ECSE 2010
Electric Circuits
Final Exam
Fall 2007

Name _____

Section (please circle one)

| 10-12 | 12-2 |
|---|---|
| Millard | Zhang |

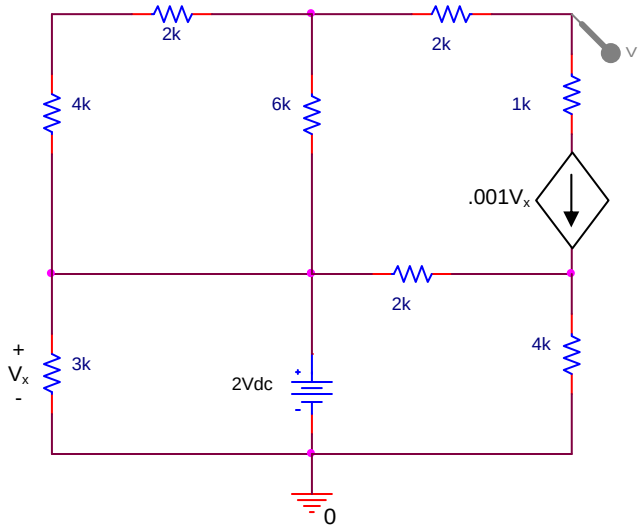
Please Note:

- Place all your answers in the spaces provided.
- You MUST show your work to receive any credit.
- Assume all resistances are in ohms, if not otherwise indicated.

| Problem No. | Pts. | Score |
|---|---|---|
| 1 | 20pts | |
| 2 | 20pts | |
| 3 | 20pts | |
| 4 | 30pts | |
| 5 | 20pts | |
| 6 | 30pts | |
| 7 | 20pts | |
| Total | 160pts | |

## Problem 1 (20pts)

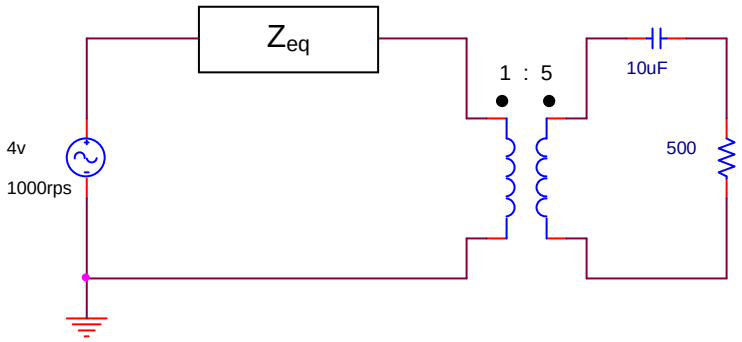
a) Find the voltage at the marker shown in the circuit below. (10pts)




| $V_{marker}$ | |
|---|---|

## Problem 1 (cont)

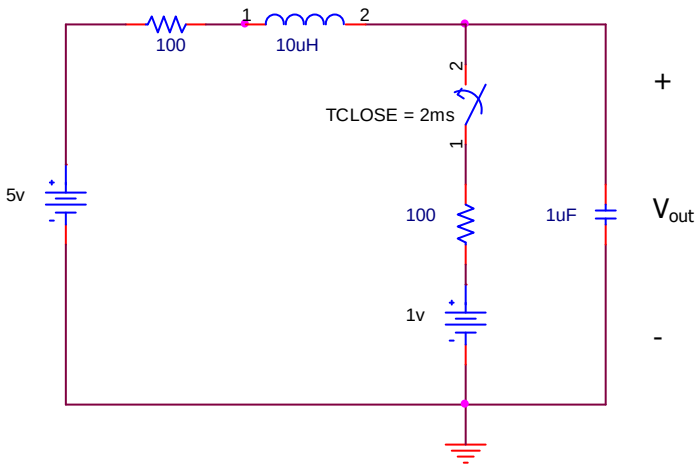
b) Find $Z_{eq}$, both the value and component type(s), that would maximize the power delivered to the 500 ohm resistor in the circuit shown. (10pts)




