CMSC 313 HW4
Due 3/7/2024 11:59pm

Please submit the completed homework through Blackboard.

There are two 4-bit unsigned values A ($A_3A_2A_1A_0$) and B ($B_3B_2B_1B_0$) provided as input with a maximum value of 7. So A_3 and B_3 will be 0.
The objective of this homework is to determine the equations for two output bits ZF and SF. The ZF bit should be 1 if A==B. The SF bit should be 1 if B>A.

The homework can be broken down into the following steps:
1. Calculate the equations for determining the 1's complement of B. The inputs of this step are $B_3B_2B_1B_0$ and the outputs of this step are $O_3O_2O_1O_0$. Hint: O_0 only depends on B_0, O_1 only depends on B_1, etc. It is not necessary to do truth table.
2. Calculate the equations for determining -B. This is the 2's complement of B. The inputs of this step are $O_3O_2O_1O_0$ and the outputs of this step of $N_3N_2N_1N_0$. The 2's complement of a number is found by adding 1 to the 1's complement of the number. So we are adding $O_3O_2O_1O_0$ and 0001. Refer to the below table from the first lecture about adding 2 numbers. For the first bit, the input A in the table is O_0 and the input B in the table is 1. The sum is N_0. N_0 is 1 if O_0 is 0. The carry-out C_1 is 1 if O_0 is 1. For the second bit, the input A in the table is O_1 and the input B in the table is C_1. The sum is N_1. N_1 is 1 if $O_1C_1' + O_1'C_1$. C_2 is 1 if O_1C_1. Similarly, calculate the equations for N_2, C_3, N_3. The equations can be left as function of the inputs of this step ($O_3O_2O_1O_0$); it is not necessary to calculate them as function of B ($B_3B_2B_1B_0$).

A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

3. Calculate A-B. The inputs for this step are A ($A_3A_2A_1A_0$) and -B ($N_3N_2N_1N_0$). The outputs for this step are S ($S_3S_2S_1S_0$). For the first bit, the input A is A_0 and the input B is B_0. The sum S_0 is 1 if $A_0B_0' + A_0'B_0$ from the table above. The carry-out C_1 is 1 if A_0B_0. For the second bit, however, there are 3 inputs: A_1, B_1, C_1. We have to use the full adder to calculate the sum and carry-out. Refer to the table that we studied in the first lecture below. In our case, the input A is A1, input B is B1 and carry-in input is C1. The sum S1 is 1 if A1 $\oplus$ B1 $\oplus$ C1 (i.e., A1 xor B1 xor C1: odd number of inputs are 1). The carry-out C2 is 1 if A1B1 + A1C1 + B1C1. Similarly calculate S2, C3, S3. The equations can be left as function of the inputs of this step: A and N.

A	B	Carry In	Sum	Carry Out
0	0	0	0	0
0	1	0	1	0
1	0	0	1	0
1	1	0	0	1
0	0	1	1	0
0	1	1	0	1
1	0	1	0	1
1	1	1	1	1

4. Calculate ZF output from S ($S_3S_2S_1S_0$). Write the equation for ZF in terms of the input S.
5. Calculate SF output from S ($S_3S_2S_1S_0$). Write the equation for SF in terms of the input S.