EE10 Final

Department of Electrical Engineering, UCLA

Summer 2017

Instructor: Prof. Gupta

1. Exam is closed book. Calculator and one double sided cheat-sheet is allowed.
2. Cross out *everything* that you don't want me to see. Points will be deducted for everything wrong!
3. Do NOT use Laplace Transforms to solve any problems.
4. No points will be given without proper explanations

Name:

Student ID:

Student on Left:

Student on Right:

Student in Front:

Time: 135 minutes

Problem	Maximum Score	Your Score
1	12	
2	8	
3	12	
4	8	
Total	40	

Q1. 12 points (2+2+2+6)

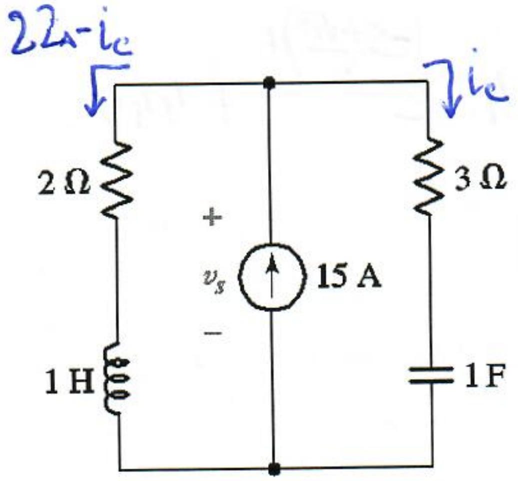
For the circuit below, the 15A current source has been operating for a long time and suddenly jumps in value to 22A at t=0. Find v_s when:

a) t= 0-

b) t=0+

c) t=inf

d) t=4s



a) $V_s(0^-) = 2\Omega \cdot 15A = \boxed{30V}$

b) $V_s(0^+) = 7A \cdot 3\Omega + V_c(0^+) = 21V + \overbrace{V_c(0^-)}^{=30V} = \boxed{51V}$

c) $V_s(t\to\infty) = 2\Omega \cdot 22A = \boxed{44V}$

d)
$$i_c 3\Omega + \frac{1}{C}\int_{0^+}^{t} i_c\,dt + V_c(0^-) = (22A - i_c)2\Omega + L\frac{d}{dt}(22A - i_c)$$

$$-14A + i_c 5\Omega + \frac{1}{1F}\int_{0^+}^{t} i_c\,dt = -1H\frac{d}{dt} i_c \rightarrow \ddot{i}_c + 5\dot{i}_c + i_c = 0$$

$$s^2 + 5s + 1 = 0 \rightarrow \frac{-5 \pm \sqrt{25-4}}{2} = \frac{-5 \pm \sqrt{21}}{2}$$ → overdamped system.

$$V_s(t) = Ae^{\frac{-5-\sqrt{21}}{2}t} + Be^{\left(\frac{-5}{2}+\frac{\sqrt{21}}{2}\right)t} + \underbrace{V_s(\infty)}_{=44V} = Ae^{-\left(\frac{5+\sqrt{21}}{2}\right)t} + Be^{\left(\frac{-5+\sqrt{21}}{2}\right)t} + 44V$$

$V_s(0^+) = A + B + 44V = 51V \rightarrow A + B = 7V$

$\dot{V}_s(0^+) = -\left(\frac{5+\sqrt{21}}{2}\right)A + \left(\frac{-5+\sqrt{21}}{2}\right)B$

$$\dot{V}_s = \dot{i}_c 3\Omega + \frac{i_c}{1F} = \frac{-3\Omega}{1H}V_L + \frac{i_c}{1F} \rightarrow \dot{V}_s(0^+) = -3\overbrace{V_L(0^+)}^{=V_s(0^+)-15A2\Omega} + \overbrace{i_c(0^+)}^{=7A} = -3(51V - 30V) + 7 = -56\frac{V}{sec}$$

$V_L = L\frac{d}{dt}(22A - i_c) \rightarrow \dot{i}_c = \frac{-V_L}{L}$

$A+B=7v$

$-\left(\frac{5+\sqrt{21}}{2}\right)A+\left(\frac{-5+\sqrt{21}}{2}\right)B=-56\frac{v}{sec}$

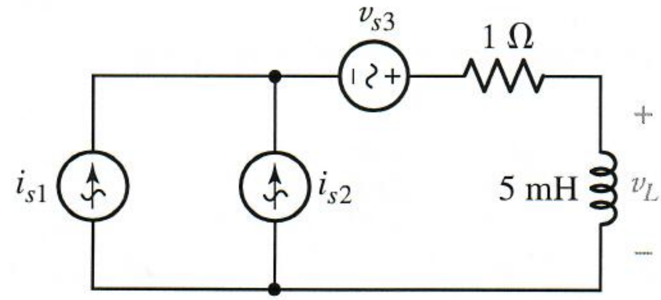
$$\begin{bmatrix} 1 & 1 \\ -\left(\frac{5+\sqrt{21}}{2}\right) & \frac{-5+\sqrt{21}}{2} \end{bmatrix}\begin{bmatrix} A \\ B \end{bmatrix}=\begin{bmatrix} 7 \\ -56 \end{bmatrix} \rightarrow \begin{bmatrix} A \\ B \end{bmatrix} \approx \begin{bmatrix} 11.90 \\ -4.9 \end{bmatrix}$$

$$V_s(t)=11.9e^{-\left(\frac{5+\sqrt{21}}{2}\right)t}-4.9e^{\left(\frac{-5+\sqrt{21}}{2}\right)t}+44v$$

$V_s(t=4sec)=41.874v$

Q2. (8 points)

In the circuit below, $i_{s1} = 2\cos(200t)$ A, $i_{s2} = 1\cos(100t)$ A, and $v_{s3} = 2\sin(200t)$ V. Find $v_L(t)$.