| | |
|---|---|
| $Z_{eq}$ | |
| Component(s) (and values) | |

## Problem 2 (20pts)

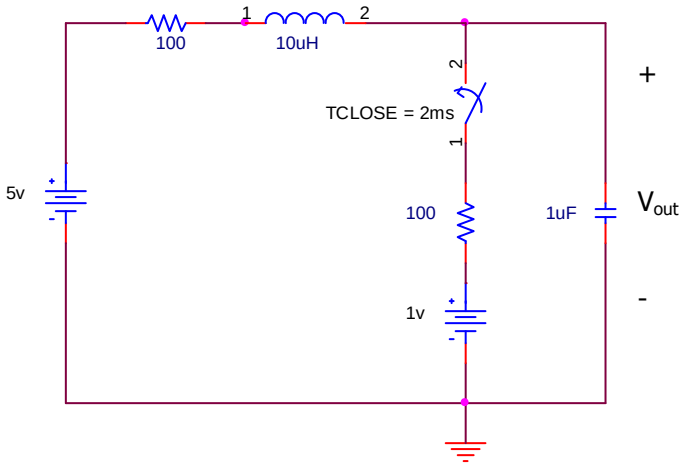
a.) Draw the circuit in the s-domain and find the damping coefficient (ζ) of the circuit for 0<t<2ms. (5pts)




| ζ | |
|---|---|

## Problem 2 (cont)

b.) What circuit modification could you make that would cause the circuit to produce a critically damped response for 0 < t < 2ms, assuming that the initial conditions were zero at t<0? Please explain your answer. (5pts)



## Problem 2 (cont)

c.) Find $V_{out}$ (s) for t >2ms (using the circuit shown in parts a & b). Remember that the Laplace transform of u(t) = 1/s. Please note: You do **NOT** have to find $V_{out}(t)$. (5pts)

| $V_{out}$ (s) (t>2ms) | |
|---|---|

d.) **Sketch** $V_{out}$ (t) for all t ≥ 0. Show all pertinent points in time, including the appropriate time constants and voltage values (5pts)

## Problem 3 (20pts)

The following three loads are connected across a $120V_{rms}$ 60Hz AC generator:

Load #1 has 900 VA and has -636 VARS
Load #2 has 364 Watts and has a $pf_1 = .5$ **lagging**
Load #3 has 875 VA and has a $pf_1 = 0$ **lagging**

a) Determine the total apparent power of the three loads. (5pts)

$|S|_{total}$ =

b) Determine the power factor of the combined loads. (5pts)

$pf_{combination}$ =

Problem 3 (cont)

c) Determine the capacitance that will be necessary in order to make the overall pf = 1.0, assuming that the voltage across the load is to be kept at $120V_{rms}$. (5pts)

