ECE 10, Winter 2023, Homework #5

Problem 1: In each of the following, do the following signals have a phasor representation? If so, what is the phasor?

a. $x(t) = -2\sin(100\pi t - 135°)$
b. $x(t) = 12\sin(100\pi t + 135°) + 5\cos(100\pi t + 60°)$
c. $x(t) = 5\sin(400\pi t - 135°) + 12\cos(4000\pi t - 60°)$

(6 points)

Problem 2: Compute the sinusoidal signals corresponding to the following phasors.

a. $\underline{X} = 4 - j3$, $\omega = 70$ krad/s
b. $\underline{X} = -8e^{-j\pi/6}$, $\omega = 100$ rad/s

(4 points)

Problem 3: Refer to Figure 1 for this problem.
(a) Derive a symbolic expression for the driving point impedance i.e. the impedance looking into the terminals "+" and "–". **Hint**: Replace each component with its impedance and apply parallel and series combinations just like in the case of resistors.
(b) Sketch the driving point impedance, as a function of ω.
(c) Suppose L = 5nH and C = 125nF. Calculate the resonant frequency of this circuit, in both rad/s and Hz.
(4 + 3 + 3 = 10 points)

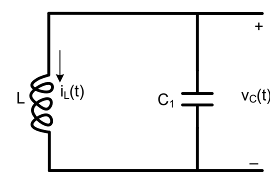

Figure 1

Problem 3: Refer to the circuit in Figure 2. Use the node voltage analysis method to determine $\underline{V}_O$ and the current delivered by the independent source. **Hint**: Note that the components are replaced by their phasor domain models especially, the inductors and capacitors are replaced by their equivalent complex impedances. Proceed by treating them just like resistors, but whose values are complex numbers.
(10 points)

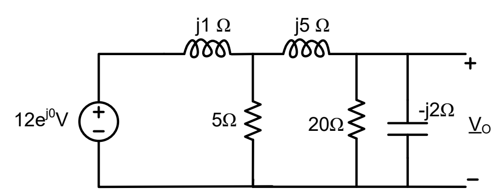

Figure 2

Problem 4: Refer to Figure 3 for this problem. Use loop current analysis method to find $\underline{V}_C$ and $\underline{I}_N$. **Hint**: Note that the components are replaced by their phasor domain models especially, the inductors and capacitors are replaced by their equivalent complex impedances. Proceed by treating them just like resistors, but whose values are complex numbers.
(15 points)

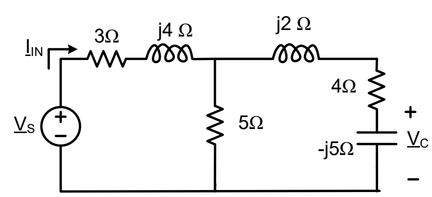

Figure 3

Problem 5: Refer to Figure 4. Considering sinusoidal steady state operation at 10 rad/s, and that L = 10H, answer the following questions.
(a) What is the phasor domain equivalent of the dependent source shown in the figure?
(b) What is the impedance looking into the terminals 1-1'?
(c) Draw a phasor diagram showing the phasors of $v_x(t)$, $i_{dep}(t)$, and $i_L(t)$ assuming that the phasor of $i_L(t)$ is $\underline{I}_L = j$.
(5 + 5 + 5 = 15 points)

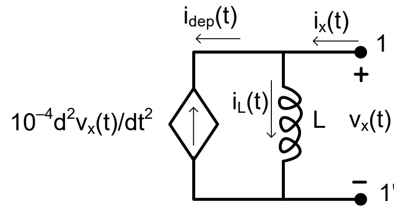

Figure 4

Problem 6: Refer to Figure 2 again for this problem. Use source transformations to find $\underline{V}_O$.
(10 points)

Problem 7: Refer to the circuit schematic shown in Figure 5.
(a) Find the equivalent impedance, Z, looking into the terminals 1-1', symbolically, in terms of R, L, C, and angular frequency, ω rad/s. **Hint**: Replace each component with its impedance and apply parallel and series combinations. Of course, the current source has to be ignored in this calculation.

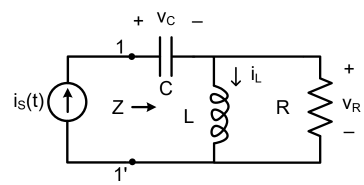

Figure 5

For the following parts, assume that C = 10pF, L = 1nH, and R = 10Ohms.
(b) Evaluate Z for ω = 1 Grad/s. Is it capacitive, inductive, or resistive? **Hint**: An impedance Z is called capacitive, resistive, or inductive depending on whether its imaginary component is negative, zero, or positive respectively; the real part is assumed to be non-negative.
(c) Suppose a sinusoidal current source $i_S(t) = 2\cos(10^{10}t - \pi/6)$ milli-Amperes. Draw a phasor diagram showing the phasors of the current source, the voltage across the capacitor, the voltage across the resistor, and the current through the inductor. **Hint**: Keep applying phasor domain component laws and KVL or KCL to calculate the phasors, and plot them.
(d) Find the non-zero frequency, f, in Hz, at which the impedance Z is purely resistive. Note that $\omega = 2\pi f$.
(6 + 3 + 6 + 5 = 20 points)

Problem 8: Please refer to Fig. P12-11 (page 367) from the textbook (also shown in Figure 6). In Hw #4, you calculated the steady state $v_a(t)$ given that $v_1(t) = 5\cos(5t)$ by substituting a parametrized sinusoidal solution. In this homework, determine $v_a(t)$ using phasor domain analysis instead.
(10 points)

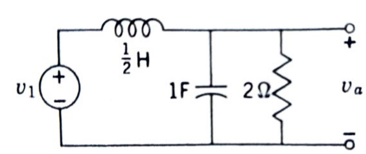

Fig. P12-11.

Figure 6