EE331

Electrical Engineering I

EXAM II

Monday October 31st, 2011

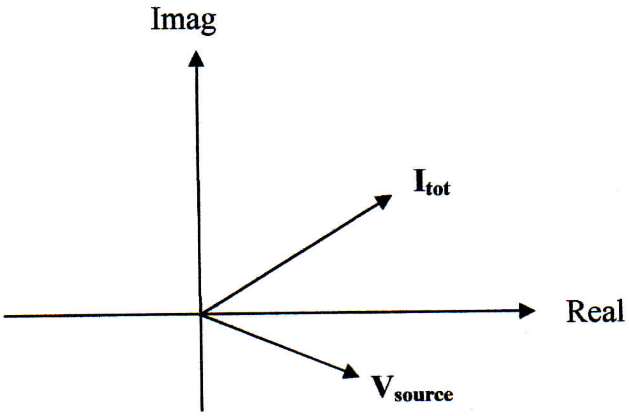
This is a 50 minute exam. Please work quickly and quietly. Place your name below before beginning. There are 6 pages including this cover sheet. Please ensure that you have all 6 pages. Show as much work as practical to maximize partial credit. Eyes should remain on your own work. There is no sharing of calculators. **Do not discuss this exam until it is returned to you.** Please commence when advised.

Page	Points	Score
1		
2	14	
3	14	
4	16	
5	20	
6	16	
Total	80	

NAME: Key

SECTION:

Problem 1 - Warm up #1 (4 pts): Given the following phasor diagram,

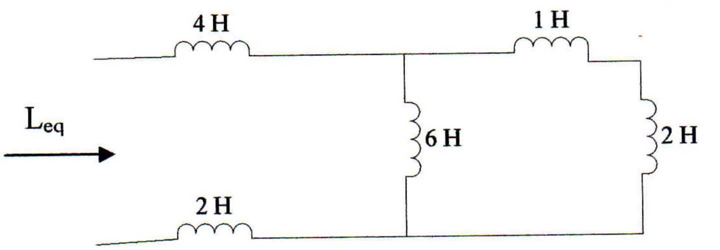


I_{tot} **leads / lags / is in phase** with V_{source} (circle one)

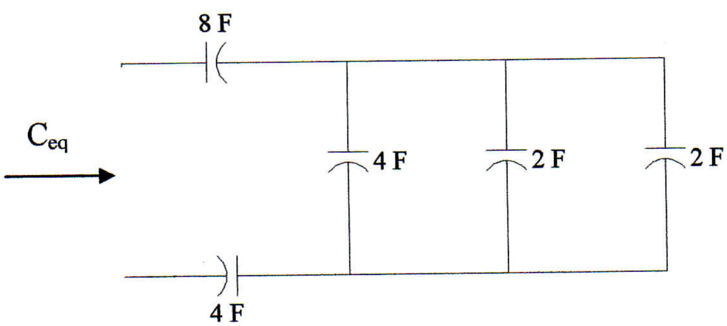
Is this an overall **inductive / capacitive** circuit? (circle one)

ICE

Problem 2 (6 pts): Find the equivalent Inductance and Capacitance in the below circuits.



L_{eq} = 8 H



C_{eq} = 2 F

Problem 3 (4 pts): Express y(t) as a single cosine with the form, $\mathbf{A*cos(\omega*t + \theta)}$:

$$y(t) = -10*\sin(377*t + 10) + 10*\cos(377*t + 100°)$$

y(t) = 20 cos(377t+100)

