Ph.D. Qualifying Exam

February 4th, 2016

1:00-5:00pm

Electrical Engineering

Part I

Instructions:

This is a closed-book/closed-notes exam module, four hours in duration. There are ten (10) problems in this exam, and you will have a choice of answering **only eight (8). The 4 questions from EE 234 and EE310 are required.** The other 4 questions can be selected from other topics.The selected eight (8) questions must be **clearly marked** in the selection boxes below.

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
EE 234	EE 234	EE310	EE 310				

Write your name and student ID below.

Full Name: _____

Student ID: _____

Please write your student ID Number of **EVERY PAGE**, but **DO NOT** write your name on any other pages of the exam.

Blank paper is provided if you need additional space to show your work. **PLEASE INDICATE THE PROBLEM NUMER ON EACH ADDITIONAL PAGE YOU USE.**

Good Luck!

Final grade for this question: _____ out of 10 Points

Question 1, ElecEng 234

Part I EE234

a) Consider the following nonhomogeneous ODEs, find their homogeneous solution, and give the form (**no need to determine coefficients**) of nonhomogeneous solution. (40 points)

i) $4y''+20y'+29y=3x^2\cosh(2.5x)$

ii) $y''+3y'=2+5\sinh(3x)$

b) Find the general solution of $y''+E^2y=2\sin(Ex)$ where E is a non-zero real constant with following steps i) Determine homogeneous solution, ii) Find nonhomogeneous solut ion **with coefficients determined using method of undetermined coefficients** and iii) Arrive at the general solution. (60 points)

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Final grade for this question: _____ out of 10 Points

Question 2, ElecEng 234

Consider the following matrix:

$$\begin{bmatrix} 3 & 0 & 1 \\ 0 & 2 & 0 \\ 1 & 0 & 3 \end{bmatrix}$$

a) Find its characteristic equation. (10 points)
b) Find all eigenvalues and the spectral radius of the matrix. (20 points)
c) Find all eigenvectors and the geometric multiplicity of each eigenvalue. (70 points)

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Final grade for this question: _____ out of 10 Points

Question 3, ElecEng 310

(a) Using time-domain transform, find the zero-state response of an LTI Digital system:

$$y[n+2] - 0.6y[n+1] - 0.16y[n] = 5x[n+2]$$

for the input $x[n] = (4)^{-n}u[n]$. (7 points)
(b) Given the two systems connected in series as
$x[n] -> h_1[n] -> w[n]$, where $w[n] = 3x[n] - 2x[n-2]$ and,
$w[n] -> h_2[n] -> y[n]$, where $y[n] = 2w[n] - 3w[n-1] - 4w[n-2]$,
compute the overall impulse response, i.e., $x[n] -> h[n] -> y[n]$, what is $h[n]$? (3 points).

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Question 4, ElecEng 310

(a) For the system described by the differential equation (2), find the zero-state unit *step* response of its inverse system, so that the cascade system of the system and its inverse system is an identity system:

$$\frac{d^2y(t)}{dt^2} - 2\frac{dy(t)}{dt} - 3y(t) = \frac{d^2x(t)}{dt^2} - 2\frac{dx(t)}{dt} - 8x(t)$$

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Final grade for this question: _____ out of 10 Points

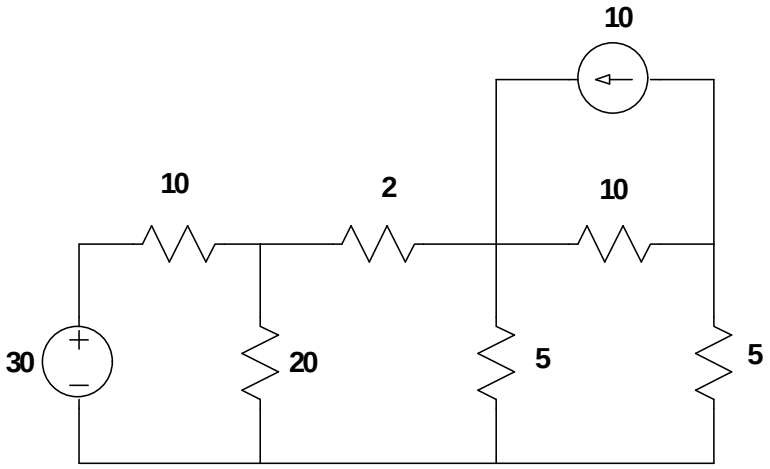
Question 5, ElecEng 301

For the circuit shown below,

(a) Determine the Thévenin equivalent circuit seen by the 2 ohm resistor.

