CSE-40534 HW #1 *Dr. Izadi*

Name: ____

Problem 1 (15 Points)

a. Three fundamental terms used in this course are *fault, error,* and, *failure.* In one to three sentences, clearly distinguish these terms from each other.
b. What is the difference between a *permanent fault,* an *intermittent fault*, and a *transient fault* in term of fault duration?
c. Comment on the following statement with justification. Single faults can cause multiple bit errors and multiple faults can cause single error.
d. Comment on the following statement with justification. A fault-tolerant system necessarily has a high reliability.
e. Define the following: *reliability, availability, safety*, and *performability*. Does a system with a high availability necessarily have a high reliability?

Problem 2 (15 Points)

Design a one-bit 5MR voter using basic gates.

Problem 3 (20 Points)

A cyclic code is to be based on the Generator polynomial $X^8 + X^6 + X^5 + X^3 + 1$. Show the logic diagram for the code encoder.

a. Generate a codeword for the input data 10101.
b. Using logic gates, design an appropriate encoder and decoder the given cyclic code.

Problem 4 (20 Points)

A 2M X 16 memory system is design using 1 M X 4 chips. Assume chip failure modes are single-bit cell (50%), single-row all-0's (20%), single-column all-0's (20%), and whole-chip all-0's (10%). Also, assume 0 and 1 values are equally likely. Compare and comment on relative performance (single-error-detection coverage) and overhead of the following approaches.

a. Bit per chip
b. Bit per multiple chips
c. Duplication
d. Single precision checksum (one sum for the entire memory).

Problem 5 (10 Points)

a. Draw a block diagram showing the overall structure of a reconfigurable NMR system (i.e. N-modular redundancy with spares) based on hybrid redundancy. Briefly explain how the system tolerates fault.
b. Compare and contrast hybrid redundancy with active redundancy scheme. Discuss the main advantages and disadvantages of the two methods.

Problem 6 (15 Points)
Consider a random-access memory that has a word format $X_7 X_6 X_5 X_4 X_3 X_2 X_1 X_0$ of size 8 bits. We want to use Hamming code to correct any single bit in this memory.

a. Show the circuitry that generates the syndrome.
b. Determine the error-free syndrome as well as resulting syndrome for each single-bit error in $X_7 X_6 X_5 X_4 X_3 X_2 X_1 X_0$.
c. Explain how you would modify the scheme in order to obtain a single error correction / double error detection code.

Problem 7 (15 Points)
Transform the circuit with the function $F = A\overline{B} + C$ into a self-dual circuit with the additional input D.

Problem 8 (20 Points)
In class we discussed that residue-3 code can be calculated using successive module-3 additions. Based on this technique, how do you obtain residue-7 check bits of $X_7 X_6 X_5 X_4 X_3 X_2 X_1 X_0$? What is the theoretical base for this easy encoding process. Hint: use the weights of bit groups.

Problem 9 (20 Points)
Using the combinatorial model, determine the reliability of a simplex, TMR, and 5MR systems as a function of reliability of a simplex system, R(t) . You may assume a fault-free voter. Plot the reliability of the three systems versus R(t) and comment on their relative reliabilities.

Problem 10 (20 Points)
Using Markov model, determine both discrete and continues-time solution for the reliability of a TMR system with λ failure rate and μ repair rate. You may assume that the system initially is fault free.

Due October 23, 2002