Design of Digital system: 2012 spring Midterm

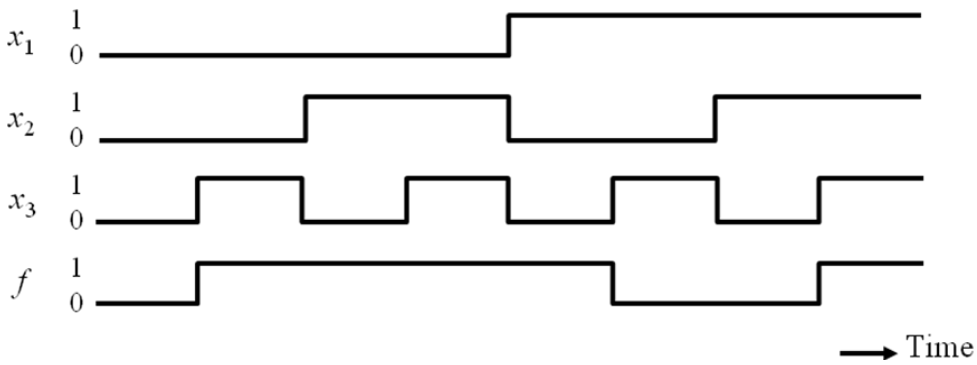
May 02, 2012

Close book, 140 minutes (PM 1:10~PM 3:30)
Prime and unprimed inputs are available for all logic gate design.

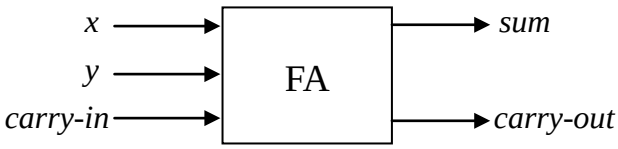
1. Finish the following arithmetic operations in binary with eight-bit 2's complement numbers. Verify your answers by converting back to decimal numbers. If not correct, why?
   (a) (–32) + (–72) (6%)
   (b) (+96) – (–41) (6%)

2. (a) Implement the following Boolean function *F*, which has the don't care conditions *d*, using AND-NOR logic design. (10%)
   $F(A, B, C, D) = \sum(0, 3, 4, 5, 7, 9, 11)$
   $d(A, B, C, D) = \sum(8, 12, 13, 14)$
   (b) Express another function $G = BC' + C'D' + A'CD + AB'D$ using Karnaugh map. Can *G* be used to implement *F*? Is G equivalent to your implementation in (a)? (10%)

3. For the timing diagram as below, design a minimized combinational circuit to implement the function $f(x_1, x_2, x_3)$ <u>with NAND gates only</u>. (18%)
   (Hint: You need to specify the truth table first.)



4. Suppose you want to determine how many bits in a six-bit unsigned number are equal to one and you only have a lot of full adders (FA) for implementation. Design the simplest circuit that can accomplish this task. Note that clear definition of inputs and outputs in your circuit is necessary. (20%)



5. Construct a 5-to-32 decoder with no more than four 3-to-8 decoders with enable and a 2-to-4 decoder. Use block diagrams for these provided components. Note that you have to briefly explain how your design works. (15%)

6. In addition to the BCD code, 2-4-2-1 code listed below is also a useful coding to represent decimal digits in self complementing manner. Please design a function F to check if the decimal input encoded by 2-4-2-1 code can be exactly divided by three. In other words, $F = 1$ if and only if the reminder of the division by 3 is zero. Make the truth table of this function and design the two-level NOR-NOR network with minimum number of logic gates and literals. Note that the input code words (a, b, c, d) and their complements can be used directly as fan-in in the logic circuit. (15%)

Decimal digit	8-4-2-1 Code (BCD)	2-4-2-1 Code
0	0000	0000
1	0001	0001
2	0010	0010
3	0011	0011
4	0100	0100
5	0101	1011
6	0110	1100
7	0111	1101
8	1000	1110
9	1001	1111