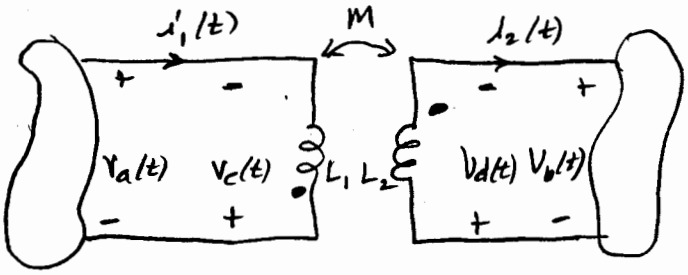
Homework Set #9

wlg

8.4 Given the following network

(a) write the d.e. for $V_a(t)$ and $V_b(t)$.

(b) write the d.e. For $V_c(t)$ and $V_d(t)$.



(a)

$$V_a(t) = L_1 \frac{di_1}{dt} + M \frac{di_2}{dt}$$

$$V_b(t) = -L_2 \frac{di_2}{dt} - M \frac{di_1}{dt}$$

(b)

$$V_c(t) = -V_a(t) = -L_1 \frac{di_1}{dt} - M \frac{di_2}{dt}$$

$$V_d(t) = -V_b(t) = L_2 \frac{di_2}{dt} + M \frac{di_1}{dt}$$

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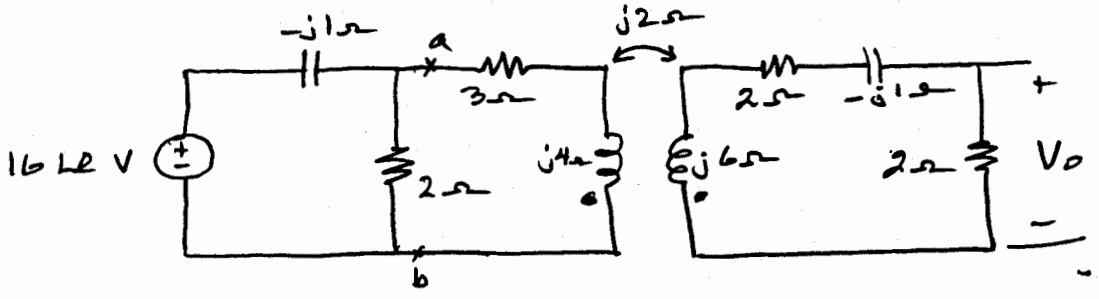
8.12 Find $\underline{V}_o$ in the network below.

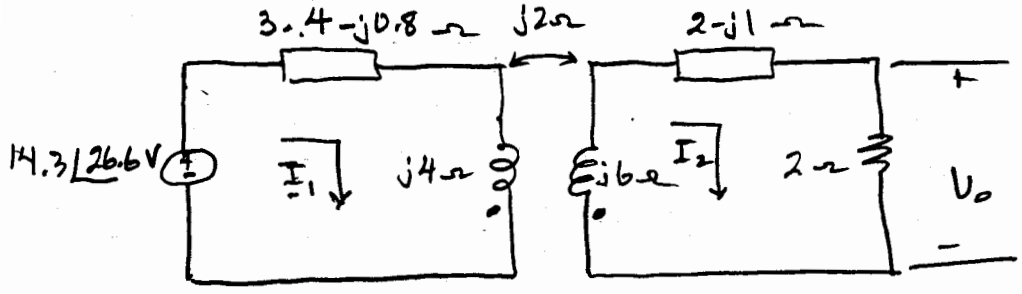


Make a Thevenin to the left of a-b

$$V_{TH} = \frac{16 \times 2}{2 - j1} = 14.3 \angle 26.6^\circ \text{ V}$$

$$Z_{TH} = \frac{2(1\angle -90)}{2 - j1} = 0.89 \angle -63.4^\circ = 0.4 - j0.8$$

