counts 10 points.

7.6 (a) $i(t) = 8\cos(377t + 68)$ A, (b) $i(t) = 4\sin(377t + 154)$ A $= 4\cos(377t + 64)$ A

7.14 $Z_{AB} = 4.79\angle -7.33\ \Omega$

7.18 $C = 431\ \mu F$

7.21 $v(t) = 5.17\cos(377t + 45)$ V

7.26 $\underline{I}_L = 1\angle -54.3$ A; $\underline{I}_C = 0.01\angle 125.7$ A

7.43 $Z = 0.78\angle 130.9\ \Omega$

7.47 $\underline{V}_o = 3.09\angle -23.8$ V

7.51 $\underline{V}_o = 9\angle 51.3$ V

7.52 $\underline{V}_o = 5.55\angle 86.8$ V

7.68 ~~$\underline{V}_o$ = 2.61∠125.8 V (from answer book; not verified, yet)~~

$V_o = 0.485 \angle 104^\circ$ V

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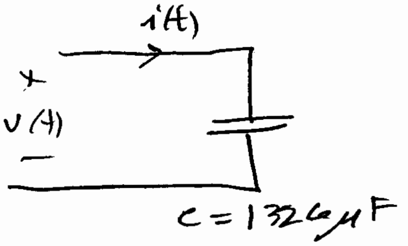
7.6 Determine $i(t)$ in the following circuit for the given $v(t)$ and capacitance

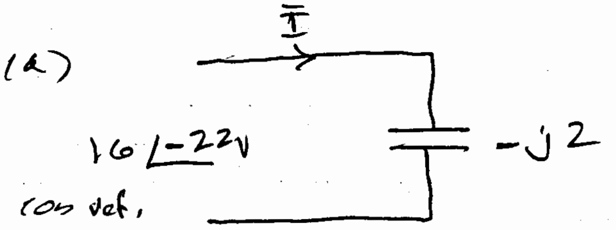


(a) $v(t) = 16\cos(377t - 22°)\,V$

(b) $v(t) = 8\sin(377t + 64°)\,V$

$$\frac{1}{\omega C} = \frac{1}{3.77\times10^{2}\times 0.1326\times10^{-2}} = 2$$

(a)



$$I = \frac{16\angle -22}{2\angle -90} = 8\angle 68$$

$$\boxed{i(t) = 8\cos(377t + 68°)\,A}$$

Also, note that

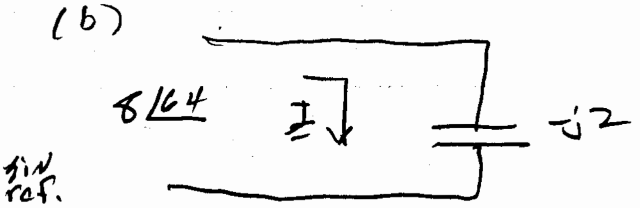
$$i(t) = C\frac{dv}{dt} = -0.1326\times10^{-2}\times 16\times 377\sin(377t - 22°)$$

$$i(t) = -8\sin(377t - 22°) = 8\cos(377t + 68)$$

$$\boxed{i(t) = 8\cos(377t + 68°)\,A}$$

Same answer as obtained by phasor method.

(b)



$$I = \frac{8\angle 64}{2\angle -90} = 4\angle 154$$

$$\boxed{i(t) = 4\sin(377t + 154°)\,A}$$

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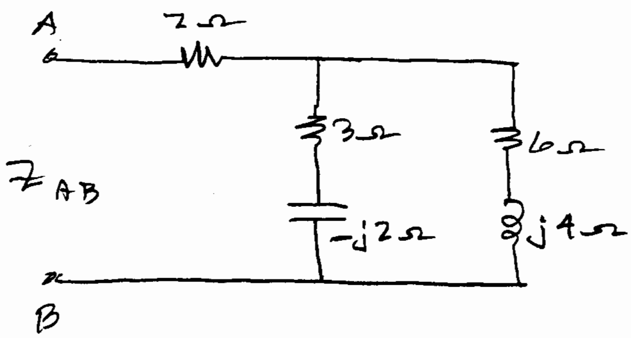
7.14 Find the impedance seen looking into terminals A-B.



