Northwestern University
Electrical Engineering and Computer Science
EECS303: Advanced Digital Design, Fall 11
Prof. Hai Zhou

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Handout #8
Due: Nov 1

Homework 3

You may discuss the assignments with your classmates but need to write down your solutions independently. Be careful with your handwriting. Unclear solutions will be assumed wrong.

1. (10 pts) The following binary numbers have a sign in the leftmost position and, if negative, are in 2s complement form. Perform the indicated arithmetic operations (show your work) and verify the answers.
   (a) $100111 + 111001$
   (b) $001011 + 100110$
   (c) $110001 - 010010$
   (d) $101110 - 110111$

2. (25 pts) Design a LCM machine which is a sequential circuit that compute the Least Common Multiple of two 4-bit unsigned numbers a and b, using the following algorithm:

   $x, y, u, v := a, b, a, b$
   do
   $\quad x > y \rightarrow x, u := x - y, u + v$
   $\quad y > x \rightarrow y, v := y - x, v + u$
   od
   output $((u + v)/2)$;

   The available basic elements include full adders, D flip-flops, and multiplexers, in addition to Boolean gates. Assume that each basic element takes 1 unit of time, what is the minimum clock period you can use.

3. (15 pts) Design a combinational circuit that compares two 4-bit unsigned numbers A and B to see whether B is greater than A. The circuit has one output X, such that $X = 1$ if and only if $A < B$.

4. (25 pts) Design a sequential multiplier that multiplies two 4-bit unsigned numbers A and B. The available basic elements include one 4-bit adder, D flip-flops, and multiplexers, in addition to Boolean gates. Assume that each basic element takes 1 unit of time, what is the minimum clock period you can use.

5. (25 pts) Implement to the gate and full adder level an ALU bit slice with three operation selection inputs S_2, S_1, S_0, that implements the following eight functions of

the two data inputs A and B (and carry-in C_i):

S_2	S_1	S_0	ALU operation
0	0	0	$F_i = 0$
0	0	1	$F_i = B - A$
0	1	0	$F_i = A - B$
0	1	1	$F_i = A + B$
1	0	0	$F_i = A\,\textsc{xor}\,B$
1	0	1	$F_i = A\,\textsc{or}\,B$
1	1	0	$F_i = A\,\textsc{and}\,B$
1	1	1	$F_I = 1$