(EE 110, Winter 2007, Midterm Examination

Instructions: This exam booklet consists of three problems, blank sheets for the solutions, a reference sheet with mathematical identities, and additional blank sheets. Please follow these instructions while answering your exam:

1. **You have 45 minutes to finish your exam.**
2. **Write your solutions in the provided blank sheets after each problem.**
3. **The sheets marked "Additional Sheets" at the end of the blanket will NOT be graded. These sheets are provided for your rough calculations only.**
4. **Write your solutions clearly. Illegible solutions will NOT be graded.**
5. **Be brief.**
6. **Draw a small box around your numerical answers.**
7. **Write your name and student identification number below.**

NAME: ____

STUDENT ID: ____________________________________

Problem	Score	Maximum
#1		10
#2		20
#3		20
Total		50

Problem 1: Refer to the circuit schematic shown in Figure 1. Determine the value of the inductance, L, such that the steady state component of $v_c(t)$ is in phase with the voltage source.

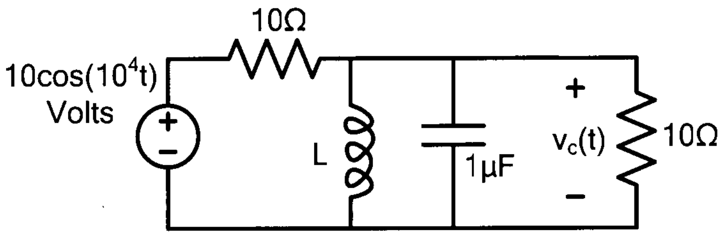
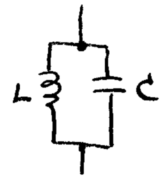
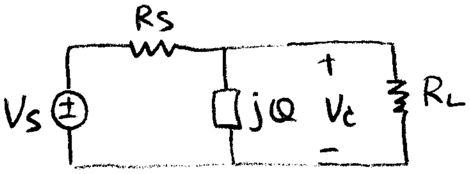


Figure 1.

(10 points)

Let jQ represents the impedance of the parallel element





Then,

$$V_c = \frac{R_L // jQ}{R_s + R_L // jQ} V_s = \frac{jR_L Q}{R_L R_s + jQ(R_s + R_L)} V_s$$

That V_c and V_s are in phace implies that

$$\angle \frac{jR_L Q}{R_L R_s + jQ(R_s + R_L)} = 0$$

This can only happen when $Q = 0$ or $Q = \infty$.

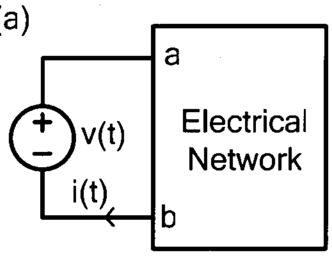
However, $Q = 0$ requires $j\omega L = 0$, i.e. $L = 0$, which is not feasible

On the other hand, $Q = \infty \Rightarrow j\omega C + \frac{1}{j\omega L} = 0$ (admittance is zero)

$$\Rightarrow L = \frac{1}{\omega^2 C} = \frac{1}{10^8 \times 10^{-6}} = 0.01 \text{ H}$$

Problem 2: Figure 2(a) shows a voltage source, v(t), applied to a linear, time-invariant, electrical network that potentially contains independent and dependent sources, resistances, inductances, and capacitances (no transformers). Figure 2(b) shows steady state measurements obtained for the set-up shown in Figure 2(a). Determine the Thevenin's equivalent circuit for the electrical network from these measurements.

(a)

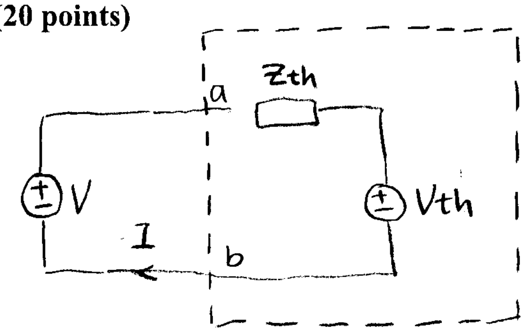


(b)

v(t) in Volts	i(t) in Amps
$\sin(10^3 t)$	0
$\cos(10^3 t)$	$(\sqrt{2})\cos(10^3 t+45^\circ)$

Figure 2.

