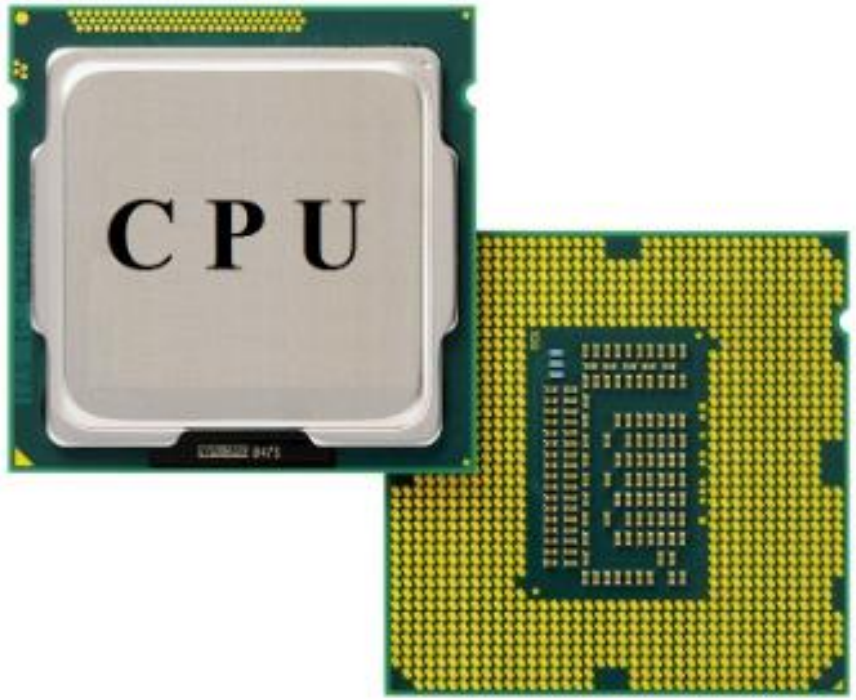
Combinational Logic Circuits

What is a combinational logic circuit

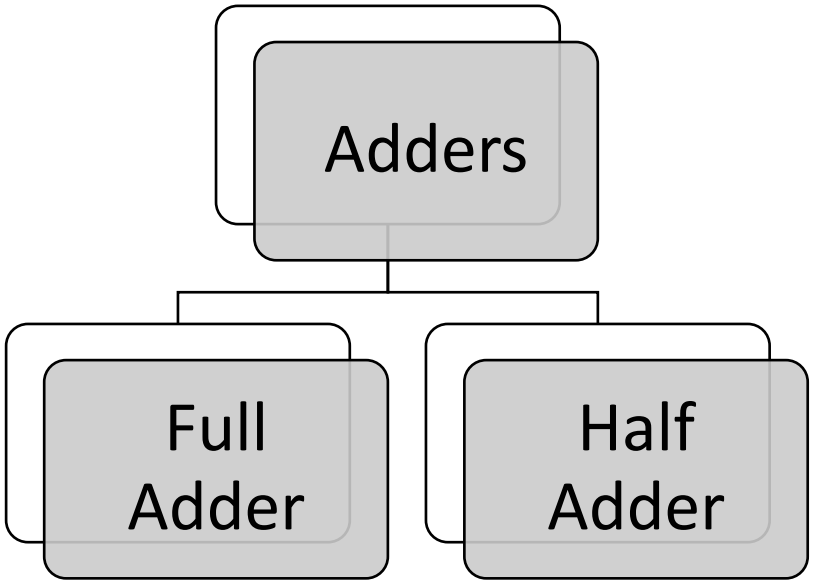
- A combinational logic circuit is a type of digital circuit whose **output is a pure function of the present input** only.
- Unlike sequential circuit combinational logic sate does not have memory element and current state is effect for next state
- **Adders, Subtractors, multiplexer, demultiplexers, encoders and decoders** are the types of combinational log circuits
- **Applications**: ALU (Arithmetic logic unit), Control systems, calculators and inside of computers

Why Adders ?