$$\bar{Z}_{AB} = 2 + \frac{(3-j2)(6+j4)}{(3-j2)+(6+j4)}$$

$$Z_{AB} = 2 + 2.82\angle{-12.53^\circ}$$

$$\boxed{Z_{AB} = 4.79\angle{-7.33^\circ}\ \Omega}$$ polar form

$$\boxed{Z_{AB} = (6.75 - j0.611)\ \Omega}$$ rectangular form

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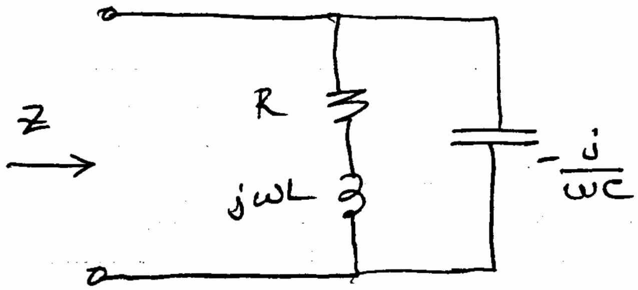
7.18 At 60 Hz, the impedance seen looking into the terminals is purely real. Determine C



$$Z = \frac{(R + j\omega L)\left(-\frac{j}{\omega C}\right)}{R + j\left(\omega L - \frac{1}{\omega C}\right)} = \frac{-j(R + j\omega L)}{\omega RC + j(\omega^2 LC - 1)}$$

$$Z = \frac{\omega L - jR}{\omega RC + j(\omega^2 LC - 1)} \times \frac{[\omega RC - j(\omega^2 LC - 1)]}{[\omega RC - j(\omega^2 LC - 1)]}$$

$$Z = \frac{\cancel{\omega^2 RLC} - j\omega L(\omega^2 LC - 1) - j\omega R^2 C - \cancel{\omega^2 RLC} + R}{\omega^2 R^2 C^2 + (\omega^2 LC - 1)^2}$$

$$= \frac{R - j[\omega L(\omega^2 LC - 1) + \omega R^2 C]}{D}$$

make $\omega L(\omega^2 LC - 1) + \omega R^2 C = 0$

$$\omega^2 L^2 C - L + R^2 C = 0$$

$$C(\omega^2 L^2 + R^2) = L$$

$$C = \frac{L}{\omega^2 L^2 + R^2} = \frac{10 \times 10^{-3}}{[377^2 \times (.01)^2 + 9]}$$

$$C = 431\ \mu F$$

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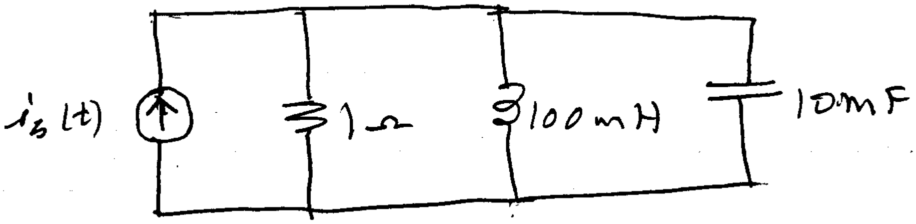
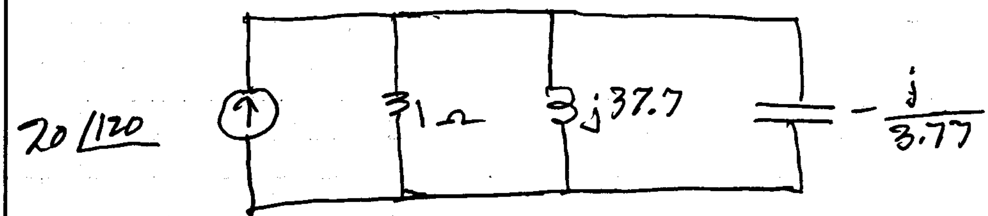
7.21 Draw the frequency-domain circuit and calculate $v(t)$ for the following:



$i_s(t) = 20\cos(377t + 120^\circ)\ A \rightarrow \omega = 377$



$$Y = 1 + \frac{1}{j37.7} - \frac{3.77}{j} = 1 - \frac{j}{37.7} + j3.77$$

$$\underline{V} = \frac{I}{Y} = \frac{20\angle 120}{1 + j3.74}$$

$$\underline{V} = 5.17\angle 45\ V$$

$$\boxed{v(t) = 5.17\cos(377t + 45^\circ)\ V}$$

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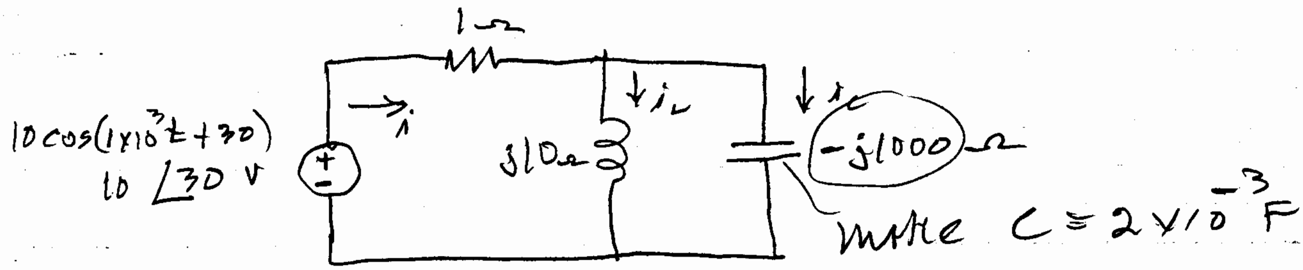
7.26 For the circuit below, determine $\hat{I}_c$ and $\hat{I}_L$. Show, both analytically and graphically (phasors) that

$$\hat{I} = \hat{I}_L + \hat{I}_c$$



$$Z = 1 + \frac{(10\angle 90)(1000\angle -90)}{990\angle \cancel{-90}}\ \Omega$$

$$Z = 10.15\angle 84.3$$

$$\hat{I} = \frac{10\angle 30}{10.15\angle 84.3} = 0.99\angle -54.3$$

$$\hat{I}_L = \frac{\hat{I}\times(1000\angle -90)}{990\angle -90} = 0.99\angle -54.3 \times \frac{1000}{990}$$

$$\boxed{\hat{I}_L = 1\angle -54.3\ \text{A}}$$

$$\hat{I}_c = \frac{\hat{I}\times j10}{990\angle -90} = \frac{0.99\angle -54.3\times 10\angle 90}{990\angle -90}$$

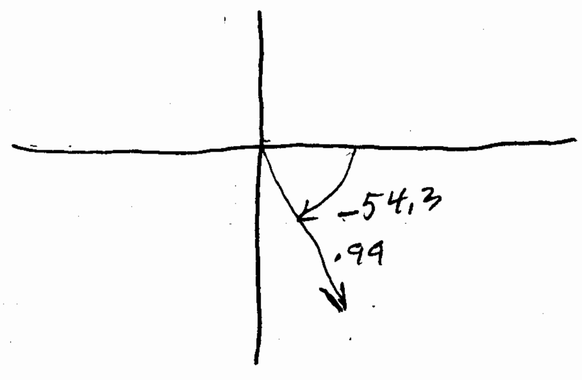
$$\boxed{\hat{I}_c = 0.01\angle 125.7\ \text{A}}$$

$$\hat{I} = 1\angle -54.3 + 0.01\angle 125.7 = 0.99\angle -54.3\ \text{A}$$

$1\times10^{-3}\times$

5×10^{-3}

5



Not good to illustrate phasors.

