ELECTRICAL AND COMPUTER ENGINEERING
PhD QUALIFYING EXAMINATION

Session 2

August 22, 2006

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 13 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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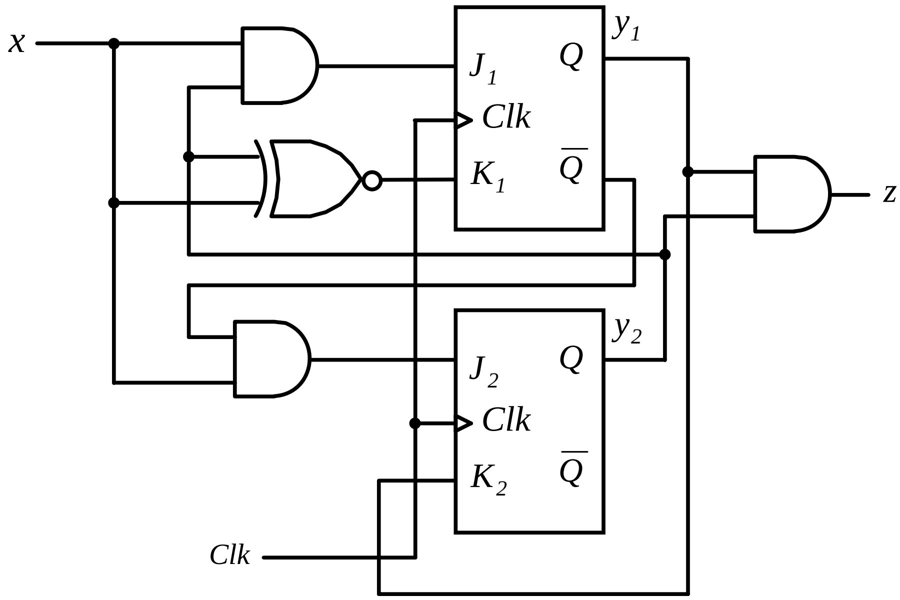
12

13

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

Problem 1-2 ID # ___________________________

Determine the function of the finite state machine described by the following logic implementation.

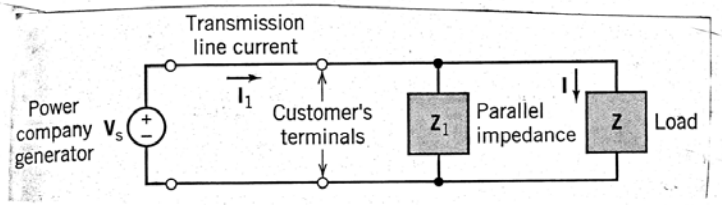


Problem 2-2 ID # ________________________

In this 60 Hz power circuit, impedance $Z = 100+j100$ is the load of a customer. The impedance Z_1 is a capacitance.

(a) Find the value of that capacitance required to make the power factor at the customer's terminals 0.95 lagging.

(b) Find the value of that capacitance required to make the power factor at the customer's terminals 1.0.



Problem 3-2 ID # ________________________

4. A discrete-time system is described by the difference equation

$$3y[n]-2y[n-1]+y[n-2]=10x[n]$$

where $x[n]$ is the excitation (input signal), $y[n]$ is the response (output signal) and n is discrete time.

(a) Find the impulse response $h[n]$ of the system. (Impulse response is the response to a unit impulse applied at time $n=0$.)

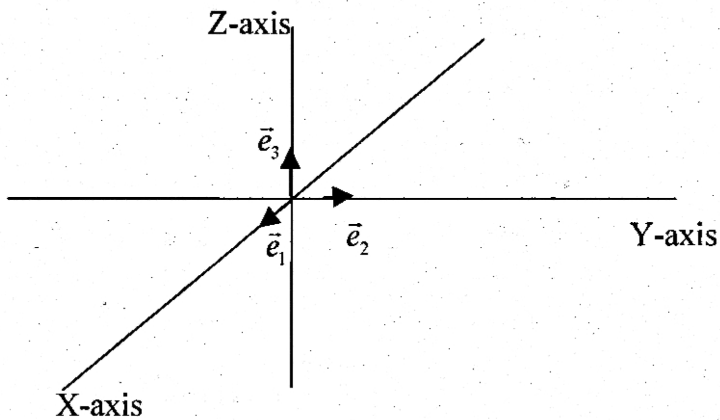
(b) Is this system stable?

Problem 4-2 ID # ________________________

Find the derivative of

$$f(x,y,z)=x^3-xy^2-z$$

at the point $(x_0,y_0,z_0)=(1,1,0)$ in the direction of the vector $\vec{u}=2\vec{e}_1-3\vec{e}_2+6\vec{e}_3$, where $\vec{e}_1$, $\vec{e}_2$, and $\vec{e}_3$ is the usual canonical basis in $\mathbb{R}^3$ (see Figure below.)



Problem 5-2 ID # ___________________________

Write a function to compare two C-style strings, returning a negative int if string a is lexicographically less than string b, a positive int if it is greater, and zero if the strings are identical. Do not use any string library functions (such as strcmp). The function prototype is:

```
int stringcompare (char * a, char * b);
```

Problem 6-2 ID # ____________________________

a) Describe the steps involved in handling an event indicated by an interrupt.
b) Describe the steps involved in handling an event using polling.
c) When would one employ interrupts compared to polling? Compare the two approaches.