$-10\cos(377t-80) + 10\cos(377t+100)$

$\downarrow$

$10\cos(377t+100) + 10\cos(377t+100)$

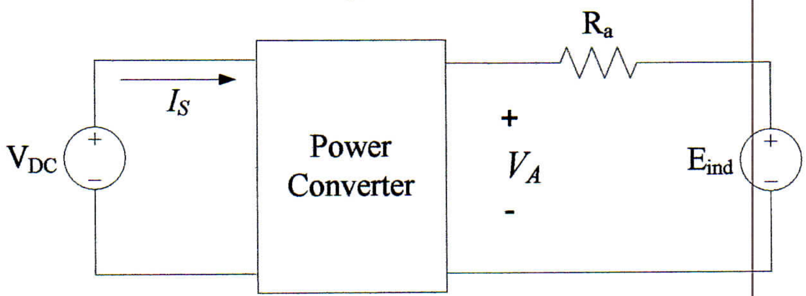
Bonus (3 pts)

1) The general relationship between the magnetic flux density **B** and the magnetic field intensity **H** is given by $B = \mu H$. (fill in the blank)

2) The current through an inductor can change instantaneously. **True / False** (circle one)

3) Faraday's Law for the induced voltage in a loop is related to the magnetic flux, φ, by $\partial\phi/\partial t$.

Problem 4: A permanent magnet DC motor is controlled with a power converter with a constant DC supply voltage, $V_{DC} = 100$ V. The motor is characterized by, $K_v = 0.133$ V*s, and $R_a = 2\ \Omega$.



a. **(8 pts)** If the $T_{load} = 0.532$ N*m, T_{loss} is negligible, and the motor speed is equal to 1800 RPM compute V_A.

- $\omega = 1800 \frac{rev}{min} \cdot \frac{1min}{60sec} \cdot \frac{2\pi rad}{1rev} = 188.5\ rad/s$
- $E_{ind} = K_v \omega = 0.133 V{\cdot}s \cdot 188.5 \frac{V}{sec} = 25.07 V$
- $T_{dev} = T_{Load} + \cancel{T_{loss}}^{\,0} = 0.532 N{\cdot}m = K_v I_a \Rightarrow I_a = 4A$
- $\Rightarrow V_A = E_{ind} + I_a \cdot R_a = 25.07V + 4 \cdot 2\Omega = \boxed{33.1 V}$

b. **(2 pts)** What is the Duty Cycle?

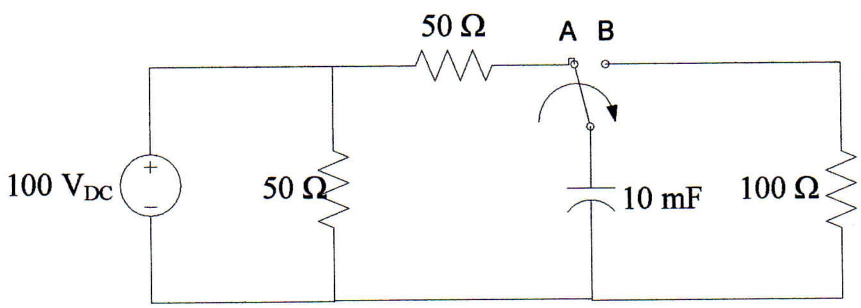
$D = \frac{33.1V}{100} = \boxed{0.331}$

c. **(4 pts)** If the Power Converter is 96% efficient, what is the value of the source current, I_S?

$0.96 = \frac{V_A \cdot I_a}{V_{DC} \cdot I_S} = \frac{33.1V \cdot 4A}{100V \cdot I_S} \Rightarrow \boxed{I_S = 1.38A}$

Problem 5: The switch has been in position A for a long time. At **t = 0**, the switch is moved to position B.

