CHAPTER - 2

THE MICROCOMPUTER SYSTEM
2.1 GENERAL ASPECTS

The first computer was developed using vacuum tubes. The computers thus developed were clumsy and dissipating more power. After the invention of transistor by Shockley (1948), the clumsy vacuum tube circuits were replaced by transistor circuits. The transistor occupies less space and dissipates less power compared to vacuum tubes. After the development of transistor, integrated circuit technology was introduced in the year 1959. In a span of ten years, integrated circuit technology has transformed the digital integrated circuit chip from an expensive electronic circuit containing only simple logic functions and limited transistors into a highly complex circuits containing upto thousands of transistors.

The microcomputer is making a great impact on every day activity of mankind in day-to-day working of industrialised societies. In the early years of computer development the emphasis was on larger and more powerful computers. The microcomputer is the outcome of the trend towards smaller computers which started in the middle of 1960. With rapid advances in semiconductor technology it became possible to fabricate the whole Central Processing Unit [CPU] of a digital computer on a single chip using Large Scale Integration [LSI] or Very Large Scale Integration [VLSI] technology.
A microprocessor is a single chip semiconductor device consisting of electronic logic circuits manufactured by using VLSI technique. A digital computer whose CPU is a microprocessor is called a microcomputer. A microprocessor combined with memory and input/output devices forms a microcomputer. The prefix micro indicates its physical size, not its computing power. The 32-bit microcomputers are as powerful as earlier mainframe (large) computers. A digital computer understands informations composed of only binary digits namely zeroes and ones, for its operation.

A microcomputer is a digital computer available in a variety of sizes. If all the functions of a digital computer are available on a single chip, it is called a single chip microcomputer.

The microcomputers have the following features:

a. An input channel by which data as well as instructions may be entered.

b. A memory in which the results and instructions may be stored, also from which data can be retrieved.

c. An Arithmetic Logic Unit [ALU] which is capable of performing both arithmetical and logical operations.

d. An output channel by means of which the data will be sent to the outside world.
e. A control section, which controls all the units and performs the above mentioned four tasks (directly or indirectly).

2.2 ARITHMETIC LOGIC UNIT [ALU]

The Arithmetic Logic Unit [ALU] performs arithmetic (Addition, Multiplication etc) and logic operations (AND, OR, COMPLEMENT, EX-OR etc) on binary data which is stored in internal registers. It also performs rotate (Right and Left) operations. The ALU must contain an adder which is capable of combining the contents of two registers in accordance with the logic of binary arithmetic.

It consists of the following registers:

a. An 8-bit accumulator,
b. An 8-bit temporary accumulator,
c. An 8-bit temporary register and
d. An 8-bit flag register.

a. 8-bit accumulator

Any data going into the microprocessor, will be through accumulator only. Hence the accumulator has a special significance in microprocessor. The results of arithmetic and logic operations performed in the arithmetic logic unit are typically stored in the accumulator. Figure(2.1) shows the typical function of an accumulator. Certain microprocessors possess two or more accumulators which make the microprocessor more flexible and allow efficient performance of tasks.
FIG 2.1: TYPICAL FUNCTION OF THE ACCUMULATOR

Diagram showing the flow between a register, ALU, and accumulator.
b. 8-bit temporary accumulator

The accumulator can be loaded from the ALU and internal bus, also transfers data to the temporary accumulator and the internal bus. In essence, the temporary register and temporary accumulator feed the arithmetic logic unit.

c. 8-bit temporary register

The eight bit temporary register receives the data from the internal bus and transmits to the arithmetic logic unit.

d. 8-bit flag register

The five bits of the eight bit flag register are Zero, Carry, Parity, Sign and Auxiliary Carry, the other three bits being nulls (undefined). This register is also known as "Status Register" and the five flags as "status flags". It is used to provide indications of overflow, sign of a number in accumulator, carry from the accumulator and number of zeroes in the accumulators. When certain instructions (e.g. ADI, XRA) are executed the status flags will get affected.

2.3 CONTROL UNIT

The control unit is generally connected to the ALU. The combination of control unit and ALU is known as central processing unit. The main function of control unit is to fetch, decode and execute the instruction of a program stored in the memory. The control unit sequences the operation of the entire system. In particular it generates and manages the control signals necessary to
synchronize operations, as well as the flow of program instructions and data within and outside the ALU. The control unit controls the flow of information on the address and data buses, interprets and manages the signals presented on the control bus. Bus is a group of conducting lines. In a typical system there are three distinct types of buses, namely:

(i) A bidirectional DATA BUS, which is used for transferring data from one subsystem to another.

(ii) A unidirectional ADDRESS BUS which provides information for selecting one or more specific subsystems.

(iii) A CONTROL BUS for carrying control and status information which are necessary for managing the data transfer operations.

2.4 MEMORY

The function of memories is to store program, data and results.

Each memory word may contain a program instruction or a simple data, which is either a constant or a variable. Each memory word has a definite address, and the data stored in that address is as a set of electrical voltages, which represent binary code. There are two kinds of memories; semi-conductor memories and magnetic memories. Semi-conductor memories are faster, smaller, lighter, consume less power and are used as the main memory of a computer. Magnetic memories are slow but they are cheaper and are used
as the secondary memories of a computer for bulk storage of data and informations.

The portion of the memory from which the CPU only reads information is called the READ ONLY MEMORY. This portion is normally non-volatile in a fully designed microcomputer, i.e., the information remains undisturbed even on switching off the power to the devices. The portion of the memory from which the CPU writes or reads information from is called read/write memory or random access memory (RAM). The memory is normally volatile, i.e., the information stored in the memory is lost when power is removed.