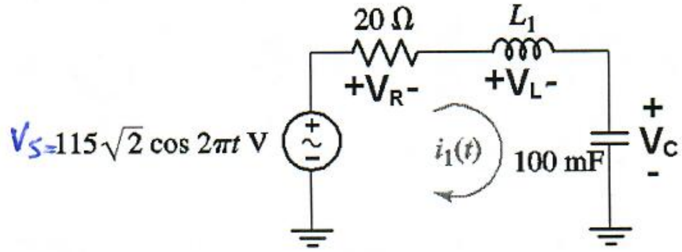
$$V_L(t) = L\frac{d}{dt}(i_{s1} + i_{s2}) = 5\,mH\left[-400\sin(200t) - 100\sin(100t)\right]$$

$$V_L(t) = -2v\sin(200t) - \frac{1}{2}v\sin(100t)$$

Q3(5 + 5 + 2 = 12points)

a) Design a combination of inductors, resistors, and capacitors that has an admittance of $4\angle -10^{\circ}$ nS at ω= 50 rad/s.

b) In the circuit below $i_1(t)$ = 8.132 cos(2πt) A. What is the inductance of L1?



c) Draw a phasor diagram showing I, V_R, V_C.

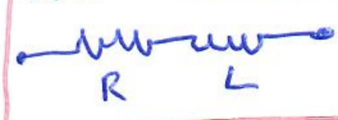
a) $Y(\omega) = 4 \cdot 10^{-9} \angle -10^{\circ} \rightarrow Z(\omega) = \frac{10^9}{4} \angle 10^{\circ}$ → inductive impedance.

$Z(\omega) = R + jL\omega = \sqrt{R^2 + (L\omega)^2} \angle \tan^{-1}\left(\frac{L\omega}{R}\right)$

$$\begin{cases} R^2 + (L\omega)^2 = \frac{10^{18}}{16} \\ \frac{L\omega}{R} = \tan(10^{\circ}) \end{cases} \rightarrow$$

$L \simeq 868$ KH

$R \simeq 246.2$ MΩ



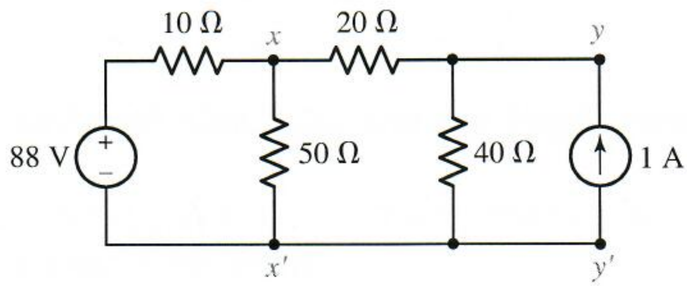
b) V_s and i_1 are in phase $\rightarrow X_L = X_c \rightarrow \omega L_1 = \frac{1}{\omega C} \rightarrow$ $L_1 = \frac{1}{\omega^2 C} \simeq 253.3$ mH

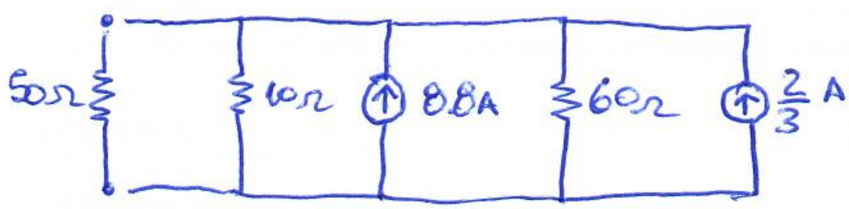
c) $V_c = 8.132 \angle 0^{\circ} \cdot \frac{1}{j\omega C}$

$V_c \simeq 12.94 \angle -90^{\circ}$

Q4. (8 points)

Find the power consumed by resistor between x and x' using Thevenin equivalent.





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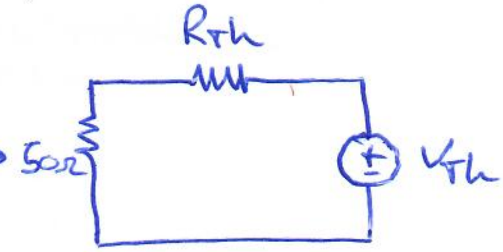

$R_{Th} = 10\Omega \| 60\Omega = \frac{60}{7}\Omega$

$V_{Th} = \frac{60}{7}\left(8.8 + \frac{2}{3}\right) V$

$$P_{50\Omega} = \left(V_{Th} \frac{50\Omega}{50\Omega + R_{Th}}\right)^2 \frac{1}{50\Omega} \simeq 95.96 W$$