EE 201.3 (Section 01/03)

(Instructors: Dr. Daniel Teng/Denard Lynch)

Final Examination

Monday, December 13, 2004

9:00 AM

Time Allowed: 3 Hours

Materials allowed: One 8½” X 11” sheet of notes,
Calculators

Instructions:

- **Answer all questions in the space provided (use page backs for rough work if necessary)**
- **State your assumptions; show all relevant work. Box, circle or otherwise highlight your answers. Please try to write neatly.**
- **Put your name and student number on the cover page; put *only* your student number on all remaining pages.**
- **Weighting for each question is indicated in the left margin (Total marks:180)**

2	3	4	5	6	7	8	Total
/	/	/	/	/	/	/	/

Name:____

Student Number:____________________________________

1) An industrial building is supplied by a 600VAC, 60Hz source. The energy demand in the building consists of the following loads:

- 1600W of incandescent lighting
- 1000W of Florescent lighting, $F_P = .8_{lagging}$
- 1kW of motor load, $F_P = .7_{lagging}$
- 8.5kW of electro-plating load, $F_P = .63_{leading}$

[18]

a) Determine the total P, Q and S for the building. Draw the Power Triangle.

b) What is the combined Power Factor, F_P, for the building?

c) What is the type (C of L) and the value (F or H) of the ***smallest*** reactive correction element that will increase the Power Factor to .9?

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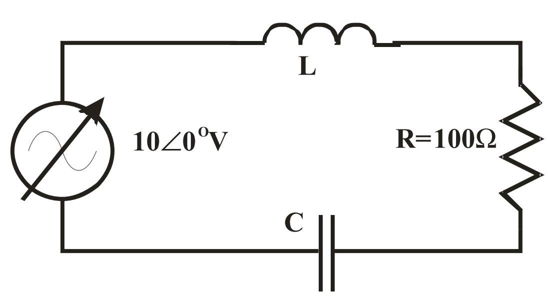
2) Consider the series circuit shown in the figure (assume the inductor is ideal). While varying the frequency of the 10V source, it was observed that the power being dissipated in the 100Ω resistor was 0.5W at a frequency of 659Hz, and again at 818Hz.

[12]

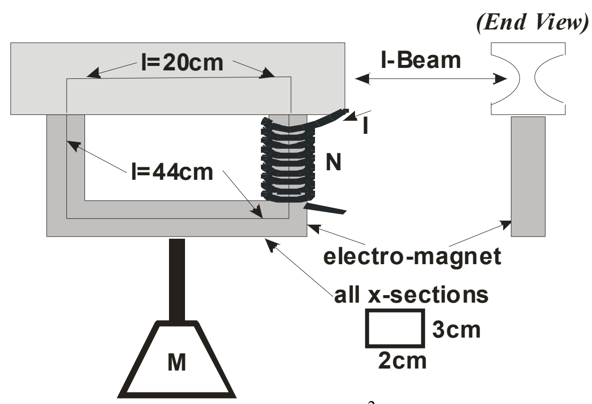


a) What is the *exact* resonant frequency, f_o, of this circuit?

b) What is the Quality Factor, Q, of this circuit?

c) Find the values for L and C in this circuit.

3) [19] An electro-magnet is used to suspend a mass, M, from an overhead I-beam. The total mass that must be supported, *including the magnet*, is 13kg. The magnet core and the I-beam are both made from *cast steel*. The coil of the magnet has 100 turns, and when the current in the coil falls below 2.5A, the magnet will detach from the beam. The cross-sectional area of the *magnet core* is 2cm X 3cm.



$$F = \frac{B^2 A}{2\mu_o}, g = 9.81 \, m/s^2$$

$$\mu_o = 4\pi \times 10^{-7} \, Wb/At-m$$

a) What is the minimum force the magnet must provide to keep itself attached to the beam?

b) What flux density, B, is required to provide this force?

c) The average path length through the beam is known (20cm), but the effective area is *not* known. Given the information above, calculate the effective *area* of the I-beam.