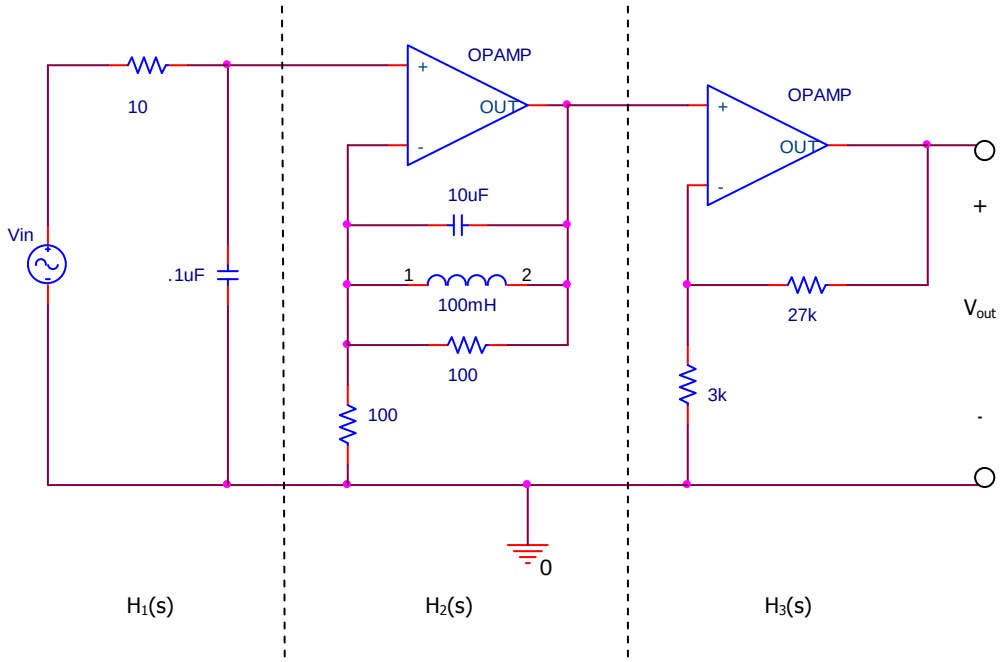
| C = |
|---|

d) Determine the difference in the current drawn from the generator (e.g the difference in the current drawn with and without power factor correction). (5pts)

| $I_{difference}$ ($I_{non\text{-}corrected} - I_{corrected}$) | |
|---|---|

## Problem 4 (30pts)

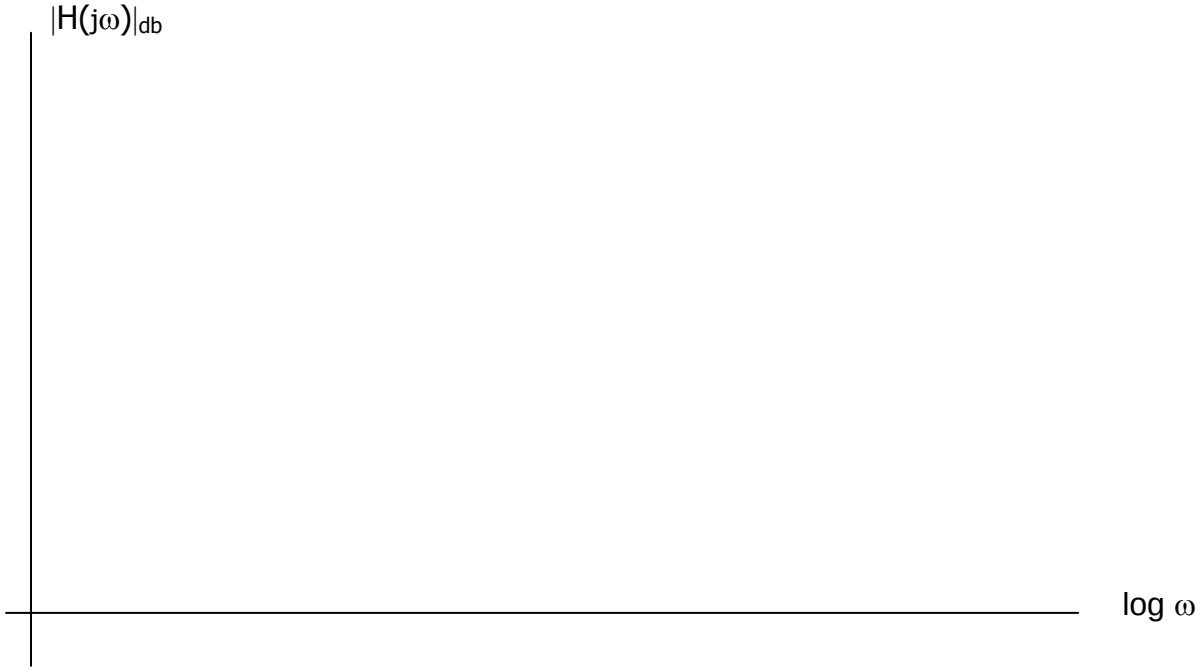
a) Find $H_1(s)$, $H_2(s)$, $H_3(s)$, and the overall transfer function $V_{out}/V_{in} = H(s) = H_1(s)H_2(s)H_3(s)$ for the circuit shown below. (10pts)




| | |
|---|---|
| $H_1(s)$ | |
| $H_2(s)$ | |
| $H_3(s)$ | |
| $H(s)$ | |

Problem 4 (cont)

b) Sketch the asymptotic graphs of $|H(j\omega)|_{db} = |V_{out}/V_{in}|$ and $\angle H(j\omega)$ for the circuit shown in part a on the previous page. Please clearly label your axes as appropriate. (10pts)




Problem 4 (cont)

c) It is desired to have an output sinusoid with an amplitude of 20v for an input $V_{in}(t)=\mathbf{A}\cos(50_{rps}t)$volts (for the circuit shown in part a). What must the value of **A** be? (5pts)

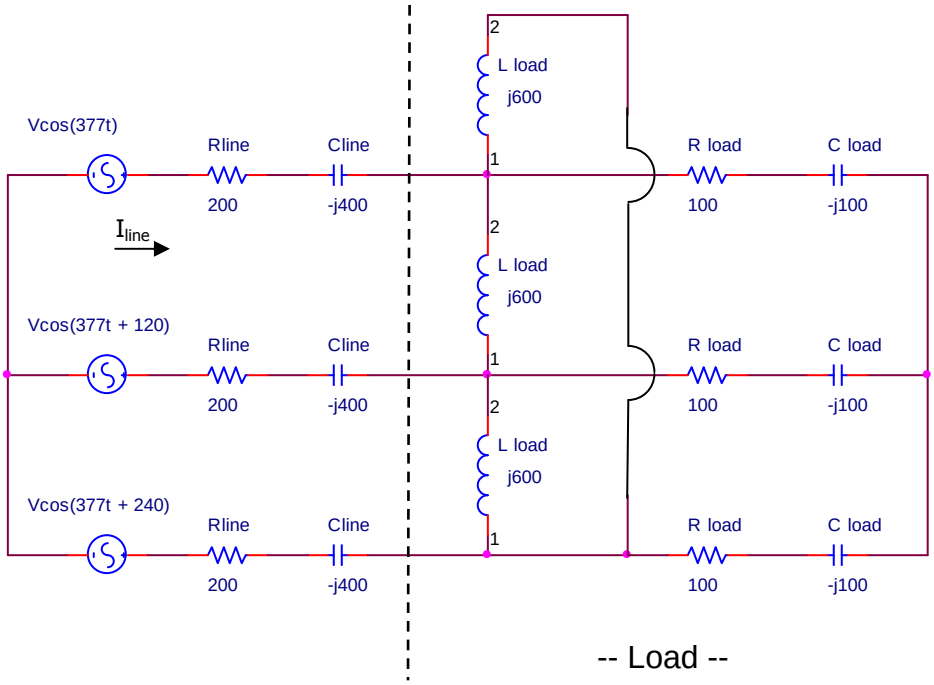
| **A** | |
|---|---|

d) What frequency ($\omega$) will change an input that is = $1\cos(\omega t)$ into an output = $7.07\cos(\omega t-45)$ (using the circuit shown in part a)? Explain and justify your response. (5pts)

| $\omega$ | |
|---|---|

## Problem 5 (20pts)

a) Given the following 3 phase circuit, what is the equivalent single phase load impedance to the right of the dashed line? (5pts) (Please justify your response)



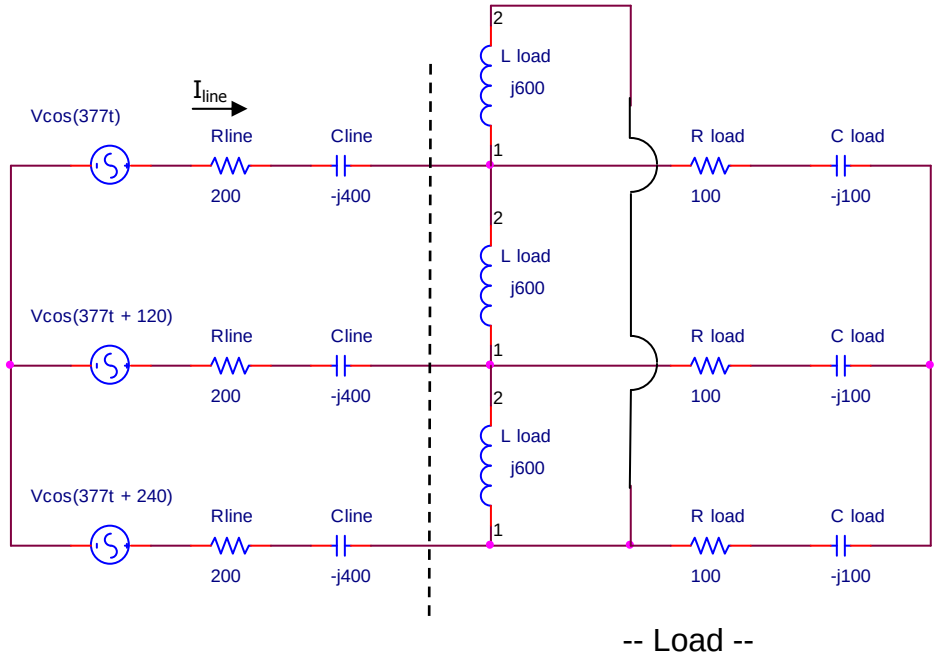

| $Z_{load}$ | |
|---|---|

b) What is the line current $I_{line}$ (in rms) flowing in each line resistance ($R_{line}$) associated with the three phases if each of the phase voltages is $V_\Phi$ = 56.6$kV_{rms}$? (5pts)

| $I_{line}$ | |
|---|---|

## Problem 5 (cont)

c) What is the total average real power (in rms) dissipated by the three phases' line resistances ($R_{line}$) if each of the phase voltages is $V_{\Phi}$ = 56.6k$V_{rms}$? (5pts)




| $P_{line}$ | |
|---|---|

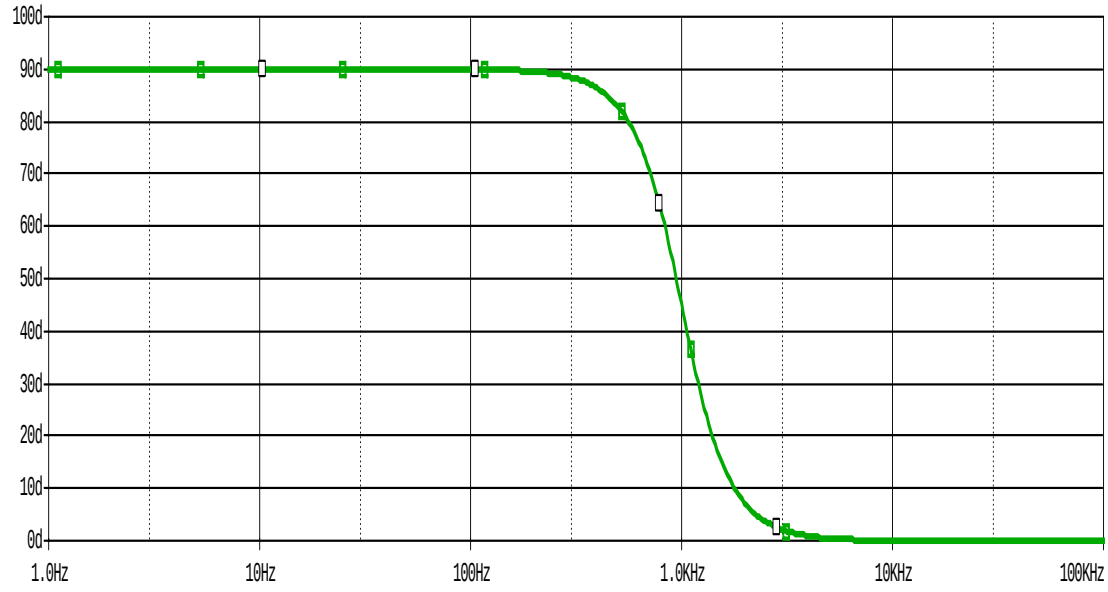
d) What is the efficiency of the transmission system, defined as: $P_{load\text{-}average}/P_{total}$*100%? (5pts)

| Efficiency | |
|---|---|

## Problem 6 (30pts)

a) Given the plots below, find the cutoff frequency $\omega_{co}$ of the circuit that would produce the response shown. (5pts)