Various types of memories (devices) available are given below:

- **RAM**: Random Access Memory
- **ROM**: Read Only Memory
- **PROM**: Programmable Read Only Memory
- **EPROM**: Erasable Programmable Read Only Memory
- **EEPROM**: Electrically Erasable Programmable Read Only Memory.

The PROM can be programmed only once whereas in EPROM, the data can be erased by standard techniques and can be reprogrammed.

RAM is subdivided into two categories as static RAM and dynamic RAM. The static RAM stores the information written into it as corresponding flip-flop in Set or Reset condition, whereas in the dynamic RAM the contents
are stored as charge across the MOS capacitors and refreshed periodically by additional hardware and software. In EPROM the program entered into it can be erased by exposing the device to UV radiation whose wavelength is of ~ 25370 A, whereas in EEPROMS or $E^2$ PROMS, the change in contents is made in milliseconds which is much less than the erasing time of an EPROM. If required single bit can also be erased. Erasing and programming of $E^2$PROM is much easier as compared to EPROM.

2.5 INPUT / OUTPUT DEVICES

The computer receives data and instructions through input devices. An input device converts instructions, input data and signals into proper binary form suitable for a digital computer. A keyboard and simple switches are used as input devices. The user enters instructions and data through a keyboard. Computers are also used to measure and control physical quantities like temperature, pressure, speed etc. For these purposes transducers are used to convert physical quantities into proportional electrical signals. A/D converters are used to convert analog electrical signals into digital signals which are sent to the computer. Transducers and sensors, data acquisition system etc. are also included in input devices. A/D converter forms a part of data acquisition system.

The computer sends results to output devices. An output device may store, print, display or send electrical signal to control/actuate certain equipment. The examples
of simple output devices are printers, CRT, LEDs, D/A converter, controllers, actuators etc.

Some times input and output devices may be combined in a single unit which acts as both an input as well as an output device. A keyboard and CRT are combined to form a video terminal which is a common I/O device for human interaction with a computer. Magnetic tape and magnetic disks are also I/O devices. These are secondary memories for bulk storage. They are connected as I/O devices. The computer reads data and programs from disks and tapes, and also stores results into these devices. Thus a tape or disk acts as an input as well as an output device. The CPU communicates with the other sub-systems through buses.

2.6 ORGANIZATION OF MICROCOMPUTERS

A microcomputer is essentially a small and inexpensive computer. The block diagram of microcomputer is illustrated in figure (2.2). It consists of input devices, output devices, microprocessor, memory and three types of buses (Address Bus, Data Bus, Control Bus) connecting all the units. Microcomputer design will be based on these basic building blocks.

A device which enables a microcomputer to receive the input data and convert it into the proper binary form for the microprocessor is known as input device. Typical examples are toggle switches, key boards, A/D converters and paper tape readers.
FIG 2.2 : BLOCK DIAGRAM OF MICRO-COMPUTER
The output devices in microcomputer are used to get the computed results to the outside world. Typical examples are Displays, Cathode Ray tubes (CRT), printers, Tape punches and light emitting diodes (LEDS).

Microprocessor is the heart of the microcomputer. It consists of the circuitry required to access the appropriate locations in memory and interpret the resulting instructions. Execution of instructions also takes place in this unit. The Arithmetic Logic Unit [ALU] a control section and various data constitutes what is known as Central Processing Unit [CPU]. The central processing unit is the nucleus of the microprocessor. The microcomputer is built by suitably interconnecting the CPU with the other subsystems.

Memory has the capability to store the data and instructions in binary form. There are several types of memories which are in use. Of these, semiconductor memories are most commonly used because of their fast response (e.g. ROM - Read Only Memory, RAM - Random Access Memory).

A bus is a group of conducting lines or wires over which electrical signals are transmitted. Various types of input/output devices and memories are connected to the microprocessor by means of buses.

The microprocessor transmits the address of a memory location or of a device over the address bus. This is a unidirectional bus. For example, if the
microprocessor has to access the contents of a memory location having address 0030, then it would transmit this address in binary form over the address bus. This particular address will be received by all the peripherals connected to the microprocessor. Only the device which has been addressed will respond.

The data bus, which is bidirectional, is used by microprocessor to communicate as well as to receive data to and from the peripheral devices.

Finally, the control bus which is unidirectional set of lines over which signals that indicate the type of activity in current process are transmitted. The typical activities are:

(a) Memory read, (b) Memory write, (c) Input / output read
(d) Input / output write (e) Interrupt acknowledge.

The width of the bus depends on the number of signal lines that constitute the bus. In case of eight bit microprocessors the data will be eight bit wide which means that a byte of information can be transmitted in parallel over the data bus. Most of the eight bit as well as sixteen bit microprocessors will have sixteen bit address bus. Hence these microprocessors can access a total of $2^{16} = 65,536$ (64k) bytes of memory locations. In Intel 8085 microprocessors, though the address bus is 16 bits wide, there are 8 pins which are dedicated to transmit the most significant 8 bits of the memory address, and the 8 bits of data bus are used to transmit...
the least significant 8 bits of memory address, forming a complete 16-bit address. This is known as multiplexing of data and address busses.

The microcomputer operates as directed by the user, wherein the user writes a sequence of instruction known as a program and requests the microcomputer to begin executing each instruction starting from the first one. The microprocessor fetches the instructions one by one from the memory and executes them.