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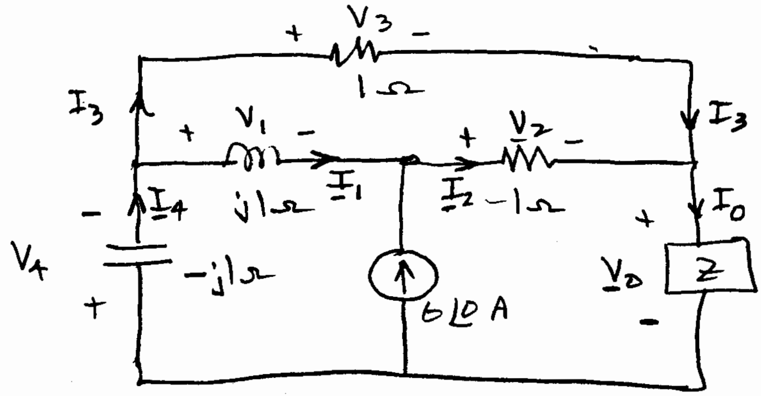
7.43 In the following Diagram $\underline{V}_1 = 2\angle 45^\circ$ V

Find Z.



$$\underline{I}_1 = \frac{\underline{V}_1}{j1} = \frac{2\angle 45}{1\angle 90} = 2\angle -45^\circ \text{ A}$$

$$\underline{I}_2 = 6 + \underline{I}_1 = 6 + 2\angle -45 = 7.414 - j1.414 \text{ A}$$

$$\underline{V}_2 = \underline{I}_2 \times 1 = 7.414 - j1.414 \text{ V}$$

$$\underline{V}_3 = \underline{V}_1 + \underline{V}_2 = 2\angle 45 + (7.414 - j1.414) = 8.83 \text{ V}$$

$$\underline{I}_3 = \frac{V_3}{1} = 8.83 \text{ A}$$

$$\underline{I}_4 = \underline{I}_1 + \underline{I}_3 = 2\angle -45 + 8.83 = (10.242 - j1.414) \text{ V}$$