(b) Using the Thévenin equivalent circuit, determine the power absorbed by the 2 ohm resistor.

(c) What value of resistance should replace the 2 ohm resistor if we desire maximum power to be delivered from the circuit to the resistor?



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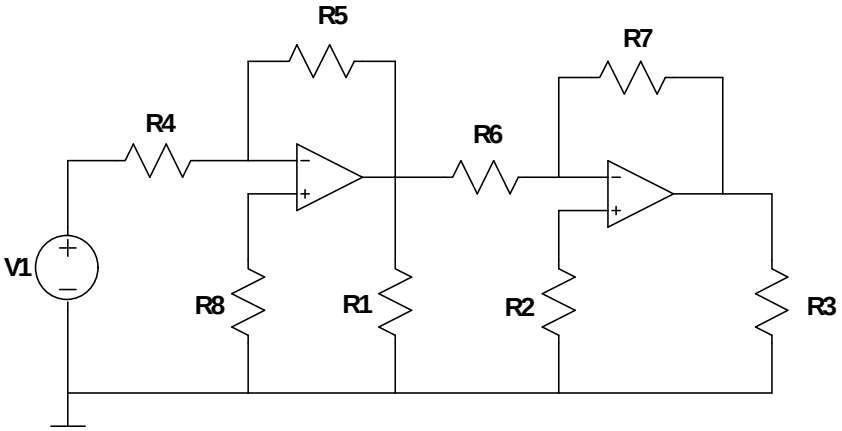
2. a) Determine the voltages across the resistors R_6 and R_7 (indicate the polarity for your answer).
   b) Repeat (a) if the resistor R_7 is replaced by a capacitor.



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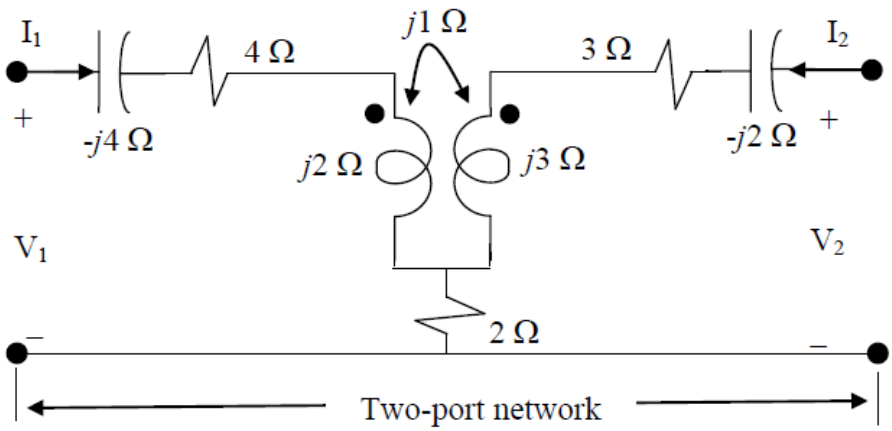
Final grade for this question: _____ out of 10 Points

Question 6, ElecEng 305

Problem : Determine Transmission parameters of the following two-port network.



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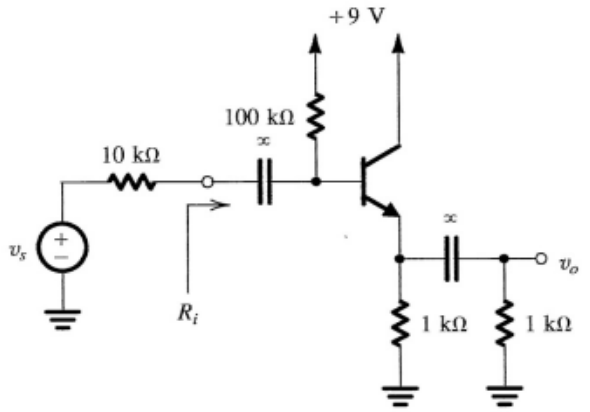
Final grade for this question: _____ out of 10 Points

Question 7, ElecEng 330

For the emitter follower circuit shown below, the BJT used is specified to have β values in the range of 30 to 300. For the two extreme values of β (β=30 and β =300), find:

(a) I_E, V_E and V_B. (5 points)
(b) The input resistance R_i. (2 points)
(c) The voltage gain v_o/v_s. (3 points)



