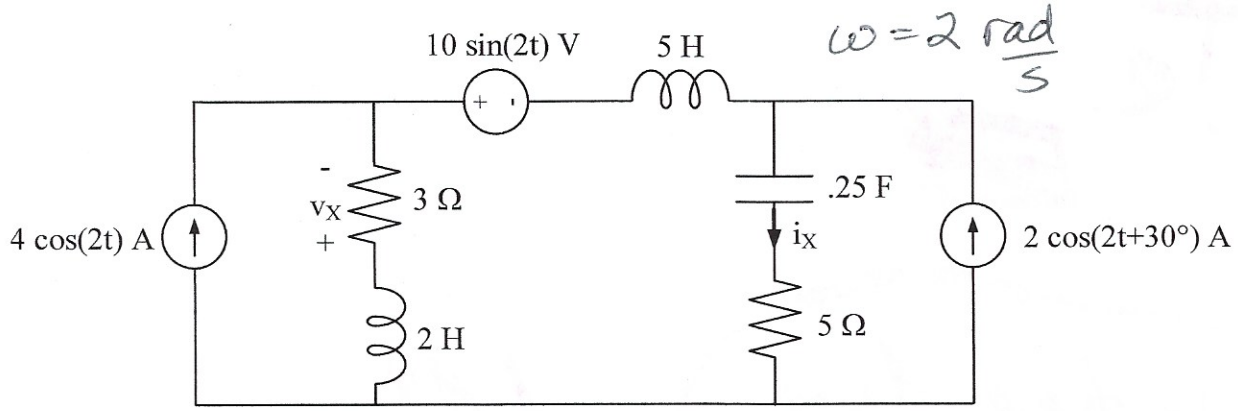
EE 213 Honors – Spring 2020 Solutions

Quiz 4 - 20 points

a) Convert the circuit from the time domain to the frequency domain.
b) Using either nodal or mesh analysis, solve for the phasor current, $\mathbf{I}_X$, and the phasor voltage $\mathbf{V}_X$.
c) What is the time domain current, $i_X(t)$ and the time domain voltage, $v_x(t)$? (Note: only the real parts of the time domain current/voltage are required.)
d) Find the average power, P, delivered by each source and absorbed by each impedance.