$$\underline{V}_4 = (-j)\,\underline{I}_4 = (-1.414 - j10.242) \text{ V}$$

$$V_o + V_4 + V_3 = 0$$

$$V_o = -(V_3 + V_4) = -8.83 + (1.414 + j10.242)$$

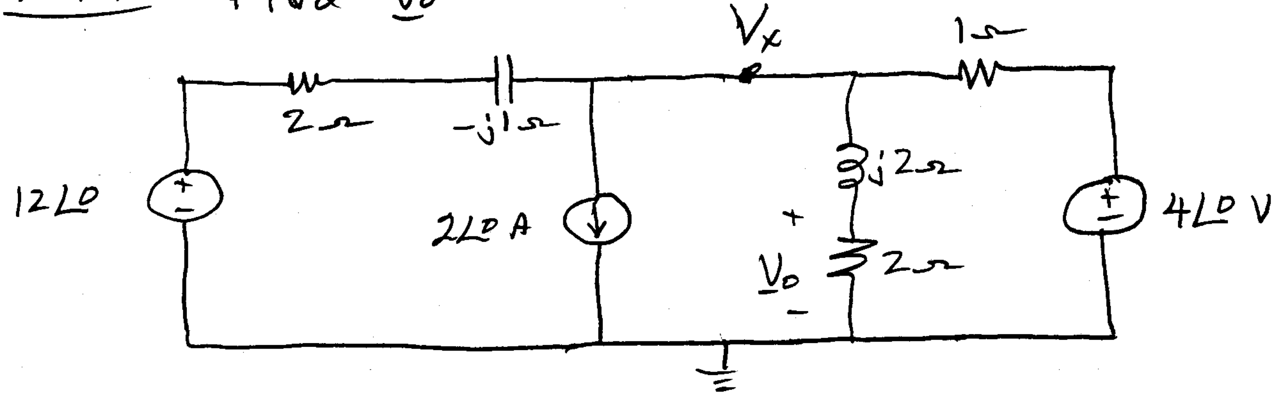
$$V_o = (-7.416 + j10.242) \text{ V}$$

$$I_o = I_2 + I_3 = 7.414 - j1.414 + 8.83 = (16.24 - j1.414) \text{ A}$$

$$Z = \frac{V_o}{I_o} = \frac{(-7.416 + j10.242)}{(16.24 - j1.414)}$$

$$\boxed{Z = 0.78\angle 130.9^\circ \ \Omega}$$

7.47 Find $\underline{V}_o$



Find $\underline{V}_x$ then

$$\underline{V}_o = \frac{2V_x}{2+j2} \qquad (1)$$

$$\frac{V_x}{2+j2} + \frac{V_x-4}{1} + \frac{V_x-12}{2-j} = -2$$

$$(0.25-j0.25)V_x + V_x - 4 + (.4+j.2)V_x - 12(.4+j.2) = -2$$

$$(1.65-j.05)V_x = 4-2+12(.4+j.2)$$
$$= 6.8+j2.4$$

$$V_x = \frac{6.8+j2.4}{1.65-j0.05} = 4.37\angle 21.18$$

$$V_o = \frac{2\times 4.37\angle 21.18}{2+j2} = 3.09\angle -23.8$$

$$\boxed{V_o = 3.09\angle -23.8 \ \text{V}}$$

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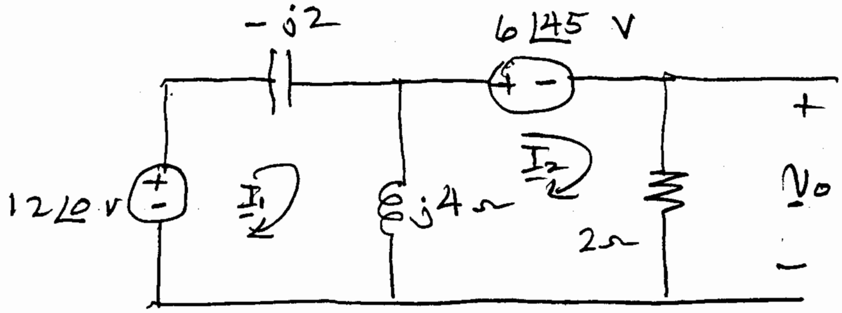
7.51 Use mesh analysis to find $\underline{V}_o$



$$\begin{bmatrix} j2 & -j4 \\ -j4 & 2+j4 \end{bmatrix} \begin{bmatrix} \underline{I}_1 \\ \underline{I}_2 \end{bmatrix} = \begin{bmatrix} 12 \\ -6\angle 45 \end{bmatrix}$$

