ADDER CIRCUITS
HALF ADDER AND FULL ADDER CIRCUIT

Learning Objective:

- To make Electronic Adder Circuits.
- Use of Gates such as AND,OR,NAND and XOR
- Use of Bread board and IC.

Introduction

An Integrated circuit (IC) is a small electronic device made out of a semiconductor material. An integrated circuit, commonly referred to as a IC, is a microscopic array of electronic circuits and components that has been diffused or implanted onto the surface of a single crystal, or chip, of semiconducting material such as silicon. It is called an integrated circuit because the components, circuits, and base material are all made together, or integrated, out of a single piece of silicon, as opposed to a discrete circuit in which the components are made separately from different materials and assembled later. ICs range in complexity from simple logic modules and amplifiers to complete microcomputers containing millions of elements.

The logic Gates, such as AND gate, OR gate, NAND gate, XOR gate, flip flops, counters; microprocessors are some well-known examples of digital ICs. These ICs operate with binary data such as either 0 or 1. Normally in digital circuit, 0 indicates 0 V and one indicate +5 V. The main components of an IC are transistors. These transistors may be bipolar or field effect depending upon the applications of ICs. As the technology is improving day by day, the number of transistors incorporated in a single IC chip is also increasing. Depending upon the number of transistors incorporated in a single chip, the ICs are categorized in five groups. Namely

1. Small Scale Integration (SSI) where the number of transistors incorporated in a single IC chip is up to 100.

2. Medium Scale Integration (MSI) where the number of transistors incorporated in a single IC chip is from 100 to 1000.
3. Large Scale Integration (LSI) where the number of transistors incorporated in a single IC chip is from 1000 to 20,000.
4. Very Large Scale Integration (VLSI) where the number of transistors incorporated in a single IC chip is from 20,000 to 10,00,000.

What is a breadboard?

A breadboard is used to build and test circuits quickly before finalizing any circuit design. The breadboard has many holes into which circuit components like ICs and resistors can be inserted. A typical breadboard is shown below:

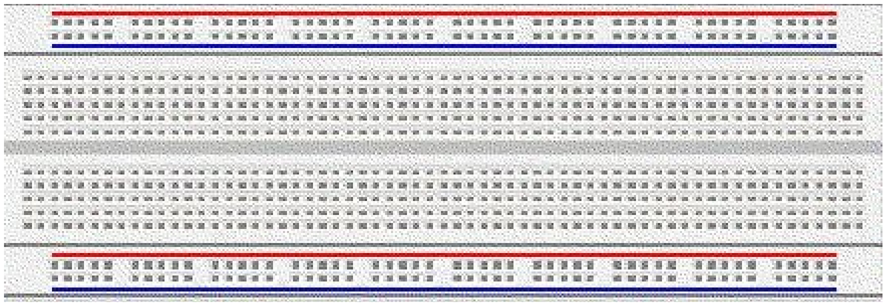

Fig 1.Front side of bread board

The bread board has strips of metal which run underneath the board and connect the holes on the top of the board. The metal strips are laid out as shown below. Note that the top and bottom rows of holes are connected horizontally while the remaining holes are connected vertically.

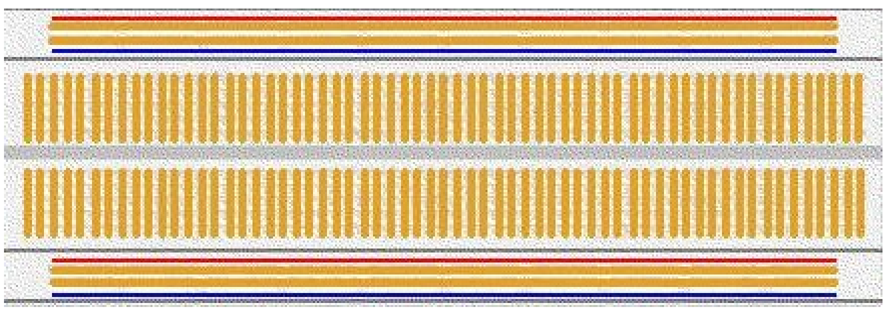

Fig 2.back side of bread board.

To use the bread board, the legs of components are placed in the holes. Each set of holes connected by a metal strip underneath forms a node. A node is a point in a circuit where two components are connected. Connections between different components are formed by putting their legs in a common node. The long top and bottom row of holes are usually used for power supply connections. The rest of the circuit is built by placing components and connecting them together with jumper wires. ICs are placed in the middle of the board so that half of the legs are on one side of the middle line and half on the other.

Bread boarding Tips:

It is important to breadboard a circuit neatly and systematically, so that one can debug it and get it running easily and quickly. It also helps when someone else needs to understand and inspect the circuit. Here are some tips:

1. Always use the side-lines for power supply connections. Power the chips from the side-lines and not directly from the power supply.
2. Use black wires for ground connections (0V), and red for other power connections.
3. Keep the jumper wires on the board flat, so that the board does not look cluttered.

4. Route jumper wires around the chips and not over the chips. This makes changing the chips when needed easier. 5. You could trim the legs of components like resistors, transistors and LEDs, so that they fit in snugly and do not get pulled out by accident.

AIM

To design and set up half adder and full adder using
a. EXOR gates and AND gates
b. NAND gates

COMPONENTS REQUIRED

IC Trainer kit, IC 7400, IC 7486, IC 7408, IC 7432,220 ohm resistance, 5v power supply, wire cutter.

PRINCIPLE

Half Adder

The simplest binary adder is called half adder. Half adder has two input bits and two output bits. One output bit is the sum and the other is the carry. They are represented by 'S' and 'C' respectively in logic symbol. The simplest binary 3 bit adder is called full adder. It has three input bits and two output bits. One output bit is the sum and the other is carry. They are represented by 'S' and 'C' respectively in logic symbol.

Truth Table			
Input		Output	
A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Fig 3.Half Adder Logic Diagram Truth Table

If we assume A and B as the two bits whose addition is to be performed, a truth table for half adder with A, B as inputs and Sum, Carry as outputs can be tabulated as follows.

The sum output of the binary addition carried out above is similar to that of an Ex-OR operation while the carry output is similar to that of an AND operation. The same can be verified with help of Karnaugh Map.

The truth table and K Map simplification for Sum output is shown below.

Truth Table		
A	B	SUM
0	0	0
0	1	1
1	0	1
1	1	0

Truth Table		
A	B	Carry
0	0	0
0	1	0
1	0	0
1	1	1

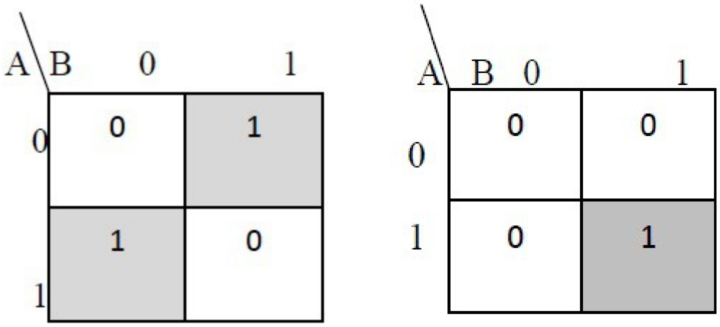

Fig4.The truth table and K Map simplification for carry is shown below.

Sum = $A\bar{B} + \bar{A}B$. Carry = AB

Hence the logic diagram for sum and carry is shown below.

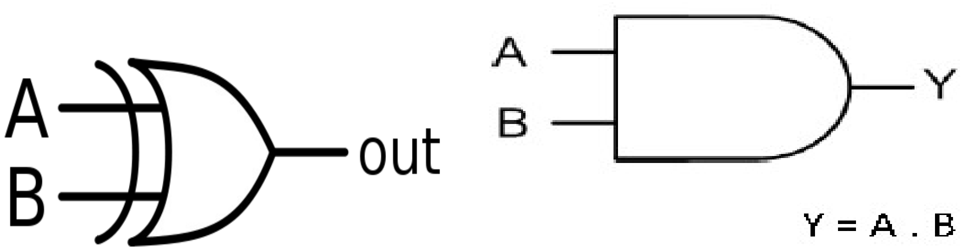

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Fig5. Implementation in Gate

If A and B are binary inputs to the half adder, then the logic function to calculate sum S is Ex – OR of A and B and logic function to calculate carry C is AND of A and B. Combining these two, the logical circuit to implement the combinational circuit of Half Adder is shown below.

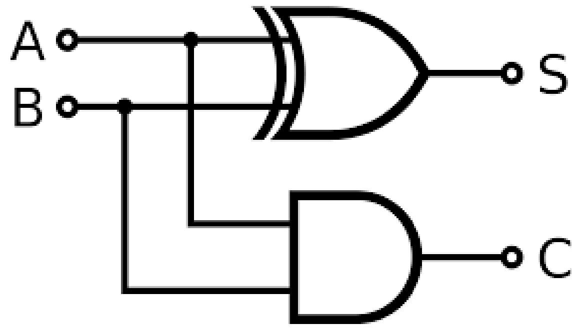


Fig 5.Half Adder circuit

As we know that NAND and NOR are called universal gates as any logic system can be implemented using these two, the half adder circuit can also be implemented using them. We know that a half adder circuit has one Ex – OR gate and one AND gate.

Full adder:

Full adder is a digital circuit used to calculate the sum of three binary bits which is the main difference between this and half adder. Full adders are complex and difficult to implement when compared to half adders. Two of the three bits are same as before which are A, the augend bit and B, the addend bit. The additional third bit is carry bit from the previous stage and is called Carry – in generally represented by CIN. It calculates the sum of three bits along with the carry. The output carry is called Carry – out and is represented by COUT.

The block diagram of a full adder with A, B and CIN as inputs and S, CoUT as outputs is shown below

Input			Output	
A	B	Cin	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

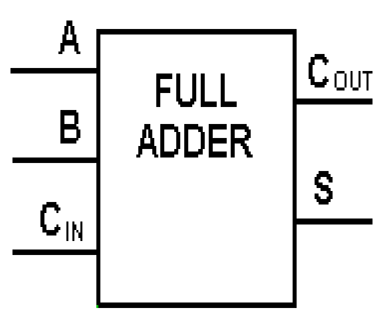


Fig 6. Full Adder Truth Table and Logic Diagram.

K_ Map for full adder.

Based on the truth table, the Boolean functions for Sum (S) and Carry – out (COUT) can be derived using K – Map.
For Sum S

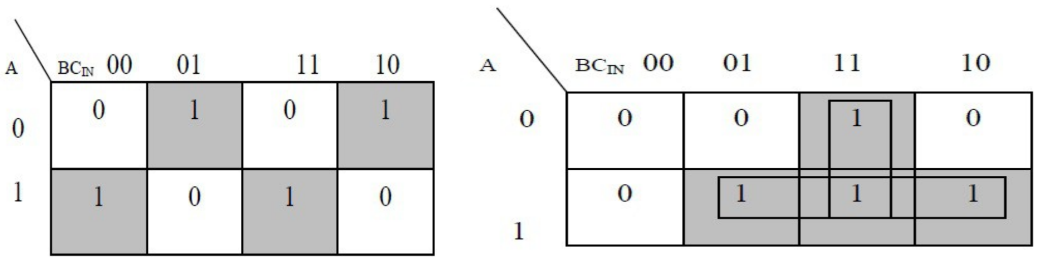


Fig .7 Implimetatiopn in K-Map

The simplified equation for sum is S = A¯B¯Cin + A¯BC¯in + ABCin

For Carry – out COUT,

The simplified equation for COUT is COUT = AB + ACIN + BCIN

In order to implement a combinational circuit for Full Adder, it is clear from the equations derived above, that we need 4 three input AND gates and 1 four input OR gate for Sum and 3 two input AND gates and I three input OR gate for Carry – out.

The logic circuit for full adder is shown below.

Implementation of Full Adder using Half Adders:

A full adder can be formed by logically connecting two half adders. The block diagram that shows the implementation of a full adder using two half adders is shown below.

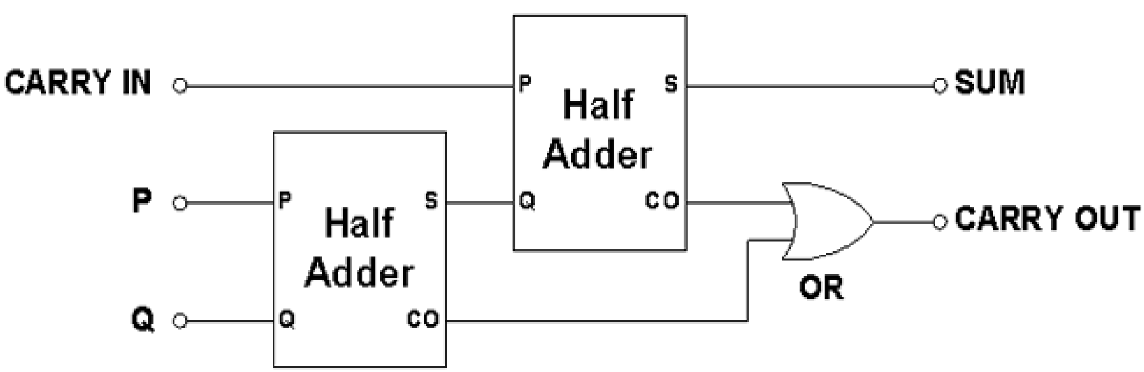


Fig 8.Implementation of full adder with two half adder

We know the equations for S and COUT from earlier calculations as

S = A¯B¯Cin + A¯BC¯in + ABCin

Cout = AB + ACin + BCin

We can rewrite the equation for sum as follows.

S = A¯B¯Cin + A¯BC¯in + ABCin = Cin (A¯B¯+ AB) + C¯in (A¯B + A B¯)

Therefore S = CIN XOR (A XOR B) = Cin (A X-NOR B) + C¯in (A X-OR B) = Cin XOR (A XOR B)

Cout is simplified as

COUT = A B + A CIN + B CIN.

COUT = AB + A CIN + B CIN (A +¯A)= ABCIN + AB + ACIN +¯A B CIN = AB (1 +CIN) + ACIN +¯A B CIN

= A B + ACIN +¯A B CIN = AB + ACIN (B +¯B) + ¬¯A B CIN = ABCIN + AB + A¯B CIN +¯A B CIN

= AB (CIN + 1) + A¯B CIN +¯A B CIN = AB + A¯B CIN +¯A B CIN = AB + CIN (¯AB + A¯B)

Therefore COUT = AB + CIN (A EX – OR B).

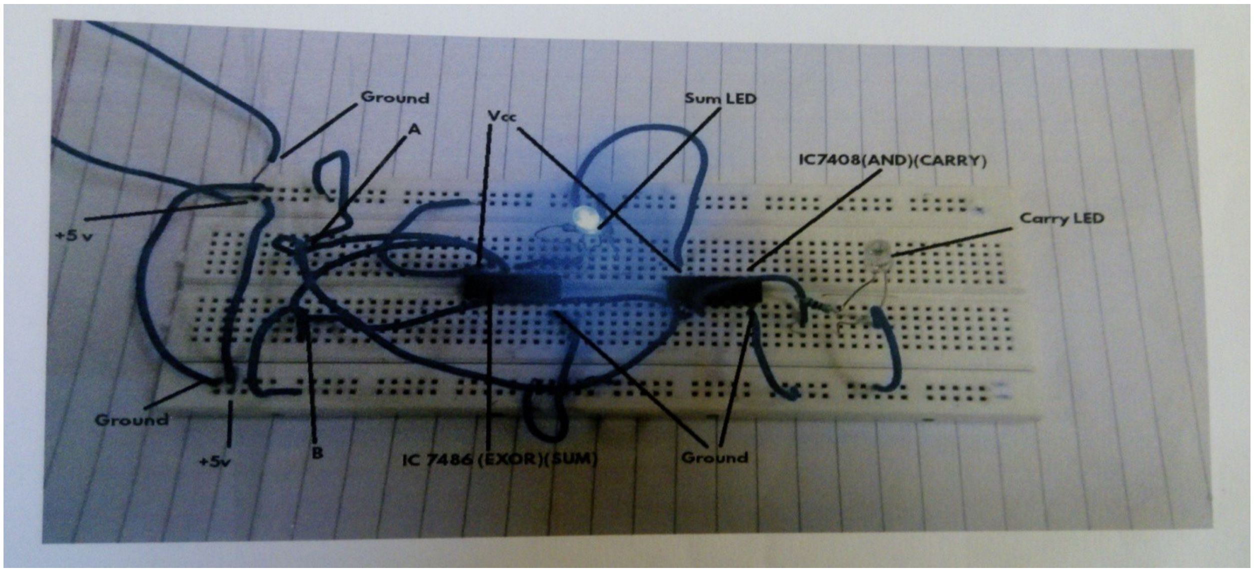
Fig9.Implementation of Full Adder with Gates: It need two ex-or gates and 2-AND gate and a NOR gate.

Fig 10.Implementation of Full Adder.

PROCEDURE: 1. Verify whether all the wires and components are in good condition
2. Set up full adder and half adder circuit and feed all the input combinations
3. Observe the output corresponding to input combinations and enter it in the Truth table

EXPERIMENTAL RESULT:

Implementation of Half Adder in bread board:



Implementation of Full Adder in bread board:

Realized Circuit :