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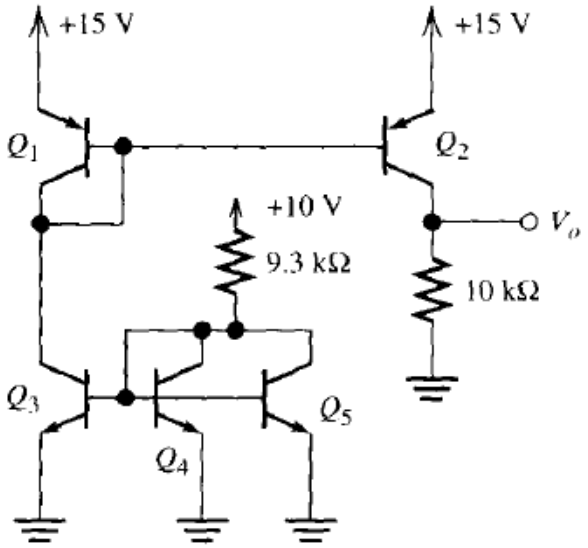
Question 8, ElecEng 335

Determine the collector currents of all of the transistors and the value of V_o in circuits shown below. Assume that the transistors have equal areas and are matched. Furthermore, assume that $|V_{BE}| = 0.7\ V$, Transistor output resistance is ∞, and the base current can be neglected.



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Question 9, ElecEng 354

a**)** Design a 2 X 4 decoder. Give its truth table, a Boolean expression for each output, and its logic circuit.

b) Design a 3 X 8 decoder using two 2 X 4 decoders.

c) Implement function F = X+ Y.Z using:

c1) AND, OR, and NOT gates.

c2) Using a decoder

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Question 10, ElecEng 367

A. How many bytes of memory can be addressed by a microprocessor with a 16-bit address bus ?

B. Make each of the number conversions

Example: Convert decimal number 237 to binary.

Answer: 237 = 128 + 64 + 32 + 8 + 4 + 1, so the binary number is %11101101

1. Convert decimal number 177 to binary.
2. Convert hexadecimal number $2A52 to binary.
3. Convert binary number %1010 0011 to hexadecimal.
4. Convert hexidecimal number $B7 to decimal.

C. An assembly language code segment from a typical microprocessor is shown below:

```
1. ADDA #1                ;; Add 1 to register A
2. JSR  $1234             ;; Jump to a sub routine at address $1234
3. PUSH B                 ;; Push the contents of register B
4. JMP  $1234             ;; Jump to address $1234
5. RTS                    ;; Return from a subroutine
```

1. Which instructions modify the stack ?

   (Circle all that apply) 1 2 3 4 5

2. Which instructions modify the program counter ?

   (Circle all that apply) 1 2 3 4 5

3. Which instructions modify data in a processor data register ?

   (Circle all that apply) 1 2 3 4 5

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D. Logic Functions in a microcomputer.

- Match each logic device with a function (choose the best answer, indicate only one letter in each blank provided).

Logic Devices: (Indicate Function)

_____ 1) D Flip Flops

_____ 2) Logic Gates, such as AND and OR

_____ 3) Tri-State buffer

_____ 4) Decoder

_____ 5) Register

Functions:

a) Build a register

b) Reverse the flow of data for reverse polish computation

c) Build a circuit to perform addition in an Arithmetic Logic Unit

d) A device in which to store a word of data in a processor

e) Provide power

f) Select one of several devices to activate, based on an address

g) Connect devices to a data bus

h) Provide timing information and device synchronization

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E. Essay Questions. Answer each of these questions with one or a few complete sentences. Incomplete sentences will count against the grade.

1. Why do microprocessors incorporate buses ?

2. Name at least 2 kinds of buses commonly used in computers and and write one or a few a sentences describing each.

3. What is bus contention ?

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Final grade for this question: _____ out of 10 Points

Question 11, ElecEng 361

Problem 1. Circle only one correct answer for any 5 out 7 questions below. Each correct answer gives 20 pt, incorrect answer gives 0 pt.