$\underline{I}_1 = 5.7\angle 10.6^\circ$ A

$\underline{I}_2 = 4.5\angle 51.3$ A

$\underline{V}_o = 2 \times \underline{I}_2$

$\underline{V}_o = 9\angle 51.3$ V

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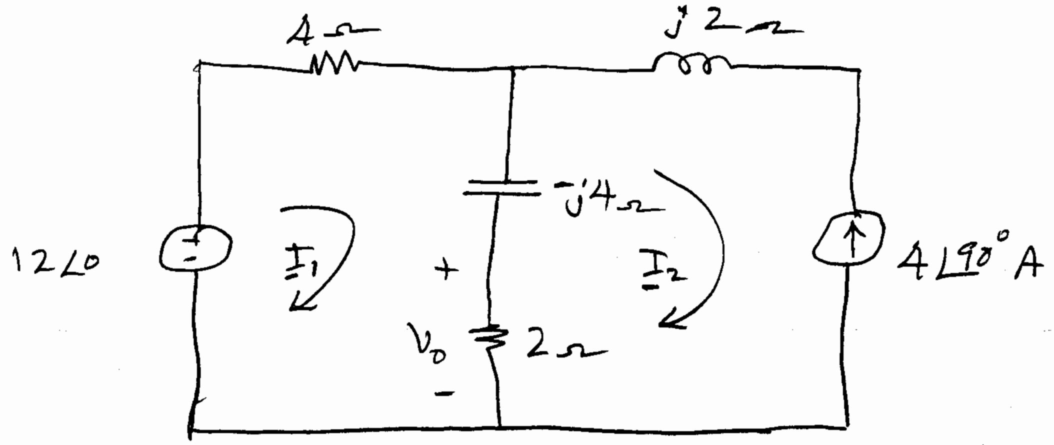
7.52 Find $\underline{V_o}$ in the circuit below using mesh analysis.



$$(6-j4)I_1 - (2-j4)I_2 = 12$$

$$0\ I_1 \quad - I_2 = 4\angle 90$$

$$I_1 = 1.24\angle -82.9 \text{ A}$$

$$I_2 = 4\angle -90 \text{ A}$$

$$\underline{V_o} = 2[I_1 - I_2]$$

$$= 2\{(1.24\angle -82.9) + (-4\angle -90)\}$$

$$\underline{V_o} = 5.55\angle 86.8^\circ \text{ V}$$

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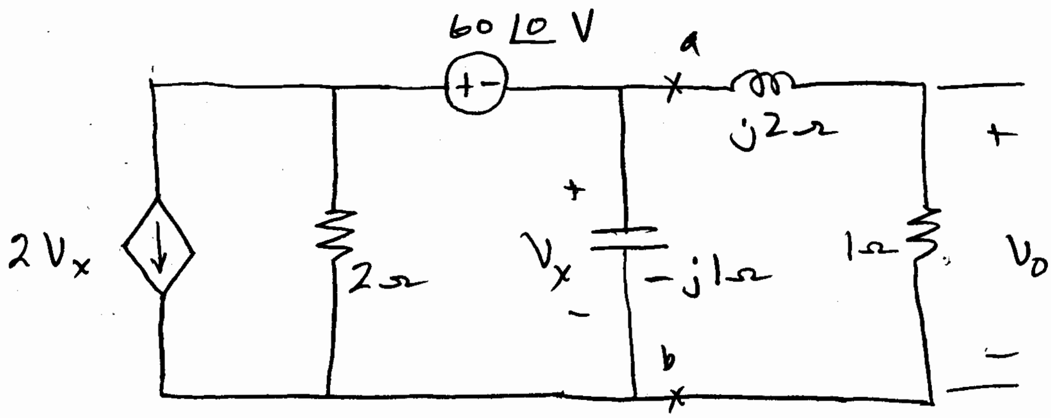
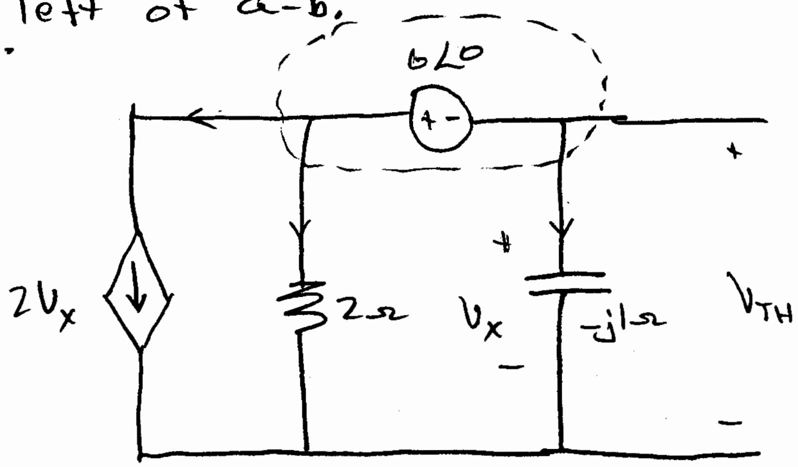
7.68

Find V_o in the following network using Thevenin's theorem.