- **(10 pts)** Write the mathematical expression for $v_C(t)$ **and** sketch $v_C(t)$ on the axis below for $t \geq 0$. Be sure to include *values for the initial voltage, final voltage, and time constant.*
- **(6 pts)** Write the mathematical expression for $i_C(t)$ **and** sketch $i_C(t)$ on the axis below for $t \geq 0$. Be sure to include *values for the initial current, final current, and time constant.*

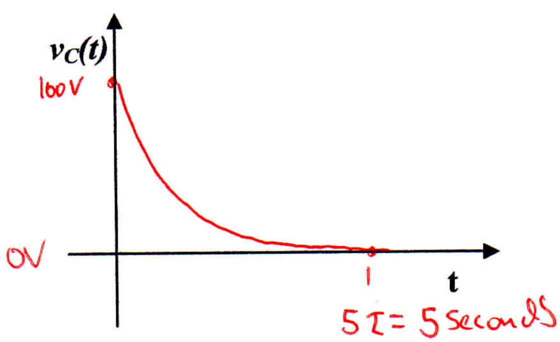


① $V_c(t) = V_f + (V_i - V_f)e^{-t/\tau}$

② $V_i = 100V$

$V_f = 0V$

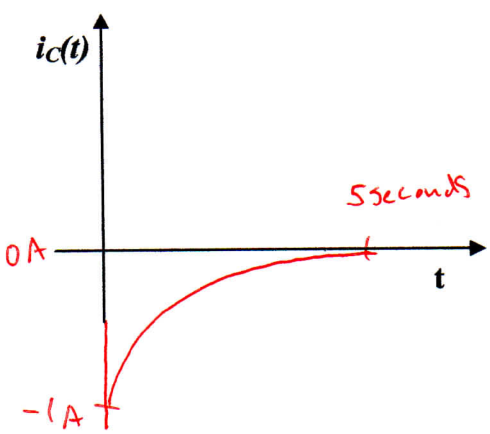
$\tau = R_{th}C = 100\Omega \cdot 10mF = 1\,sec$



$v_C(t) =$ $100e^{-t}$

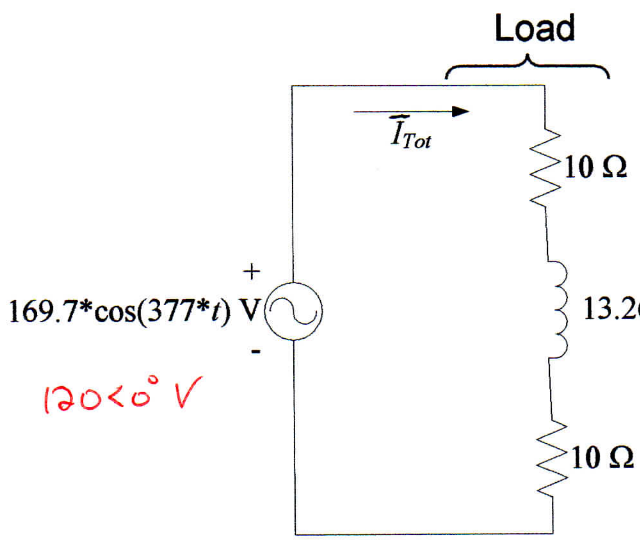
$i_c(t) = C\frac{dv_c(t)}{dt} = 10mF \cdot (-100)e^{-t} = -e^{-t}$

(Discharging)



$i_C(t) =$ $-e^{-t}$

Problem 6 (14 pts): Given the following single-phase AC circuit compute the following quantities below:



$\rightarrow Z_L = j\omega L = 5j$

$120\angle 0^\circ$ V

$\hat{I}_{tot} = \dfrac{120\angle 0}{20.6\angle 14^\circ} = 5.83\angle -14^\circ$

$\hat{S}_{Tot} = \dfrac{|V|^2}{Z^*} = \dfrac{120^2}{20-5j} = 698.5\angle 14^\circ = 677.6 + j169.4$

$\bar{Z}_{Tot}$ = $20+5j = 20.6\angle 14^\circ\ \Omega$

$\bar{I}_{Tot}$ = $5.83\angle -14^\circ$ A

$\bar{S}_{Tot}$ = $677.6 + j169.4$ VA

P_{Tot} = 677.6 W

Q_{Tot} = 169.4 VAR

Power Factor = 0.97 LAGGING

Question 1 (2 pts): The source voltage **leads / lags / is in phase with** the total current in the above circuit.

