ELECTRICAL AND COMPUTER ENGINEERING
PhD QUALIFYING EXAMINATION
Session 2
Tuesday, January 6, 2009

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

4

5

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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# _____ _____ _____ __

Answer the following (all three sections are independent of one another):

a. The following is a canonical Boolean function of four variables:

$$F(a,b,c,d) = \sum(0,1,5,6,7,9,12,15)$$

Design the function $F(a,b,c,d)$ using a 4x1 multiplexer.

You may use the following **4** gates:
1 Inverter
1 AND
1 OR
1 XOR
Do not use the constants '0' or '1'.

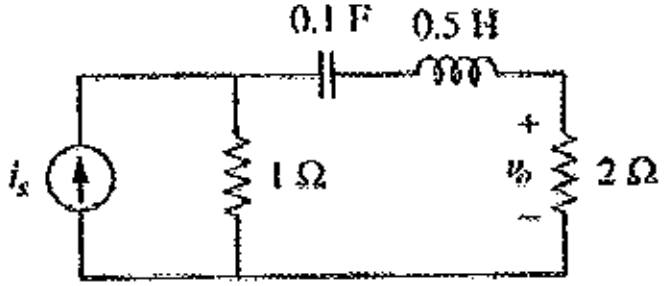
b. Design a 4x16 Decoder using **5** 2x4 Decoders (do not forget the enable input).

c. Design a Half Subtractor (draw the black box, derive the truth table and implement the outputs B and D)

Problem 2-2

ID# _____ _____ _____

If the voltage v_o over the 2-Ω resistor is $20\cos 2t$ (V), obtain i_s.



Problem 3-2 ID# _____

A periodic continuous-time signal $x(t)$ has a Fourier transform

$$X(f)=\delta(f-10)+\delta(f-15)+\delta(f-35)+\delta(f+10)+\delta(f+15)+\delta(f+35).$$

Another signal $x_s(t)$ is defined by

$$x_s(t)=\sum_{n=-\infty}^{\infty} x(nT_s)h_{zoh}(t-nt/8)$$

where $h_{zoh}(t)=\begin{cases}1 & , \ 0<t<T_s \\ 0 & , \text{ otherwise}\end{cases}$.

(a) What is the fundamental period of $x(t)$?
(Fundamental period is defined as the minimum positive time in which a periodic signal repeats.)

(b) Let $T_s=1/40$. What is the fundamental period of the signal $x_s(t)$?

(c) Let $T_s=1/8$. What is the fundamental period of the signal $x_s(t)$?

(d) Let $T_s=1/3$. What is the fundamental period of the signal $x_s(t)$?

Problem 4-2

ID# _____ _____ _____ _____

A. Show that the function $f(x)=|x|$ has no derivative at $x=0$.

B. Show that the function $y=\sin\left(\frac{1}{x}\right)$ has no limit as $x\to 0$.

Problem 5-2 ID# _ _____ _____ _____ ___

The following is a code segment that uses a couple of features related to function design, e.g., call-by-reference, call-by-value, inline function, function overloading, etc.

a) What is the output of this code?

b) Point out which variable is passed by reference, and which one is passed by value in the three functions.

c) What's the advantage of using inline function?

d) What is function overloading?

```
#include <iostream>
using namespace std;

void func1(float, float &);
float func2(float);
inline int func2(int a) { return a + a; }

int main()
{
    float x1, x2, x = 2.0;

    func1(x, x1);
    x2 = func2(x1);

    cout << "The value of x is: " << x;
    cout << "The value of x1 is: " << x1;
    cout << "The value of x2 is: " << x2;

    cout << "The return is " << func2((int)x2) << endl;

    return 0;
}

void func1(float a, float &r)
{
    r = a * a;
}

float func2(float a)
{
    return a * a;
}
```

Problem 6-2

ID# _____ _____ _____ _____

Two random variables X and Y are selected independently and uniformly in [-1,1]. Calculate $E(||X-Y||^2)$.

Problem 7-2

ID# _____ _____ _____ _____

A. You are given a 7 MHz upper single sideband (USSB) transmitter. The carrier frequency is 7.000 MHz and the output spectrum has power from 7.000 to 7.050 MHz. Design a system to convert the transmitter's output signal to a lower single sideband (LSSB) whose carrier frequency is 50.000 MHz. Your design should be in labeled block diagram form and the blocks will consist of filters, oscillators, mixers, etc. Be sure your blocks are clearly labeled and that you prove that your design works as intended. Suggestion: draw the output spectrum from each block. Note also, the input to your system is the 7 MHz USSB signal.

B. What is the minimum intermediate frequency required for a superhetrodyne receiver that will pick up commercial FM broadcasts that range from 88 to 107 MHz such that images will be outside the FM band. In other words, if images occur they will be at frequencies below 88 MHz and/or above 107 MHz.
Justify your answer.

Problem 8-2

ID# _____ _____ _____

A certain benchmark was run on a 1 GHz embedded processor after compilation with optimization turned on. The embedded processor is based on an existing1 GIz RISC processor that includes floating-point functional units, but the embedded processor does not include such units for reasons of cost, power consumption and lack of need for floating-point by most target applications. The compiler allows floating-point instructions to be calculated with the hardware units (as in the RISC processor) or using software routines (as in the embedded processor), depending on compiler flags. The benchmark took 2.0 seconds on the RISC processor and 8.0 seconds using software on its embedded version. Assume that the CPI using the RISC processor was measured to be 10.0, while the CPI of the embedded version of the processor was measured to be 7.0.

(a) What is the total number of instructions executed for both runs?

(b) What is the MIPS rating for both runs?

Problem 9-2

ID# _____

For the memory reference string (page addresses) shown below, indicate which references result in a page fault for the page replacement algorithms: FIFO (First-In-First-Out), OPTIMAL and LRU (full Least Recently Used). Assume that there are three physical page frames and there is only one process.

A. For each memory reference shown, place an **F** in the cell below the memory reference if that reference results in a page fault (for the algorithm). Assume there is nothing in physical memory when the reference string begins.

Reference String	0	1	2	0	1	2	3	4	2	5	0	6	0	7	7	8	0	6
FIFO																		
OPTIMAL																		
LRU																		

B. For the same memory reference sequence, complete this table.

Page referenced	Pages in memory when the reference is made		
	FIFO	OPTIMAL	LRU
0	nothing	nothing	nothing
1	0	0	0
2	01	01	01
0	012	012	012
1	012	012	120
2	012	012	201
3			
4			
2			
5			
0			
6			
0			
7			
7			
8			
0			
6			

Problem 10-2

ID# ___ _____ _____ _____ ___

a) What does quicksort do?

b) Quicksort is an O(nlogn) recursive algorithm. Explain what "O", "n", "log", "recursive", and "algorithm" mean.

c) Consider the list 3, 21, 9.5, 0.5, 4, 5, 6, 2, 1. Sort this by quicksort. Show the intermediate sequences.

Problem 11-2 ID# ____ _____ _____ _____

A 1 GHz x-polarized TEM wave traveling in the +z-direction is incident in air upon a metal surface coincident with the x-y plane at z=0. If the amplitude of the electric field of the incident wave is 12 (mV/m) and the metal surface is made of copper with $\mu_r = 1$, $\varepsilon_r = 1$, and $\sigma = 5.8\times10^7$ (S/m).

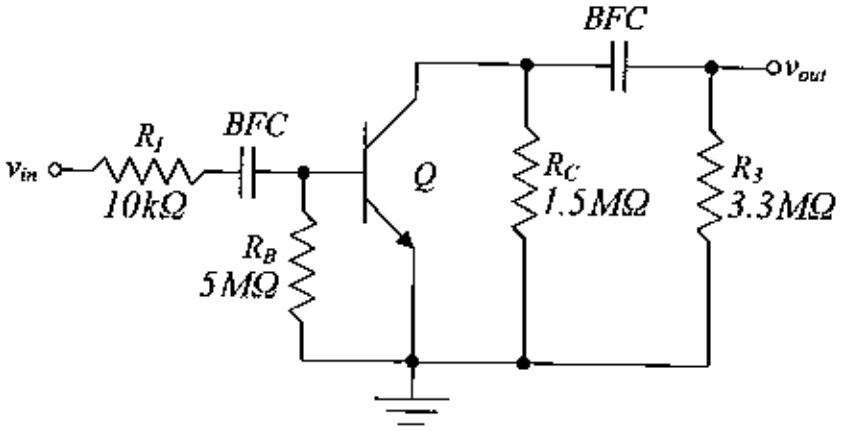
a) Calculate the skin depth.
b) Calculate the attenuation constant in the conducting media.
c) Calculate the propagation constant in the conducting media.
d) Calculate the complex characteristic impedance of the conducting media.
e) Calculate the reflection coefficient at the air-conducting media interface.
f) Obtain expressions for the instantaneous electric and magnetic fields in the air medium.
g) Calculate the transmitted field at a distance of two skin-depth deep in the conducting medium.

Assume the metal surface to be several skin depths deep.

Problem 12-2

ID# _____ _____ _____ _

The AC equivalent circuit for an amplifier is shown below. Calculate the mid-band small-signal voltage gain $A_v = v_{out}/v_{in}$ for the amplifier if the BJT quiescent point is (1 μA, 1.5 V) (i.e., I_C = 1 μA and V_{CE} = 1.5 V). Assume β_o = 40 and V_A = 50 V. Also assume v_{in} is provided by an ideal voltage source. In the schematic, "*BFC*" means Big Fat Capacitor, i.e., a capacitor of huge value.



A_v =

Problem 13-2

ID# _____ _____ _____

Consider two nXn matrices A and B. Suppose that C=A+B. Show that

$$\text{rank}(A) + \text{rank}(B) \leq \text{rank}(C)$$

Problem 14-2

ID# ___ _____ _____ _____ ___

A balanced, three-phase, 4-pole, 60 Hz induction motor runs at 1710 rpm when it delivers rated output power. Determine:

a) The synchronous speed.
b) The value of slip.
c) The frequency of the rotor currents.
d) The speed of the rotor field relative to the rotor structure.
e) The speed of the rotor field relative to the stator structure.