4-bit binary adder / subtractor

binary addition

$$\begin{array}{ccccc} & A_3 & A_2 & A_1 & A_0 \\ & B_3 & B_2 & B_1 & B_0 \\ & C_3 & C_2 & C_1 & C_0 (=0) \\ \hline C_4 & S_3 & S_2 & S_1 & S_0 \end{array}$$

(C_{out})

Ex:

$$\begin{array}{r} 1000 \\ 1001 \\ \hline 10001 \end{array}$$

Binary subtraction by 2's complement

$$\begin{array}{ccccc} & A_3 & A_2 & A_1 & A_0 \\ & \bar{B}_3 & \bar{B}_2 & \bar{B}_1 & \bar{B}_0 \\ & C_3 & C_2 & C_1 & C_0 (=1) \\ \hline & S_3 & S_2 & S_1 & S_0 \end{array}$$

Carry neglected

Ex:- Using 1's complement

$$\begin{array}{r} 1001 \\ -\ 1000 \\ \hline \end{array} \Rightarrow \begin{array}{r} 1001 \\ 0111 \\ \hline 1\,0000 \\ +1 \\ \hline 0001 \end{array}$$

positive

0001 result

$$\begin{array}{r} 1000 \\ -\ 1001 \\ \hline \end{array} \quad \begin{array}{r} 1000 \\ 0110 \\ \hline 0\,1110 \\ \hline 0001 \end{array}$$

negative 0001

Result is 1's complement

Using 2's complement

$$\begin{array}{r} 1001 \\ -\ 1000 \\ \hline \end{array}$$

2's complement of 1000 = 0111

$$\begin{array}{r} 0111 \\ 1 \\ \hline 1000 \end{array}$$

$$\begin{array}{r} 1001 \\ +\ 1000 \\ \hline 1\,0001 \end{array}$$

→ result.

positive & neglect

$$\begin{array}{r} 1000 \\ -\ 1001 \\ \hline \end{array}$$

2's complement of 1001 = 0110

$$\begin{array}{r} 0110 \\ 1 \\ \hline 0111 \end{array}$$

$$\begin{array}{r} 1000 \\ +\ 0111 \\ \hline 0\,1111 \end{array}$$

Negative result is 2's complement of 1111

$= (-)0001$

Now we implement common circuit for 4 bit binary adder & subtractor.

m = 0 addition

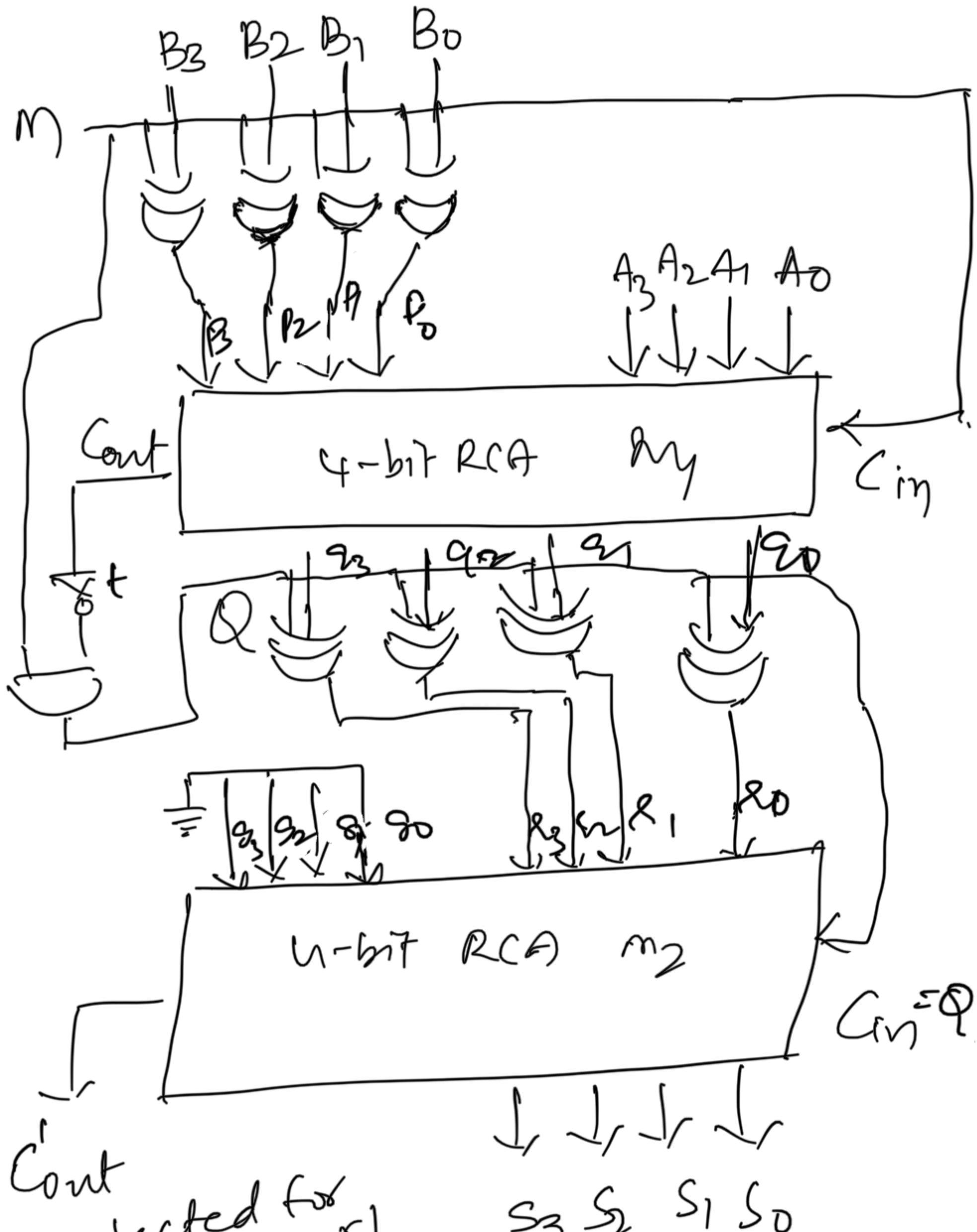
m = 1 subtraction

$A_3A_2A_1A_0$ is common for all

if m = 0 xor gate sends $B_3B_2B_1B_0$

if m = 1 xor gate sends $\bar{B_3}\bar{B_2}\bar{B_1}\bar{B_0}$ (1's complement)

but we want 2's complement so $C_{in} = m$ (= 0/1)



C'_{out} (neglected for subtractor)

consider for addition

M	cout	Q
0	0	0
0	1	0
1	0	1
1	1	0

$Q = M\overline{C_{out}}$