4. Combinational Logic Circuits (Half Adder, Full Adder), MUX & DEMUX

18 November 2021 09:02

COMBINATIONAL LOGIC CIRCUITS

- Half adder — Addition of 2 bits
- Full adder — Addition of 3 bits

Combinational circuits' output depends on present input only whereas sequential circuits' output depends on the present input as well as the past output.

Eg: Sequential → traffic lights, registers, counters
Combinational → analog signals to digital displays, alarm systems

HALF ADDER

Inputs		Outputs	
A	B	S	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

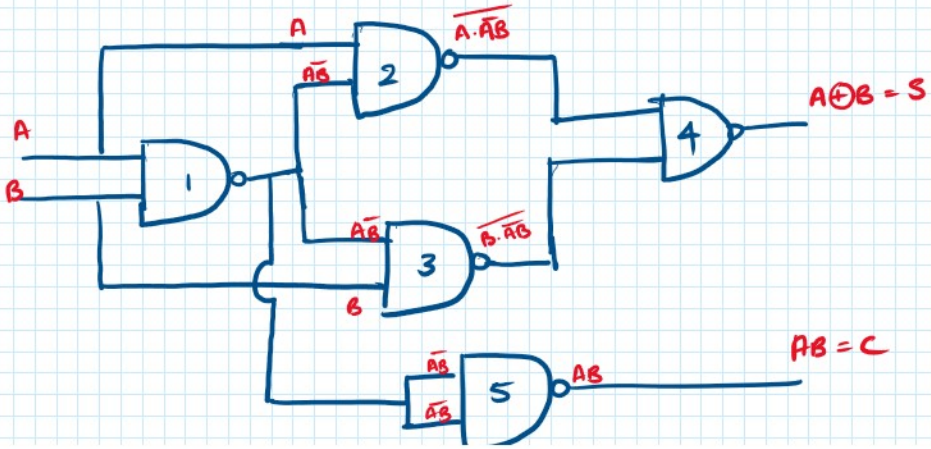
Sum: $\bar{A}B + A\bar{B} = A \oplus B$

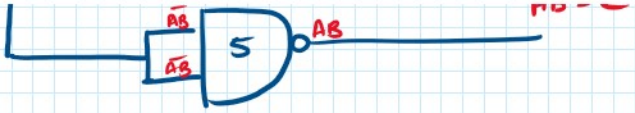
Carry: AB

$$\begin{array}{r} 1 \\ +\ 1 \\ \hline 10 \end{array}$$

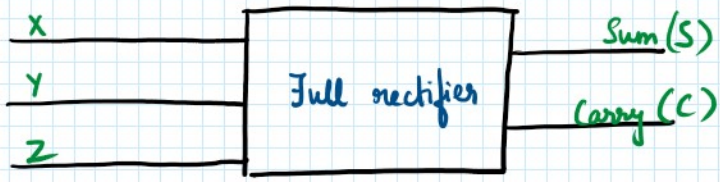
C = 1, S = 0

Half adder using only NAND gates





Full Adder

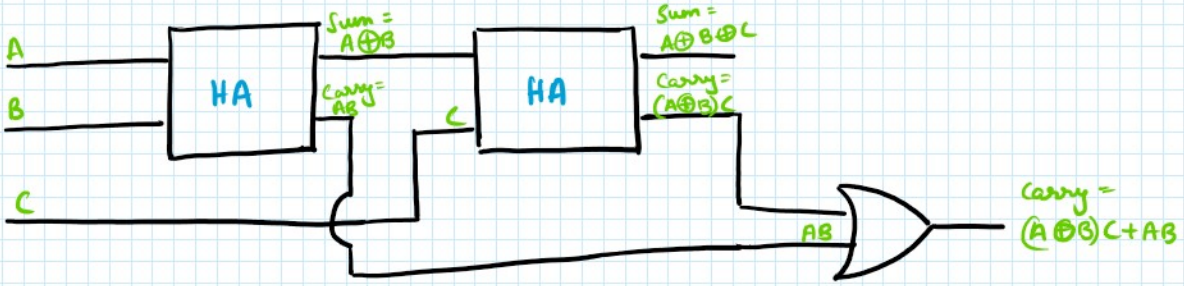


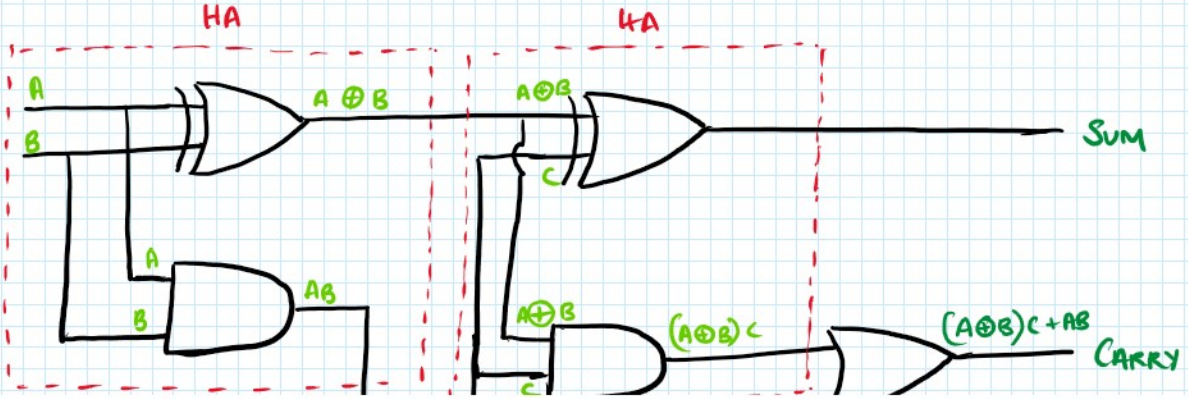
Inputs			Outputs	
X	Y	Z	C	S
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

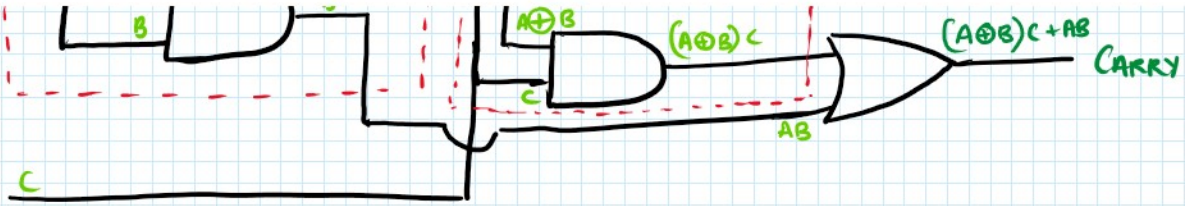
Sum: $\bar{x}\bar{y}z + \bar{x}y\bar{z} + x\bar{y}\bar{z} + xyz = x \oplus y \oplus z$

