ELECTRICAL AND COMPUTER ENGINEERING
PhD QUALIFYING EXAMINATION

Session 2

January 9, 2007

Be sure to put your ID number on each sheet that has material to be graded. Do not put your name on any sheet.

There are 14 equally weighted problems. You are to SELECT ANY EIGHT of these to answer. You must make it very clear which eight that you choose. (If it is not clear, then the first eight problems that you attempt will be graded.) Indicate your selections in two ways:

1. Circle below which eight problems that you want graded.
2. If you write anything other than your ID number on the page of a question that you do not graded, the cross out that page with a large X from corner to corner.

Circle the eight questions that you want graded:

1

2

3

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12

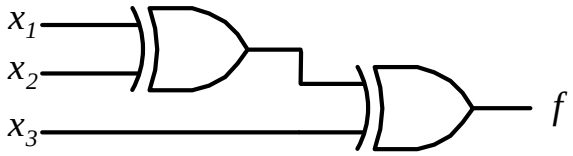
13

14

Do all work on the paper supplied to you. Do not write on the back of any page.

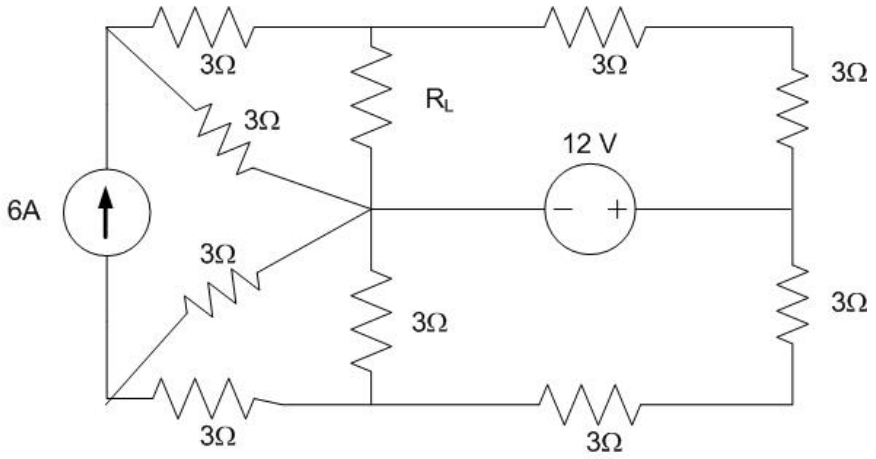
Problem 1-2 ID # _____

Implement the function of the following logic circuit using 2:1 multiplexers only.



Problem 2-2 ID # _____

Find the value of R_L that will draw maximum power.



Problem 3-2 ID # _____

2. A continuous-time function $x(t)$ has a Fourier transform $X(f)$ where the Fourier transform is defined by $X(f) = \int_{-\infty}^{\infty} x(t)e^{-j2\pi ft}dt$. In other words $x(t) \overset{F}{\longleftrightarrow} X(f)$. If $X(f) = 2e^{-2f^2}$, $e^{-\pi t^2} \overset{F}{\longleftrightarrow} e^{-\pi f^2}$ and $y(t) \overset{F}{\longleftrightarrow} X(4f)$, what is the numerical value of $y(2)$?

$\left[\text{If } x(t) \overset{F}{\longleftrightarrow} X(f) \text{ then } (1/|a|)x(at) \overset{F}{\longleftrightarrow} X(af)\right]$

Problem 4-2 ID # _____

Determine whether the alternating harmonic series $\sum_{n=1}^{\infty} \frac{(-1)^{n-1}}{n}$ is

a) Convergent.
b) Absolutely convergent.

Problem 5-2 ID # _____

Write a C++ function that calculates and prints to an ostream object passed by reference as the function's first argument the binary representation of any positive integer representable using 32 or less bits.

Problem 6-2 ID # _____

At the end of regulation time in a basketball game, team A is trailing by one point and their lead player (a pretty lousy free-throw shooter) goes to the line for two free throws. If he makes exactly one free throw the game goes into overtime. The probability that the first free throw is good is 1/3. Moreover, if the first attempt is good, the player relaxes and the second attempt is good with probability 3/4. However, if the player misses the first attempt, the added pressure reduces the success probability on the second attempt to 1/4.

a. What is the probability that the game goes into overtime?
b. Given that the game goes into overtime, what is the probability that the player made the first shot?

Problem 7-2 ID # _____

For a pipelined processor, data hazards can limit performance. What are the types of data hazards? Give examples of techniques used to eliminate or reduce the impact of these hazards.

Problem 8-2 ID # _____

An array contains N numbers, and you want to determine whether two of the numbers sum to a given number K. For instance, if the input is 8, 4, 1, 6 and K is 10, the answer is yes (4 and 6). A number maybe used twice. Do the following.

a. Give an $O(N^2)$ algorithm to solve this problem.
b. Give an O(N log N) algorithm to solve this problem. (Hint: Sort the items first. After doing so, you can solve the problem in linear time.)

