INTRODUCTIONN TO MICROPROCESSORS & MICROCOMPUTERTS

Digital Computer: a programmable machine that processes binary data, it accepts input information, process it according to a program stored in the memory and produce the result as output. The major components of any computer system are the: CPU (central processing unit), memory, and I/O devices; as shown in Fig (1-1).

The CPU is the brain of any computer system; it performs arithmetic and logic operation and controls memory and I/O.

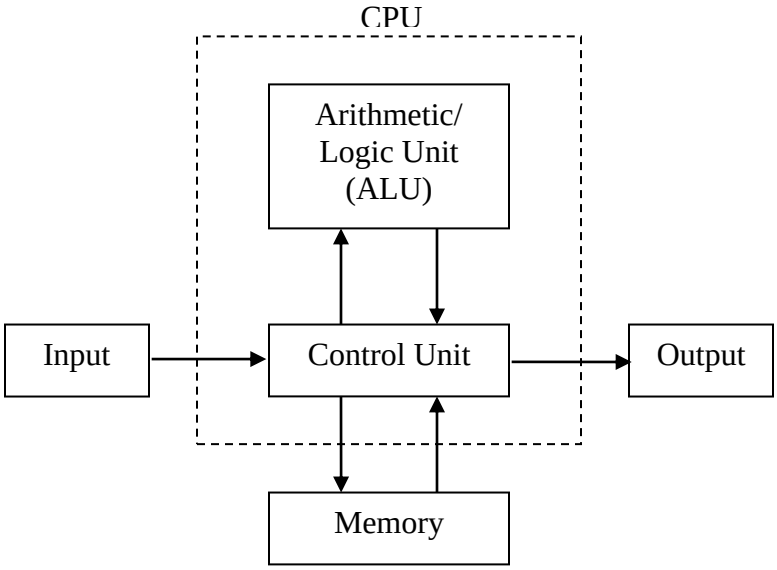

Fig (1-1) Traditional Block Diagram of a Computer System

As changes in the technology were incorporated into the design of computers, their cost and size were reduced dramatically.

- In 1940s, CPUs were designed using vacuum tubes; these computers occupied entire rooms and required an air-conditioned environment to operate reliably.

- In 1950s, transistors were invented and they take place the vacuum tubes in the design of computers.
- In 1959, the first IC (Integrated Circuit) was invented and the use of it in the design of CPU boards became common in 1960s. It was not until the 1970s that the entire CPU was put on a single IC chip; the first working CPU on a chip was invented by Intel in 1971, this CPU was called a “microprocessor”. The first microprocessor used SSI (small-scale integration) technology which is referred to the process of designing a few logic gate circuits on a single chip. As semiconductor technology advanced; more than hundred gates were fabricated on a single chip and this was called medium-scale integration (MSI).
- Within a few years, it was possible for designing more than a thousand gates on a single chip; this came to be known as large-scale integration (LSI).
- Now we are in the area of very-large-scale integration (VLSI) and super-large-scale integration (SLSI).

Table (1-1): Computer Generations

Generation	Approximate Dates	Technology	Typical Speed (operations per second)
1	1946–1957	Vacuum tube	40,000
2	1958–1964	Transistor	200,000
3	1965–1971	Small and medium scale integration	1,000,000
4	1972–1977	Large scale integration	10,000,000
5	1978–1991	Very large scale integration	100,000,000
6	1991-	Ultra large scale integration	1,000,000,000

So the "**microcomputer**" can be defined as, a computer that is designed using a "microprocessor" as its CPU.

The traditional block diagram shown in Fig (1-1) can be replaced by the block diagram shown in Fig (1-2).

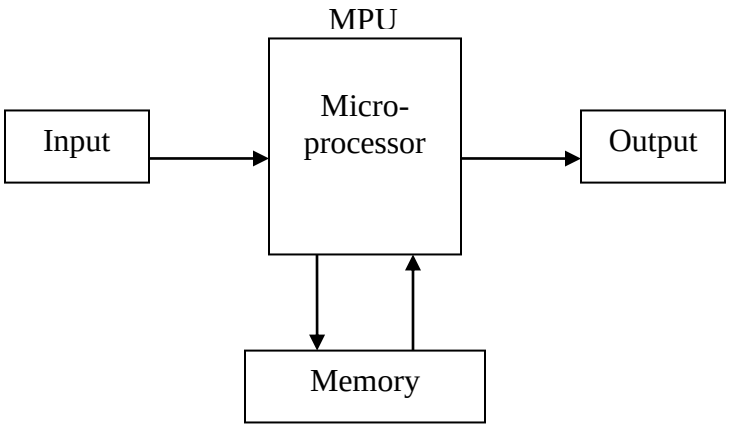

Fig (1-2) The Block Diagram of a Microprocessor Based Computer System (Microcomputer).

