Logic Design and Computer Organization

Assignment-1

Aim: Realize Full Adder and subtractor using a) Basic Gates and b) Universal Gates.

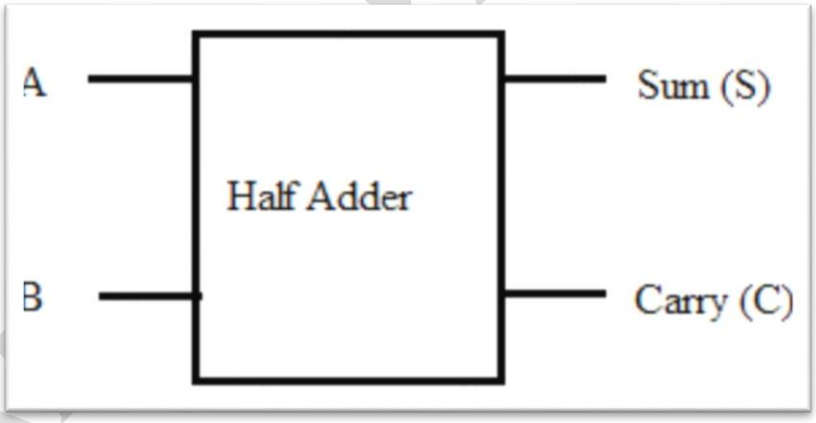
Theory:

What is Adder? In electronics an adder is digital circuit that performs addition of numbers. In modern computer adder reside in the arithmetic logic unit (ALU).

Adders: Adders are important not only in the computer but also in many types of digital systems in which the numeric data are processed.

Types of adder:

1. Half adder
    a. Half adder: The half adder accepts two binary digits on its inputs and produce two binary digits outputs, a sum bit and a carry bit.
    b. The half adder is an example of a simple, functional digital circuit built from two logic gates. The half adder adds to one-bit binary numbers (AB). The output is the sum of the two bits (S) and the carry (C).

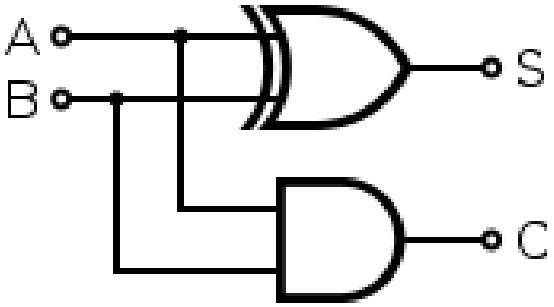


C. Note that how the same two inputs are directed to two different gates. The inputs to the XOR gate are also the inputs to the AND gate. The input "wires" to the XOR gate are tied to the input wires of the AND gate; thus, when voltage is applied to the A input of the XOR gate, the A input to the AND gate receives the same voltage.

Truth Table:

A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Boolean Expression **Logical Circuit :**



Sum= $A \oplus B$
Carry= AB

2. Full adder

a. The full adder accepts two inputs bits and an input carry and generates a sum output and an output carry.

b. The full-adder circuit adds three one-bit binary numbers (Cin, A, B) and outputs two one-bit binary numbers, a sum (S) and a carry (Cout). The full-adder is usually a component in a cascade of adders, which add 8, 16, 32, etc. binary numbers.

c. If you look closely, you'll see the full adder is simply two half adders joined by an OR.

d. We can implement a full adder circuit with the help of two half adder circuits. The first half adder will be used to add A and B to produce a partial Sum. The second half adder logic can be used to add CIN to the Sum produced by the first half adder to get the final S output. If any of the half adder logic produces a carry, there will be an output carry. Thus, COUT will be an OR function of the half-adder Carry outputs.

Full adder truth table:

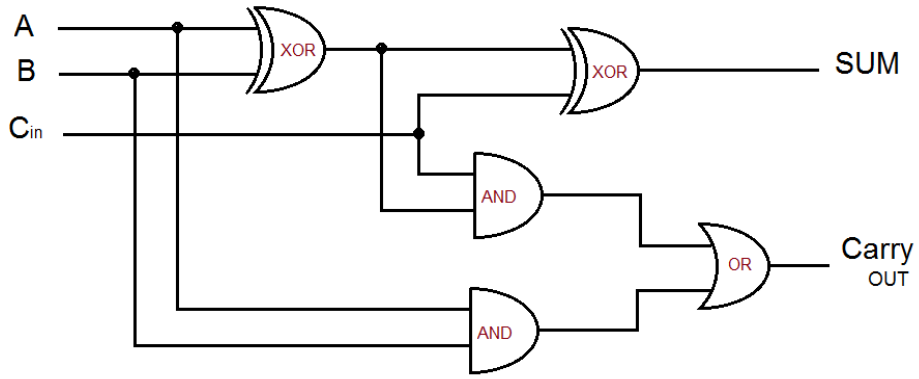
C_{in}	A	B	Sum	Carry
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

Boolean Expression

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

Carry= $A.B + (A \oplus B).C_{in}$

Logical Circuit :



❖ **What is Subtractor?**

Subtractor is an electronic logic circuit for calculating the difference between two binary numbers which provides the difference and borrow as output.

Types of Subtractor:

1. Half Subtractor: It is used for subtracting one single bit binary number from another single bit binary number. It has two inputs; Minuend (A) and Subtrahend (B) and two outputs; Difference (D) and Borrow (Bout).

2. Full Subtractor: A logic Circuit which is used for subtracting three single bit binary numbers is known as Full Subtractor.
   It has three inputs; Minuend (A), Subtrahend (B) and following Subtrahend (C) and two outputs; Difference (D) and Borrow (Bout).