Problem 9-2 ID # _____

The producer-consumer problem illustrates the need for synchronization in systems where many processes share a resource. In the problem, two processes share a fixed-size buffer. One process produces information and puts it in the buffer, while the other process consumes information from the buffer. These processes do not take turns accessing the buffer, they both work concurrently. Herein lies the problem. What happens if the producer tries to put an item into a full buffer? What happens if the consumer tries to take an item from an empty buffer? Complete the following pseduocode to implement producer and consumer functions, respectively.

```
BufferSize = 3;
count = 0;

Producer()
{









}

Consumer()
{









 }
```

Problem 10-2 ID # _____

Answer for the following matrix:

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

(a) Find the eigenvalues and corresponding eigenvectors of $\boldsymbol{A}$.

(b) Are the eigenvectors linearly independent?

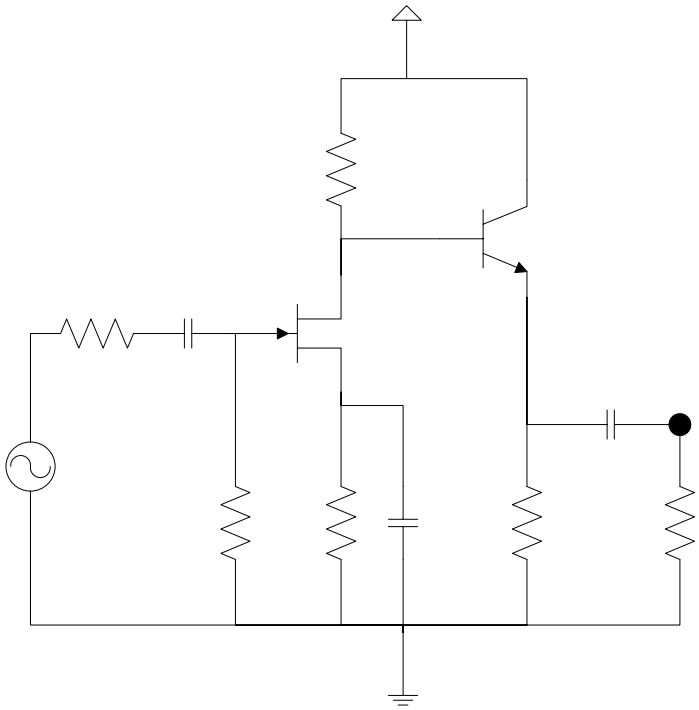
(c) Find a formula for $\boldsymbol{A}^k$, $k = 0,1,2,3,\ldots$.

(d) Confirm the formula in (c) for $k = 2$.

Problem 11-2 ID # _____

For this question assume β_F= 100, V_A= ∞, I_{DSS} = 5 mA, and V_P = -1 V, and that C_1, C_2, and C_3 are large value capacitors.

a. Find the DC bias current for J_1 and Q_2, as well as V_{DS} for J_1 and V_{CE} for Q_2.
b. What are the midband gain, input resistance, and output resistance of the amplifier?
c. What is the midband gain if C_2 is removed?



240k

1k C_1

J

V_S

Problem 12-2 ID # _____

A dc machine is operated as a shunt motor with a terminal voltage of 125 V. The armature resistance is 0.25 ohms, and the field resistance, R_{fw}, is 100 ohms. The magnetization curve for the machine when running at 1200 rpm is as follows:

I_f (A)	0.0	0.25	0.5	0.75	1.00	1.25	1.50	1.75
E_a (V)	10	45	96	130	150	165	173	178

(a) When the field circuit rheostat, R_{fc}, is set to 150 ohms, the motor runs at 1450 rpm. Find the back emf and the developed torque of the motor at this condition.

(b) If the rotational losses are 250 W at 1450 rpm, calculate the efficiency of the machine for the condition given in part (a) when considering all of the power losses in the machine.

Problem 13-2 ID # _____

A generator with a 50 Ω source impedance and 10V peak voltage, is connected to a lossless transmission line of a 1.5 wavelength and 50Ω characteristic impedance, the line is connected to an antenna with equivalent input impedance of (60+j50) Ω. Use Smith Chart to find:

a) The reflection coefficient at the load
b) The VSWR on the line
c) The load admittance
d) The input impedance of the line
e) The distance from the load to the first voltage minimum and maximum
f) Then use single stub matching at the center frequency, what is the 10% bandwidth?
g) If the line has a loss of 1dB/m what is effect of this loss on match.

Problem 14-2 ID # _____

You have a superhetrodyne receiver with an IF of 20 MHz and whose local oscillator is less than the incoming signal's carrier frequency and is required to receive AM and SSB signals. The front end (RF stage) is fairly wideband too. The receiver is supposed to receive signals in the 50 to 54 MHz range.

a. What is the range of frequencies required for the local oscillator?

b. What, if any spurious frequencies will be received?

c. What type of detector is necessary for your receiver?

d. Your receiver happens to also pick up local civil defense radio transmitter operating at 5 MHz. It has been found that this station is outputting only in their assigned channel. What would be the optimum remedy for this problem without shutting down the civil defense station?

e. Your receiver has been tested so that that the minimum input voltage is 1 microvolt and has a dynamic range of 50 dB. What is the maximum input voltage the receiver can accept before the front end overloads? Justify your answer.

Problem _-_ ID # _____