So we have



$$(3.4 + j3.2)\underline{I}_1 - j2\underline{I}_2 = 14.3 \angle 26.6$$

$$-j2\underline{I}_1 + (4 + j5)\underline{I}_2 = 0$$

$$\underline{I}_1 = 3.03 - j0.47 \qquad \underline{I}_2 = 0.833 + j0.474 = 0.958 \angle 29.6 \text{ A}$$

$$\underline{V}_o = 2(0.958 \angle 29.6)$$

$$\boxed{\underline{V}_o = 1.92 \angle 29.6^\circ \text{ V}}$$

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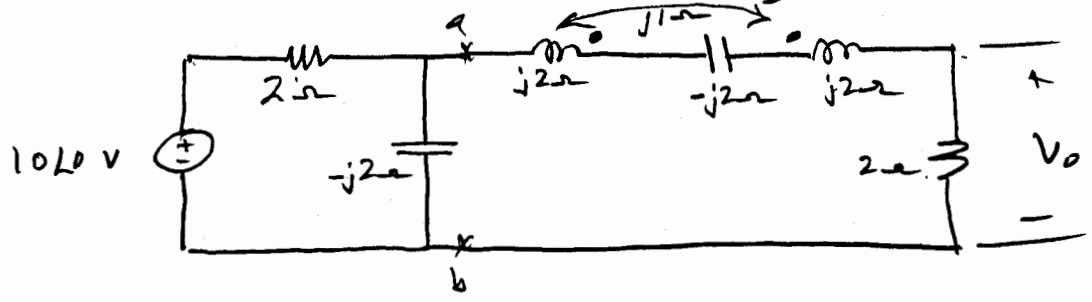
8.24 Find V_o in the following circuit

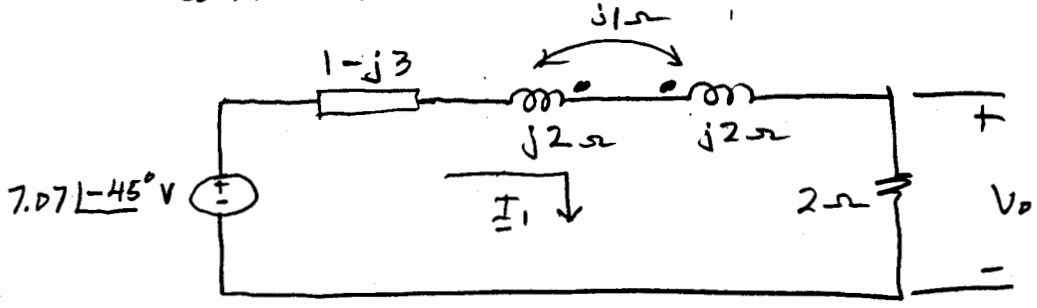


Apply Thevenin to the left of a-b

$$V_{TH} = \frac{-10 \times 2\angle -90}{2 - j2} = 5 - j5 = 7.07\angle -45^\circ \text{ V}$$

$$Z_{TH} = \frac{2(2\angle -90)}{2 - j2} = 1 - j1$$

Redraw the circuit:



$$(3 - j3)\bar{I}_1 + j4\bar{I}_1 - j1\bar{I}_1 - j1\bar{I}_1 = 7.07\angle -45$$

$$(3 - j1)\bar{I}_1 = 7.07\angle -45$$

$$I_1 = 2 - j1 = 2.24\angle -26.6 \text{ A}$$

$$V_o = 2I_1 = 4.48\angle -26.6^\circ \text{ V}$$

$$\boxed{V_o = 4.48\angle -26.6^\circ \text{ V}}$$

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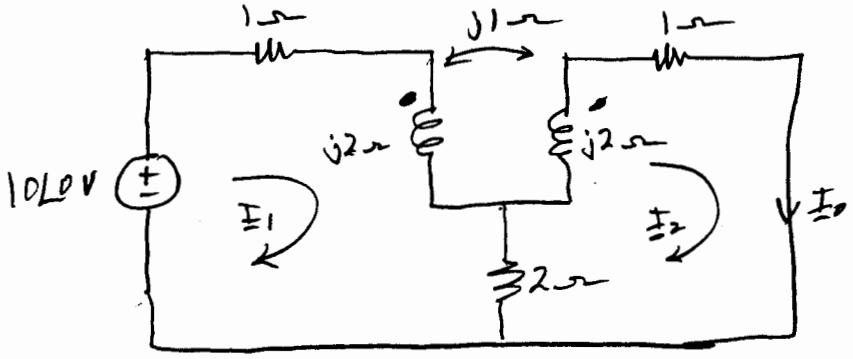
8.30

