Digital Circuits

By: Amrita Prakash
Assistant Professor
Department of Computer Science
Patna Women's College

What is Digital Circuit???

- Digital Circuits are electronics that operate on digital Signals.
- It is a circuit where the signal must be one of two discrete levels i.e. Either 0 or 1.

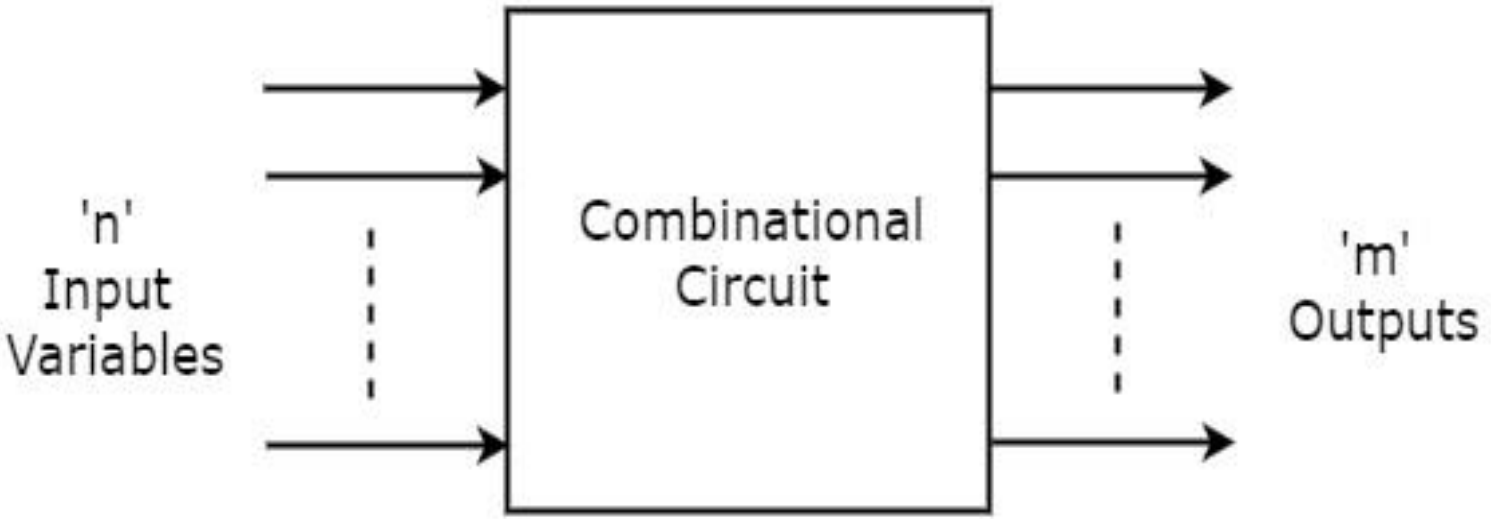
Types of Digital Circuits

Any digital device can have two types of circuits:-

- Combinational Circuit
- Sequential Circuit

Combinational Circuit

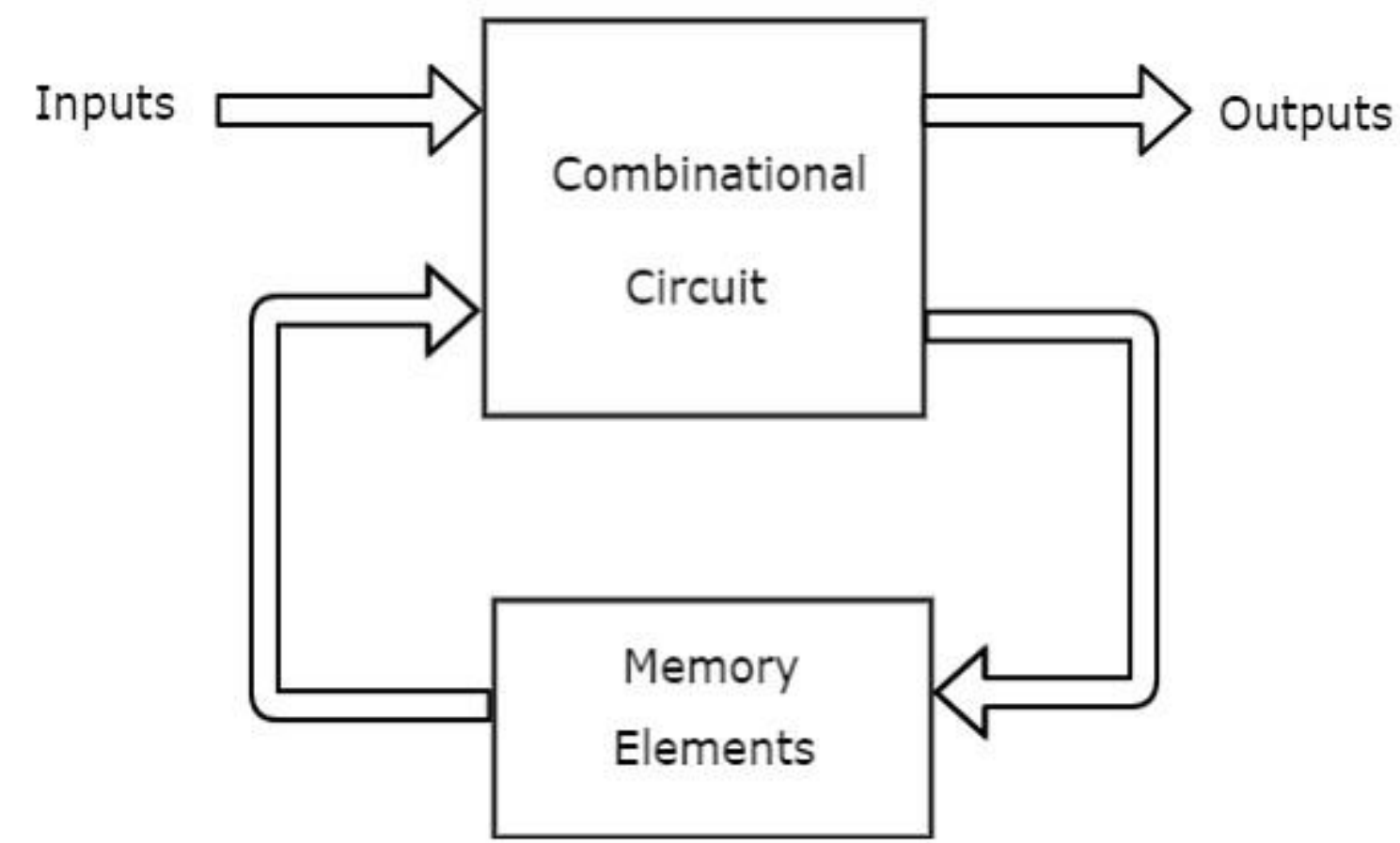
- A combinational circuit is a logic circuit that consists of a set of interconnected logic gates with a set of binary inputs and outputs.