(20 points)



Consider the Thevenin's equivalent circuit shown on the left. Then we have

$$V - V_{th} = I Z_{th} \qquad (*)$$

(1) when $v(t) = \sin(10^3 t)$ and $i(t) = 0$, we have

$$V = 1 \angle -90^\circ \text{ and } I = 0$$

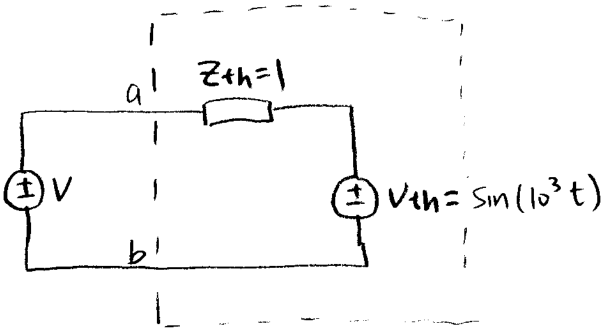
Thus, by $(*)$

$$V_{th} = V - I Z_{th} = 1 \angle -90^\circ - 0$$

$$= 1 \angle -90^\circ$$

i.e.,

$$v_{th}(t) = \sin(10^3 t)$$



(2) when $v(t) = \cos(10^3 t)$ and $i(t) = \sqrt{2}\cos(10^3 t + 45^\circ)$, we have

$$V = 1 \angle 0^\circ \text{ and } I = \sqrt{2} \angle 45^\circ$$

Thus, by $(*)$

$$Z_{th} = \frac{V - V_{th}}{I} = \frac{1\angle 0^\circ - 1\angle -90^\circ}{\sqrt{2}\angle 45^\circ}$$

$$= 1$$

Problem 3: Refer to the circuit shown in Figure 3.

a. Determine the complex power delivered to the load.
b. Does the independent voltage source in this circuit consume or deliver average real power ? How much ?

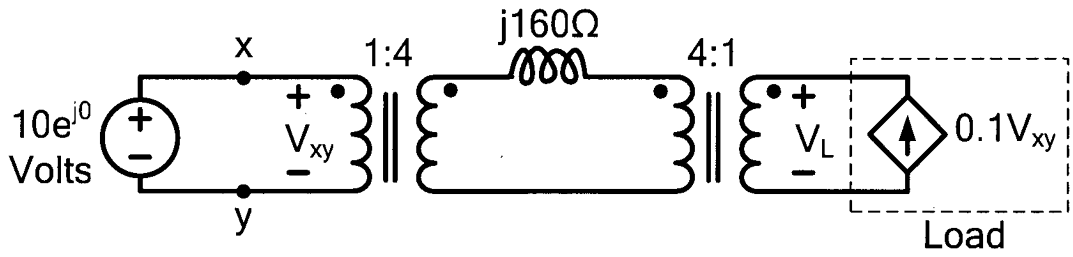
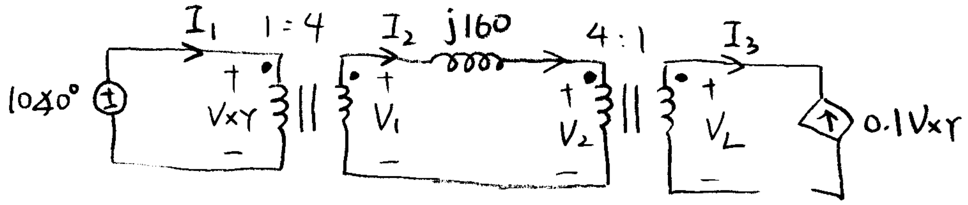


Figure 3.

(10 + 10 = 20 points)



(a) Note that $I_3 = -0.1\,V_{XY} = -0.1 \times 10 = -1$

$$\frac{I_2}{I_3} = \frac{1}{4} \Rightarrow I_2 = \frac{1}{4} I_3 = \frac{1}{4} \times (-1) = -0.25$$

$$\frac{I_1}{I_2} = \frac{4}{1} \Rightarrow I_1 = 4 I_2 = 4 \times (-0.25) = -1$$

$$\frac{V_1}{V_{XY}} = \frac{4}{1} \Rightarrow V_1 = 4 V_{XY} = 4 \times 10 = 40$$

$$V_2 = 40 - j160 I_2 = 40 - j160 \times (-0.25) = 40 + j40$$

$$\frac{V_L}{V_2} = \frac{1}{4} \Rightarrow V_L = \frac{1}{4} V_2 = \frac{1}{4} \times (40 + j40) = 10 + j10$$

The complex power delivered to the load is then given by

$$S_L = \frac{1}{2} V_L I_3^* = \frac{1}{2} \times (10 + j10) \times (-1) = -5 - j5 \text{ VA}$$

(b) The real power delivered by the source is

$$P = \frac{1}{2} \times 10 \times (-1) = -5 \text{ W}$$

Then the source is consuming power 5W.