| Course: Digital Systems Design | | Course Number: COEN312/1 | Section: CC |
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| Examination: Midterm | Date: Aug. 14, 2009 | Time: 3 hours | # of pages: 2 |
| Instructor: Dr. M.R. Soleymani | | | |
| Books and Material: No material, no calculator allowed (only one crib sheet) | | | |
| Special Instructions: Try all questions. | | | |

1) Using Boolean Algebra minimize:

   a) $F_1 = ABC' + A'BC + ABC + A'BC'$ (1 Marks)

   b) $F_2 = (A + B' + C')(A' + C')$ (1 Marks).

2) Find the complement of the following function and implement it using NOR gates only:

   $$F = (w'x + yz)u' + u \qquad \text{(3 Marks).}$$

3) Using only three half adders, implement the following four functions (3 Marks):
   a. $F_a = X \oplus Y \oplus Z$
   b. $F_b = X'YZ + XY'Z$
   c. $F_c = XYZ' + (X' + Y')Z$
   d. $F_d = XYZ$.

4) For the function $F(A,B,C,D) = \sum(0,2,3,8,10)$ :
   a. List all *prime implicants* and *essential prime implicants* (show them on a K-map and give their algebraic expression (3 Marks).
   b. Find the minimal sum of products expression for F (2 Marks).
   c. Find the minimal product of sums expression for F (2 Marks).

5) Using a decoder and minimal additional gates the function $y = 2x^2 + 3$, where $x$ is a 3-bit binary number (5 Marks).

6) Design a circuit that generates even parity for a 4-bit input:
   a. Using a multiplexer (4 Marks).
   b. Using exclusive-OR gates only (1 Mark).

7) In the circuit shown in Figure 1, the propagation delay of a NOR gate is 15 ns and the propagation delay of and inverter is 10 ns.
   a. Find the propagation delay of the longest path through the circuit (1 Marks).
   b. Assume that the inputs are A=B=C=D=E=1. What is the output? (1 Mark)
   c. Assume that at time $t_0$ the inputs B and C drop to zero. Draw the signal at different points of the circuit including F (4 Marks).

Figure 1

8) Consider the following vending machine. The machine sells jawbreaker candy bars at 25 ¢ a bar. The machine accepts N (nickels=5 ¢D (dimes=10 ¢), and Q (quarters=25 ¢). When the sum of coins inserted is equal or more than 25 ¢, the machine dispenses one jawbreaker by making DJ equal to one an returns to its initial state. No change is returned. DJ=0 for all other states. If anything less than 25 ¢ is inserted and the CR (Coin Return) pushbutton is pushed, then the coins deposited are returned through the coin return slot by making RC equal to 1, after which the machine returns to its initial sate. RC equals zero in all other states.
   a. Find the state diagram of the machine. Use Moore outputs for your design (4 Marks).
   b. Design the sequential circuit for the above state machine. Use 1-hot state assignment, D flip-flops, AND gate, OR gates and inverters (6 Marks).

9) Using JK flip-flops design a synchronous counter that counts 0, 1, 2, 4, 5, 7, 0 … (5 Marks).

10) Consider a $256 \times 8$ ROM chip with an enable input:
   a. How many address lines are needed? How many data lines are needed? (1 Mark)
   b. Construct a $1K \times 16$ ROM using the above chip: find the number of chips, the size of the decoder and show the external connections (3 Marks).