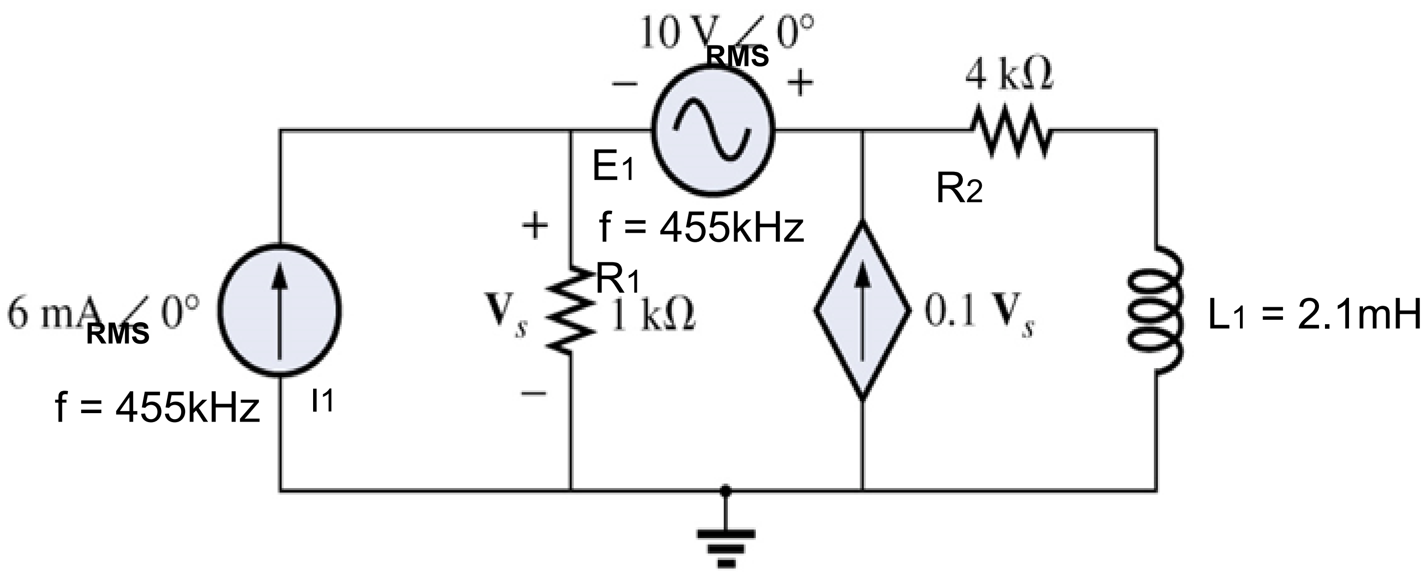
In Class Problem (also a modified homework problem)



Find:

- The current through the inductor

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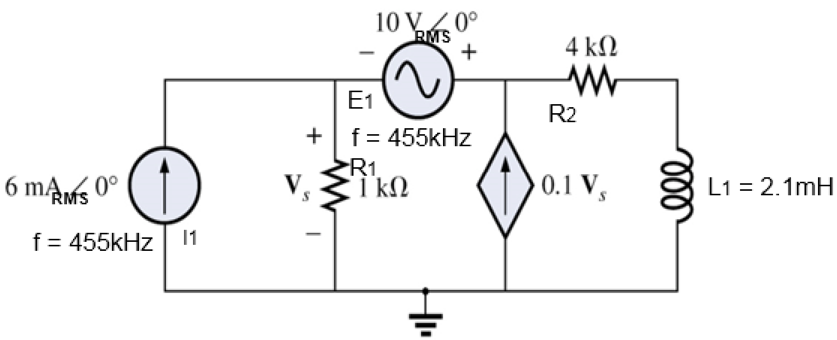


Convert to the phasor domain, draw the impedance boxes and mesh currents:

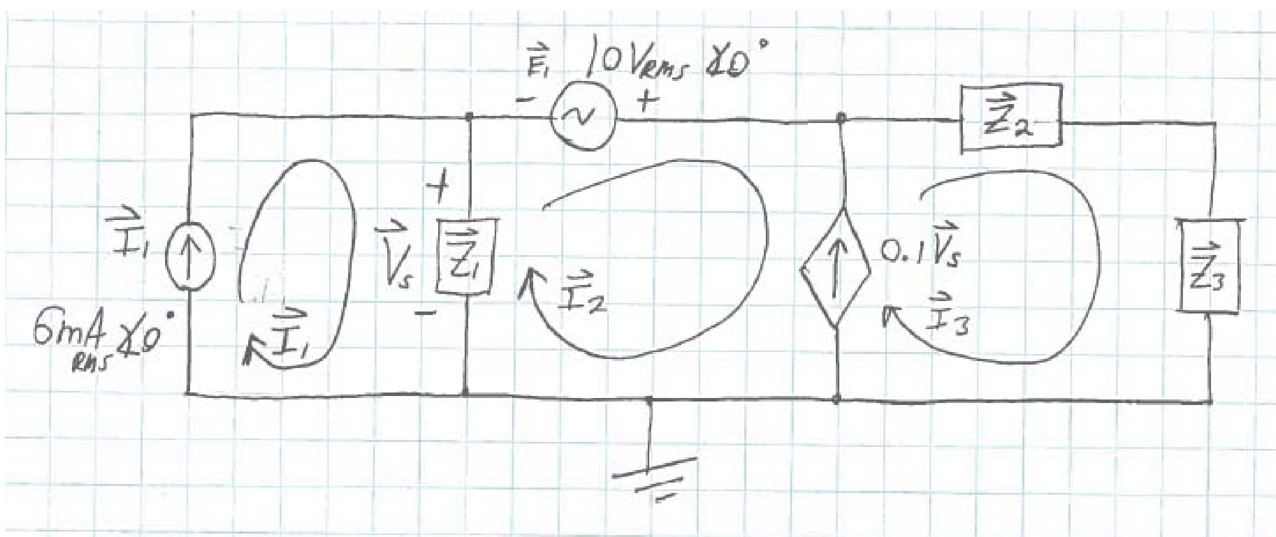
$$\vec{Z}_1 = 1000\,\Omega$$

$$\vec{Z}_2 = 4000\,\Omega$$

$$\vec{Z}_3 = jX_L = j\,2\pi f L$$

$$= j(2\pi)(455kHz)(2.1mH)$$

$$\vec{Z}_3 = j\,6004\,\Omega$$



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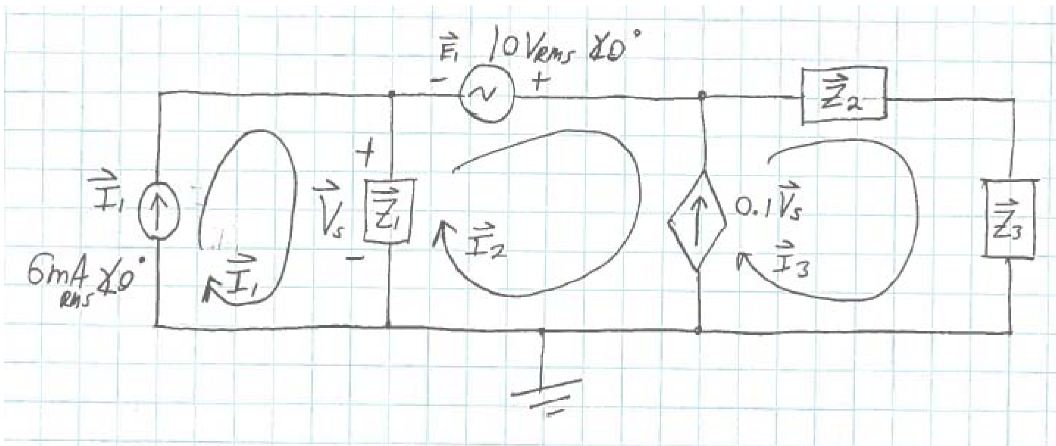

$$\vec{Z}_1 = 1000\,\Omega$$

$$\vec{Z}_2 = 4000\,\Omega$$

$$\vec{Z}_3 = jX_L = j\,2\pi f L$$

$$= j(2\pi)(455\text{kHz})(2.1\text{mH})$$

$$\vec{Z}_3 = j\,6004\,\Omega$$

Write the KVL equation for each loop without a current source:

X – No individual loop equations, there is a current source in each of the three loops…

Relating each current source to the loop currents:

$$\vec{I}_1 = 6\text{ mA}_{RMS}\angle 0^\circ$$

$$0.1\vec{V}_s = \vec{I}_3 - \vec{I}_2 \qquad (1)$$

$$\text{BUT: } \vec{V}_s = (\vec{I}_1 - \vec{I}_2)\vec{Z}_1$$

Into (1) yields:

$$0.1(\vec{I}_1 - \vec{I}_2)\vec{Z}_1 = \vec{I}_3 - \vec{I}_2$$

Simplifying:

$$0.1\vec{I}_1\vec{Z}_1 - 0.1\vec{I}_2\vec{Z}_1 + \vec{I}_2 - \vec{I}_3 = 0$$

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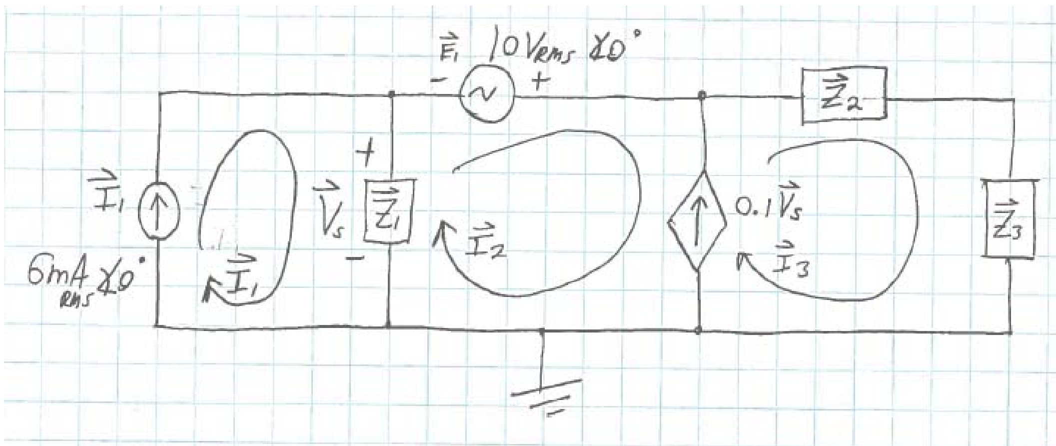

$$\vec{Z}_1 = 1000\,\Omega$$

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$$\vec{Z}_3 = jX_L = j\,2\pi f L$$

$$= j(2\pi)(455\,kHz)(2.1\,mH)$$

$$\vec{Z}_3 = j\,6004\,\Omega$$

$$0.1\,\vec{I}_1\vec{Z}_1 - 0.1\,\vec{I}_2\vec{Z}_1 + \vec{I}_2 - \vec{I}_3 = 0$$

Substituting values and simplifying further:

$$(0.1)(6\times10^{-3}\angle 0^\circ)(1000) - 0.1(1000\,\Omega)\,\vec{I}_2 + \vec{I}_2 - \vec{I}_3 = 0$$

$$0.6\angle 0^\circ - 99\,\vec{I}_2 - \vec{I}_3 = 0$$

$$99\,\vec{I}_2 + \vec{I}_3 = 0.6 \qquad (2)$$

We have **I1** and one equation but 2 unknowns…

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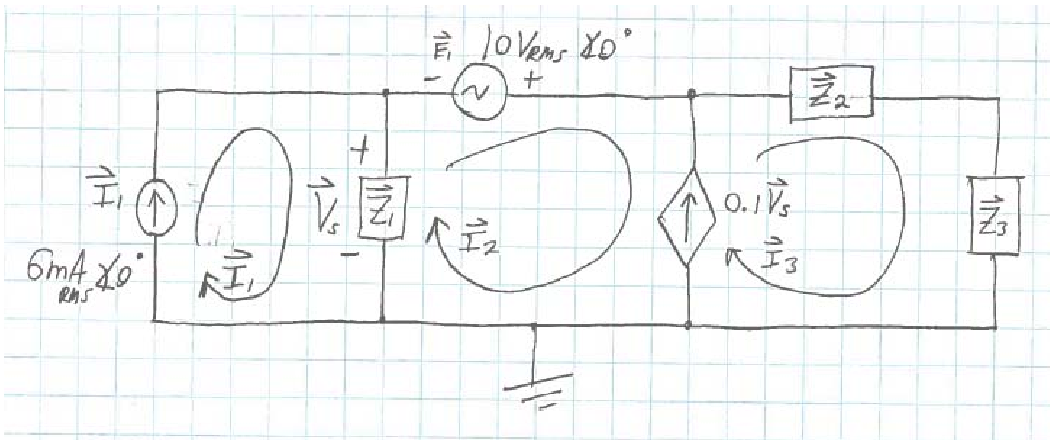