$4\cos 2t\,A \rightarrow 4\angle 0^\circ\,A$

$10\sin 2t\,V \rightarrow 10\angle -90^\circ\,V$

$2\cos(2t+30^\circ)\,A \rightarrow 2\angle 30^\circ\,A$

$3\Omega \rightarrow 3\Omega$

$5\Omega \rightarrow 5\Omega$

$2H \rightarrow j4\Omega$

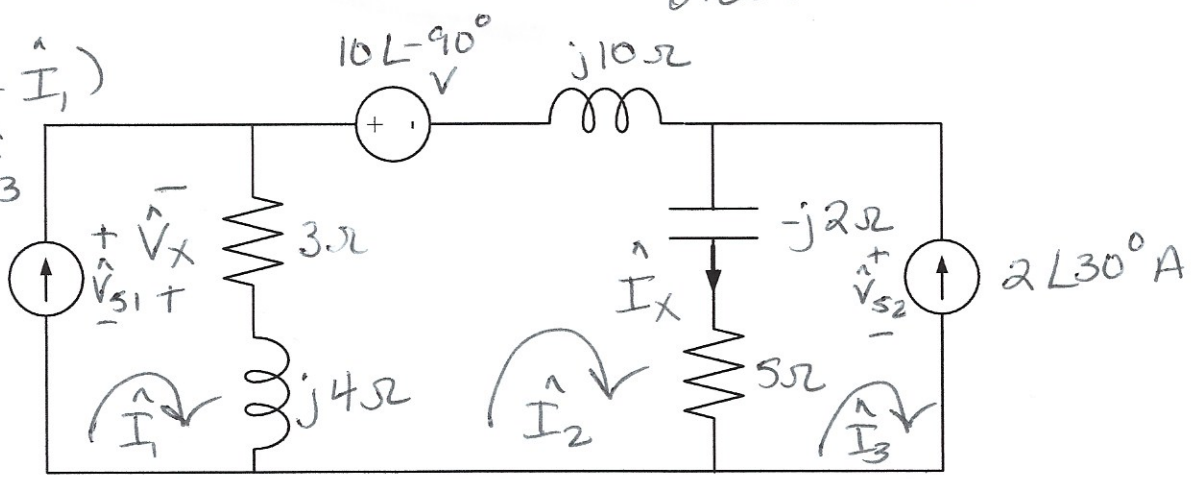
$5H \rightarrow j10\Omega$

$0.25F \rightarrow -j2\Omega$

Know

$\hat{V}_x = 3(\hat{I}_2 - \hat{I}_1)$

$\hat{I}_x = \hat{I}_2 - \hat{I}_3$



$\hat{I}_1 = 4\angle 0^\circ\,A \qquad \hat{I}_3 = -(2\angle 30^\circ)\,A$

m2: $-(3+j4)(\hat{I}_2 - \hat{I}_1) - 10\angle -90 - j10\hat{I}_2 - (5-j2)(\hat{I}_2 - \hat{I}_3) = 0$

$\hat{I}_2(-8-j12) = (10\angle -90) - (3+j4)\hat{I}_1 - (5-j2)\hat{I}_3$

pg2

$$\hat{I}_2(-8-j12) = 10\angle -90 - (20\angle 53.13^\circ) - (10.77\angle -171.80)$$

$$\hat{I}_2(-8-j12) = 24.5\angle -93.13^\circ$$

$$\hat{I}_2 = 1.70\angle 30.55^\circ \text{ A}$$

$(1.46 + j\,0.86)$ A

$$\hat{V}_x = 3(\hat{I}_2 - \hat{I}_1)$$

$$\boxed{\hat{V}_x = 8.04\angle 161.20^\circ \text{ V}}$$

$\hat{V}_x = -7.61 + j\,2.59$ V

$v_x(t) = 8.04\cos(2t + 161.20^\circ)$ V

$$\hat{I}_x = \hat{I}_2 - \hat{I}_3$$

$$\boxed{\hat{I}_x = 3.70\angle 30.26^\circ \text{ A} \quad (3.19 + j\,1.86)\text{ A}}$$

$i_x(t) = 3.70\cos(2t + 30.26^\circ)$ A

Find $\hat{V}_{s1}$ and $\hat{V}_{s2}$

m1: $\hat{V}_{s1} - (3+j4)(\hat{I}_1 - \hat{I}_2) = 0$ $\quad \hat{V}_{s1} = 13.40\angle 34.31^\circ$ V $\quad (11.06 + j\,7.55)$ V

m2: $-(5-j2)(\hat{I}_3 - \hat{I}_2) - \hat{V}_{s2} = 0$ $\quad \hat{V}_{s2} = 19.92\angle 8.45^\circ$ V $\quad (19.71 + j\,2.93$ V$)$

Power (remember these are magnitude units)

$\hat{V}_{s1} = 9.48\angle 34.31^\circ$ Vrms

$\hat{V}_{s2} = 14.09\angle 8.45^\circ$ Vrms

$\hat{I}_1 = 2.83\angle 0^\circ$ Arms

$\hat{I}_2 = 1.20\angle 30.55^\circ$ Arms

$\hat{I}_3 = 1.41\angle -150^\circ$ Arms

pg3

$\hat{V}_x = 5.69 \angle 161.20^\circ$ Vrms

$\hat{I}_x = 2.62 \angle 30.26^\circ$ Arms

Power: Impedances

$j4\Omega$: $P = 0$

$j10\Omega$: $P = 0$

$-j2\Omega$: $P = 0$

3Ω : $P = \frac{|\hat{V}_x|^2}{3} = 10.79$ W, Abs

5Ω : $P = |\hat{I}_x|^2(5) = 34.32$ W, Abs

Power Sources

$2.83 \angle 0^\circ$ Arms : $P = |\hat{V}_{s1}| \cdot (2.83) \cos(34.31^\circ - 0)$

