Chapter – 1
Introduction

1.1 Definition of Microprocessor and its Application:

Definition:

A Microprocessor is a multipurpose programmable, clock driven, register based electronic device that reads binary instructions from a storage device called memory, accepts binary data as input, processes data according to those instructions and provide results as output. It is a computer processor that incorporates the functions of a central processing unit on a single integrated circuit (IC), or at most a few integrated circuits. Microprocessors contain both combinational logic and sequential digital logic.

Application:

The impact of microprocessor in different fields is significant. The availability of low cost, low power and small weight, computing capability makes it useful in different applications. Now a day, a microprocessor based systems are used in instructions, automatic testing product, speed control of motors, traffic light control, light control of furnaces etc. Some of the important areas are mentioned below:

a. Instrumentation:

It is very useful in the field of instrumentation. Frequency counters, function generators, frequency synthesizers, spectrum analyses and many other instruments are available, when microprocessors are used as controller. It is also used in medical instrumentation.

b. Control:

Microprocessor based controllers are available in home appliances, such as microwave oven, washing machine etc., microprocessors are being used in controlling various parameters like speed, pressure, temperature etc. These are used with the help of suitable transduction.

c. Communication:

Microprocessors are being used in a wide range of communication equipments. In telephone industry, these are used in digital telephone sets. Telephone exchanges and modem etc. The use of microprocessor in television, satellite communication has made teleconferencing possible.

d. Office Automation and Publication:

Microprocessor based micro computer with software packages has changed the office environment. Microprocessors based systems are being used for word processing, spread sheet operations, storage etc. The microprocessor has revolutionized the publication technology.

e. Consumer:

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

Now the Microprocessors are used in:
Calculators, Accounting system, Games machine, Complex Industrial Controllers, Traffic light Control, Data acquisition systems, Multi user, multi-function environments, Military applications and Communication systems.

1.2 Evolution of Microprocessor, Von Neumann and Harvard Architecture:

Evolution of Microprocessor:

a. 4-bit Microprocessors

The first microprocessor was introduced in 1971 by Intel Corp. It was named Intel 4004 as it was a 4 bit processor. It was a processor on a single chip. It could perform simple arithmetic and logic operations such as addition, subtraction, Boolean AND and Boolean OR. It had a control unit capable of performing control functions like fetching an instruction from memory, decoding it, and generating control pulses to execute it. It was able to operate on 4 bits of data at a time. This first microprocessor was quite a success in industry. Soon other microprocessors were also introduced. Intel introduced the enhanced version of 4004, the 4040. Some other 4 bit processors are International's PPS4 and Toshiba's T3472.

b. 8-bit Microprocessors

The first 8 bit microprocessor which could perform arithmetic and logic operations on 8 bit words was introduced in 1973 again by Intel. This was Intel 8008 and was later followed by an improved version, Intel 8088. Some other 8 bit processors are Zilog-80 and Motorola M6800.

c. 16-bit Microprocessors

The 8-bit processors were followed by 16 bit processors. They are Intel 8086 and 80286.

d. 32-bit Microprocessors

The 32 bit microprocessors were introduced by several companies but the most popular one is Intel 80386.

e. Pentium Series

Instead of 80586, Intel came out with a new processor namely Pentium processor. Its performance is closer to RISC performance. Pentium was followed by Pentium Pro CPU. Pentium Pro allows allow multiple CPUs in a single system in order to achieve multiprocessing. The MMX extension was added to Pentium Pro and the result was Pentium II. The low cost version of Pentium II is Celeron.

The Pentium III provided high performance floating point operations for certain types of computations by using the SIMD extensions to the instruction set. These new instructions make the Pentium III faster than high-end RISC CPUs.
Interestingly Pentium IV could not execute code faster than the Pentium III when running at the same clock frequency. So Pentium IV had to speed up by executing at a much higher clock frequency.

Von-Neumann Architecture:

The simplest way to organize a computer is to have one processor, register and instruction code format with two parts op-code and address/operand. The memory address tells the control where to find an operand in memory. This operand is read from memory and used as data to be operated on together with the data stored in the processor register. Instructions are stored in one section of same memory. It is called stored program concept.