$$\vec{Z}_1 = 1000\,\Omega$$

$$\vec{Z}_2 = 4000\,\Omega$$

$$\vec{Z}_3 = jX_L = j\,2\pi f L$$

$$= j(2\pi)(455\,kHz)(2.1\,mH)$$

$$\vec{Z}_3 = j\,6004\,\Omega$$

$$99\vec{I}_2 + \vec{I}_3 = 0.6 \quad (2)$$

There is still one independent path that we CAN write a KVL equation around: Loop 2,3

$$-\vec{Z}_1(\vec{I}_2 - \vec{I}_1) + \vec{E}_1 - \vec{Z}_2\vec{I}_3 - \vec{Z}_3\vec{I}_3 = 0$$

$$-\vec{I}_2\vec{Z}_1 + \vec{I}_1\vec{Z}_1 + \vec{E}_1 - \vec{Z}_2\vec{I}_3 - \vec{Z}_3\vec{I}_3 = 0$$

$$\vec{Z}_1\vec{I}_1 - \vec{Z}_1\vec{I}_2 - (\vec{Z}_2 + \vec{Z}_3)\vec{I}_3 + \vec{E}_1 = 0$$

Substituting and simplifying further:

$$1000\vec{I}_1 - 1000\vec{I}_2 - (4000 + j6004)\vec{I}_3 + \vec{E}_1 = 0$$

$$\text{But } \vec{I}_1 = 6\,mA_{rms} \angle 0°$$

Substituting yields:

$$-1000\vec{I}_2 - (4000 + j6004)\vec{I}_3 + 6 + 10 = 0$$

We now have that elusive 2nd equation:

$$1000\vec{I}_2 + (4000 + j6004)\vec{I}_3 = 16 \quad (3)$$

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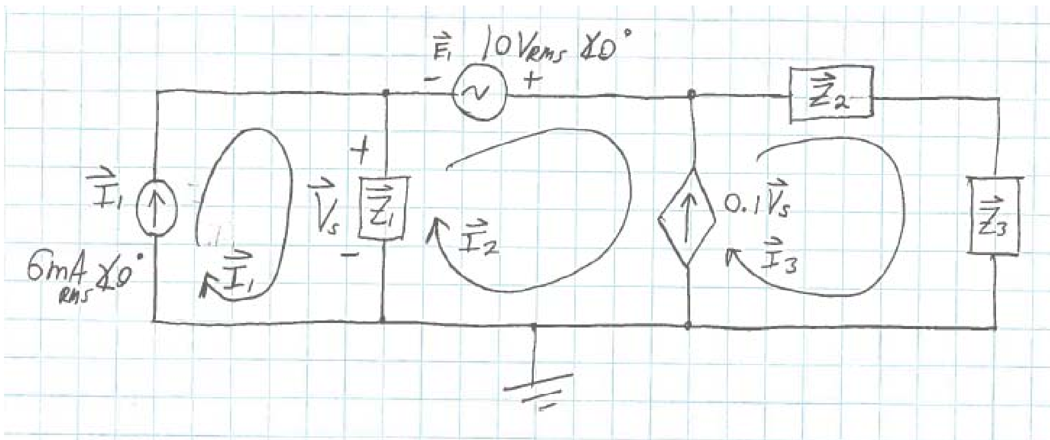