(Note: You may use the following table to assist with your calculations)

Leg	Φ (Wb)	A (m^2)	B (T)	H (At/m)	L (m)	Hl (At)	

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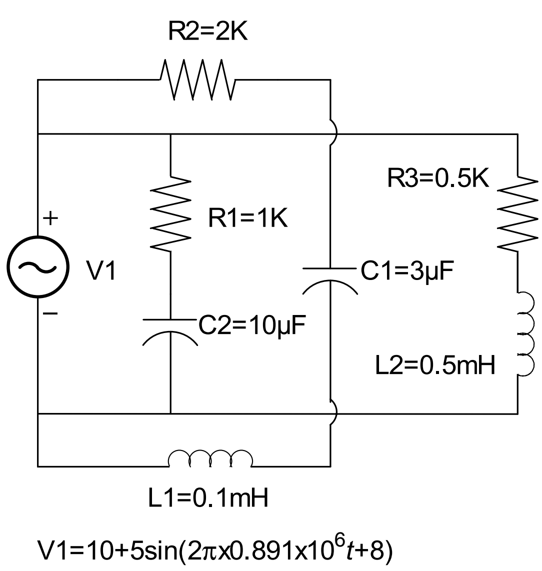
4) [15] A designer would like to verify the following circuit design with a circuit simulator. He/She wrote a SPICE input file and tried to run transient analysis, but the simulator pops up a message window saying there are errors in the SPICE input file.