The task of entering and altering the programs for ENIAC was tedious. It could be facilitated if the program could be represented in a form suitable for storing in memory alongside the data. So the computer could get its instructions by reading from the memory and program could be set or altered by setting the values of a portion of memory. This approach is known as 'stored program concept' was first adopted by John Von Neumann and such architecture is named as von-Neumann architecture and shown in figure below:

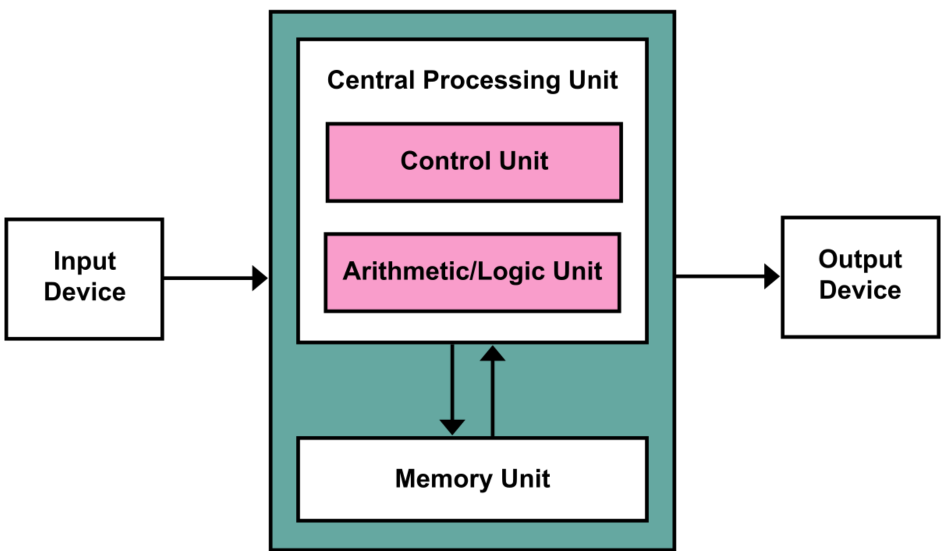

Fig: Von –Neumann Architecture

The main memory is used to stare both data and instructions. The arithmetic and logic unit is capable of performing arithmetic and logical operation on binary data. The program control unit interprets the instruction in memory and causes them to be executed. The I/O unit gets operated from the control unit.

The Von–Neumann architecture is the fundamental basis for the architecture of modern digital computers. It consisted of 1000 storage locations which can hold words of 40 binary digits and both instructions as well as data are stored in it. The storage location of control unit and ALU are called registers and the various models of registers are:

MAR – memory address register – contains the address in memory of the word to be written into or read from MBR.
MBR – memory buffer register – consists of a word to be stored in or received from memory.
IR – instruction register – contains the 8-bit op-code instruction to be executed.
IBR – instruction buffer register – used to temporarily hold the instruction from a word in memory.
PC - program counter - contains the address of the next instruction to be fetched from memory.
AC & MQ (Accumulator and Multiplier Quotient) - holds the operands and results of ALU after processing.

Harvard Architecture:

In von-Neumann architecture, the same memory is used for storing instructions and data. Similarly, a single bus called data bus or address bus is used for reading data and instructions from or writing to memory. It also had limited the processing speed for computers.

The Harvard architecture based computer consists of separate memory spaces for the programs (instructions) and data. Each space has its own address and data buses. So instructions and data can be fetched from memory concurrently and provides significance processing speed improvement.

In figure below, there are two data and two address buses multiplexed for data bus and address bus. Hence, there are two blocks of RAM chips one for program memory and another for data memory addresses.

