EEE 120

Add_Sub Extra Credit Problem

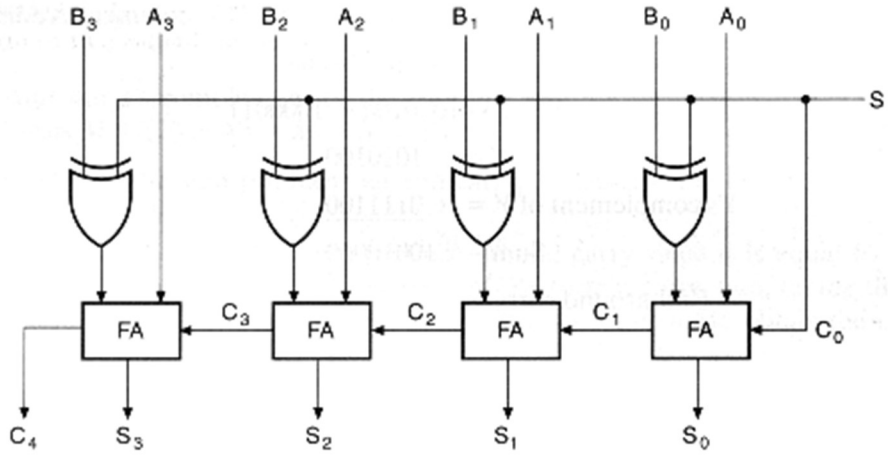
Preliminaries

The Add/Sub circuit you studied in practice problem 10, week 3, is shown below. It adds two 4-bit numbers X and Y. Now, let's assume that the user has two numbers **X and Y that are both positive signed numbers**, one of the following four scenarios might occur:

1. If the required is X + Y, then the user inputs **X to the A** input and **Y to the B** input and set the circuit to ADD (i.e. S=0).
2. If the required is X – Y, then the user inputs **X to the A** input and **Y to the B** input and set the circuit to SUB (i.e. S=1).
3. If the required is –X + Y, then the user inputs the **2's complement of X to the A** input and **Y to the B** input and set the circuit to ADD (i.e. S=0).
4. If the required is –X – Y, then the user inputs the **2's complement of X to the A** input and the **2's complement of Y to the B** input and set the circuit to ADD (i.e. S=0).

Note the following two facts:

1. In the 3rd and 4th scenario, taking the 2's complement is done by hand first (i.e. the user has to take the 2's complement before feeding the number to the circuit).
2. In the third scenario, while the user could avoid taking the 2's complement (by converting **–X + Y** to **Y – X** and thus applying the second scenario), taking the two's complement is inevitable in the fourth scenario.



Required

In this problem we want you to remodel this Add/Sub circuit such that the user doesn't have to take the 2's complement at all neither in third nor in the fourth scenario. In other words, we want the machine to perform the following: **Assuming X and Y are both positive signed numbers**:

1. If the required is X + Y, then the user inputs **X to the A** input and **Y to the B** input and set the circuit to do the operation X+Y.
2. If the required is X – Y, then the user inputs **X to the A** input and **Y to the B** input and set the circuit to do the operation X – Y.
3. If the required is –X + Y, then the user inputs **X to the A** input and **Y to the B** input and set the circuit to do the operation –X + Y.
4. If the required is –X – Y, then the user inputs **X to the A** input and **Y to the B** input and set the circuit to do the operation –X – Y.

Hints:

1. As opposed to the original circuit where we have one control input S to choose between two operations (Add or Sub), in our circuit we expect to have 2 control inputs SA and SB to choose among the four possible operations.
2. One of the components that you might want to add to your circuit is the incrementer circuit that you built in sim lab S1.
3. You can tackle the problem by dividing it into two tasks:
    a. One that solves the problem of taking the two's complement in scenario 3. Then,
    b. One that solves the problem of taking the two's complement in scenario 4.