Find I_o in the circuit below.



$$(1+j2+2)\underline{I}_1 - 2\underline{I}_2 - j1\underline{I}_2 = 10\angle 0$$

$$(3+j2)\underline{I}_1 + (-2-j1)\underline{I}_2 = 10\angle 0$$

$$(-2-j)\underline{I}_1 + (3+j2)\underline{I}_2 = 0$$

$$\begin{bmatrix} 3+j2 & -2-j \\ -2-j & 3+j2 \end{bmatrix} \begin{bmatrix} \underline{I}_1 \\ \underline{I}_2 \end{bmatrix} = \begin{bmatrix} 10 \\ 0 \end{bmatrix}$$

$\underline{I}_1 = 3.24 - j2.94$ $\qquad I_2 = \underline{I}_o = 1.77 - j2.05 = 2.7\angle -49.4^\circ$ A

$$\underline{I}_o = 2.7\angle -49.4^\circ \text{ A}$$

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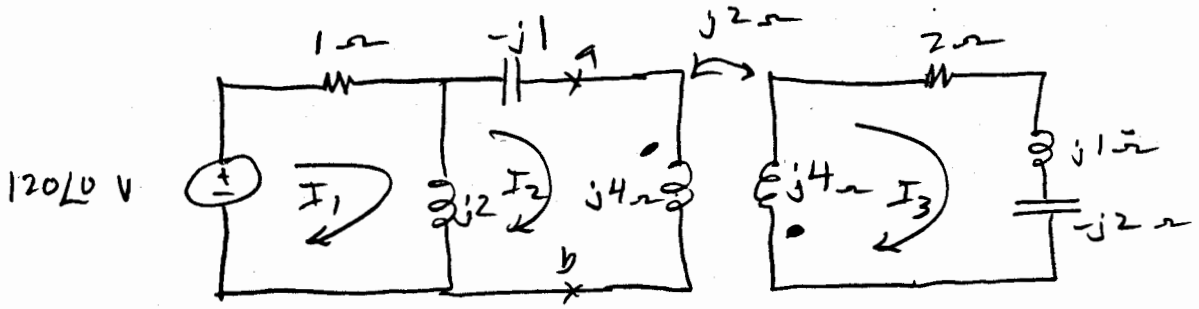
8.35

Determine the impedance seen by the source in the network below.



mesh #1

$$(1+j2)I_1 - j2I_2 = 120\angle 0$$

mesh #2

$$-j2I_1 + j5I_2 + j2I_3 = 0$$

mesh #3

$$j2I_2 + (2+j3)I_3 = 0$$

$$\begin{matrix} & I_1 & I_2 & I_3 \end{matrix}$$

$$\begin{bmatrix} 1+j2 & -j2 & 0 \\ -j2 & j5 & j2 \\ 0 & j2 & 2+j3 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 120 \\ 0 \\ 0 \end{bmatrix}$$