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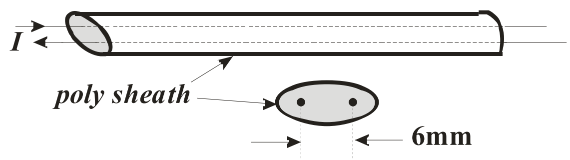
DESIGN SIMULATION
V1 1  10 SIN(10 5 0.891M 8 0)
R1 1  2  10^3
R2 1  3  2K
R3 1  6  0.5K
L2 6  7  0.5m
C1 3  5  3U
C2 2  10 10U   UIC=5V
L1 5  10 100U  UIC=0
.PLOT    V1 V5
.PRINT   V1 V5
.TRANS   0.1U 1U
.ENDS
```

a) Compare the SPICE input file with the circuit diagram and circle and correct all the errors in the SPICE input file.

b) After the designer fixed the syntax errors and ran the simulation again, the simulation result only showed a rough waveform and the result doesn't seem correct. Find the cause of the problem and fix it.

5) [14] A 2-conductor cable is used to carry alternating current (at 60Hz). The manufacturer specifies that the sheath will fail (i.e. rupture or tear) at a force of 0.47N/cm, exposing the conductors.



a) The conductors are placed 6mm apart in the sheath. Calculate the maximum peak current that the cable can carry before it fails. (Recall: the field, B, produced by a current, i, a distance d from the wire is given by: $B = \frac{\mu_o i}{2\pi d}$)

b) Write the sinusoidal expression for this current.

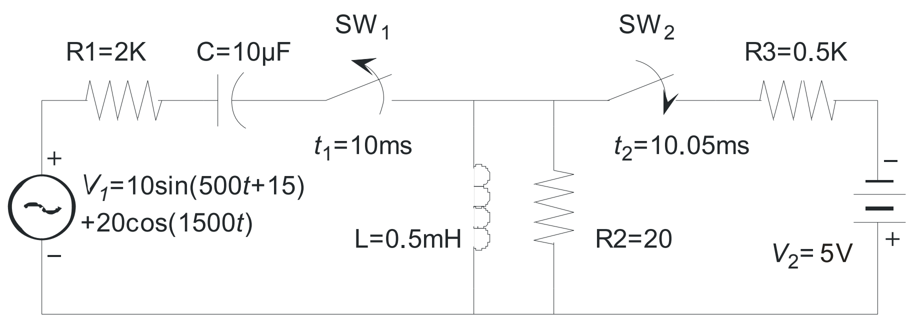
i(t) =

c) What is the RMS value of this current?

(free work space)

6) For the circuit network shown below, we would like to have SW_1 open and SW_2 closed at the same time when t = 0 second. However, it is found there is 10ms of time delay to open SW_1 and 10.05ms of time delay to close SW_2.

[24]



a) Develop the expression of $i_L(t)$ as a function of time before switch SW_1 is opened

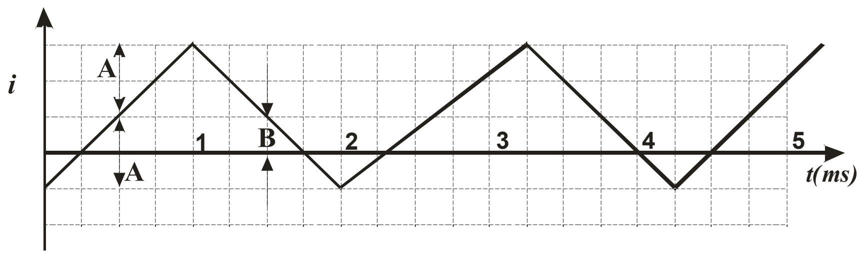
b) What is current flowing in the inductor at the moment SW_1 is opened?

c) Develop the expression of $i_L(t)$ as a function of time between t_1 and t_2.