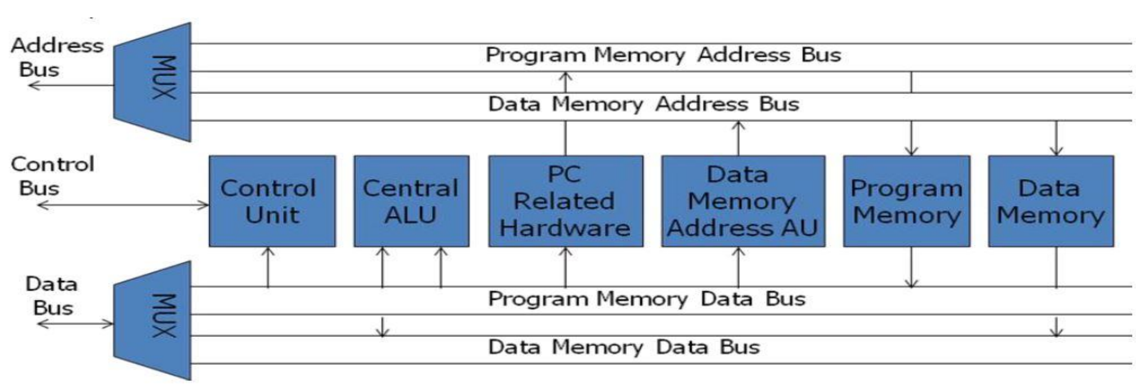

Fig: Harvard Architecture Based Microprocessor

The control unit controls the sequence of operations. Central ALU consists of ALU, multiplier, accumulator and scaling chief register. The PC used to address program memory and always contains the address of next instruction to be executed. Here data and control buses are bidirectional and address bus is unidirectional.

1.3 Components of Microcomputer:

Microprocessor based system includes there components microprocessor, input/output and memory (read only and read/write). These components are organized around a common communication path called a bus.

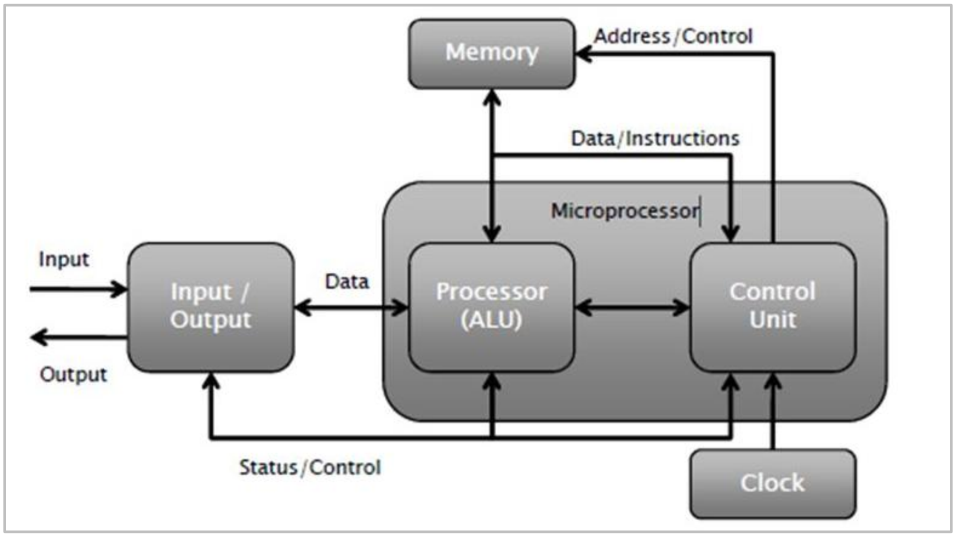

Fig: Component of Microcomputer

Microprocessor:

It is clock driven semiconductor device consisting of electronic logic circuits manufactured by using either a large scale integration (LSI) or very large scale integration (VLSI) technique. It is capable of performing various computing functions and making decisions to change the sequence of program execution. It can be divided in to three segments.

a. **Arithmetic/Logic unit:** It performs arithmetic operations as addition and subtraction and logic operations as AND, OR & XOR.

b. **Register Array:** The registers are primarily used to store data temporarily during the execution of a program and are accessible to the user through instruction. The registers can be identified by letters such as B, C, D, E, H and L.

c. **Control Unit:** It 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 & peripherals.

Memory:

Memory stores binary information such as instructions and data, and provides that information to the up whenever necessary. To execute programs, the microprocessor reads instructions and data from memory and performs the computing operations in its ALU. Results are either transferred to the output section for display or stored in memory for later use. Memory has two sections.

A. Read only Memory (ROM): Used to store programs that do not need alterations and can only read.

B. Read/Write Memory (RAM): Also known as user memory which is used to store user programs and data. The information stored in this memory can be easily read and altered.

Input/output:

- It communicates with the outside world using two devices input and output which are also Known as peripherals.
- The input device such as keyboard, switches, and analog to digital converter transfer binary information from outside world to the microprocessor.
- The output devices transfer data from the microprocessor to the outside world. They include the devices such as LED, CRT, digital to analog converter, printer etc.