1. Consider a infinite cylindrical wire with radius r_0 carrying current I_0 ; assuming that current density is constant, the strength of magnetic field produced by the wire is to
   a) increase linearly with r for $r < r_0$
   b) decrease as ~ 1/r for $r < r_0$
   c) decrease as ~ $1/r^2$ for $r > r_0$
   d) decrease as ~ $1/r^3$ for $r > r_0$
   e) increase as ~r^2 for $r < r_0$
   f) none of the above

2. A plane EM -wave travels in a free space along *x*-direction. The $\vec{H}$ -vector associated with the wave is most likely given by the following equation
   a) $\vec{H} = 0.1\cos(10^{10} t - 133z)\,\hat{x}$
   b) $\vec{H} = 3\cos(10^{10} t - 133x)\,\hat{z}$
   c) $\vec{H} = \cos(10^{10} t - 133x)\,\hat{x}$
   d) $\vec{H} = \cos(10^{10} t - 133y)\,\hat{x}$
   e) $\vec{H} = 10\cos(10^{10} t - 133y)\,\hat{z}$

3. A proton of a constant velocity $\vec{u}_0 = u_x\hat{x} + u_y\hat{y} + u_z\hat{z}$ enters a region of a constant magnetic field, $\vec{B}_0 = B_0\hat{x}$. The trajectory of the proton in the region will be
   a) straight line
   b) circle
   c) solenoid-like
   d) sinusoid
   e) parabola
   f) none of the above

4. In electrostatics, the following remains true
   a) gravitational forces are neglected
   b) the net charge of the system is conserved
   c) electric field is to be produced by both polarized and free charges
   d) both a) and b)
   e) both b) and c)
   f) all of the above

5. In magnetostatics a magnetization vector, $\vec{M}$ was introduced. This vector
   a) gives a magnetic dipole moment of unit volume of magnetic material
   b) is a analog of $\vec{P}$ -vector in electrostatics
   c) for a magnetized Fe-bar, $M \approx 0$
   d) both a) and b)
   e) both b) and c)
   f) all of the above

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6. Consider a system of N charges, with a net charge $Q = \sum_{i=1}^{N} q_i = 0$. The following is true.
    a) the system can generate a non-zero electrostatic potential, V
    b) the dipole moment of the system is always zero.
    c) the system can generate a non-zero electric field
    d) both a) and b)
    e) both a) and c)
    f) all of the above

7. For charge continuity equation, the following is <u>not</u> true.
    a) The equation represents a charge conservation law stated in integral form
    b) Recombination-generation processes are not considered as a part of derivation
    c) The equation is used to find the relaxation time constant of an electrostatic system
    d) both a) and b)
    e) both b) and c)
    f) none of the above

Problem 2.

Two spherical surfaces of radii $R=a$ and $R=b$ ($>a$) carry surface charged densities of ρ_{sa} and ρ_{sb}, respectively. <u>Find</u> $\vec{E}$ everywhere and the relation between $\boldsymbol{a}$ and $\boldsymbol{b}$ so that electric field, $\vec{E}$ vanishes at $R > b$ region.

Final grade for this question: _____ out of 10 Points

Question 12, ElecEng 362

1. ***Machine Overview.*** Please answer the following questions. Note: this is to test your comprehension of the basic concepts. One to three word answers are sufficient.
    a. For a DC machine and Synchronous Machine:
        i. Name the two winding **types**

        ii. For the DC machine, identify which type of winding is used to control torque

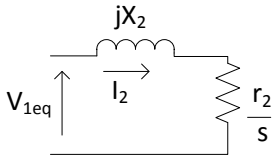
        iii. Of the two machine types, which has its field on the stator?

        iv. Which machine type uses commutator and brushes to get DC current into the rotor?

        v. Which machine type uses slip rings and brushes to get DC current into the rotor?

        vi. Which machine type has a magnetomotive force (mmf) that is fixed in space as the rotor is turning?

    b. The general expression for torque in an induction machine is $T = -K \cdot I_r \sin(\delta_r)$. For an induction motor, it can be shown that $\delta_r = -(90° + \emptyset_2)$ where $\emptyset_2$ is the power factor looking into the rotor circuit from the air gap (see the circuit below).



Assume that the controls to the induction motor can "effectively" change what the circuit parameters are (yes this is possible). Since the slip has to be non-zero to produce torque what would X_2 have to be changed to in order to ensure ***maximum torque per ampere***?

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c. The single phase equivalent circuit parameters for an induction motor in ohms/phase are:

$$R_1 = 0.1, R_2 = 0.3, X_1 = 1.1, X_2 = 0.9, X_m = 75$$

The friction and windage losses are 800 W. Neglect the core loss. The machine has *four poles* and is 3-phase Wye-connected, and a voltage of 460V rms L-L and frequency of 60Hz are applied. If the rated speed is $n = 1760\ ^{r}/_{min}$

i. What is the rated slip?

ii. What is the phase current at rated slip?

iii. What are the resultant mechanical power, shaft power and shaft torque at rated slip?

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