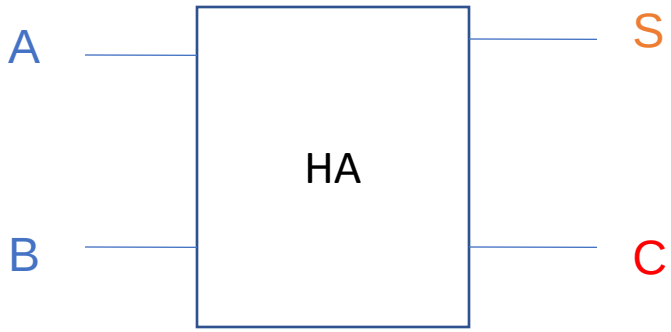


- CPU of a computer contains an arithmetic logic circuit
- It is a combinational circuit that performs arithmetic operations such as +,-, x, ÷

- A adder is used to performed binary numbers addition in a arithmetic logic circuit



Half Adder



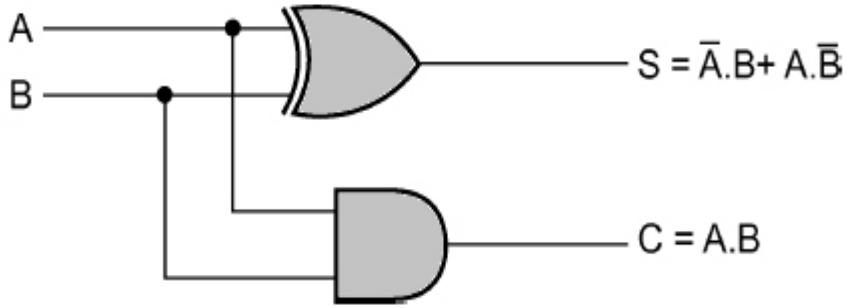
- Use to add two bit binary numbers
- Two bit adder has two inputs and two outputs, sum and carry.

A	B	S	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

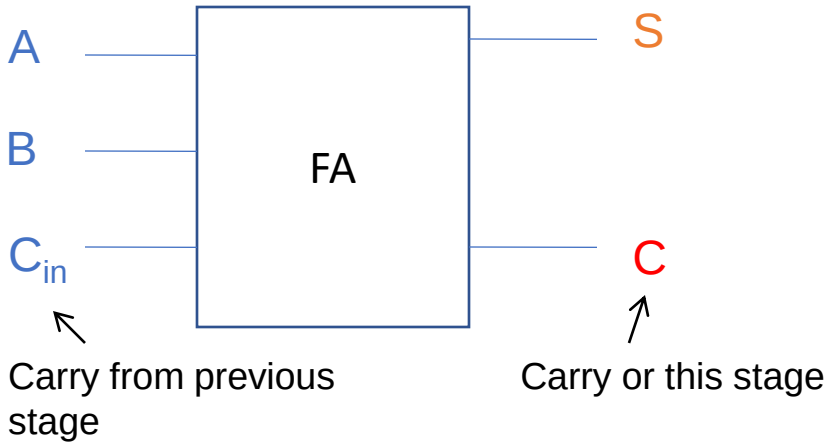
$$\begin{array}{r} 1 \\ +0 \\ \hline 0\ 1 \end{array} \qquad \begin{array}{r} 1 \\ +1 \\ \hline 1\ 0 \end{array}$$

S=A’B + AB’ =A⊕B

C= AB



Full Adder



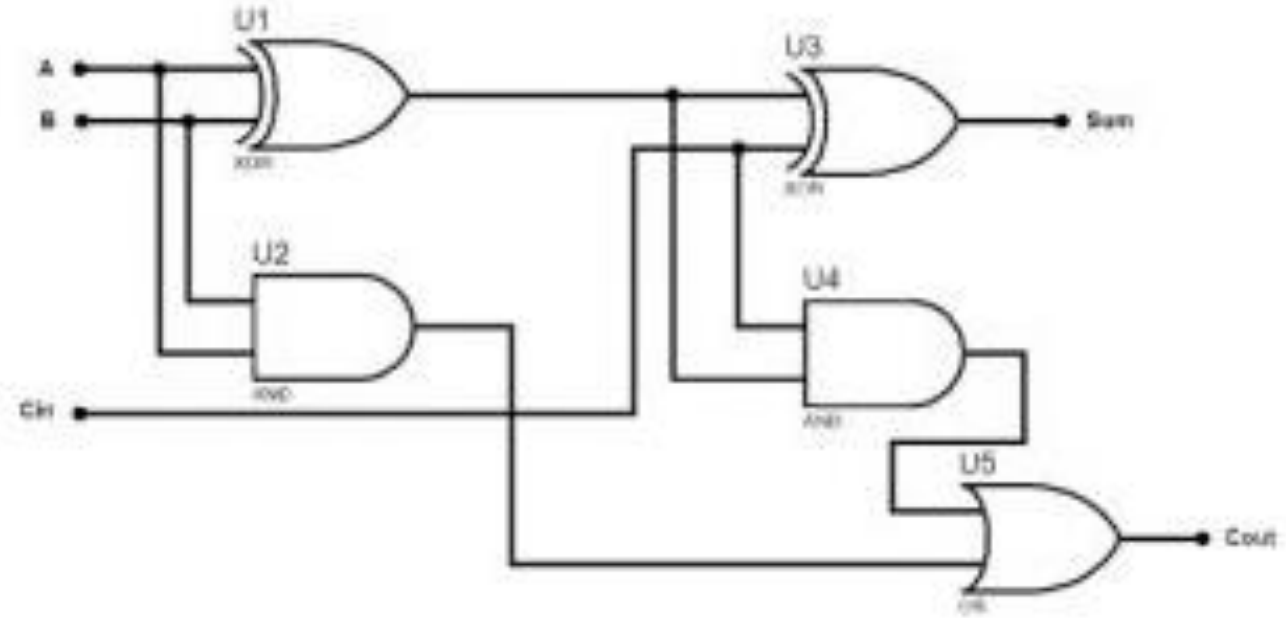
$$\begin{array}{r} 1 \\ 01 \\ +11 \\ \hline 0 \end{array}$$

One that performs the addition of two bits is called a full adder.