Find the Thevenin equivalent circuit to the left of a-b.



At the supernode;

$$\frac{V_x + 6}{2} + 2V_x + \frac{V_x}{j} = 0$$

$$0.5V_x + 3 + 2V_x + jV_x = 0$$

$$(2.5 + j)V_x = -3$$

$$V_x = \frac{-3}{(2.5+j)} = 1.114 \angle 158.2^\circ \text{ V}$$

$$\boxed{V_{TH} = 1.114 \angle 158.2 \text{ V}}$$

continued

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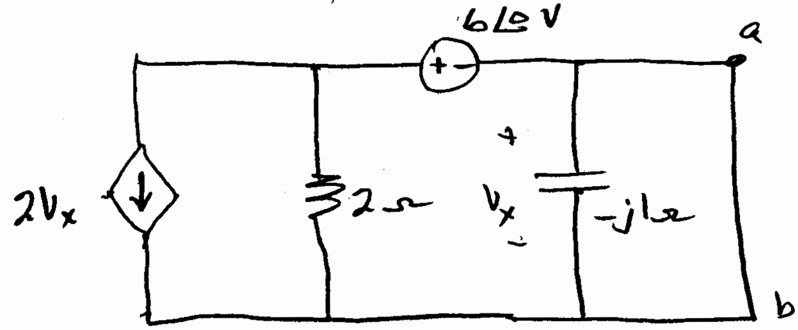
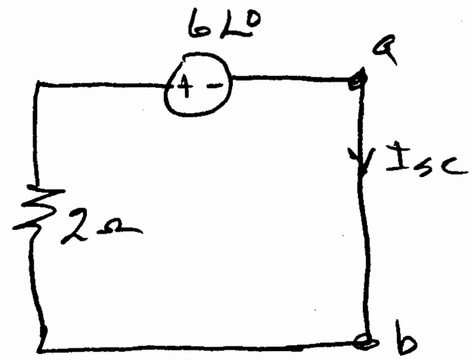
Now find I_{sc}

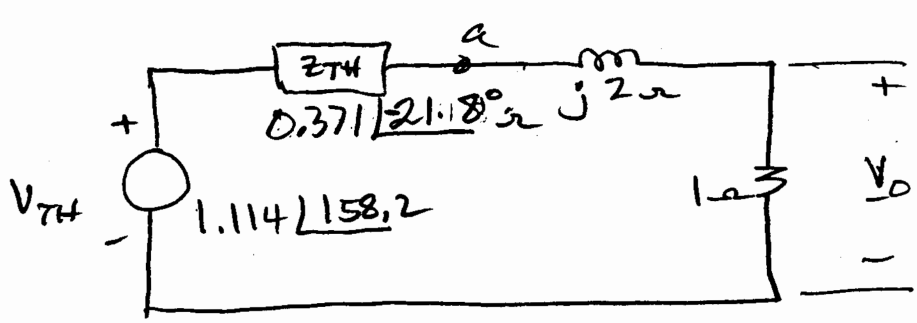


When you short a-b this make $V_x = 0$ which disables the $2V_x$ current source, leaving



$$I_{sc} = -\frac{6}{2} = -3$$

$$Z_{TH} = \frac{V_{os}}{I_{sc}} = \frac{1.114\angle 158.2}{-3} = 0.371\angle -21.8$$



$$V_o = \frac{(1.114\angle 158.2)(1)}{((1+j2)+(0.371\angle -21.8))} = 0.485\angle 104^\circ \text{ V}$$

$$\boxed{V_o = 0.485\angle 104^\circ \text{ V}}$$