1. Half Subtractor

Truth table:

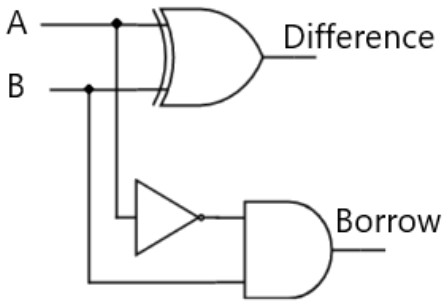
A	B	Difference	Borrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

Boolean Expression

Difference== $A \oplus B$

Borrow= $A' B$

Logical Circuit :



2. Full Subtractor

Truth table:

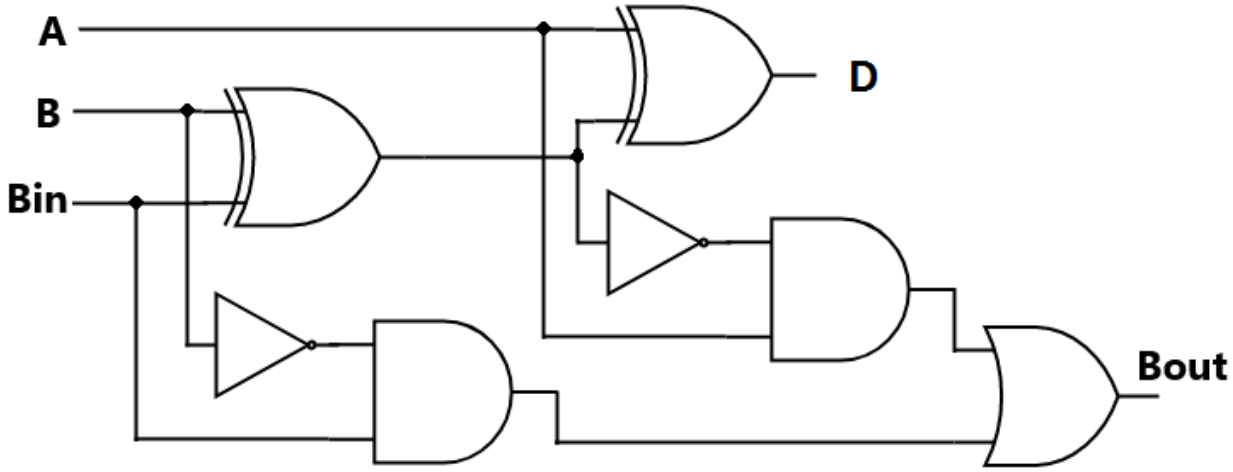
C_{in}	A	B	Difference	Borrow
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

Boolean Expression

Difference=$\mathbf{A \oplus B \oplus C_{in}}$

Borrow= $\mathbf{AB + A C'_{in} + B C'_{in}}$

Logical Circuit :



CONCLUSION:

Student able to realize Full Adder and subtractor using a) Basic Gates and b) Universal Gates.

FAQ's:

1. What is the difference between half adder and a full adder circuit?

Parameter	Half Adder	Full Adder
Basics	The Half Adder is a type of combinational logic circuit that adds two of the 1-bit binary digits. It generates carry and sum of both the inputs.	The Full Adder is also a type of combinational logic that adds three of the 1-bit binary digits for performing an addition operation. It generates a sum of all three inputs along with a carry value.
Adding the Previous Carry	The Half Adder does not add the carry obtained from the previous addition to the next one.	The Full Adder, along with its current inputs A and B, also adds the previous carry.
Hardware Architecture	A Half Adder consists of only one AND gate and EX-OR gate.	A Full Adder consists of one OR gate and two EX-OR and AND gates.
Total Inputs	There are two inputs in a Half Adder- A and B.	There are a total of three inputs in a Full Adder- A. B. C-in.
Usage	The Half Adder is good for digital measuring devices, computers, calculators, and many more.	The Full Adder comes into play in various digital processors, the addition of multiple bits, and many more.
Logical Expression	Here is the logical expression of Half Adder: $C = A * B$ $S = A \oplus B$	Here is the logical expression of Full Adder: $Cout = (AB) + C_{in}A \oplus C_{in}B$ $S = A \oplus B \oplus C_{in}$

2. What is the difference between half subtractor and a full subtractor circuit?

Parameter	Half Subtractor	Full Subtractor
Basics	The Half Subtractor is a type of combinational logic circuit that subtracts two of the 1-bit binary digits. It generates Difference and borrows of both the inputs.	The Full Subtractor is also a type of combinational logic that adds three of the 1-bit binary digits for performing a subtraction operation. It generates a subtraction of all three inputs along with a carry value.
Adding the Previous Carry	The Half subtractor does not considee the borrow obtained from the previous subtraction to the next one.	The Full Subtractor, along with its current inputs A and B, also subtracts the previous borrow.
Hardware Architecture	A Half Subtractor consists of only one AND gate and EX-OR gate.	A Full Subtractor consists of one OR gate and two EX-OR and AND gates.
Total Inputs	There are two inputs in a Half Subtractor - A and B.	There are a total of three inputs in a Full Subtractor - A. B. C-in.
Usage	Half subtractor is used to reduce the force of audio or radio signals, in amplifiers to reduce the sound distortion, in ALU of processor	The Full subtractor ALU (Arithmetic logic unit) in computers to subtract as CPU & GPU for the applications of graphics to decrease the circuit difficulty, These are also applicable for different microcontrollers for arithmetic subtraction, timers, and the program counter (PC), It is also useful for DSP and networking based systems.
Logical Expression	Here is the logical expression of Half Subtractor: $C = A * B$ $S = A \oplus B$	Here is the logical expression of Full Subtractor: $Borrow = (A'B) + C_{in}A' \oplus C_{in}B$ $Difference = A \oplus B \oplus C_{in}$