CHAPTER – 1

OVERVIEW OF MICROPROCESSORS

1.1 GENERAL

A microprocessor is one of the most exciting technological innovations in electronics since the appearance of the transistor in 1948. This wonder device has not only set in the process of revolutionizing the field of digital electronics, but it is also getting entry into almost every sphere of human life. Applications of microprocessors range from the very sophisticated process controllers and supervisory control equipment to simple game machines and even toys.

It is, therefore, imperative for every engineer, specially electronics engineer, to know about microprocessors. Every designer of electronic products needs to learn how to use microprocessors. Even if he has no immediate plans to use a microprocessor, he should have knowledge of the subject so that he can intelligently plan his future projects and can make sound engineering judgements when the time comes.

The subject of microprocessors is overviewed here with the objective that a beginner gets to know what a microprocessor is, what it can do, how it fits in a system and gets an overall idea of the various components of such a system. Once he has understood signam of each component and its place in the system, he can go deeper into the working details and design of individual components without difficulty.

1.2 WHAT IS A MICROCOMPUTER?

To an engineer who is familiar with mainframe and mini computers, a microcomputer is simply a less powerful mini computer. Microcomputers have smaller instruction sets and are slower than mini computers, but then they are far less expensive and smaller too.

To an engineer with a hardware background and no computer experience, a microcomputer will look like a sequential state machine that can functionally replace thousands of random logic chips, but occupies a much lesser space, costs much lesser and the number of device interconnections being fewer in it, is much more reliable.

A microcomputer is primarily suited, because of its very low cost and very small size, to dedicated applications. On the same grounds, the mainframe computer is as a rule suitable as a general purpose computer. Mini computer finds applications in both areas.

1.3 WHAT IS A MICROPROCESSOR?

A computer, large or small, can be represented functionally (in a simplified form) by the block diagram in Figure. 1.1. As shown, it comprises of three basic parts or sub-systems:

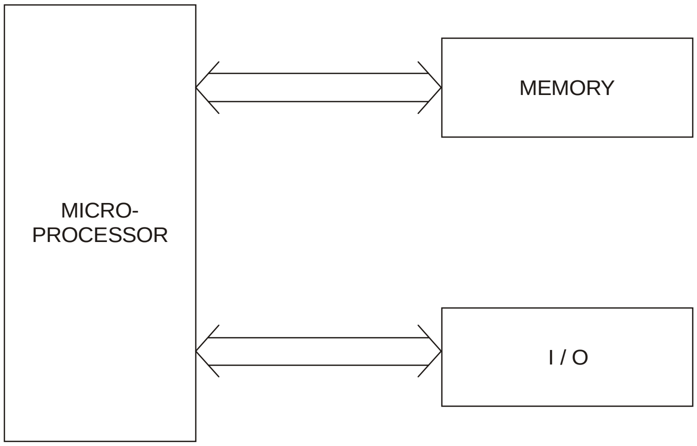

Figure 1.1 Block Digram of Microcomputer

(*a*) *Central Processing Unit* (*CPU*)

It performs the necessary arithmetic and logic operations and controls the timing and general operation of the complete system.

(*b*) *Input/Output* (*I/O*) *Devices*

Input devices are used for feeding data into the CPU, examples of these devices are toggle switches, analog-to-digital converters, paper tape readers, card readers, keyboards, disk etc. The output devices are used for delivering the results of computations to the outside world; examples are light emitting diodes, cathode ray tube (CRT) displays, digital-to-analog converters, card and paper-tape punches, character printers, plotters, communication lines etc. The input-output subsystem thus allows the computer to usefully communicate with the outside world. Input-output devices are also called as peripherals.

(*c*) *Memory*

It stores both the instructions to be executed (i.e., the program) and the data involved. It usually consists of both RAMs (random-access memories) and ROMS (read-only memories).

A microprocessor is an integrated circuit designed to function as the CPU of a microcomputer.

1.4 WHAT IS INSIDE A MICROPROCESSOR ?

The microprocessor or CPU reads each instruction from the memory, decodes it and executes it. It processes the data as required in the instructions. The processing is in the form of arithmetic and logical operations. The data is retrieved from memory or taken from an input device and the result of processing is stored in the memory or delivered to an appropriate output device, all as per the instructions.