Sequential Circuit

- This sequential circuit contains a set of inputs and output(s). The output(s) of sequential circuit depends not only on the combination of present inputs but also on the previous output(s).
- Previous output is nothing but the **present state**. Therefore, sequential circuits contain combinational circuits along with memory (storage) elements. Some sequential circuits may not contain combinational circuits, but only memory elements.

Sequential Circuit

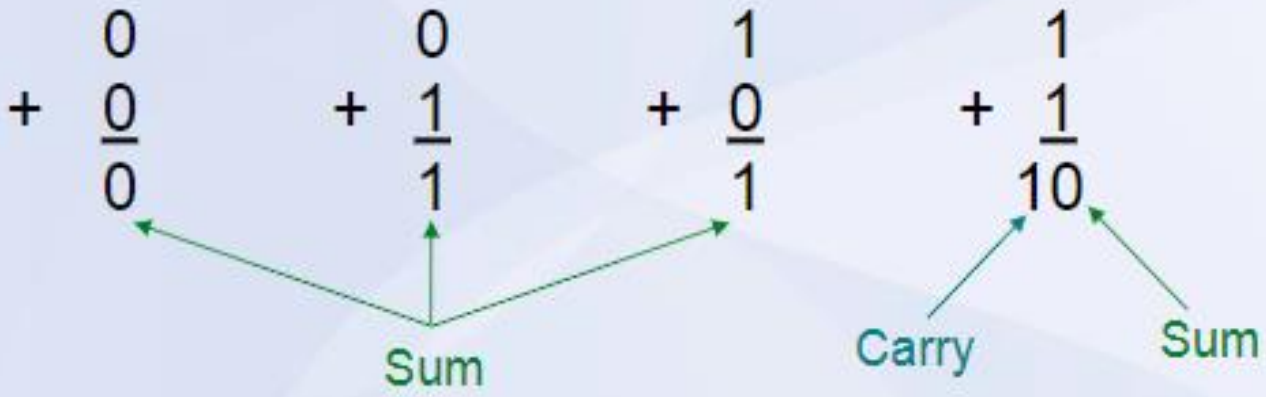


Following table shows the differences between combinational circuits and sequential circuits.