1.4 System Bus:

A system bus is a single computer bus that connects the major components of a computer system, combining the functions of a data bus to carry information, an address bus to determine where it should be sent, and a control bus to determine its operation. It is a communication path between the microprocessor and peripherals; it is nothing but a group of wires to carry bits. System bus divides into:

Data Bus:

A data bus is a system within a computer or device, consisting of a connector or set of wires, that provides transportation for data. Different kinds of data buses have evolved along with personal computers and other pieces of hardware.

A data bus can transfer data to and from the memory of a computer, or into or out of the central processing unit (CPU) that acts as the device's "engine." A data bus can also transfer information between two computers.

Address Bus:

An address bus is a computer bus architecture used to transfer data between devices that are identified by the hardware address of the physical memory (the physical address), which is stored in the form of binary numbers to enable the data bus to access memory storage.

The address bus is used by the CPU or a direct memory access (DMA) enabled device to locate the physical address to communicate read/write commands. All address busses are read and written by the CPU or DMA in the form of bits.

Control Bus:

A control bus is a computer bus that is used by the CPU to communicate with devices that are contained within the computer. This occurs through physical connections such as cables or printed circuits.

The CPU transmits a variety of control signals to components and devices to transmit control signals to the CPU using the control bus. The control bus is bidirectional and assists the CPU in synchronizing control signals to internal devices and external components.

1.5 Microprocessor with Bus Organization:

Bus is a common channel through which bits from any sources can be transferred to the destination. A typical digital computer has many registers and paths must be provided to transfer instructions from one register to another. The number of wires will be excessive if separate lines are used between each register and all other registers in the system. A more efficient scheme for transferring information between registers in a multiple register configuration is a common bus system. A bus structure consists of a set of common lines, one for each bit of a register, through which binary information is transferred one at a time. Control signals determine which register is selected by the bus during each particular register transfer.

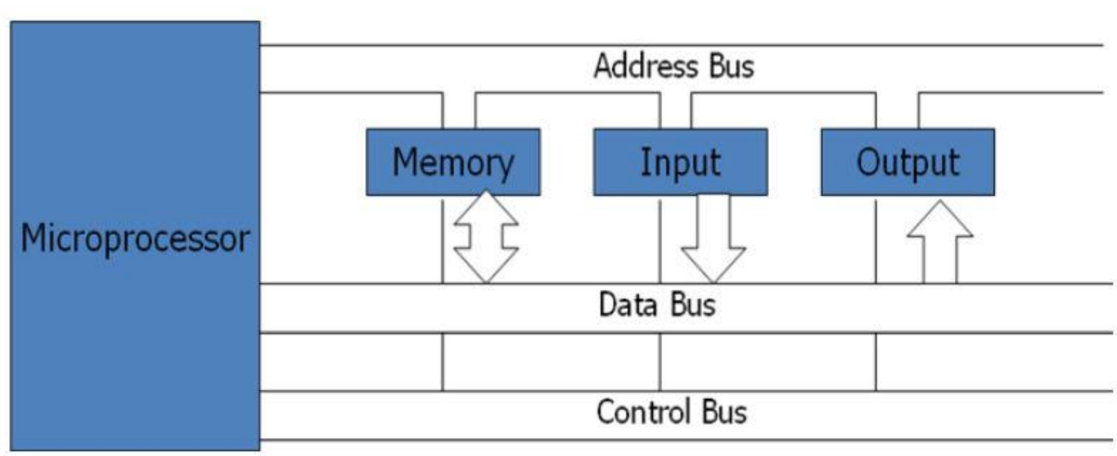

Fig: Bus Organization

A very easy way of constructing a common bus system is with multiplexers. The multiplexers select the source register whose binary information is then pleased on the bus.
A system bus consists of about 50 to 100 of separate lines each assigned a particular meaning or function. Although there are many different bus designers, on any bus, the lines can be classified into three functional groups; data, address and control lines. In addition, there may be power distribution lines as well.

- The data lines provide a path for moving data between system modules. These lines are collectively called data bus.
- The address lines are used to designate the source/destination of data on data bus.
- The control lines are used to control the access to and the use of the data and address lines. Because data and address lines are shared by all components, there must be a means of controlling their use. Control signals transmit both command and timing signals indicate the validity of data and address information. Command signals specify operations to be performed. Control lines include memory read/write, i/o read/write, bus request/grant, clock, reset, interrupt request/acknowledge etc.