Need I_1: $I_1 = 57.4 - j52.2$

$$Z_{IN} = \frac{120}{I_1} = \frac{120}{57.4 - j52.2}$$

$$Z_{IN} = 1.55 \angle 42.3^\circ \ \Omega$$

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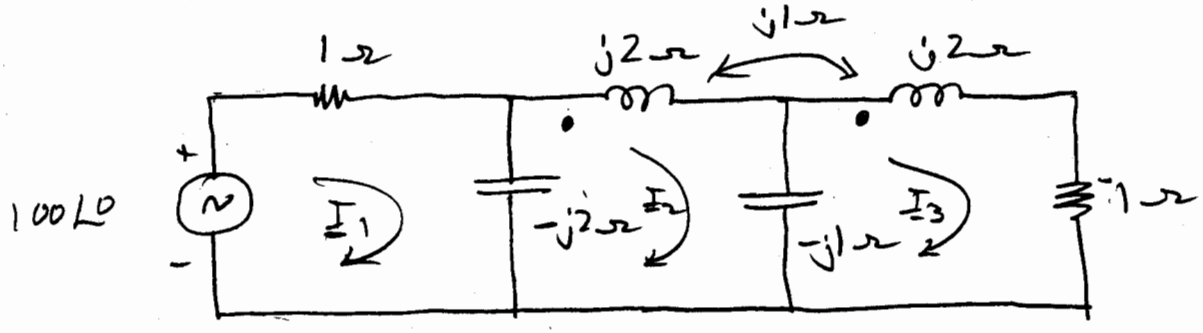
8.38

Determine the input impedance of the network below.



We assume a $100\angle 0$ V source

mesh #1

$$(1-j2)\underline{I}_1 + j2\underline{I}_2 = 100$$

mesh #2

$$j2\underline{I}_1 + (-j3+j2)\underline{I}_2 + j1\underline{I}_3 + j1\underline{I}_3 = 0$$

mesh #3

$$j1\underline{I}_2 + (-j1+j2+1)\underline{I}_3 + j1\underline{I}_2$$

$$\begin{matrix} & \underline{I}_1 & \underline{I}_2 & \underline{I}_3 \end{matrix}$$

$$\begin{bmatrix} 1-j2 & j2 & 0 \\ j2 & -j1 & j2 \\ 0 & j2 & 1+j \end{bmatrix} \begin{bmatrix} \underline{I}_1 \\ \underline{I}_2 \\ \underline{I}_3 \end{bmatrix} = \begin{bmatrix} 100 \\ 0 \\ 0 \end{bmatrix}$$

Need $\underline{I}_1 = 42.86 + j28.6$

$$Z_{IN} = \frac{100}{42.86+j28.6} = 1.94\angle -33.7^\circ \ \Omega$$

$$\boxed{Z_{IN} = 1.94\angle -33.7 \ \Omega}$$

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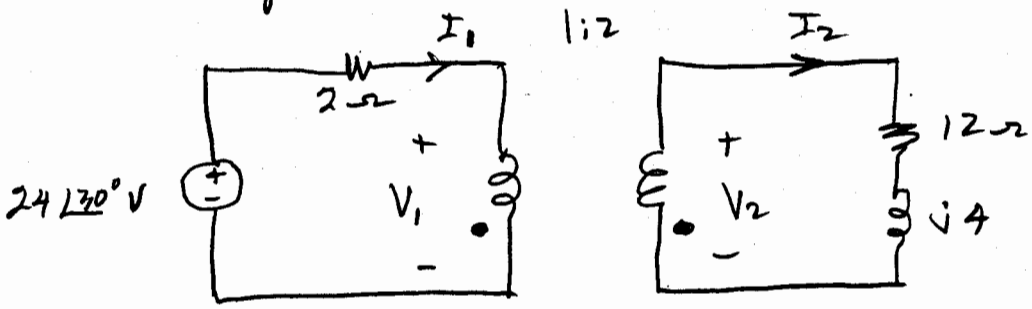
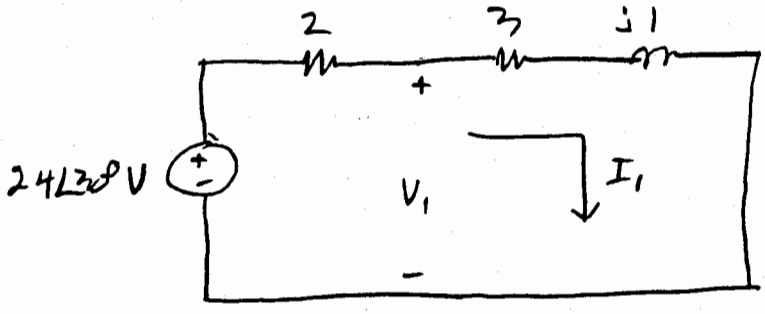
8.46 Find all currents and voltages in the following network.