Problem 7-2 ID # ________________________

Consider the following sorting algorithm. Loop through the list of input items, inserting each item in turn into an ordinary binary search tree. Then, perform an in-order traversal of the tree, and output the items in in-order. Find the worst-case and best-case running time of the algorithm.

Problem 8-2 ID # ____________________________

Define process synchronization. What are the two conditions (correctness properties) that a lock implementation needs to satisfy?

Problem 9-2 ID # ________________________

Singular value decomposition refers to a factorization of an $m \times n$ matrix A into a matrix product $U\Sigma V^T$, where U is an $m \times m$ orthogonal matrix, V is an $n \times n$ orthogonal matrix, and Σ is an $m \times n$ matrix whose off-diagonal entries are all zeros and whose diagonal elements (singular values) satisfy $\sigma_1 \geq \sigma_2 \geq \cdots \geq \sigma_n \geq 0$. Let

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

(a) Find the eigenvalues of $A^T A$.

(b) Compute the singular values and the singular value decomposition of A.

Problem 10-2 ID # ______________________

1. a) When a MOSFET is "turned-on" (e.g., $V_{GS} > V_{TN}$ for the *n*-channel MOSFET) and able to conduct current, the silicon layer immediately beneath the gate oxide (or silicon-dioxide/silicon interface) is described as being in a) *accumulation*, b) *depletion*, or c) *inversion* (circle one).

b) Recall that for an *n*-channel MOSFET operating in the linear region, the drain current is described by

$$i_{DS} = \mu_n C''_{ox} \frac{W}{L}\left(v_{GS} - V_{TN} - \frac{v_{DS}}{2}\right)v_{DS}$$

for $v_{GS} - V_{TN} \geq v_{DS} \geq 0$. Terms within the drain current expression can be rearranged to show how drain current is determined by the average charge per unit length in the channel times the drift velocity of electrons in the channel:

$$i_{DS} = (\text{avg. charge per unit length}) \times (\text{drift velocity})$$

Which terms in the linear-region i_{DS} expression describe drift velocity? Recall that $v_x(x) = -\mu_n E_x$.

$\lvert v_x \rvert =$

Problem 11-2 ID # ____________________________

A three-phase, balanced induction machine is connected to rated supply. The synchronous speed of this machine is 1800 rpm. The parameters of its Thevenin equivalent circuit (for one-phase) under rated supply is given as:

$$V_{th}=250\text{V},\ R_{th}=0.10\ \Omega,\ X_{th}=0.30\ \Omega,\ R'_2=0.05\ \Omega,\ X'_2=0.35\ \Omega$$

Determine:

1) Draw the Thevenin equivalent circuit (for one-phase).
2) The maximum torque the machine can develop.
3) The speed at which the maximum torque is developed.
4) The startup torque.
5) The external resistance required in each rotor phase, if the maximum torque is to occur at start. Assume a turns ratio (stator to rotor) of 1.5.

Needed equations (for one-phase):

$$\omega_{syn} = n_s \frac{2\pi}{60}$$

$$T_{mech} = \frac{1}{\omega_{syn}} \frac{V_{th}^2}{(R_{th} + R'_2/s)^2 + (X_{th} + X'_2)^2} \frac{R'_2}{s}$$

$$s_{T_{\max}} = \frac{R'_2}{\sqrt{R_{th}^2 + (X_{th} + X'_2)^2}}$$

$$T_{\max} = \frac{1}{2\omega_{syn}} \cdot \frac{V_{th}^2}{R_{th} + \sqrt{R_{th}^2 + (X_{th} + X'_2)^2}}$$

A three-phase, balanced induction machine is connected to rated supply. The

Problem 12-2 ID # ___________________________

2) A uniform plane wave with

$E_i(z,t)=a_z E_{io} \cos\omega(t-z/u_p)$

In medium 1 (ε_1, μ_1) is incident normally onto a lossless dielectric slab (ε_2, μ_2) (medium 2) of thickness d backed by a perfectly conducting plane find:

a) $E_r(z,t)$
b) $E_1(z,t)$
c) $E_2(z,t)$
d) Poynting vector in media 1 and media 2
e) Determine the thickness d that makes $E_i(z,t)$ the same as if the dielectric slab were absent.

Problem 13-2 ID # ____________________________

What are the 2 essential stages of an FM slope detector and then describe how the slope detector can demodulate the following FM signal.

$$x_C(t) = A_C \cos[2\pi f_C t + \frac{f_\Delta}{2\pi} \int_t x(\lambda) d\lambda]$$

2b. You have a superhetrodyne receiver with $f_{IF} = 100$ MHz and $f_{LO} = 50$ MHz. The local oscillator has a 4th harmonic too. You can assume the receiver has a wideband front end. What input frequencies will the receiver pick up? Justify your answer.

2c. Answer, define or explain the following:

(1) The Hartley-Shannon Law

(2) What stage in a receiver is used to reject adjacent channel interference?

(3) List methods for multiple access to a channel (i.e. more than one user).

Problem _-_ ID # ___________________________