Carry: $xy + yz + xz = (x \oplus y)z + xy$

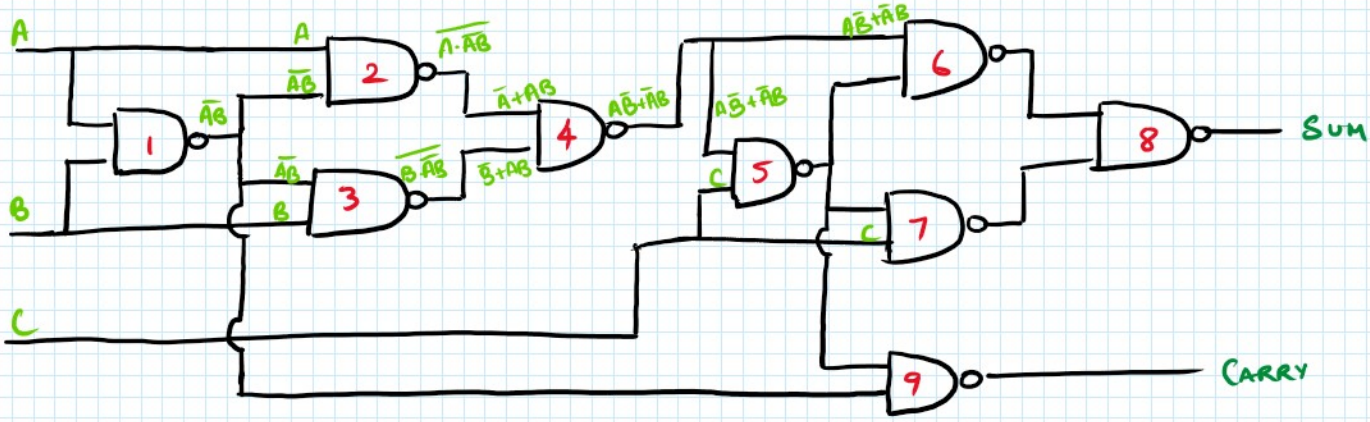
Implementation of full adder using two half adders