To perform all these functions, the µP (microprocessor) incorporates various functional units in an appropriate manner. Such an internal structure or organizational structure of µP, which determines how it operates, is known as its architecture.

A typical microprocessor architecture is shown in Figure 1.2. The various functional units are as follows:

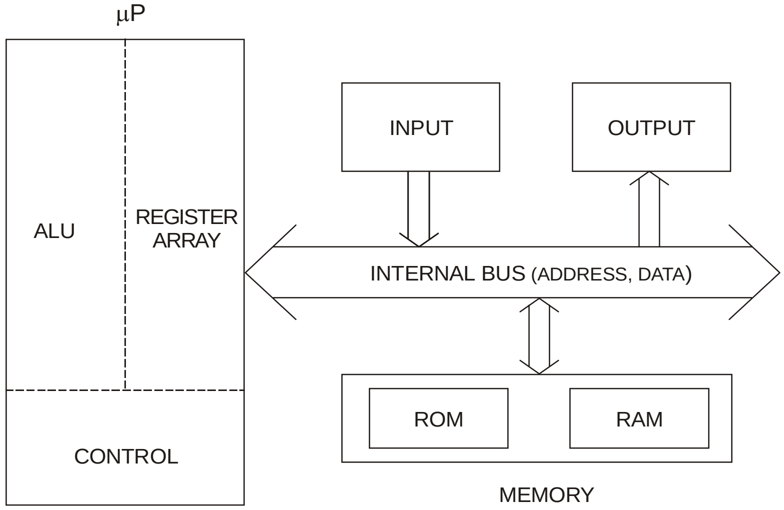

Figure 1.2 Architecture of Microprocessor

1.4.1 Busses

μC (microcomputer), like all computers, manipulates binary information. The binary information is represented by binary digits, called bits. μC operates on a group of bits which are referred to as a word. The number of bits making-μP a word varies with the μP. Common word sizes are 4, 8, 12 and 16 bits (μPs with 32 bit-word have also of late entered the market). Another binary terms that will be of interest in subsequent discussions are the byte and the nibble, which represent a set of 8 bits and 4 bits, respectively.

Figure 1.2 shows busses interconnecting various blocks. These busses allow exchange of words between the blocks. A bus has a wire or line for each bit and thus allows exchange of all bits of a word in parallel. The processing of bits in the μP is also in parallel. The busses can thus be viewed as data highways. The width of a bus is the number of signal lines that constitute the bus.

The figure shows for simplicity three busses for distinct functions. Over the address *bus*, the μP transmits the address of that I/O device or memory locations which it desires to access. This address is received by all the devices connected to the processor, but only the device which has been addressed responds. The *data bus* is used by the μP to send and receive data to and from different devices (I/O and memory) including instructions stored in memory. Obviously the address bus is unidirectional and the data bus is bi-directional. The control bus is used for transmitting and receiving control signals between the μP and various devices in the system.

1.4.2 Arithmetic-Logic Unit (ALU)

The arithmetic-logic unit is a combinational network that performs arithmetic and logical operations on the data.

1.4.3 Internal Registers

A number of registers are normally included in the microprocessor. These are used for temporary storage of data, instructions and addresses during execution of a program. Those in the Intel

8085 microprocessor are typical and are described below:

(*i*) *Accumulator* (*Acc*) *or Result Register*

This is an 8-bit register used in various arithmetic and logical operations. Out of the two operands to be operated upon, one comes from accumulator (Acc), whilst the other one may be in another internal register or may be brought in by the data bus from the main memory. Upon completion of the arithmetic/logical operation, the result is placed in the accumulator (replacing the earlier operand). Because of the later function, this register is also called as result register.

(*ii*) *General Purpose Registers or Scratch Pad Memory*

There are six general purpose 8-bit registers that can be used by the programmer for a variety of purposes. These registers, labelled as B, C, D, E, H and L, can be used individually (e.g., when operation on 8-bit data is desired) or in pairs (e.g., when a 16-bit address is to be stored). Only B-C, D-E and H-L pairs are allowed.