Reflecting secondary to primary



$$\underline{I}_1 = \frac{24\angle 30}{5 + j1} = 4.7\angle 18.7° \text{ A} \quad \text{check}$$

$$\underline{I}_2 = \frac{\underline{I}_1}{2} = 2.23\angle 18.7 \text{ A} \quad \text{check}$$

$$\underline{V}_1 = 24\angle 30 - 2(4.7\angle 18.7°)$$

$$\underline{V}_1 = 14.9\angle 37.1° \text{ V}$$

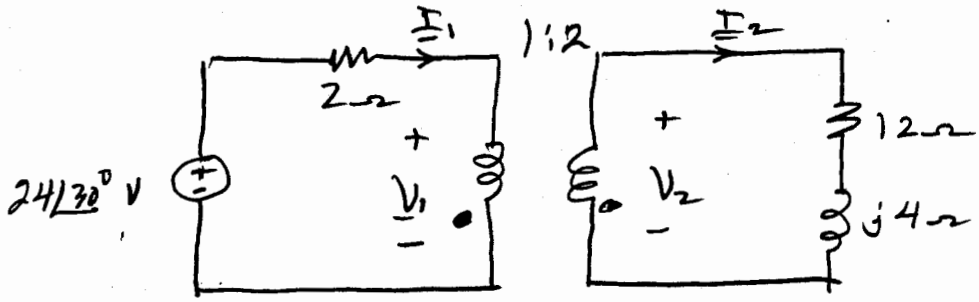
$$V_2 = 2 \times V_1$$

$$V_2 = 30\angle 37.1 \text{ V}$$

wlg

8.46

Find all currents and voltages in the following network



Standard Mesh equation solution.

$$2I_1 + V_1 = 24\angle 30^\circ$$

$$(12+j4)I_2 - V_2 = 0$$

$$\frac{V_2}{V_1} = 2 \rightarrow 2V_1 - V_2 = 0$$

$$\frac{I_1}{I_2} = 2 \qquad I_1 - 2I_2 = 0$$

$$\begin{matrix} V_1 & V_2 & I_1 & I_2 \end{matrix}$$

$$\begin{bmatrix} 1 & 0 & 2 & 0 \\ 0 & -1 & 0 & 12+j4 \\ 2 & -1 & 0 & 0 \\ 0 & 0 & 1 & -2 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 24\angle 30^\circ \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$V_1 = 11.87 + j\,8.98 = 14.88\angle 37^\circ$ V $\qquad V_2 = 23.7 + j\,17.97 = 29.7\angle 37.1$ V

$I_1 = 4.46 + j\,1.51 = 4.7\angle 18.7^\circ$ A $\qquad I_2 = 2.23 + j\,0.75 = 2.35\angle 18.6^\circ$ A

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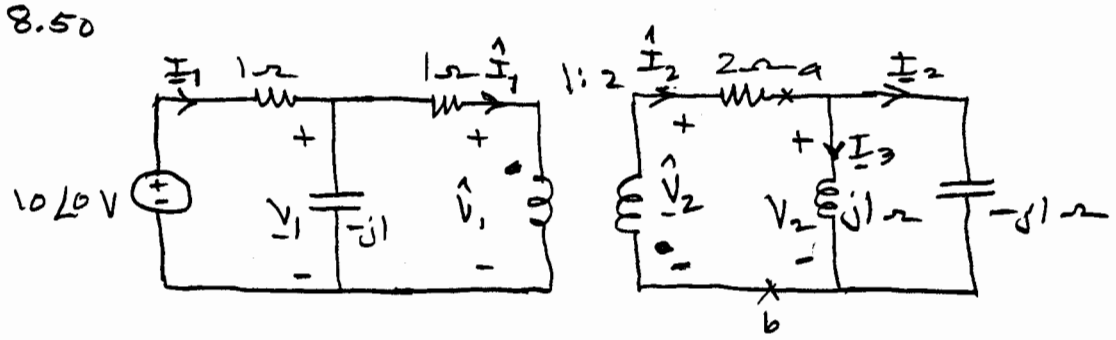
8.50



To the right of a-b we have $j1 \parallel -j1 = \infty$, so it looks like an open circuit.

