Lehigh University

Department of Electrical Engineering

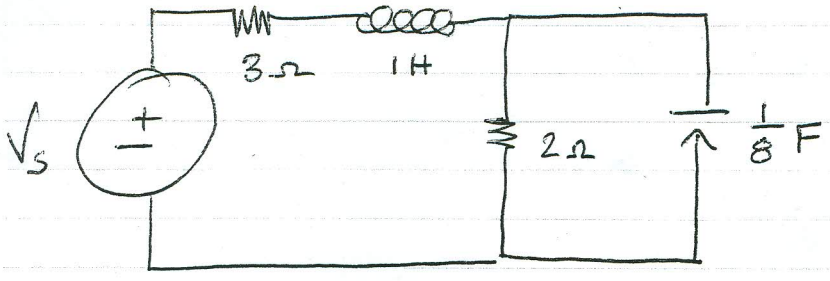
ECE 083 - Spring 2009

Exam #2

8 April 2009

Solutions

Problem #1: (10) Find the Current i for the Following Circuit.



$V_s = 10\cos 4t$ V

$\omega = 4$

$j\omega L = j4$

$\frac{-j}{\omega C} = \frac{-j}{4(\frac{1}{8})} = -j2$

$2 // -j2 = \frac{-j4}{2-j2}$

$3 + j4 - \frac{j4}{2-j2} = Z_{eq} = \frac{14 - j2}{2 - j2} = \frac{14.1\angle -8.1}{2.8\angle -45} = 5\angle 36.9 = Z_{eq}$

$\bar{I} = \frac{\bar{V}}{Z} = \frac{10}{5\angle 36.9} = 2\angle -36.9$

$i(t) = 2\cos(4t - 36.9)$ (*)

Problem #2: (10) Consider A Load that has An Impedance Value of $\bar{Z} = 100 - j50\ \Omega$. The Current Passing through the Load is $\bar{I} = 25\sqrt{2}\angle 45°$. Is the Load Capacitive or Inductive? Determine the Power, Power Factor, Reactive Power, Apparent Power and Power Angle Delivered to the Load.

$\bar{Z} = 100 - j50 \Rightarrow \bar{Z} = 111.8\angle -26.56$

Capacitive since j term is negative

$\bar{I} = 25\sqrt{2}\angle 45° \Rightarrow \bar{I}_{rms} = 25\angle 45°$

$P = (I_{rms})^2 R = (25)^2(100) = 62.500\ W = 62.5\ kW$

$Q = (I_{rms})^2 X = (25)^2(-50) = -31.250\ VAR = -31.25\ kVAR$

$P_{app} = \sqrt{P^2 + Q^2} =$ [redacted] $69.87\ kVA$

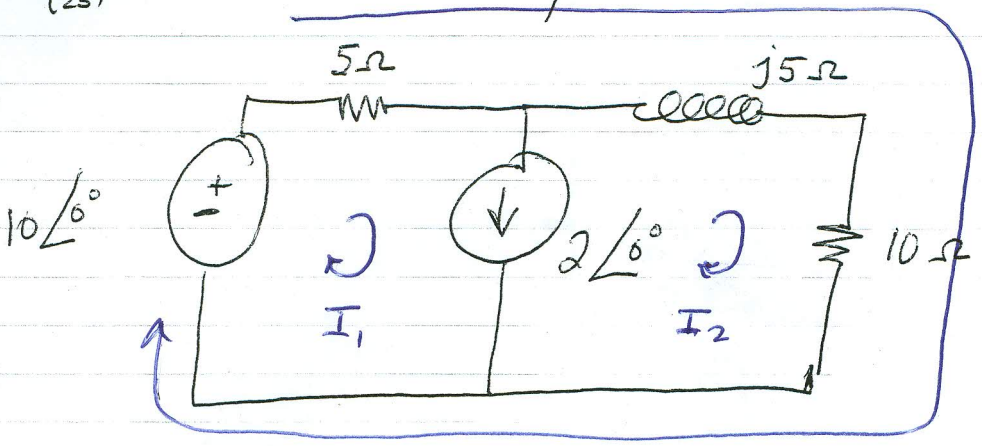
$$V_{rms} = Z_{rms} I_{rms} = \left[118.8 \angle -26.58\right]\left[25 \angle 45\right] = 2.97 \angle 18.5$$

$$\theta = (\theta_v - \theta_i) = 18.5 - 45 \Rightarrow \boxed{\theta = -26.5}$$

$$PF = \cos(\theta) \Rightarrow \boxed{PF = 0.894 = 89.4\%}$$

Problem #3: (25)

Find the Mesh Currents for the Following Circuit.