(*iii*) *Instruction Register* (*IR*)

This 8-bit register stores the next instruction to be executed. At the proper time this stored word (instruction) is fed to an instruction decoder which decodes it and supplied appropriate signals to the control unit. When the execution has been accomplished the new word in the instruction register is processed.

(*iv*) *Program Counter* (*PC*)

This is a 16-bit register which holds the address of the next instruction that has to be fetched from the main memory and loaded into the instruction register. The program controlling the operation is stored in the main memory and instructions are retrieved from this memory normally in order. Therefore, normally the address contained in the PC is incremented after each instruction is fetched. However, certain classes of instruction can modify the PC so that the programmer can provide for branching away from the normal program flow. Examples are instructions in the “jump” and ‘call subroutine’ groups.

(*v*) *Stack Pointer* (*SP*)

This is also a 16-bit register and is used by the programmer to maintain a stack in the memory while using subroutines.

(*vi*) *Status Register or Condition Flags*

A status register consisting of a few flip-flops, called as condition flags (in 8085 the number of flags is five) is used to provide indication of certain conditions that arise during arithmetic and logical operations. These are:

‘zero’	Flag is set if result of instruction is 0.
‘sign’	Set if MSB of result is 1.
‘parity’	Set if result has even parity.
‘carry’	Set if carry or borrow resulted.
‘auxiliary carry’	Set if instruction caused a carry out of bit 3 and into bit 4 of the resulting value.

(*vii*) *Dedicated Registers*

Several other registers are incorporated in the μP for its internal operation. They cannot be accessed by the programmer and hence do not concern much a μP user.

1.4.4 Instruction Decoder and Control Unit

It decodes each instruction and under the supervision of a clock controls the external and internal units ensuring correct logical operation of the system.

1.5 SEMICONDUCTOR MEMORIES

As mentioned earlier, semiconductor memories are required in a microcomputer for storing information which may comprise of (*a*) the data to be used for computation, (*b*) instructions and (*c*) computational results. A program starts as a set of instructions on a paper, then this is transferred to a set of cards with the instructions punched in code on them. These instructions also can be transferred to magnetic tape, paper tape or directly into semiconductor memory which is the eventual storage space for a program. The semiconductor memory chips are connected to the μP through the address bus, data bus and control bus. (This is also the way that I/O devices are connected to the μP). See Figure 1.3.

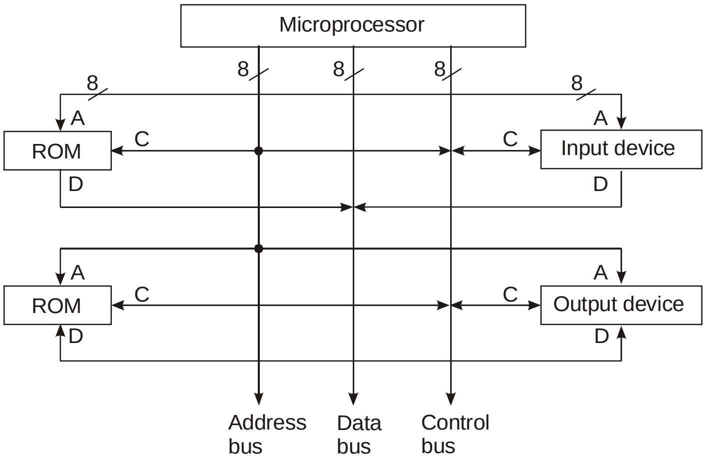

Figure 1.3 Connection of I/O Devices and Memory

1.5.1 Memory Classes

Memories may be broadly divided into two classes:

(*a*) *Random Access Memory* (*RAM*) *or Read/Write Memory* (*RWM*)

There is provision in RAMs (RWMs) for writing information into the memory and reading it when the microcomputer is in operation. It is, therefore, used to store information which changes or may change during the operation of the system, viz. data for calculations and results of calculations. It is also used to store the programs which are to be changed frequently. Semiconductor RAM is a volatile memory.

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