C_{in}	A	B	S	C
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

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

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



Full Adder using Two Half Adders

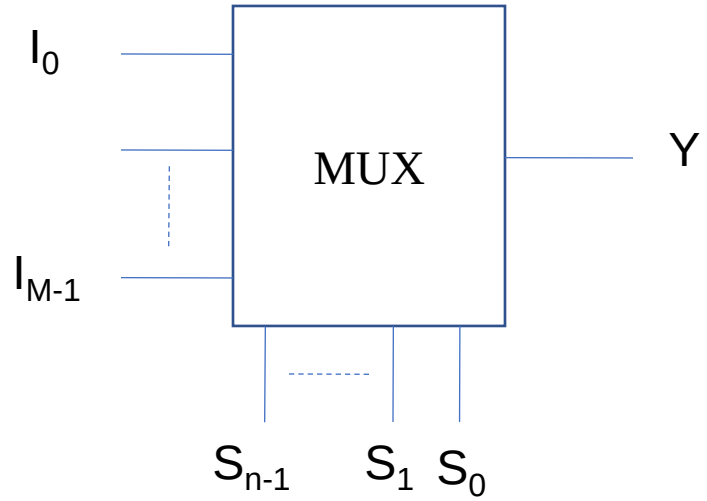
Sum of product for sum and carry bits

$S = A \oplus B \oplus C_{in}$

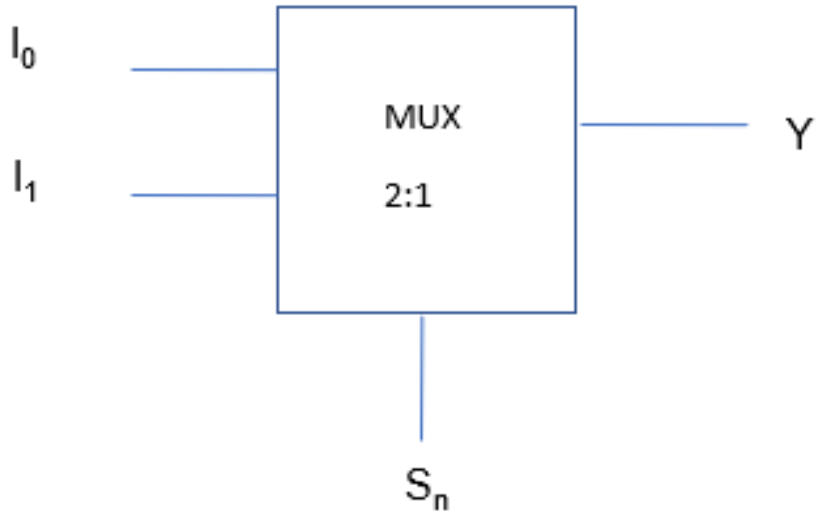
$C = AB + C_{in}(A \oplus B)$

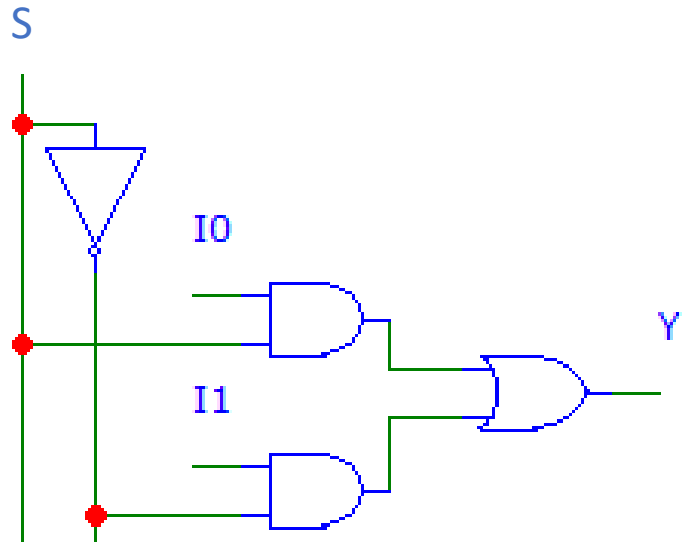
Multiplexer

- Select one binary signal out from many input lines
- During the process of multiplexing select one particular input into output or multiplexed out put
- This process is happening according to selection lines
- The amount of input lines are denoted by “M” and these M number of lines are controlled by “n” selection lines
- $M = 2^n$ M- Input lines n- selection lines
- $n = \log_2 M$