$$\vec{Z}_1 = 1000\,\Omega$$

$$\vec{Z}_2 = 4000\,\Omega$$

$$\vec{Z}_3 = jX_L = j\,2\pi f L$$

$$= j(2\pi)(455\text{kHz})(2.1\text{mH})$$

$$\vec{Z}_4 = j6004\,\Omega$$

Solving equations (2) and (3):

$$99\vec{I}_2 + \vec{I}_3 = 0.6 \qquad (2)$$

$$1000\vec{I}_2 + (4000 + j6004)\vec{I}_3 = 16 \qquad (3)$$

AX = B FORM

$$\therefore X = A^{-1}B = \begin{bmatrix} 6.05\times10^{-3} \angle 0.110^\circ \\ 1.38\times10^{-3} \angle -56.4^\circ \end{bmatrix}$$

$$\therefore \boxed{\vec{I}_3 = 1.38\,\text{mA}_{RMS} \angle -56.4^\circ}$$

Don't forget to CHECK your results!

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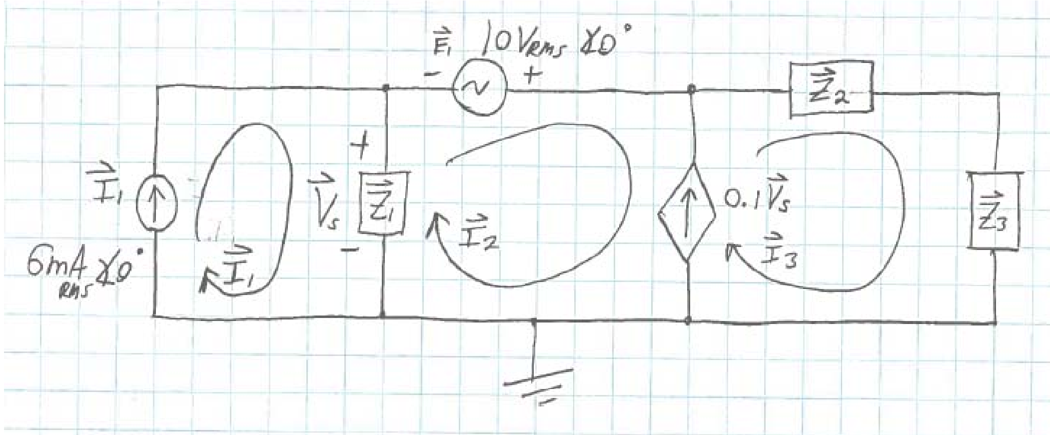

$$\vec{Z}_1 = 1000\,\Omega$$

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$$= j(2\pi)(455\,kHz)(2.1\,mH)$$

$$\vec{Z}_4 = j\,6004\,\Omega$$

$$AX = B \text{ FORM}$$

$$\therefore\ X = A^{-1}B = \begin{bmatrix} 6.05\times10^{-3}\ \angle\ 0.110^\circ \\ 1.38\times10^{-3}\ \angle -56.4^\circ \end{bmatrix}$$

Recall:

$$\vec{V}_s = (\vec{I}_1 - \vec{I}_2)\,\vec{Z}_1 \quad \sim \text{OHMS LAW}$$

Using our solutions for **I1** and **I2** yields:

$$= \left(6\,mA_{RMS}\ \angle 0^\circ - 6.05\,mA_{RMS}\ \angle 0.110^\circ\right)(1000\,\Omega)$$

$$\vec{V}_s = 51.3\,mV_{RMS}\ \angle -166.9^\circ$$

But we also know (KCL):

$$0.1\,\vec{V}_s = \vec{I}_3 - \vec{I}_2 \qquad (1)$$

PLUG INTO (1):

$$0.1\underbrace{\left(51.3\,mV_{RMS}\ \angle -166.9^\circ\right)}_{\vec{V}_s} \overset{?}{=} \left(\overbrace{1.38\,mA_{RMS}\ \angle -56.4^\circ}^{\vec{I}_3} - \underbrace{6.05\,mA_{RMS}\ \angle 0.110^\circ}_{\vec{I}_2}\right)$$

$$5.13\times10^{-3}\ \angle -166.9^\circ \overset{?}{=} 5.41\times10^{-3}\ \angle -167.6^\circ$$

Yes, some rounding error

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