This means $\hat{I}_2 = 0$. Therefore $\hat{I}_1 = 0$.

Then

$$\underline{V}_1 = \frac{10 \times (-j1)}{1 - j1} = 7.07\angle -45° \text{ A}$$

$$\underline{I}_1 = \frac{10\angle 0}{1 - j1} = 7.07\angle 45 \text{ A}$$

since $\hat{I}_1 = 0$, $\hat{V}_1 = V_1$

With the dot marking given,

$$\hat{V}_2 = -2\hat{V}_1 = -14.14\angle -45° \text{ V}$$

$$\hat{\underline{V}}_2 = \boxed{14.14\angle 135 \text{ V} = \underline{V}_2}$$

With $\hat{I}_2 = 0$, $\underline{V}_2 = \hat{\underline{V}}_2$, then

$$\underline{I}_2 = \frac{\underline{V}_2}{-j1} = \frac{14.14\angle 135}{1\angle -90} = 14.14\angle -135 \text{ A}$$

Note;

$$\underline{I}_3 = \frac{\underline{V}_2}{j1} = \frac{14.14\angle 135}{1\angle 90} = 14.14\angle 45$$

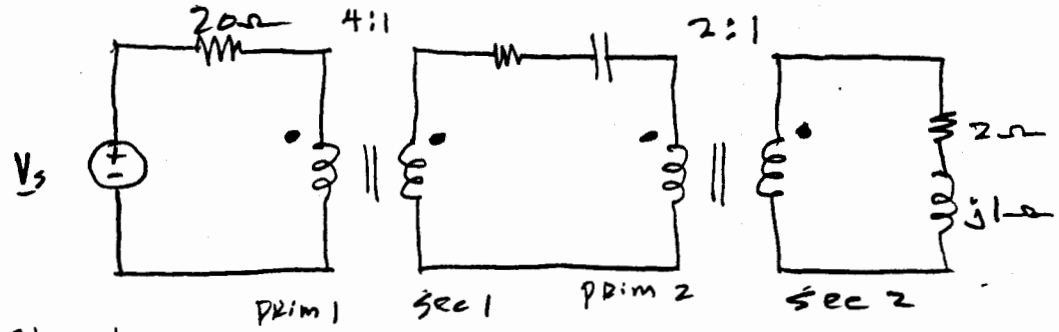
We see $\underline{I}_2 + \underline{I}_3 = 0$ As it should.

We have an ideal tank circuit.

"Perpetual motion"

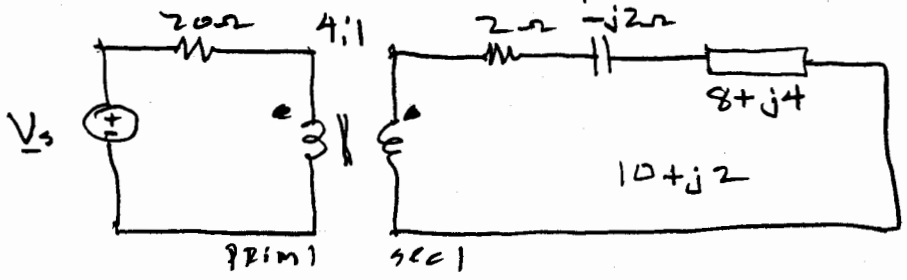
wlg

8.54 Determine the input impedance seen by the source in the network below.

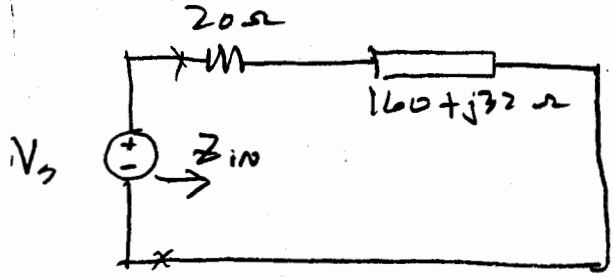


Step 1:

Reflect sec 2 to prim 2 $\quad 2^2(2+j1) = 8+j4$



$$4^2(10+j2) = 16(10+j2) = 160+j32$$



$$Z_{in} = 20 + 160 + j32$$

$$\boxed{Z_{in} = 180 + j32\ \Omega}$$

3FE-2

Select $N_2 : N_1$ for maximum pwr transfer. Calculate this power.