2:1 MUX

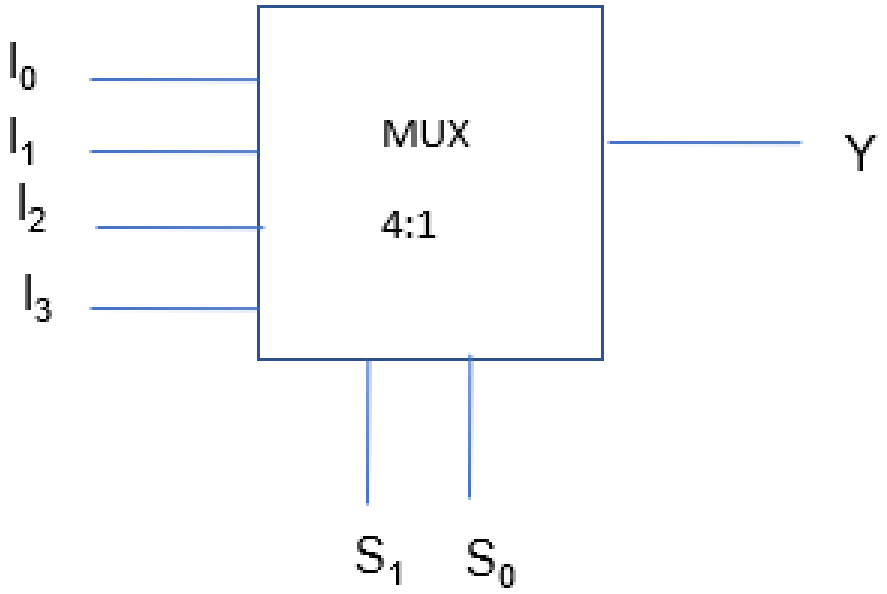




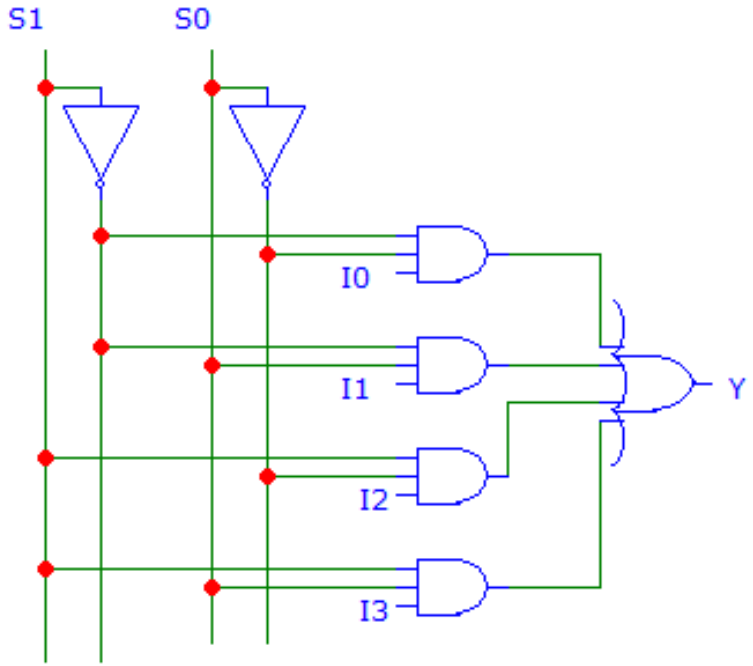
S_n	Y
0	I_0
1	I_1

$$Y = SI_0 + \overline{S}I_1$$

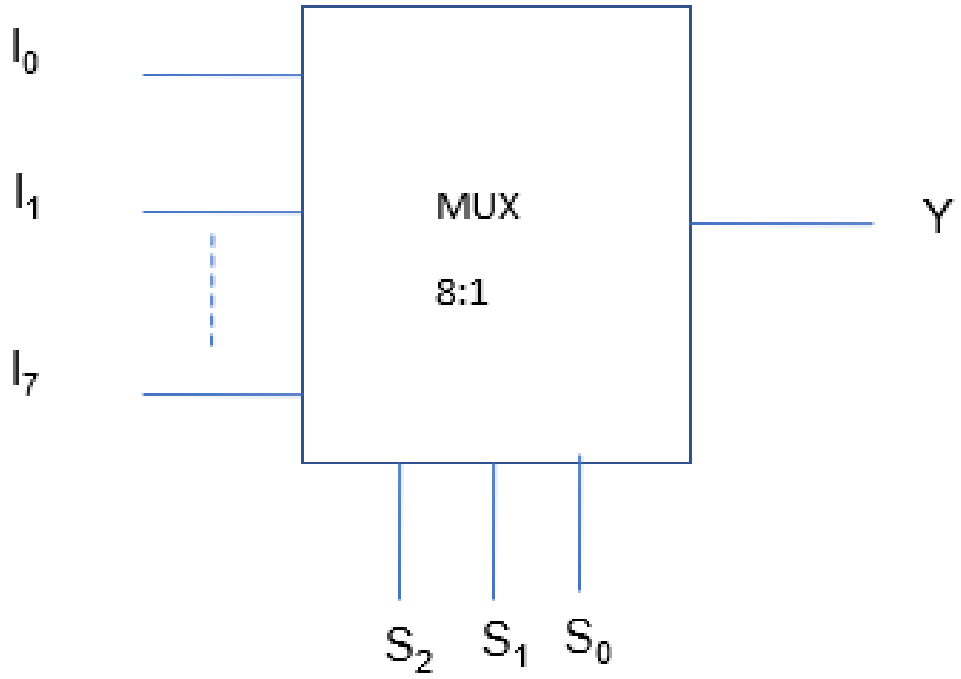
4: 1 MUX



S_0	S_1	Y
0	0	I_0
0	1	I_1
1	0	I_2
1	1	I_3



8:1 MUX

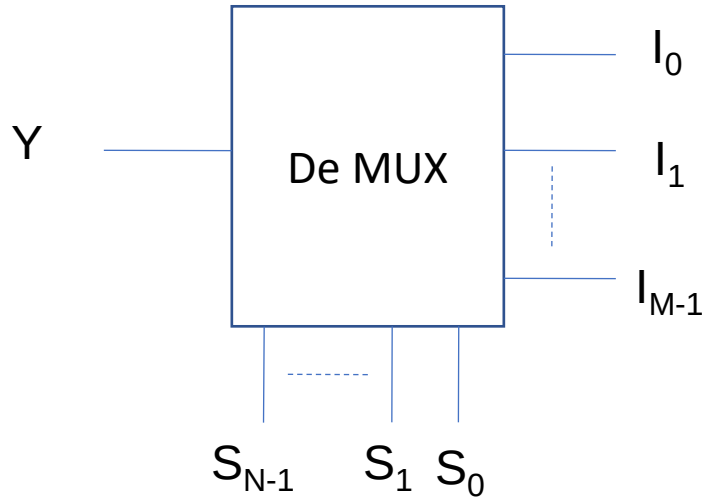


S_0	S_1	S_2	Y
0	0	0	I_0
0	0	1	I_1
0	1	0	I_2
0	1	1	I_3
1	0	0	I_4
1	0	1	I_5
1	1	0	I_6
1	1	1	I_7

- Draw the Logic Diagram
- Implement Mux design of 16:1 Multiplexer

Demultiplexer

- Inverse of multiplexing
- Output the multiple number of output lines by only one input line
- The selection of a particular output line is controlled by a set of selection lines
- There are M output lines controlled by N ($M = 2^N$) selection lines



Question 01

- A Fire Alarm system has two sensors to detect smoke or fire in a building. A manual key can also manually breakdown and activate the fire alarm system. When ever
  - If the emergency switch is presses, the alarm will switch on
  - If smoke detecting sensor and fire detecting sensors are activated at the same time the alarm will switch on
  - Either one sensor detect a smoke or fire the alarm will one

i. Draw the truth table to the given system
ii. Derive the simplified SOP expression for the output
iii. Implement the digital circuit of the output alarm
   a. Only basic logic gates (AND, OR, NOT)
   b. Only NAND gates
   d. A suitable Multiplexer

Question 02