The microcomputer system consists of:

1- **Microprocessor Unit**: a semiconductor device (integrated circuit), it includes the ALU, number of registers, and control circuits on a single chip.

Each μp recognizes and processes a group of bits called the word and they are classified according to their word length.

a) **Arithmetic logic unit:** this is the area of the microprocessor where arithmetic and logic operations are performed.

b) **Registers:** these registers are primarily used to store data temporarily during the execution of a program and are accessible to the user through instructions.

c) **Control unit:** provides the necessary timing and control signals to all the operations in the μc. It controls the flow of data between the μp and memory and I/O.

2- **Memory:** the part of the μc that stores such binary information as programs (instructions) and data, and provides that information to the μp whenever necessary.

The memory is organized in a group of N bits to be stored or retrieved in a single operation. Each group of N bits is referred as a word. N is called the word length. Each word location in the memory has its unique identity number or address.

Memory storage usually expressed with the below terms:

Kilobyte: (1k) $=2^{10}$ =1024 bytes

Megabyte: (1MB) = 2^{20} = 1,048,576 (over 1 million bytes)

Gigabyte: (1GB) = 2^{30} = (over billion bytes)

Terabyte: (1TB) = 2^{40} = (over trillion byte)

Ex: 64 k==64*2^{10} = 65536 = 2^{16}, range 0 --- 65536 (0000 ---- FFFF)

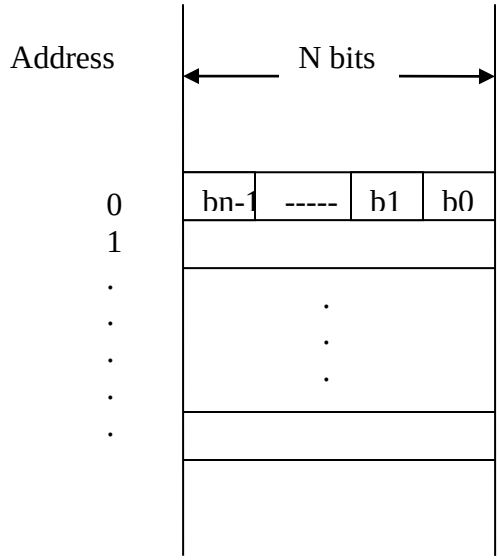

Fig (1-3) Memory Organization

Two commonly types of memory used in μcs are RAM and ROM

a) **RAM** (Read Access memory or Read/Write memory): a memory that stores binary information during the operation of the computer. The information stored in this memory can be read and altered easily.

b) **ROM** (Read-Only memory): a memory that stores binary information permanently. The information can be read from this memory but cannot be altered.

3- **I/O:** are the means by which the microprocessor communicates with the outside world. Input devices such as keyboard, mouse and the most widely used output devices are the printer and monitor.

4- **Buses:** group of lines (wires) used to transfer bits between the microprocessor and other components of the microcomputer system.

There are three types of buses: address, data, and control bus.

a) **Address bus:** is a unidirectional bus (bits flow in one direction- from the μp to memory or to I/O devices). It contains the address of the next location to be read or the location where data to be stored. Total memory size is fixed by the number of lines provided by the address bus. For ex. a μp with 16 address lines can provide a total of 65,536 (2^{16}) or 64k bytes of addressable memory. Another ex. a μp with 24 address lines and 16 data lines, the total accessible memory is 16 megabytes (2^{24}=16 megabytes), ie., there would be 2^{24} locations.