ELI

Problem 7 (6 pts): A capacitor, C = 31.2 μF, is placed in parallel with the Load above. Compute the new total complex power and power factor as seen by the source.

$\tilde{S}_{Cap} = \dfrac{|V|^2}{Z^*} = 0 - j169.4$ VA

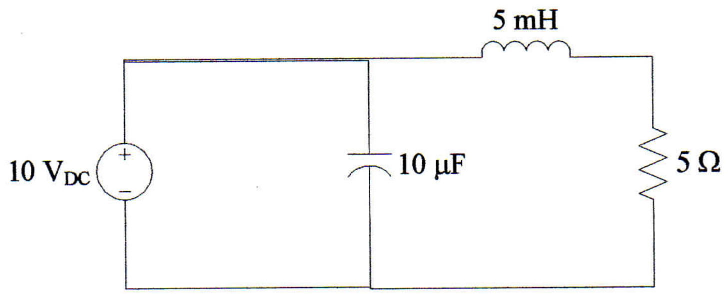
$\hat{S}_{Tot} = \hat{S}_{Load} + \hat{S}_{CAP} = 677.6$ W

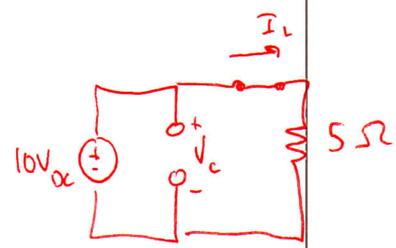
$Z_c = -1/\omega c\, j = -85j\ \Omega$

S_{Tot} = 677.6 W

Power Factor = 1.0

Problem 8 (8 pts): Calculate the energy stored in the capacitor and inductor for the circuit below.





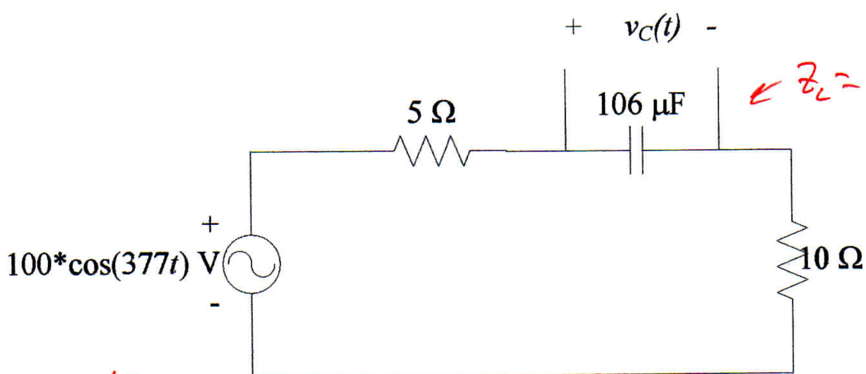
W_C = $0.5\ mJ$

W_L = $10\ mJ$

$W_C = \frac{1}{2} C V^2 = \frac{1}{2} \cdot 10\mu F \cdot 10^2 =$

$W_L = \frac{1}{2} L I^2 = \frac{1}{2} \cdot 5mH \cdot 2^2 =$

Problem 9 (6 pts): Compute $v_C(t)$ for the circuit below



← $Z_C = -j25\,\Omega$

$100V_{peak}\angle 0$

Voltage Divider

$$\hat{V}_C = \frac{100V_{peak}\angle 0^\circ \cdot (-j25)}{15-25j} = 85.7\angle -31^\circ\ V_{peak}$$

$v_C(t)$ = $85.7\cos(377t - 31)\ V$

Question 2 (2 pts): What happens to $v_C(t)$ as the frequency of the source is increased?

$1/\omega C$ as $\omega \uparrow \Rightarrow |Z_C| \downarrow$ $\quad |V_C(t)| \downarrow$ and $\theta \Rightarrow -90^\circ$

Bonus (1 pt): What type of filter is this circuit? **Low pass / High pass (circle one)**