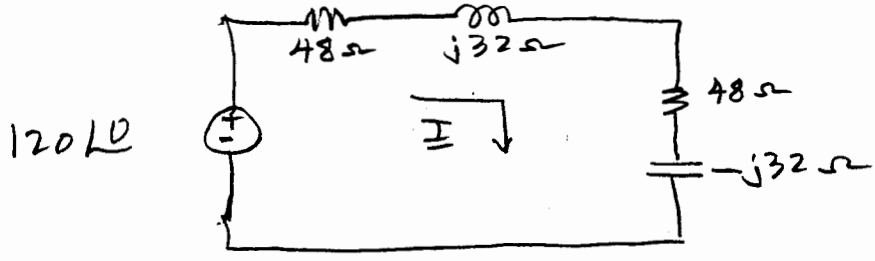
Want $n = \frac{N_2}{N_1}$ such that

$$\frac{3 - j^2}{n^2} = (48 + j32)^* = 48 - j32$$

$$n^2 = \frac{1}{16}$$

$$\frac{1}{n} = \frac{N_1}{N_2} = \sqrt{16} = 4$$

$$\frac{N_1}{N_2} = 4$$



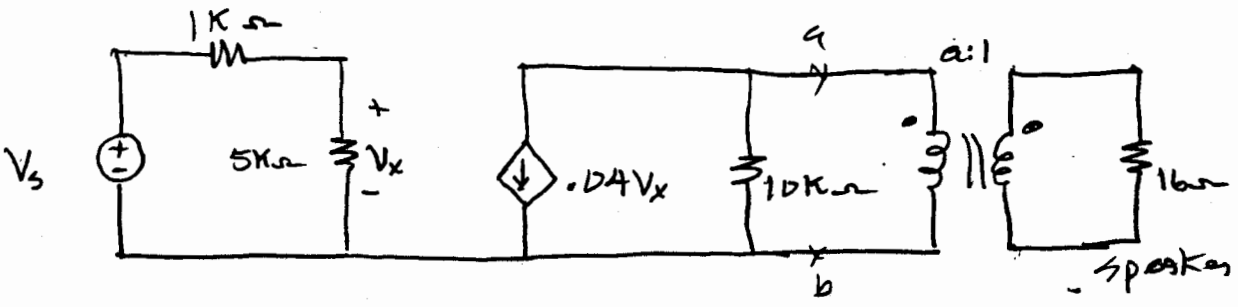
$$I = \frac{120}{96}.$$

$$P_{48} = \left(\frac{120}{96}\right)^2 \frac{48}{2} = 37.5\ W$$

$$\boxed{P_{48} = 37.5\ W}$$

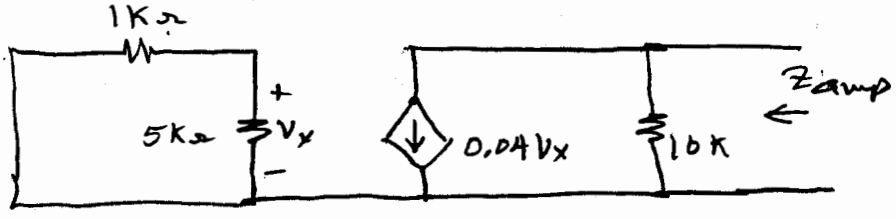
wlg

3FE-3



Select "a" so that the output impedance of the transistor amplifier matches the reflected resistance of the speaker.

Look into a-b with independent voltages replaced with shorts:



With $V_s = 0$, $V_x = 0$. This make the dependent current source $0.04V_x = 0$ (open). Thus

$Z_{amp} = 10\,k\Omega$.

Want

$$a^2 \times 16 = 10K$$

$$a^2 = 625$$

$$\boxed{a = 25}$$