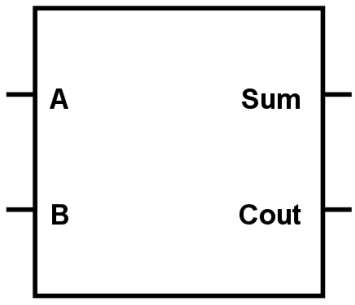
Adding Binary Bits

$$\begin{array}{r} 0 \\ +\ 0 \\ \hline \end{array} \qquad \begin{array}{r} 0 \\ +\ 1 \\ \hline \end{array} \qquad \begin{array}{r} 1 \\ +\ 0 \\ \hline \end{array} \qquad \begin{array}{r} 1 \\ +\ 1 \\ \hline \end{array}$$

$$\begin{array}{r} 5 \\ +\ 4 \\ \hline \end{array} \qquad \begin{array}{r} 5 \\ +\ 5 \\ \hline \end{array}$$

Binary Adders

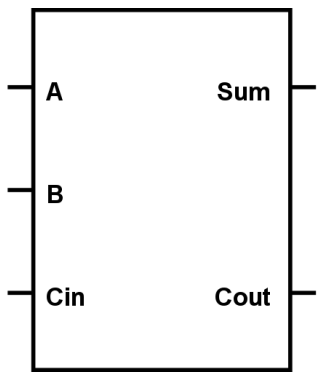


A B	Sum Cout
0 0	
0 1	
1 0	
1 1	

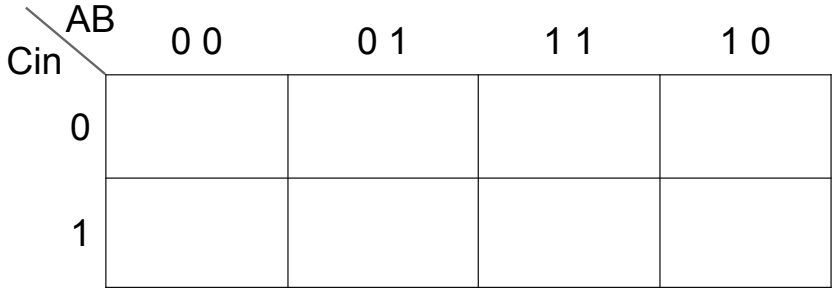
Adding Binary Numbers

0 0 1 0	0 0 1 0	0 1 1 0	0 1 1 0
+ 1 0 0 0	+ 1 1 0 0	+ 1 0 0 0	+ 0 1 0 0
0 0 1 0	0 0 1 0	0 1 1 0	0 1 1 0
+ 1 0 1 0	+ 0 1 1 0	+ 0 0 1 0	+ 0 1 1 0

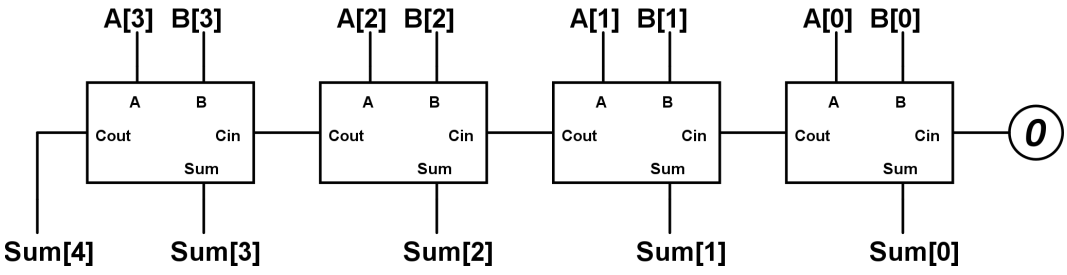
Binary Adders



Full Adder



Bit Slice Adders



Subtracting Binary Numbers

1 0 0	1 0 0	1 1 0
- 0 1 0	- 0 1 1	- 0 1 1

Negative Numbers

Unsigned (only positive)	Signed (positive and negative)
000 =	000 =
001 =	001 =
010 =	010 =
011 =	011 =
100 =	100 =
101 =	101 =
110 =	110 =
111 =	111 =

1's Complement

Positive:	Negative
000 =	111 =
001 =	110 =
010 =	101 =
011 =	100 =

2's Complement

Positive:	Negative:
000 = 0	000 =
001 = 1	111 =
010 = 2	110 =
011 = 3	101 =
	100 =

2's Complement

2's Complement

2		0 1 0		0 1 0
- 2	⇨	- 0 1 0	⇨	+
1		0 0 1		0 0 1
- 3	⇨	- 0 1 1	⇨	+

2's Complement

2's Complement

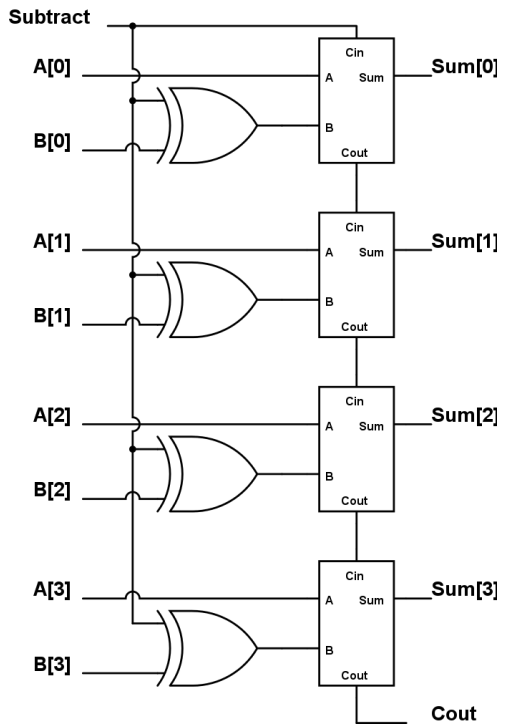
Value	3 bits	4 bits	5 bits
2			
4			
6			
8			
-3			
-4			
-7			
-8			

2's Complement

3 bits
000
001
010
011
100
101
110
111

4 bits	
0000	1000
0001	1001
0010	1010
0011	1011
0100	1100
0101	1101
0110	1110
0111	1111

Adder / Subtractor



Addition / Subtraction Errors

$$\begin{array}{r} 5 \\ +\ 3 \\ \hline 8 \end{array} \quad \Rightarrow \quad \begin{array}{r} 0101 \\ +\ 0011 \\ \hline \end{array}$$

$$\begin{array}{r} 7 \\ +\ 7 \\ \hline 14 \end{array} \quad \Rightarrow \quad \begin{array}{r} 0111 \\ +\ 0111 \\ \hline \end{array}$$

Addition / Subtraction Errors

$$\begin{array}{r} -5 \\ +\ -4 \\ \hline -9 \end{array} \quad \Rightarrow \quad \begin{array}{r} 1011 \\ +\ 1100 \\ \hline \end{array}$$

$$\begin{array}{r} -8 \\ +\ -8 \\ \hline -16 \end{array} \quad \Rightarrow \quad \begin{array}{r} 1000 \\ +\ 1000 \\ \hline \end{array}$$

2's Complement Addition / Subtraction