

Decimal Adder

- Computers or calculators that perform arithmetic operations directly in the decimal number system represent decimal numbers in
 - binary coded form.
- An adder for such a computer must employ arithmetic circuits that accept coded decimal numbers and present results in the same code.
- A decimal adder requires a minimum of nine inputs and five outputs, since four bits are required to code each decimal digit and the circuit must have an input and output carry.
- There is a wide variety of possible decimal adder circuits, depending upon the code used to represent the decimal digits.
- Here we examine a decimal adder for the BCD code.

BCD Adder

- Addition of two decimal numbers $9 + 9 = 18$
- If there is a previous carry $9 + 9 + 1 = 19$
- If we add in binary format
 - We will not be able to display decimal nos. correctly
- Use BCD numbers

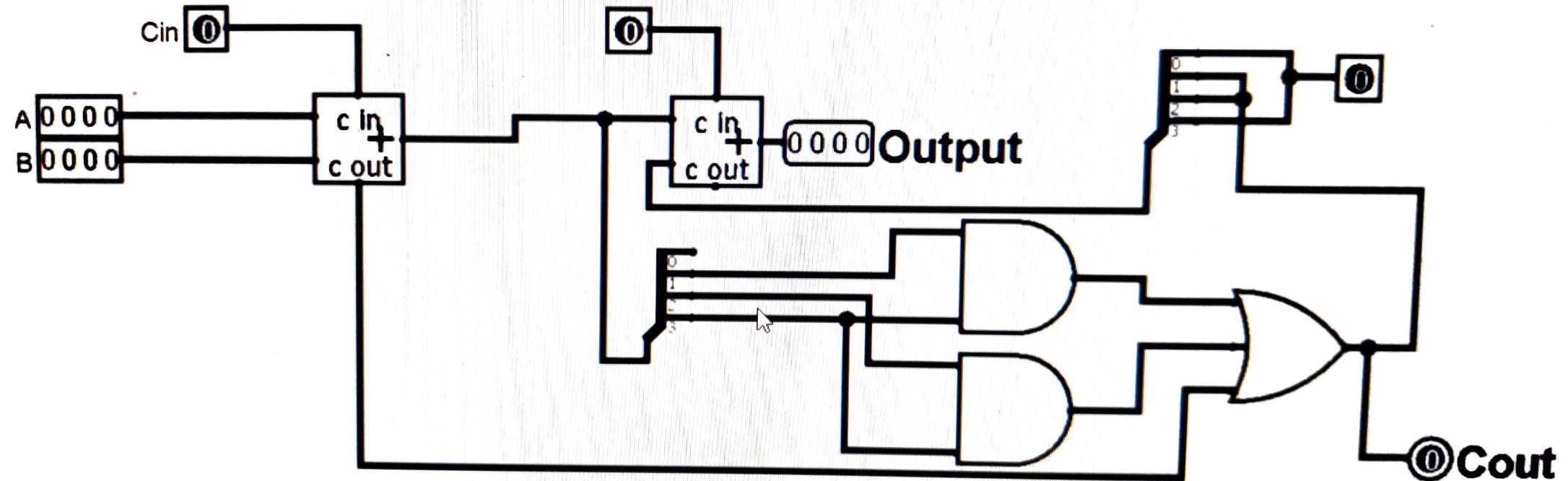
$$\begin{array}{r} & 9 & 1001 \\ & 9 & 1001 \\ + & 1 & \hline 19 & 10011 \\ 1 & 3 & ? \end{array}$$