d) Develop the expression of $i_L(t)$ as a function of time for $t \geq t_2$.

e) Graph the waveform of $i_L(t)$ as a function of time.

7) The triangular waveform shown in the graph below has a peak-to-peak value of 10A (i.e. A = 5A). It is "offset" by an unknown amount, B. If the RMS value of the waveform is known to be 3.5A, find the DC-offset value, B. (*Hint*: RMS value of the triangle wave without the offset is $A/\sqrt{3}$)



[4]

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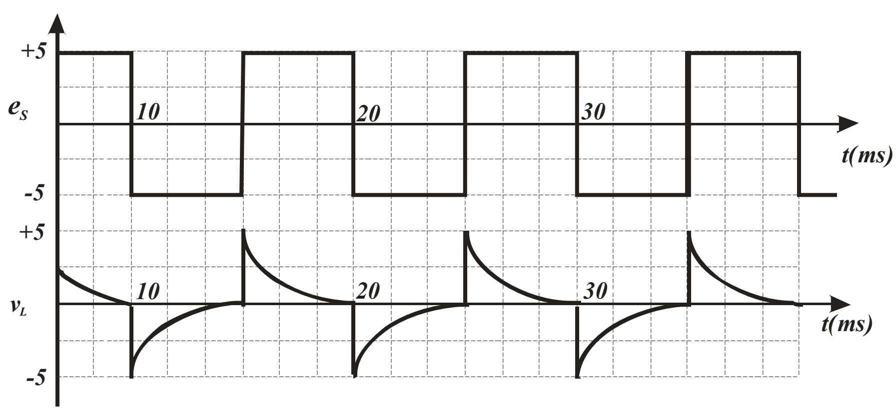
8) A R – L circuit consisting of a 500Ω resistor and a 0.5H inductor are connected to a square-wave generator, e_S. The waveform can be described by the decaying inductive transient expression: $v_L = \pm 5e^{-t/\tau} V$. The source waveform and resulting voltage across the inductor, v_L are shown in the following graph:

[16]



Find the RMS value of the voltage across the inductor.

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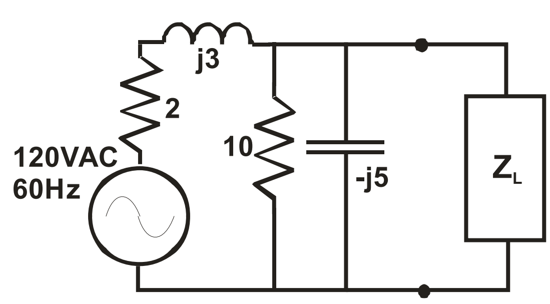
9) Find the necessary load impedance to maximize the amount of power transferred to the load for the network shown in the accompanying figure.

[5]



10) A single-phase 6hp motor is connected to a 240VAC, 60Hz supply. On average, the motor is loaded to 75% of it's rated power. Its efficiency is 81%, and the name plate rating states 6.9kVA at full load. (Note: 1hp = 746W)

[12]

a) What is the Power Factor. F_P, for the motor *without* any correction?

b) What type and size of element (C or L, in F or H) would be required to improve the Power Factor to $0.9_{Lagging}$ if operated at its average 75% loading?

c) What is the minimum VA rating for this correction element?