$|H(j\omega)|_{db}$


2*Pi*Frequency

$\omega_{(rps)}$

$\omega_{co}$ =

## Problem 6 (cont)

b) Design a circuit that would produce the Bode Plot given in part (a). Assume that you only have **one** capacitor, **one** inductor, **six** resistors and **two** op-amps available. Please provide values for your component choices and show your circuit schematic. Please specify and provide support for your component choices and circuit topology. (Note: you don't have to use all the components). (15pts)

Problem 6 (cont)

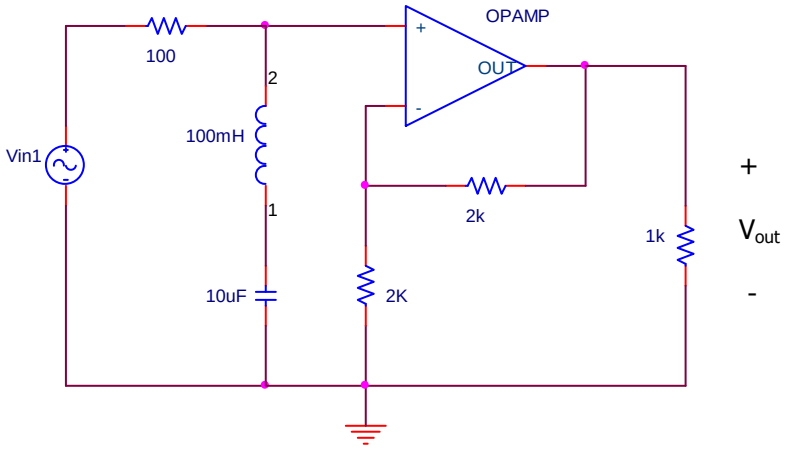
c) Develop H(s) for the circuit you designed in part b. (5pts)

| | |
|---|---|
| H(s) | |

d) **briefly** justify that it produces the graphs shown in part a. (5pts)

## Problem 7 (20pts)

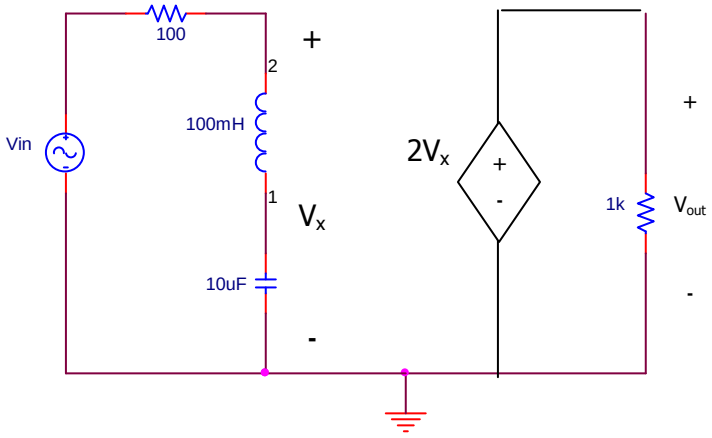
a.) Find $V_{out}(t)$ for the circuit below, if the circuit is being driven by an input signal $V_{in}(t) = 10\cos(\omega_o t)$ where $\omega_o$ is the resonant frequency. Please briefly justify your response. (5pts)




| $V_{out}(t)$ | |
|---|---|

## Problem 7 (cont)

b) Find $V_{out}(s)$ in terms of $V_{in}(s)$ for the circuit shown below. (Note: $V_x$ is across both the inductor and the capacitor.) Please show your work for credit. (10pts)




| $V_{out}(s)$ | |
|---|---|

c) Briefly discuss the relationship of the circuit shown in part b to that which is shown in part a. (5pts)

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Extra space (if needed) Name _____