(1) $5I_1 + j5I_2 + 10I_2 - 10 = 0$

(2) $I_1 - I_2 = 2$

$5I_1 + (10 + j5)I_2 = 10$

$I_1 = 2 + I_2$

$5(2 + I_2) + (10 + j5)I_2 = 10$

$10 + 5I_2 + (10 + j5)I_2 = 10$

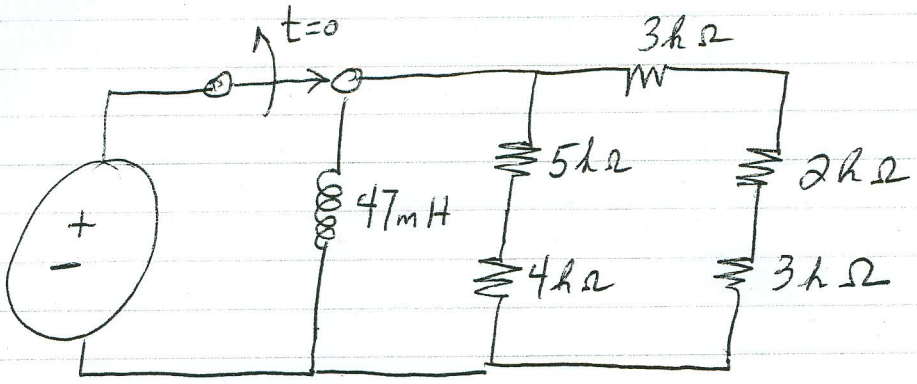
$10 + (15 + j5)I_2 = 10$

$$I_2 = \frac{0}{15 + j5}$$

$I_2 = 0\ A$

$I_1 = 2\ A$

Problem #4: (15) Find the Time Constant for the given Circuit, after the Switch opens.



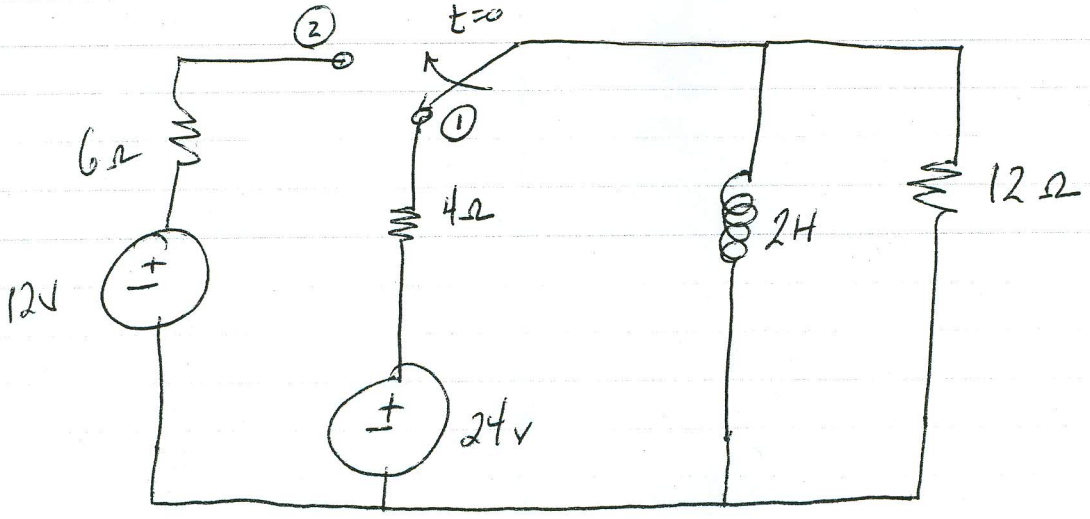
$R_{TH} \Rightarrow 9 // 8$

$R_{TH} = \frac{72}{17} = 4.23\,k\Omega$

$\tau = \frac{L}{R_{TH}} = \frac{47 \times 10^{-3}}{4.23 \times 10^{3}}$

$\tau = 1.11 \times 10^{-5}\ s$

Problem #5: (30) The Circuit is in Steady State @ $t=0$. Find $i(t)$ if the Switch is moved from ① to ② @ $t=0$.



Before Switch Changes Position

$$i_L(0) = \frac{24}{4} = 6A$$

Note: in SS the $\mathcal{L}$ behaves like an Inductor which "shorts" out the 12Ω R.

After Switch Changes Position

$$i_L(\infty) = \frac{12}{6} = 2A$$

Note: By some reasoning 12Ω R is "shorted" out.

By Eqn: $i_L(t) = i_L(\infty) - (i_L(\infty) - i_L(0))e^{-t/\tau}$

However:

$R_{TH} \Rightarrow 6 // 12 \Rightarrow R_{TH} = 4$

$$\tau = \frac{L}{R} = \frac{2}{4} = 0.5s$$

$$i_L(t) = 2 + 4e^{-2t}$$

Problem #6: (10)

From the Perspective of the Engineer Why would you want to have the Voltage & Current in Phase for A given Circuit?

1. Peaks at Same time
2. No Reactive Power → No Surges
3. Better Efficiency
4. "Backup" For Changes in Circuit Voltage @ Surge