Combinational Circuits	Sequential Circuits
Outputs depend only on present inputs.	Outputs depend on both present inputs and present state.
Feedback path is not present.	Feedback path is present.
Memory elements are not required.	Memory elements are required.
Clock signal is not required.	Clock signal is required.
Easy to design.	Difficult to design.

ADDER, HALF ADDER & FULL ADDER

Binary Addition



ADDER

- In electronics, an **adder** is a digital circuit that performs addition of numbers.
- In modern computers and other kinds of processors, adders are used in the arithmetic logic unit (ALU), but also in other parts of the processor, where they are used to calculate addresses, table indices, and similar operations.
- Although adders can be constructed for many numerical representations, such as binary-coded decimal or excess-3, the most common adders operate on binary numbers.

Types of Adder

- There are two types of Adder

1. **Half Adder**

2. **Full Adder**

Half Adder

- The half adder accepts two binary digits on its inputs A and B.
- It produce two binary digits outputs, a sum bit (S) and a carry bit (C).
- The simplest half-adder design, pictured incorporates an XOR gate for ***S*** and an AND gate for ***C***.

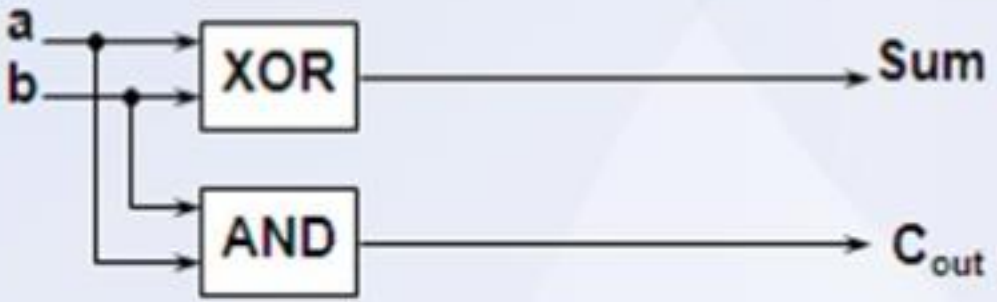
```
Carry  <= X AND Y;
Sum    <= X XOR Y;
```

$$C = (A \cdot B) \qquad S = A \oplus B$$

Diagram

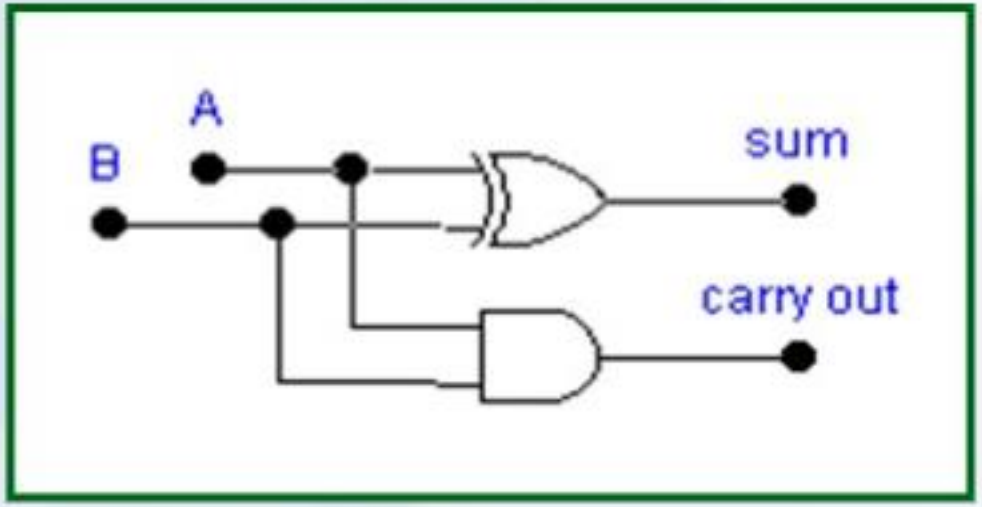
Logic Symbol:

Logic Diagram:

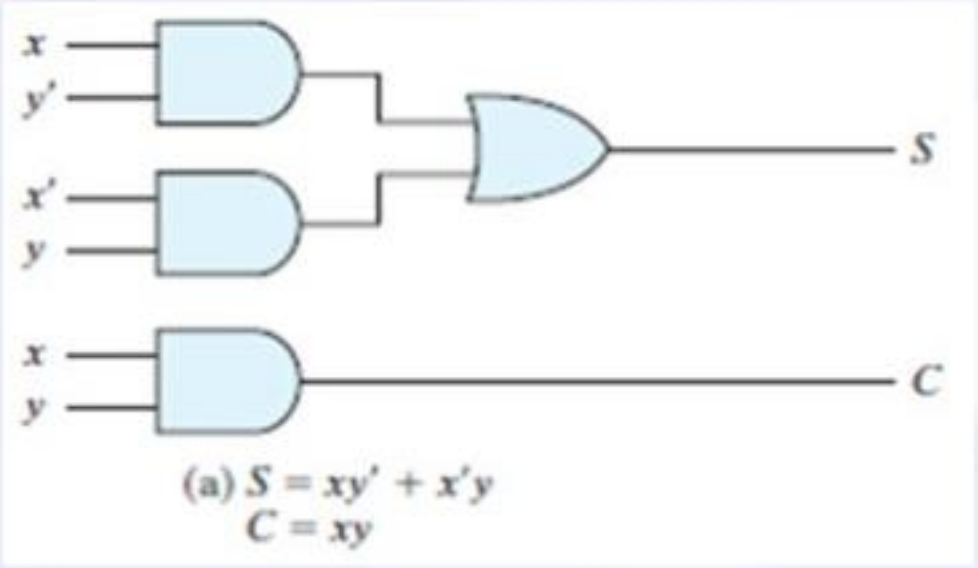


Diagram

Logic Diagram:



Logic Diagram:



(a) $S = xy' + x'y$
$C = xy$

Truth Table

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

Full Adder

- A **full adder** adds binary numbers and accounts for values carried in as well as out.
- A one-bit full adder adds three one-bit numbers input , often written as A, B, and C_{in}; A and B are the operands, and C_{in} is a bit carried in.
- A full adder can be constructed from two half adders by connecting A and B to the input of one half adder, connecting the sum from that to an input to the second adder, connecting C_{in} to the other input and OR the two carry outputs

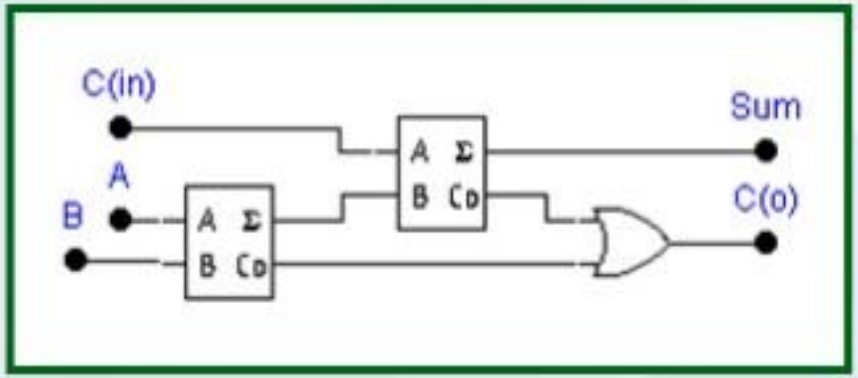
S = X xor Y xor Cin

Cout = X.Y + X.Cin + Y.Cin

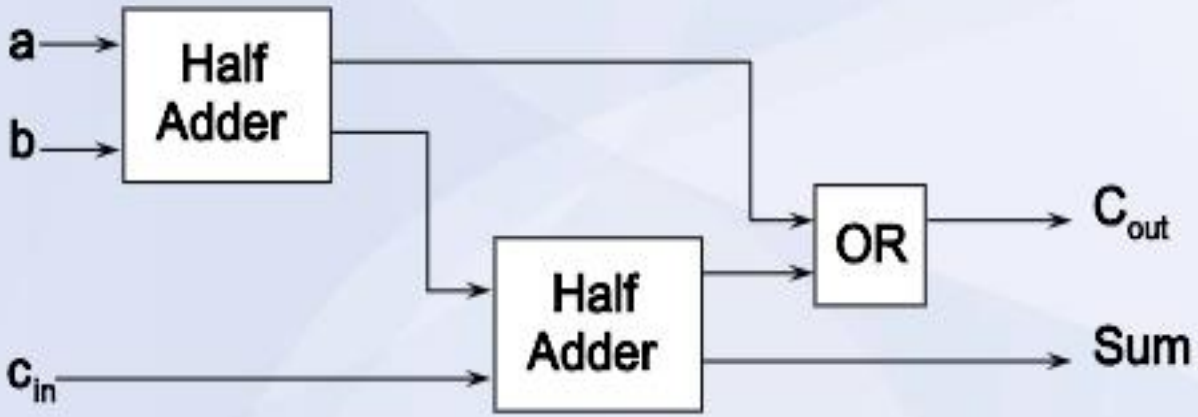
Diagrams

Logic Symbol:

Logic Diagram:



Diagram



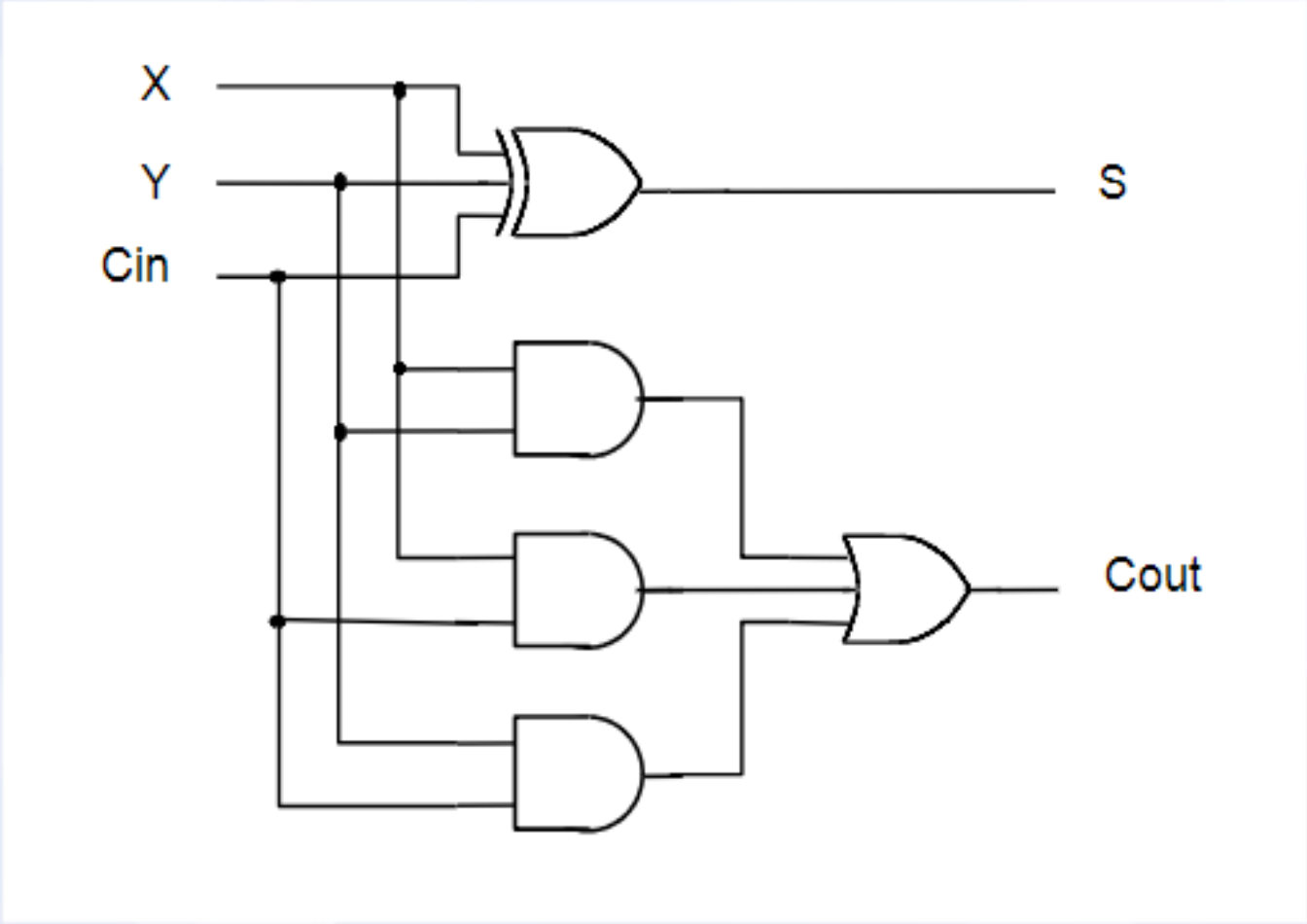
Truth Table

Inputs			Output	
A	B	C_{in}	C_{out}	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

- S is 1 if an odd number of inputs are 1.
- COUT is 1 if two or more of the inputs are 1.

- Sum is `1' when one of the following four cases is true:
  - a=1, b=0, c=0
  - a=0, b=1, c=0
  - a=0, b=0, c=1
  - a=1, b=1, c=1

The Full Adder




Thank
you!!