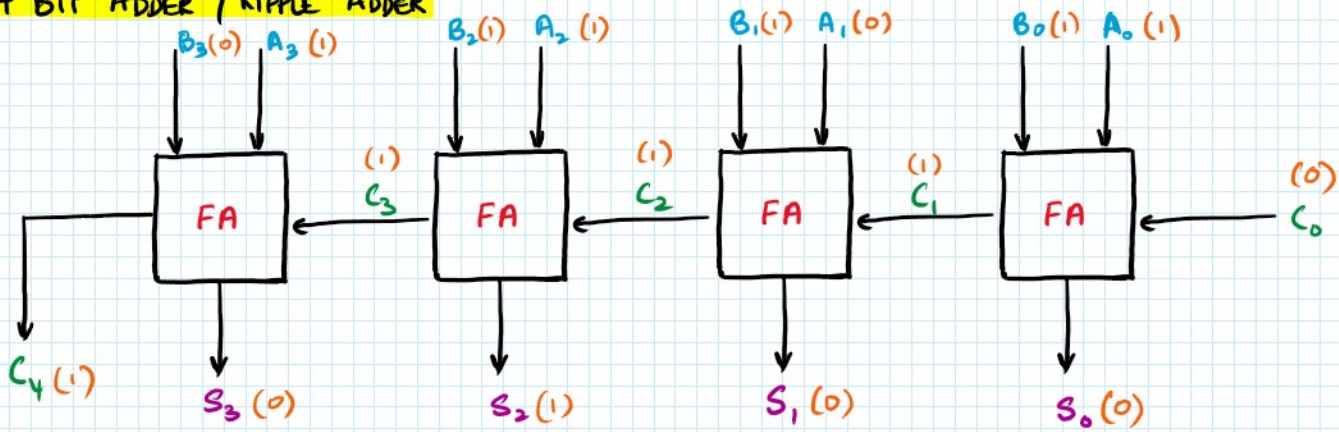




Full adder circuit using only NAND gates



4 Bit Adder / Ripple Adder



	C_3	C_2	C_1	C_0
	1	1	1	0
A =	1	1	0	1
B =	0	1	1	1
	1	0	1	0	0

C_4

Multiplexer & Demultiplexer } Data processing units

→ MUX → DeMUX

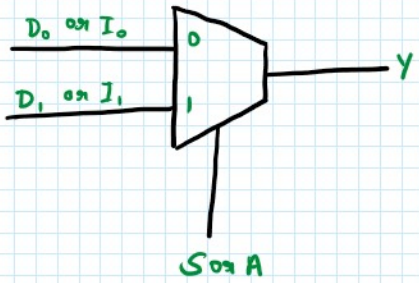
Select line / Control signal

Acts like a token system; controls which input goes through MUX at any time

MUX Input : Output

$2^N : 1$ → select lines

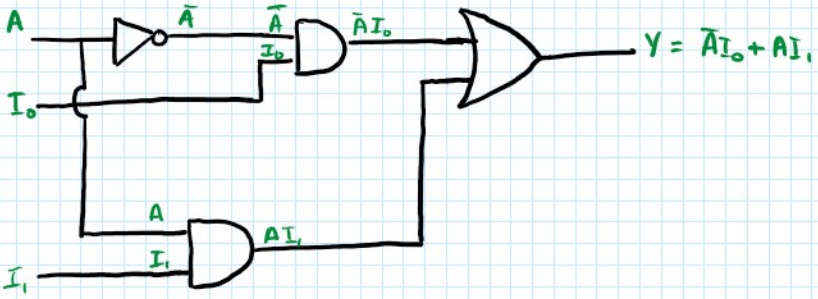
① 2:1 MUX



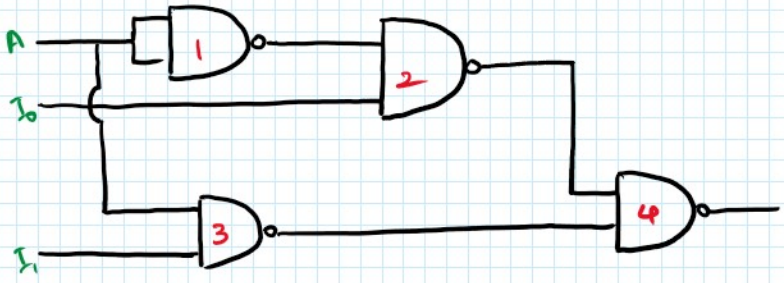
A	Y
0	I_0
1	I_1

$Y = \bar{A} I_0 + A I_1$	
If $Y = 0$, $Y = I_0$	If $Y = 1$, $Y = I_1$

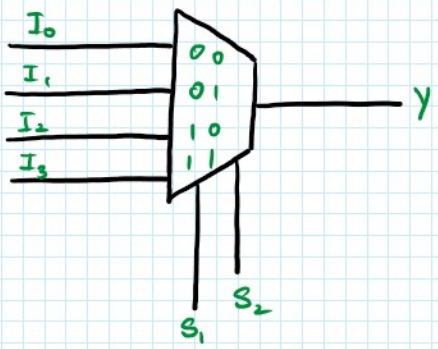
Using basic gates



Using NAND gates



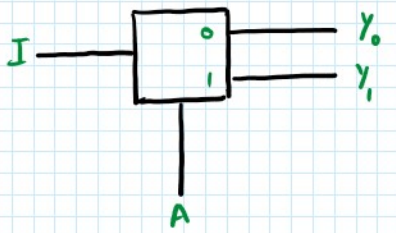
② 4:1 MUX



S_1	S_2	Y
0	0	I_0
0	1	I_1
1	0	I_2
1	1	I_3

$$Y = \bar{S}_1 \bar{S}_2 I_0 + \bar{S}_1 S_2 I_1 + S_1 \bar{S}_2 I_2 + S_1 S_2 I_3$$

③ 1:2 DEMUX

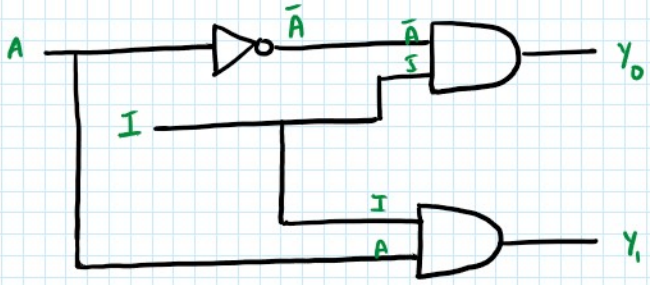


A	Y_0	Y_1
0	I	0
1	0	I

$$Y_0 = \bar{A} I$$

$$Y_1 = A I$$

Using basic gates



Using NAND gates