[The number of memory locations are always equal to 2^x, where x: is the number of address lines].

b) **Data bus:** is a bidirectional bus (data flow in both directions between the μp and memory and I/O devices) that is used to carry information in and out the μp, that information may be either instruction to be decoded or data to be manipulated. The direction of the flow is determined by the control section of the μp. An 8-bit μc has 8 connecting lines in the data bus, and 16-bit μc has 16 line data bus.

c) **Control bus:** is a unidirectional bus, which carries information describing what operation is to be performed (read or write) and which functional unit (memory or I/O) is to be respond. Control bus size is determined by the number of control signals required for the μp and it is determined by the designer.

EVOLUTION OF THE INTEL MICROPROCESSORS

The principal way in which μps and μcs are categorized is in terms of word length. Over time five standard data widths have evolved: 4-bit, 8-bit, 16-bit, 32-bit, and 64-bit. μp

Table (2) illustrates the evolution of Intel's μp since their introduction in 1971.

- The first μp, the 4004, was designed to process data arranged as 4-bit words (nibble of data). Its common use was in calculators.
- Beginning in 1972 a second generation of μps was introduced. These devices, the 8008, 8080, and 8085, were 8-bit μps
- In the mid-1970s, development of third generation 16-bit μp was announced. Intel's first 16-bit μp, the 8086, became available in 1978 and was followed the next year by its 8-bit bus version; the 8088.this was the birth of Intel's 8086 family. Other 8086 family members, such as 80286, 80386, 80486.
- The 80286 is a 16-bit internal and external data buses; and it uses virtual memory.

  Virtual memory: is a way of fooling the microprocessor into thinking that it has access to an almost unlimited amount of memory by swapping data between disk storage and RAM.
- The 80386 (sometimes called 80386DX), it has internally and externally a 32-bit μp while the 80386SX has 16-bit external data bus.
- In 1989, the 80486 was introduced; like 80386 is still a 32-bit microprocessor with capability of addressing 4G of memory. Intel integrated the 80387 math coprocessor in addition to 8 K bytes of cache memory into a single chip.

Cache memory: is a static RAM with a very fast access time.

- To make it more affordable, a stripped-down version of the 80486 called the 80486SX was introduced; it is exactly like the 80486 except that it does not contain the math coprocessor. A math coprocessor is available on a separate chip.
- In 1993, Intel announced release of the newest ×86 microprocessor, the Intel Pentium. The Pentium family is fully compatible with previous ×86 processors but includes several new features, including separate 8K cache memory and 64-bit bus.

Table (1-2): Evolution of the Intel Microprocessors

(a) 1970s Processors

	4004	8008	8080	8086	8088
Introduced	1971	1972	1974	1978	1979
Clock speeds	108 kHz	108 kHz	2 MHz	5 MHz, 8 MHz, 10 MHz	5 MHz, 8 MHz
Bus width	4 bits	8 bits	8 bits	16 bits	8 bits
Number of transistors	2,300	3,500	6,000	29,000	29,000
Feature size (μm)	10		6	3	6
Addressable memory	640 Bytes	16 KBytes	64 KBytes	1 MB	1 MB
Virtual memory	—	—	—	—	—

(b) 1980s Processors

	80286	386TM DX	386TM SX	486TM DX CPU
Introduced	1982	1985	1988	1989
Clock speeds	6 MHz - 12.5 MHz	16 MHz - 33 MHz	16 MHz - 33 MHz	25 MHz - 50 MHz
Bus width	16 bits	32 bits	16 bits	32 bits
Number of transistors	134,000	275,000	275,000	1.2 million
Feature size (μm)	1.5	1	1	0.8 - 1
Addressable memory	16 megabytes	4 gigabytes	16 megabytes	4 gigabytes
Virtual memory	1 gigabyte	64 terabytes	64 terabytes	64 terabytes

(c) 1990s Processors

	486TM SX	Pentium	Pentium Pro	Pentium II
Introduced	1991	1993	1995	1997
Clock speeds	16 MHz - 33 MHz	60 MHz - 166 MHz,	150 MHz - 200 MHz	200 MHz - 300 MHz
Bus width	32 bits	32 bits	64 bits	64 bits
Number of transistors	1.185 million	3.1 million	5.5 million	7.5 million
Feature size (μm)	1	0.8	0.6	0.35
Addressable memory	4 gigabytes	4 gigabytes	64 gigabytes	64 gigabytes
Virtual memory	64 terabytes	64 terabytes	64 terabytes	64 terabytes