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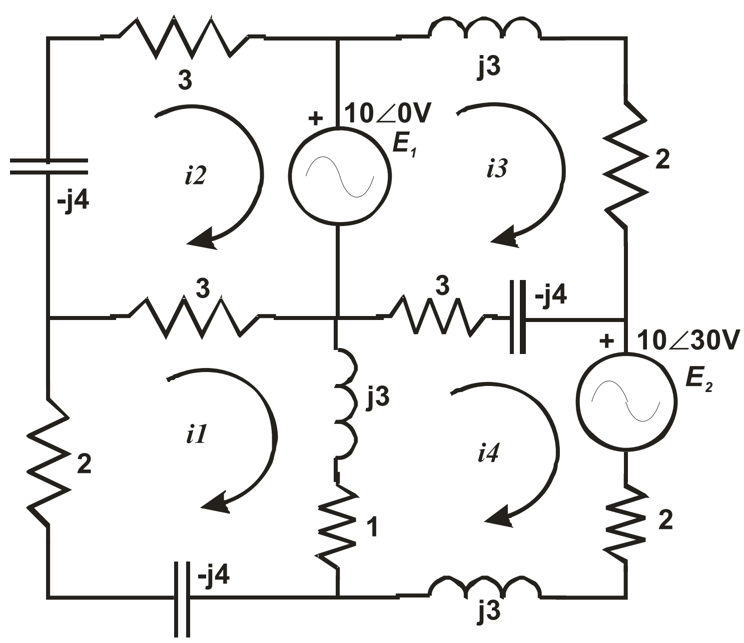
11) Write the loop equations necessary to solve for the four loop currents in the network shown at right. *Don not solve* for the currents, but put the coefficients in matrix form:

[16]

e.g.:

$$\begin{bmatrix} a11 & a12 & a13 & a14 \\ a21 & a22 & a23 & a24 \\ a31 & a32 & a33 & a34 \\ a41 & a42 & a43 & a44 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \\ i_4 \end{bmatrix} = \begin{bmatrix} b1 \\ b2 \\ b3 \\ b4 \end{bmatrix}$$



12) You were asked to design a circuit to have a resonant frequency of $\omega_0 = 50\text{Krad/s}$ and a quality factor $Q = 10$. However, you have found only the following components in the lab.

Resistors:	$R = 1$		Quantity: 5
Inductors:	$L = 100\mu H$	$Q_L = 15@8KHz$	Quantity: 1
	$L = 220\mu H$	$Q_L = 20@8KHz$	Quantity: 1
Capacitors:	$C = 8\mu F$		Quantity: 1
	$C = 1.4uF$		Quantity: 1

Try to use the available components to design the resonant circuit with error within 5%.

a) What is the target bandwidth?

[25]

b) Determine the combination of inductor(s) and capacitor(s) to achieve the resonant frequency.

c) Calculate the internal resistance of the two inductors at the resonant frequency.

d) Determine the value of the required external resistor.

e) Draw the circuit diagram of your final design.

f) Calculate the error percentage of the resulting ω_0 and Q.
NOTE: If the error percentage is greater than 5%, your design doesn't meet the requirements.

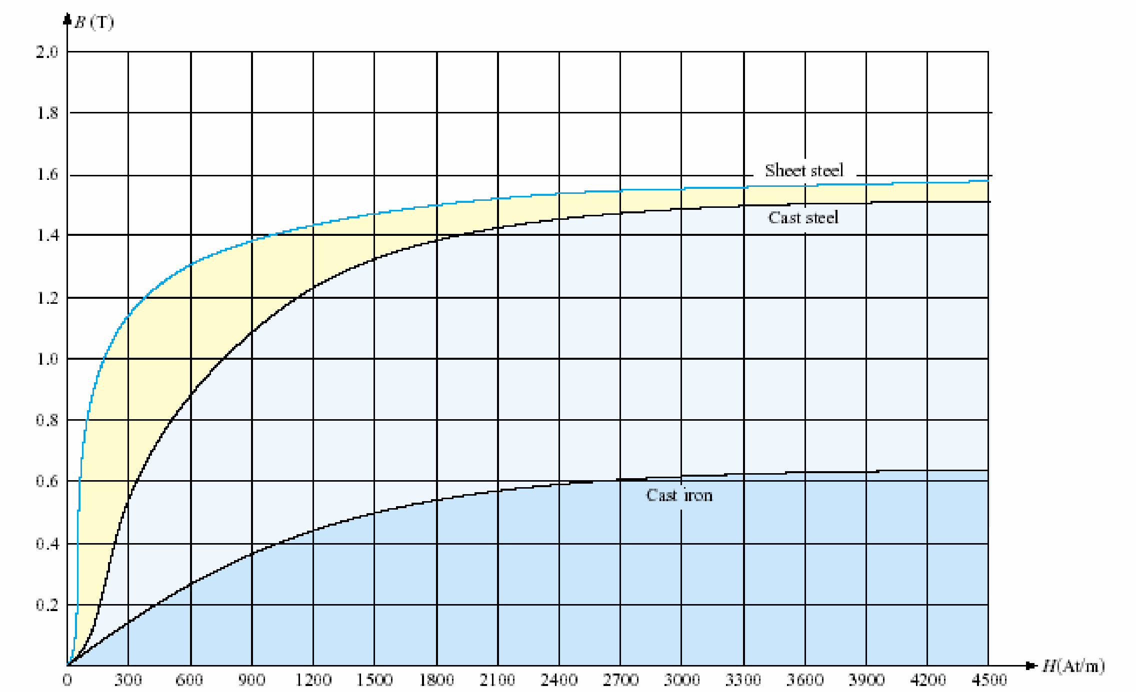


FIG. 11.23
Normal magnetization curve for three ferromagnetic materials.

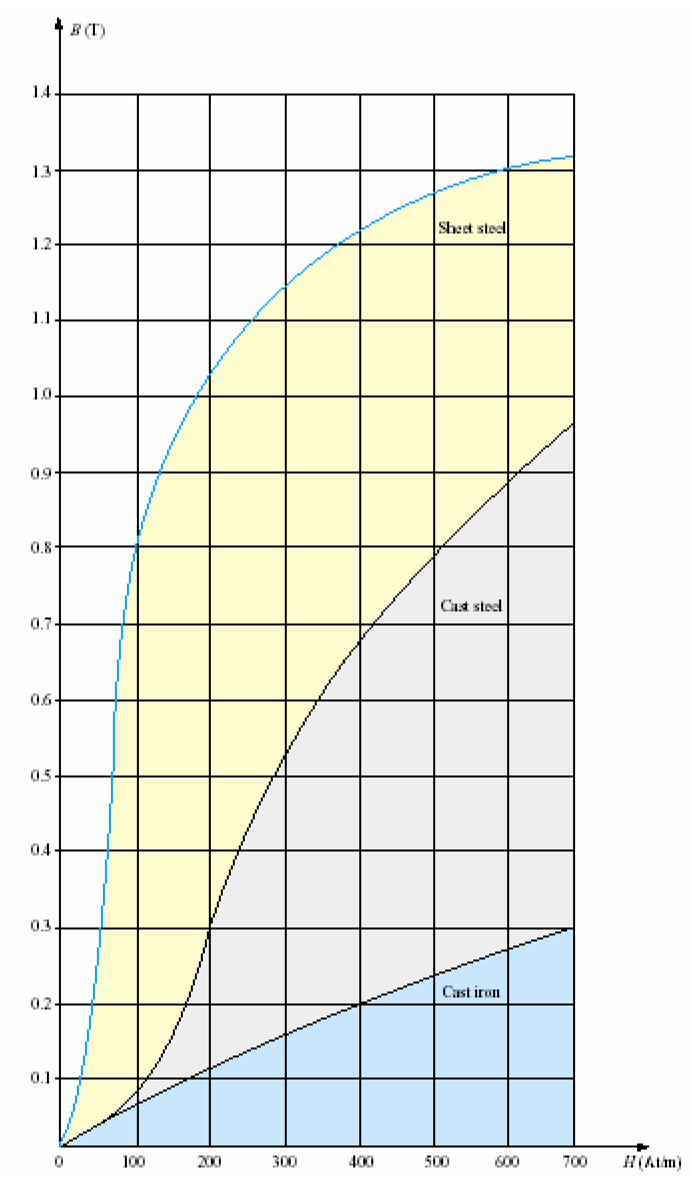


FIG. 11.24
Expanded view of Fig. 11.23 for the low magnetizing force region.

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