- The directors of a company wish to automate the voting procedure at board meetings. When voting, each director has a percentage vote equal to his holdings in the company. A total vote greater than 50% is required to pass a motion. Each director is to have a switch with which to indicate a yes or no vote and a single result lamp is to be turned on if the total vote cast is greater than 50%. The company shares are distributed among the four directors as follows:
  - A owns 45%
  - B owns 30%
  - C owns 15%
  - D owns 10%

  Design a system to implement the above specification

  i. Draw a truth table

  ii. Implement the system using suitable Multiplexer

Question 03

- An assembly line has 3 failsafe sensors and 1 emergency shutdown switch. The line should keep moving unless any of the following conditions arises.
  - If the emergency switch is presses, the system shut down
  - If sensor1 and sensor2 are activated at the same time the system shut down
  - If sensor2 and sensor3 are activated at the same time the system shut down
  - If all 3 sensors are activated at the same time the system shut down

Question 04

- A solar energy system has four sensors S1, S2, S3 and S4. The sensor alarm(Y) connected to the heater system will be ON if the following conditions are satisfied:
  - If sensors S3 and S4 are activated at the same time.
  - If at least three of the four sensors are activated at the same time

i. Construct a truth table, which describes the input/output relationship

ii. Derive the simplified SOP and POS expression for the output

iii. Implement the digital circuit of the assembly line using:

a. Only basic logic gates (AND, OR, NOT)

b. Only NOR gates

c. A suitable Multiplexer