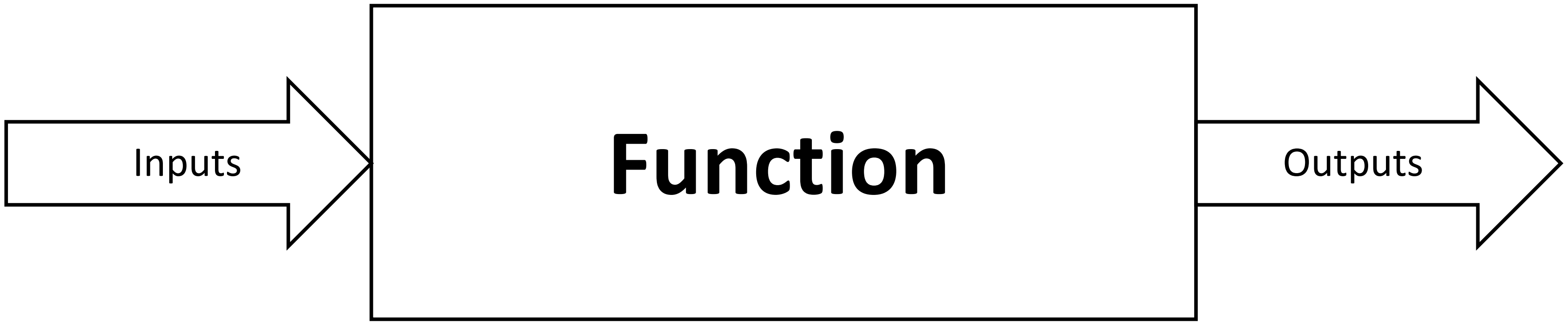
Digital System Design

Lecture - 1

What is a System?

- A set of related components working as a whole to achieve a definite goal
- A system contains:
  a. Inputs
  b. A function that converts the inputs to outputs
  c. Outputs



What is a Digital System?

- A system in which signals have a finite number of discrete values
- **Advantages:**
    a. Easy to design
    b. Low cost, automated design and fabrication
- **Disadvantages:**
    a. Physical World is analog
    b. Less precision
- **Example:**
    a. Calculator
    b. Digital Voltmeter

A Combinational Circuit

- Consists of logic gates whose outputs at any time are determined directly from the present combination of inputs without regard to previous inputs.
- Example: Half Adder, Full Adder

A Sequential Circuit

- The outputs of a sequential circuit depend not only on present inputs, but also on past inputs. Moreover, the circuit behavior (function) must be specified by a time sequence of inputs and internal states.
- Example: Flip-flop

Types of Adders:

- **Half Adder:** The half adder accepts two binary digits as its input and produce two binary digits as output- a sum bit and a carry bit.

- **Full Adder:** The full adder accepts three binary digits as its input and produce two binary digits as output- a sum bit and a carry bit.

Half Adder

Truth Table:

Input		Output	
A	B	S	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

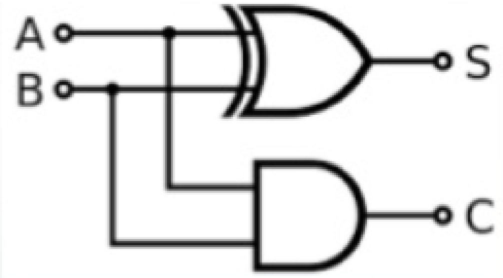
Output Function:

$S = A'B + AB'$

$\quad = A \oplus B$

$C = AB$

Logic Circuit:



Full Adder

Truth Table:

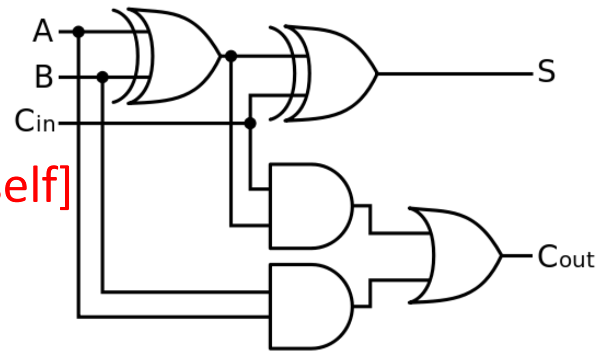
Input			Output	
A	B	C_{in}	S	C_{out}
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

Output Function:

$S = A \oplus B \oplus C_{in}$ [Try yourself]

$C_{out} = AB + (A \oplus B)\, C_{in}$ [Try yourself]

Logic Circuit:



Full Adder (Contd.)