Decimal	BCD
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

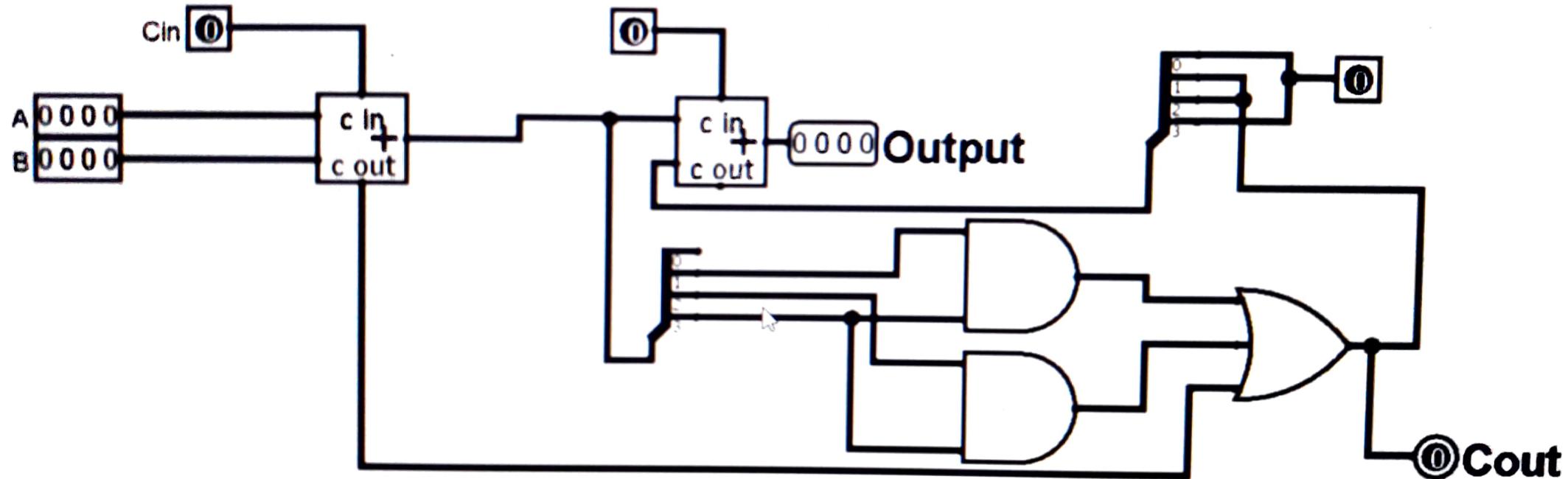
Decimal	Binary					Decimal	BCD				
	K	Z_8	Z_4	Z_2	Z_1		C	S_8	S_4	S_2	S_1
0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	1	1	0	0	0	0	1
2	0	0	0	1	0	2	0	0	0	1	0
3	0	0	0	1	1	3	0	0	0	1	1
4	0	0	1	0	0	4	0	0	1	0	0
5	0	0	1	0	1	5	0	0	1	0	1
6	0	0	1	1	0	6	0	0	1	1	0
7	0	0	1	1	1	7	0	0	1	1	1
8	0	1	0	0	0	8	0	1	0	0	0
9	0	1	0	0	1	9	0	1	0	0	1
10	0	1	0	1	0	1 0	1	0	0	0	0
11	0	1	0	1	1	1 1	1	0	0	0	1
12	0	1	1	0	0	1 2	1	0	0	1	0
13	0	1	1	0	1	1 3	1	0	0	1	1
14	0	1	1	1	0	1 4	1	0	1	0	0
15	0	1	1	1	1	1 5	1	0	1	0	1
16	1	0	0	0	0	1 6	1	0	1	1	0
17	1	0	0	0	1	1 7	1	0	1	1	1
18	1	0	0	1	0	1 8	1	1	0	0	0
19	1	0	0	1	1	1 9	1	1	0	0	1

Decimal	Binary					Decimal	C	BCD			
	K	Z_8	Z_4	Z_2	Z_1			S_8	S_4	S_2	S_1
0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	1	1	0	0	0	0	1
2	0	0	0	1	0	2	0	0	0	1	0
3	0	0	0	1	1	3	0	0	0	1	1
4	0	0	1	0	0	4	0	0	1	0	0
5	0	0	1	0	1	5	0	0	1	0	1
6	0	0	1	1	0	6	0	0	1	1	0
7	0	0	1	1	1	7	0	0	1	1	1
8	0	1	0	0	0	8	0	1	0	0	0
9	0	1	0	0	1	9	0	1	0	0	1
10	0	1	0	1	0	10	1	0	0	0	0
11	0	1	0	1	1	11	1	0	0	0	1
12	0	1	1	0	0	12	1	0	0	1	0
13	0	1	1	0	1	13	1	0	0	1	1
14	0	1	1	1	0	14	1	0	1	0	0
15	0	1	1	1	1	15	1	0	1	0	1
16	1	0	0	0	0	16	1	0	1	1	0
17	1	0	0	0	1	17	1	0	1	1	1
18	1	0	0	1	0	18	1	1	0	0	0
19	1	0	0	1	1	19	1	1	0	0	1

BCD Adder

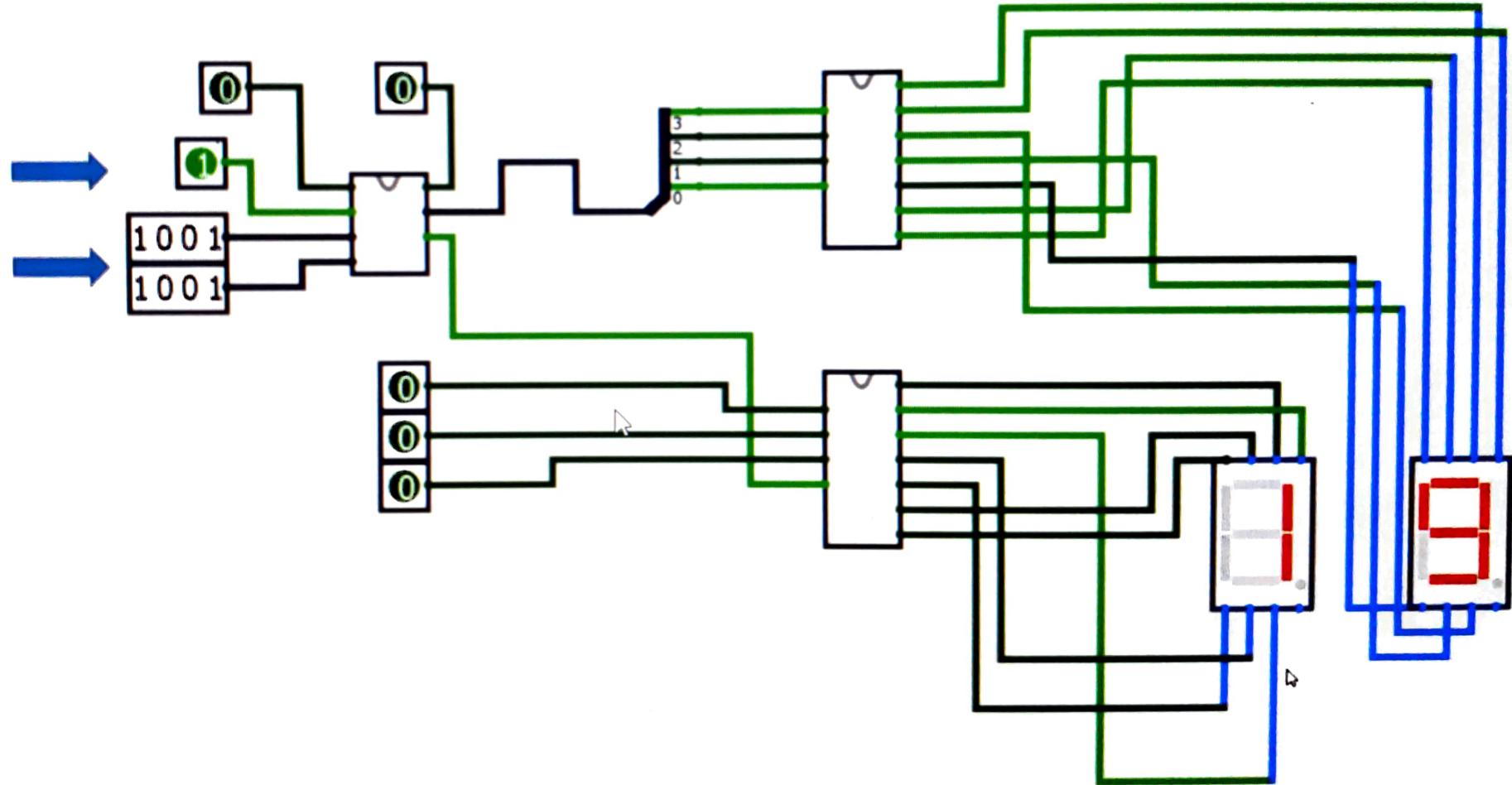


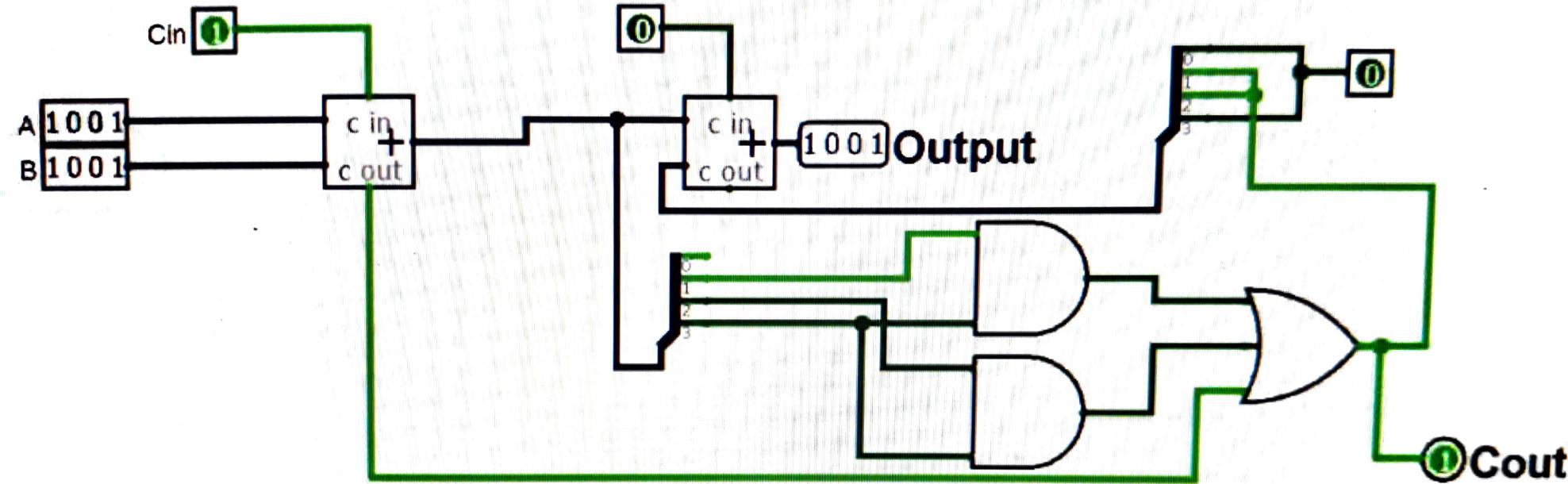
BCD Adder



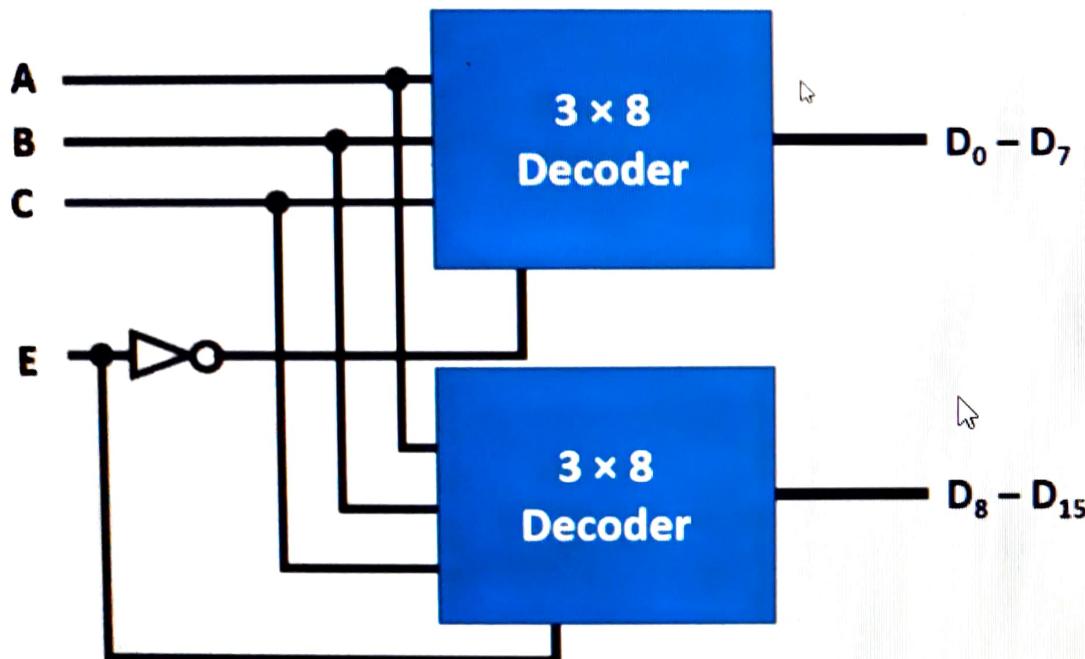
$$C = K + Z_8 Z_4 + Z_8 Z_2$$

BCD Adder





4×16 decoder constructed with two 3×8 decoders



- When $E = 0$, top decoder is enabled
- Minterms from $0000 - 0111$ are generated from the top decoder
- When $E = 1$, Bottom decoder is enabled
- Minterms from $1000 - 1111$ are generated from the bottom decoder

Implementation of a full adder with a decoder

Input			Output	
A	B	C	Carry	Sum
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

Truth table for 3 bit addition

- $\text{Sum}(A, B, C) = \Sigma(1,2,4,7)$
- $\text{Carry}(A, B, C) = \Sigma(3,5,6,7)$