$P = 22.16$ W, Del

$10 \angle -90^\circ$ V

$7.07 \angle -90^\circ$ Vrms

$P = (7.07)(|\hat{I}_1|) \cos(-90 - 30.55)$

$= -4.31$ W, Abs

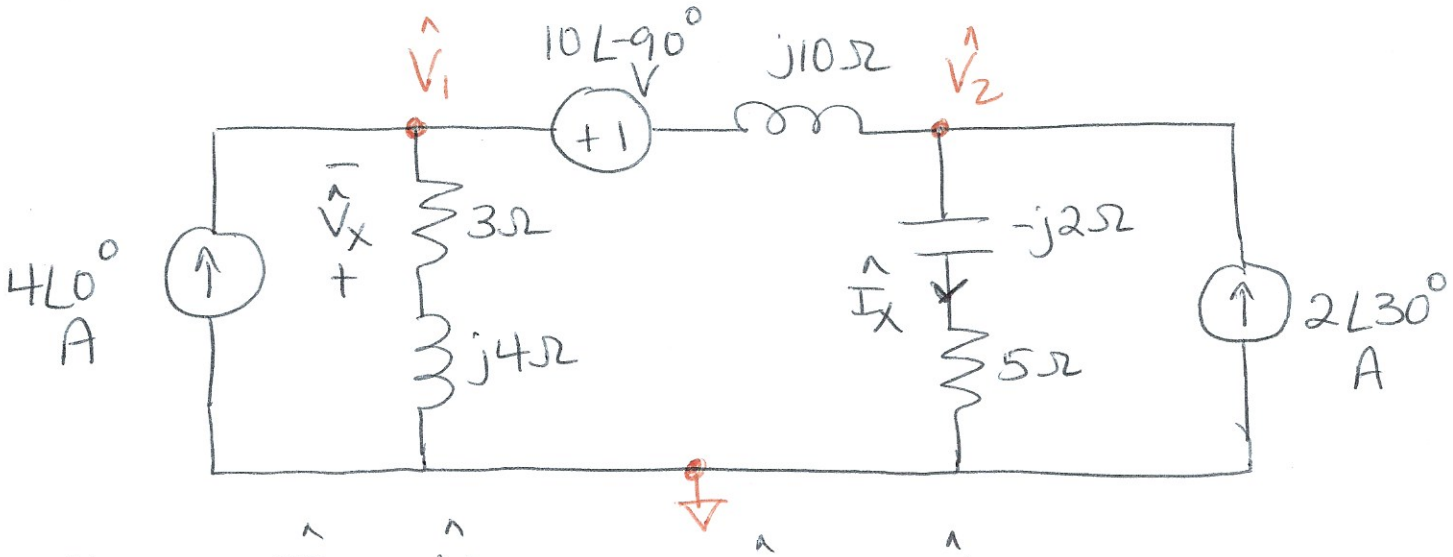
$= 4.31$ W, Del

$1.41 \angle 30^\circ$ Arms

$P = |\hat{V}_{s2}| \cdot (1.41) \cos(8.45 - 30^\circ)$

$P = 18.48$ W, Del

pg4



Know $\hat{I}_x = \dfrac{\hat{V}_2}{5-j2}$ $\qquad \hat{V}_x = \dfrac{-\hat{V}_1}{3+j4}(3)$

(1) $$\frac{\hat{V}_1 - 10\angle -90^\circ - \hat{V}_2}{j10} + \frac{\hat{V}_1}{3+j4} + (-4\angle 0^\circ) = 0$$

(2) $$\frac{\hat{V}_2 + 10\angle -90^\circ - \hat{V}_1}{j10} + \frac{\hat{V}_2}{5-j2} + (-2\angle 30) = 0$$

$$\hat{V}_1(0.286\angle -65.22^\circ) + \hat{V}_2(0.1\angle 90^\circ) = 3\angle 0^\circ$$

$$\hat{V}_1(0.1\angle 90^\circ) + \hat{V}_2(0.175\angle -10.20) = 2.91\angle 20.1^\circ$$

$\hat{V}_1 = 13.42\angle 34.28^\circ$ V $\qquad \hat{I}_x = 3.70\angle 30.22^\circ$ A

$i_x(t) = 3.70\cos(2t + 30.22^\circ)$ A

$\hat{V}_2 = 19.94\angle 8.42^\circ$ V $\qquad \hat{V}_x = 8.05\angle 161.15^\circ$ V

$v_x(t) = 8.05\cos(2t + 161.15^\circ)$ V