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CLA CS-450
Computer Architecture

Fall 1994 Quiz ONE
10/04/94 – 11:10 AM

Total Time: 75 minutes | **Open Book** | **Total Pts: 110/100**

Please write your full name and your login name on your blue book and then proceed to solve as much as you can from the following 4 problems:

a. Given the following boolean function:

$$F(w, x, y, z) = \sum(2, 3, 4, 5, 6, 7, 11, 14, 15)$$

1. Show the 4-variable map of the above function. **(8 pts)**
2. Minimize the above function in the sum-of-products normal form. **(8 pts)**
3. Minimize the above function in the product-of-sums normal form. **(8 pts)**
4. What is the least number of transistors needed to realize the function, assuming a CMOS VLSI technology. **(8 pts)**

b. Derive the state diagram and state table of a circuit featuring one input line, Y (in additon to the clock input). The circuit has one output Z, which is to be 0 unless the input has been stable (i.e. either 0 or 1) for the most recent three consecutive clock tics. The following is an example of a Y signal and the corresponding Z signal.

```
Clock:     0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9

   Y: .... 0 1 0 1 1 1 0 1 1 1 1 1 1 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 1 1
   Z: ............ 0 1 0 0 0 1 1 1 1 0 0 0 0 0 1 1 0 0 0 1 1 1 1 1 0 0
```

1. Show the state diagram and state table of your circuit. **(15 pts)**
2. Also, show a minimized realization using D flip-flops. **(15 pts)**

c. Design a combinational circuit that accepts 4 binary inputs: a, b, c, and d and produces a 2-bit integer $X = x_1x_0$ such that X equals the number of inputs equal to 1. For example, if a, b, c, and d are equal to 1, 0, 0, and 1, respectively, then $x_1 = 1$ and $x_0 = 0$ (i.e. $X = 2$).

1. Show the truth table of the circuit. **(12 pts)**
2. Show a minimized implementation using *only* NAND gates. **(12 pts)**

d. Answer the following questions:

1. Construct a 16-to-1 line multiplexer using only 4-to-1 line multiplexers. **(8 pts)**
2. What is the value of the following binary numbers if the 2's-complement representation system is used? **(8 pts)**
   a = $(00101011)_2$ b = $(01100111)_2$ c = $(11100101)_2$ d = $(10001110)_2$
3. In the above question, what would be the binary representation of $a + b$, $c - b$, and $c - d$? Identify any overflow or underflow conditions. **(8 pts)**

Good Luck!