Let,

$C_{in} = C$

Hence, $S_i = A_i \oplus B_i \oplus C_i$

And, C_{out} is the C_{in} for the next step.

Hence, $C_{i+1} = A_iB_i + (A_i \oplus B_i)\, C_i$

Let,

$A_i \oplus B_i = P_i$ and $A_iB_i = G_i$

So, we get,

$C_{i+1} = G_i + P_iC_i$

Substituting i=1,2,……., we get,

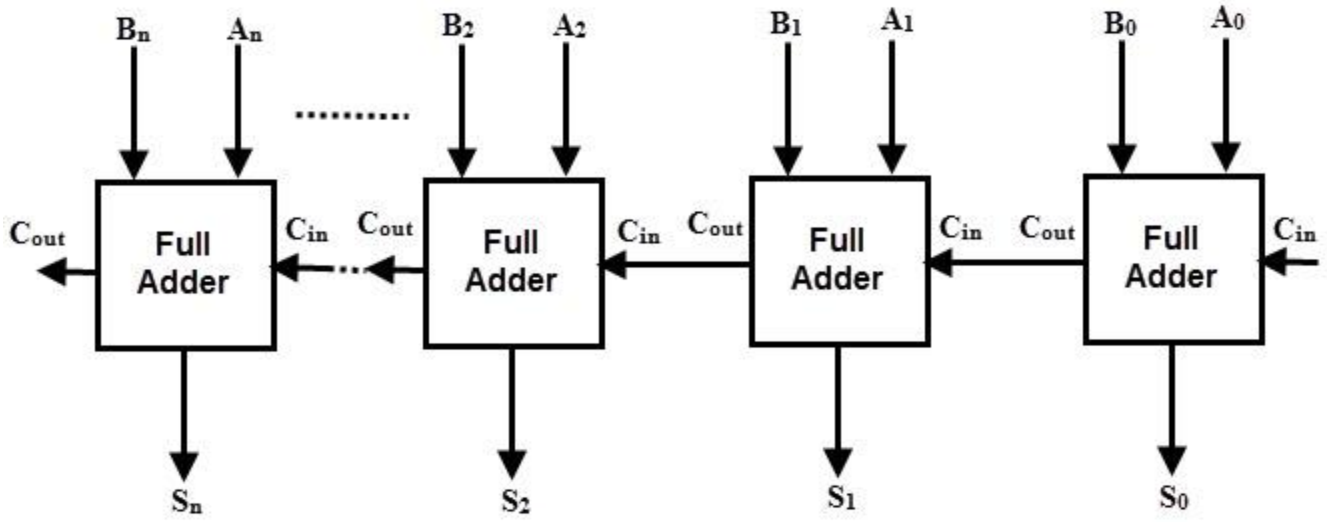
$C_2 = G_1 + P_1C_1$

$C_3 = G_2 + P_2C_2$

$\quad = G_2 + P_2\,(G_1 + P_1C_1)$

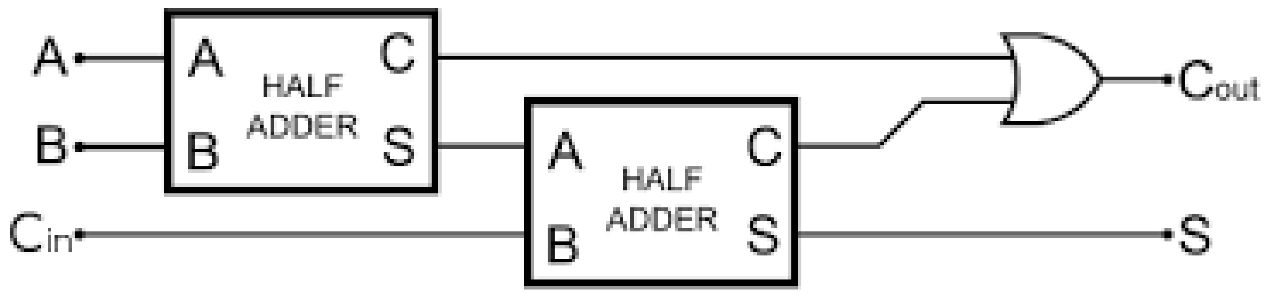
. . . .

Binary Adder



Full Adder using Half Adders

Block Diagram:



Circuit Diagram: