Chapter 1. Introduction

1.1. Introduction to Microprocessors

A microprocessor is a multipurpose, programmable logic device that reads binary instructions from a storage device called memory, accepts binary data as input and processes data according to those instructions, and provides result as output. A typical programmable machine can be represented with four components: microprocessor, memory and I/O as shown.

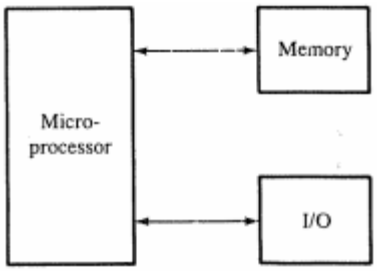

Figure 1-1: A programmable Machine

1.2. Evolution of Microprocessor

The first microprocessor was introduced in the year 1971. It was introduced by Intel and was named Intel 4004. Intel 4004 is a 4 bit microprocessor and it was not a powerful microprocessor. It can perform addition and subtraction operation on 4 bits at a time.

However it was Intel's 8080 was the first microprocessor to make it to Home computers. It was introduced during the year 1974 and it can perform 8 bit operations. Then during the year 1976, Intel introduced 8085 processors which is nothing but an update of 8080 processors.8080 processors are updated by adding two Enable/Disable Instructions, Three added interrupt pins and serial I/O pins.

Intel introduced 8086 pins during the year 1976. The major difference between 8085 and 8086 processor is that 8085 is an 8 bit processor, but 8086 processor is a 16 bit processor.

The greatest advantage of the above processors are that it do not contain Floating point instructions. Here floating point refers to the radix point or decimal point. For example: 123.456 is a floating point representation. Processors such as 8085 and 8086 do not support such representations and instructions.

Intel later introduced 8087 processor which was the first math co-processor and later the 8088 processor which was incorporated into IBM personal computers.

As the years progressed lots of processors from 8088,80286,80386,80486,Pentium II, Pentium III, Pentium IV and now Core2Duo,Dual Core and Quad core processors are the latest in the market.

Apart from Intel, there are some other manufacturers who produce the CMOS version of 8085 microprocessor. Such manufacturers are called second source manufacturers. The second source manufacturers include: AMD Mitsubishi NEC; OKI; Toshiba; Siemens

CMOS stands for **COMPLEMENTARY METAL OXIDE SEMICONDUCTOR.** It is a technology used in Microprocessors and Microcontrollers for making Integrated circuits.
The devices which are made of CMOS have high immunity towards noise and the static power consumption is low.

1.3. Organization of Microprocessor-Based System

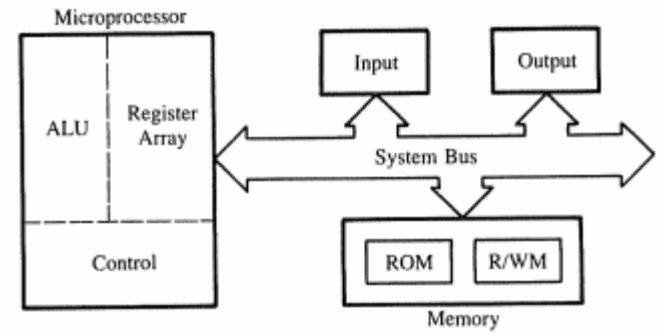

Figure 1-2: Microprocessor-Based System with Bus Architecture

The functional block diagram of any microprocessor-based system is as shown in Fig. 1-2. It consists of four components: microprocessor, input, output, and memory (Read/Write Memory and Read-Only Memory). These components are organized around a common communication path called a bus. The function of each component is described as below:

MICROPROCESSOR
The microprocessor is a semiconductor device consisting of electronic logic circuits manufactured by using either a large-scale (LSI) or very-large-scale integration (VLSI) technique. The microprocessor is capable of performing various computing functions and making decisions to change the sequence of program execution. Internally, the microprocessor is made up of three main units: Arithmetic/Logic Unit (ALU), Register Array, and Control Unit.
Arithmetic/Logic Unit:
This is the area of the microprocessor where various computing functions are performed on data. The ALU unit performs arithmetic and logical operations. The results are stored either in registers or in memory.
Register Array
This area of the microprocessor consists of various registers. These registers are primarily used to store data temporarily during the execution of a program. Some of the registers are accessible to the user through instructions.
Control Unit
The control unit provides the necessary timing and control signals to all the operations in the microcomputer. It controls the flow of data between the microprocessor and memory and peripherals.

MEMORY
Memory stores information such as instructions and data in binary format (0 and 1). It provides this information to the microprocessor whenever it is needed. The memory block (Figure 1-2) has two sections: Read-Only Memory (ROM) and Read/Write Memory(R/WM).
The ROM is used to store programs that do not need alterations. Programs stored in ROM can only be read; they cannot be altered.
The Read/Write Memory(R/WM) is also known as user memory. It is used to store user programs and data. The information stored in this memory can be easily read and alterd.
INPUT
The input section transfers data and instructions in binary from the outside world to the microprocessor.
OUTPUT
The output section transfers data from the microprocessor to such output devices as light emitting diodes (LEDs), a cathode-ray tube (CRT), a printer, a magnetic tape, or another computer.
SYSTEM BUS

The system bus is a communication path between the microprocessor and peripherals (I/O); it is nothing but a group of wires to carry bits.

1.4. How does the microprocessor works?

To execute a program, the microprocessor “reads” each instruction from memory, “interprets” it, then “executes” it.

To use the right names for the cycles:

– The microprocessor fetches each instruction,

– decodes it,

– Then executes it.

This sequence is continued until all instructions are performed.

1.5. Bus Organization

To communicate with any peripheral or memory location, the microprocessor needs to perform the following steps:

1. Identify the memory location or the peripheral with its address.
2. Transfer the binary data.
3. Providing timing and synchronization signal.

Therefore, the microprocessor requires three sets of communication lines called buses: the first group of lines, called the address bus, to identify the memory location; the second group, called the data bus, to transfer data; and the third group, called the control lines, for timing signals. The group of this buses collectively called system bus.

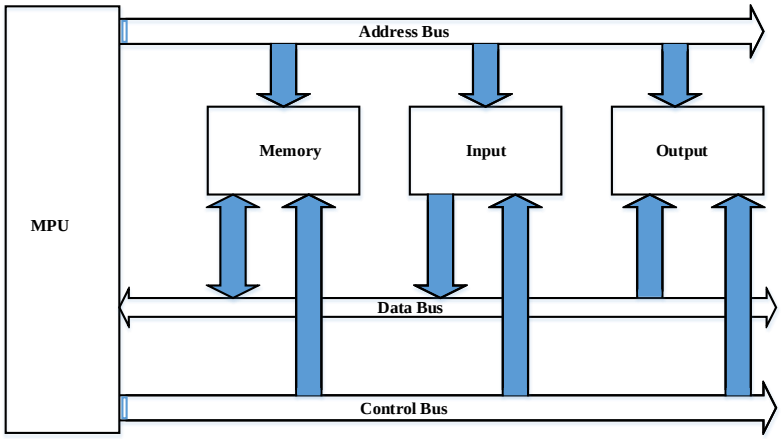

Figure 1-3: Bus Structure

ADDRESS BUS

This is a group of wires which is used to carry address information. Address bus is unidirectional—the signals flows from MPU to peripherals because only the MPU sends out an address.

The number of wires in address bus (no. of address bits) signifies the memory size that can be connected to the microprocessor. If the microprocessor has 'n' no. of bits (wires) in address bus then the microprocessor can address 2^n bits memory location. For instance, if a microprocessor has 16 bits address lines then it is capable of addressing 65,536 (2^{16}) memory location, commonly known as 64K memory.

DATA BUS

These lines are used to transfer data and are bidirectional. The number of lines in data bus signifies two things:

1. First one is, it is called the word size of microprocessor which means no. of bits the microprocessor can process at a time
2. Second one is, it gives the maximum number of instruction that the microprocessor can have.

If the microprocessor has 'n' lines on data bus then, the processor can process the only up to n bits data and it can have maximum 2^n instructions.

For e.g. for 8-bit microprocessor (8085). Word length= 8-bits Maximum number of instructions = 2^8=256	For e.g. for 4-bit microprocessor. Word length= 4-bits Maximum number of instructions= 2^4=16

CONTROL BUS

These are individual signal lines generated by the MPU to indicate its operation. The MPU generates a specific signal for each of its four operations- Memory Read, Memory Write, I/O Read, and I/O Write. These are timing signals that are used to enable, or active, peripherals. For example,

to fetch(or read) an instruction from a memory locations, the MPU sends a timing pulse called Memory Read to enable the memory chip.

1.6. Von Neumann Architecture

All computers more or less based on the same basic design, the Von Neumann Architecture. Most of today's computer designs are based on concepts developed by John von Neumann referred to as the VON NEUMANN ARCHITECTURE. Von Neumann computer systems contain three main building blocks: the central processing unit (CPU), memory, input/output devices (I/O) as shown in fig 1-4.These three components are connected together using the *system bus*. In von Neumann architecture the data and instruction are stored in a single read-write memory and the program instructions are executed sequentially.

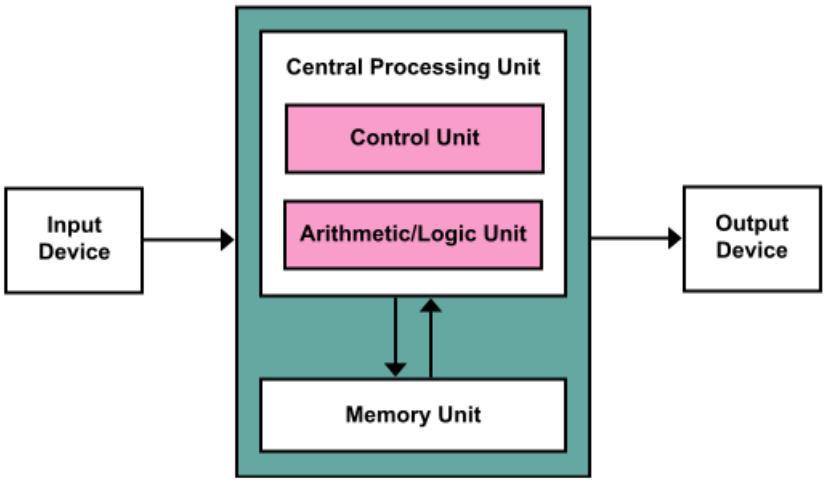

Figure 1-4: Von Neumann architecture scheme

Memory: Storage of information (data/program)
Processing Unit: Computation/Processing of Information
Input: Means of getting information into the computer. E.g. keyboard, mouse
Output: Means of getting information out of the computer. E.g. printer, monitor
Control Unit: Makes sure that all the other parts perform their tasks correctly and at the correct time
Arithmetic/Logic Unit: This part of the architecture is solely involved with carrying out calculations upon the data. All the usual Add, Multiply, Divide and Subtract calculations will be available but also data comparisons such as 'Greater Than', 'Less Than', 'Equal To' will be available.

1.7. Arithmetic Logical Unit

Executes arithmetic (addition, multiplication...) and logical (AND, OR...) operations.

Half adder:

The digital arithmetic circuit that adds two binary digits.

Sum = $x \oplus y$

Carry = xy

Full adder:

It adds 3-bits, it has 3-inputs and 2-outputs.

Sum = $x \oplus y \oplus z$

Carry = $z (x \oplus y) + xy$

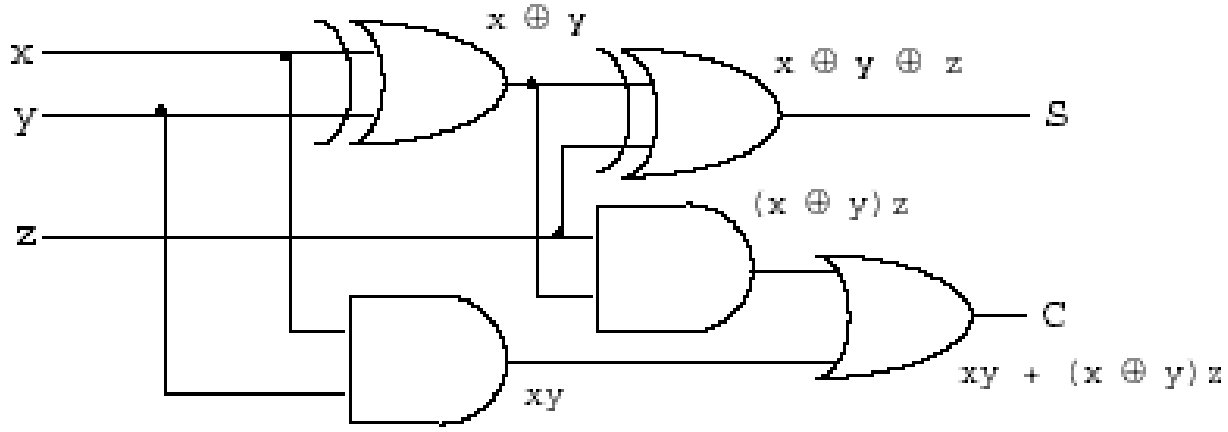

Figure 1-4:.The logic diagram of full adder

Binary adder:

Binary adder is constructed with full-adder circuits connected in cascade.

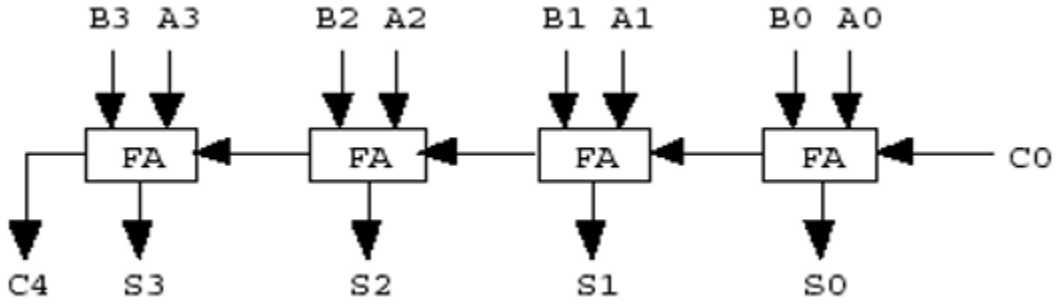

Figure 1-5: 4-bit binary adder

Binary adder-subtractor

The addition and subtraction operations can be combined into one common circuit by including an exclusive-OR (XOR) gate with each full-adder.

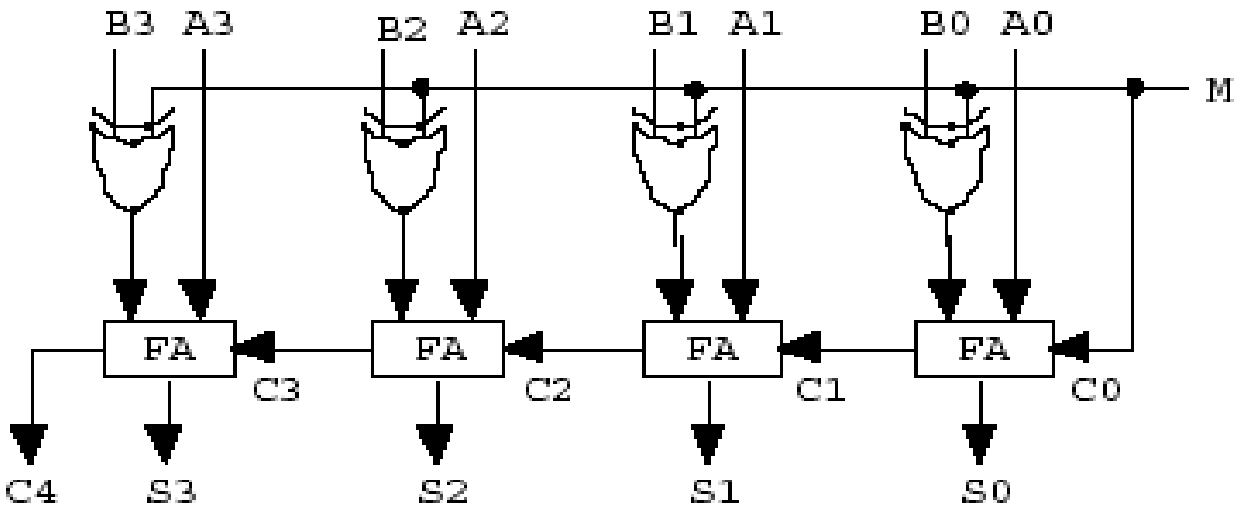

Figure 1-6: 4 bit binary adder/subtractor

- M = 0: Note that B XOR 0 = B. This is exactly the same as the binary adder with carry in C0 = 0.
- M = 1: Note that B XOR 1 = B' (flip all B bits). The outputs of the XOR gates are thus the 1's complement of B.
- M = 1 also provides a carry in 1. The entire operation is: A + B' + 1.

1.8. Application

Microprocessor are advanced form of computers, so they are also called as microcomputers. The availability of low cost, low power, and small weight, computing capability makes it useful in different applications. Now a days a microprocessor based systems are used in instruments, automatic testing product, speed control of motors, traffic light control, light control of furnace etc. Some of the important areas are mentioned below:

i) Instrumentation

Microprocessor is very useful in the field of instrumentation. Frequency counter, function generators, spectrum analyzer, and many other instruments are available where microprocessor are used as controllers. They are also used in medical instruments to measure blood pressure and temperature.

ii) Control

Microprocessor controllers are now available in home appliances such as microwave oven, washing machine. In industry, microprocessors are used in controlling various process parameters such as speed, temperature, moisture and pressure.

iii) Communication

In the telephone industry, microprocessors are used in digital telephone sets, telephone exchanges and modems. They are also used in railway reservation system at the national level and air reservation system at international level. Satellite communication systems, mobile phones and televisions are also using microprocessors.

iv) Office Automation and Publication

With the availability of inexpensive and user friendly microcomputers along with wide range of software packages, office works are computerized. Microcomputers are used in office to perform word processing, spreadsheet operations, storage and retrieval of huge information. In publishing houses microprocessor based systems are used for making automatic photo copies. Microprocessor based LASER printers are used to achieve good speed in printing.

v) Consumer

The use of microprocessor in toys, entertainment equipment, and home applications is making them more entertaining and full of features.