UNIT:1 Basics of Computer Organization and Processor Evolution

Topics:

1.1.1. Observe the characteristic of Intel processor from 4 bit (4004) to i7

1.2.1. Basic CPU Structure: CU, ALU and MU

1.2.2. Various Registers used in CPU & its applications

AC, DR, AR, PC, MAR, MBR, IR

1.3.1. Types of Buses used in CPU

Common / Shared Bus v/s Dedicated Bus

Serial Bus v/s Parallel Bus

1.1.1. Observe the characteristic of Intel processor from 4 bit (4004) to i7

- Transistor was invented in 1948 (23 December 1947 in Bell lab).
- IC was invented in 1958 (Fair Child Semiconductors) By Texas Instruments J Kilby.
- The first microprocessor was invented by INTEL(INTegrated ELectronics).
- **Size of the microprocessor –** 4 bit

Name	Year of Invention	Clock speed	Number of transistors	Inst. per sec
INTEL 4004/4040	1971 by Ted Hoff and Stanley Mazor	740 kHz	2300	60,000

- **Size of the microprocessor – 8 bit**

Name	Year of Invention	Clock speed	Number of transistors	Inst. per sec
8008	1972	500 kHz	3500	50,000
8080	1974	2 MHz	6000	10 times faster than 8008

8085	1976 (16-bit address bus)	3 MHz	6500	769230

- **Size of the microprocessor** – 16 bit

Name	Year of Invention	Clock speed	Number of transistors	Inst. per sec
8086	1978 (multiply and divide instruction, 16-bit data bus and 20-bit address bus)	4.77 MHz, 8 MHz, 10 MHz	29000	2.5 Million
8088	1979 (cheaper version of 8086 and 8-bit external bus)			2.5 Million
80186/80188	1982 (80188 cheaper version of 80186, and additional components like interrupt controller, clock generator, local bus controller, counters)	6 MHz		
80286	1982 (data bus 16bit and address bus 24 bit)	8 MHz	134000	4 Million

- **Size of the microprocessor** – 32 bit

Name	Year of Invention	Clock speed	Number of transistors	Inst. per sec
INTEL 80386	1986 (other versions 80386DX, 80386SX, 80386SL , and data bus 32-bit address bus 32 bit)	16 MHz – 33 MHz	275000	

INTEL 80486	1986 (other versions 80486DX, 80486SX, 80486DX2, 80486DX4)	16 MHz – 100 MHz	1.2 Million transistors	8 KB of cache memory
PENTIUM	1993	66 MHz		Cache memory 8 bit for instructions 8 bit for data

- **Size of the microprocessor** – 64 bit

Name	Year of Invention	Clock speed	Number of transistors	Inst. per sec
INTEL core 2	2006 (other versions core2 duo, core2 quad, core2 extreme)	1.2 GHz to 3 GHz	291 Million transistors	64 KB of L1 cache per core 4 MB of L2 cache
i3, i5, i7	2007, 2009, 2010	2.2GHz – 3.3GHz, 2.4GHz – 3.6GHz, 2.93GHz – 3.33GHz		

❖ **Generations of microprocessors:**

1. **First-generation –**

From 1971 to 1972 the era of the first generation came which brought microprocessors like INTEL 4004 Rockwell international PPS-4 INTEL 8008 etc.

2. **Second generation –**

The second generation marked the development of 8-bit microprocessors from 1973 to 1978. Processors like INTEL 8085 Motorola 6800 and 6801 etc came into existence.

3. **Third generation –**

The third generation brought forward the 16-bit processors like INTEL 8086/80186/80286 Motorola 68000 68010 etc. From 1979 to 1980 this generation used the HMOS technology.

4. **Fourth generation –**

The fourth-generation came into existence from 1981 to 1995. The 32-bit processors using HMOS fabrication came into existence. INTEL 80386 and Motorola 68020 are some of the popular processors of this generation.

5. **Fifth-generation –**

From 1995 till now we are in the fifth generation. 64-bit processors like PENTIUM, Celeron, dual, quad, and octa-core processors came into existence.

❖ **Types of microprocessors:**

· **Complex instruction set microprocessor:**

The processors are designed to minimize the number of instructions per program and ignore the number of cycles per instruction. The compiler is used to translate a high-level language to assembly-level language because the length of code is relatively short and an extra RAM is used to store the instructions. These processors can do tasks like downloading, uploading, and recalling data from memory. Apart from these tasks, this microprocessor can perform complex mathematical calculations in a single command.

Example: IBM 370/168, VAX 11/780

Reduced instruction set microprocessor:

These processors are made according to function. They are designed to reduce the execution time by using the simplified instruction set. They can carry out small things in specific commands. These processors complete commands at a faster rate. They require only one clock cycle to implement a result at uniform execution time. There is a number of registers and less number of transistors. To access the memory location LOAD and STORE instructions are used.
Example: Power PC 601, 604, 615, 620

Superscalar microprocessor:

These processors can perform many tasks at a time. They can be used for ALUs and multiplier-like arrays. They have multiple operation units and perform tasks by executing multiple commands.

Application-specific integrated circuit:

These processors are application-specific like personal digital assistant computers. They are designed according to proper specifications.

Digital signal multiprocessor:

These processors are used to convert signals like analog to digital or digital to analog. The chips of these processors are used in many devices such as RADAR SONAR home theatres etc.

- **Features:**

Clock speed: One of the earliest features of microprocessors was the clock speed, which refers to the speed at which the processor can execute instructions. Over time, clock speeds have increased, with modern processors capable of speeds in the billions of cycles per second (GHz).

Instruction set architecture: Microprocessors have evolved to support different instruction set architectures, including CISC (complex instruction set computer) and RISC (reduced instruction set computer), which affect the efficiency and complexity of processing.

Cache memory: Microprocessors now include a cache memory, which is a small amount of high-speed memory that stores frequently used data for quicker access.

Multi-core processors: Modern microprocessors have multiple cores, allowing for multiple tasks to be executed simultaneously, increasing performance and multitasking capabilities.

Virtualization: Microprocessors now support virtualization, which enables multiple operating systems to run on the same physical hardware.

Power management: Modern processors include power management features, which reduce power consumption and improve energy efficiency.

Graphics processing: Many modern microprocessors include integrated graphics processing units (GPUs), which allow for faster and more efficient handling of graphics-intensive tasks.

Security features: Microprocessors now include security features, such as hardware-level encryption and secure boot, to protect against malware and hacking.

Internet connectivity: Microprocessors now include built-in networking capabilities, such as Wi-Fi and Ethernet, which allow for seamless internet connectivity.

Machine learning capabilities: Some modern microprocessors include specialized processing units for machine learning and artificial intelligence tasks, allowing for faster and more efficient processing of these tasks.

Advantages of the microprocessor:

1. High processing speed
2. Compact size
3. Easy maintenance
4. Can perform complex mathematics
5. Flexible
6. Can be improved according to a requirement

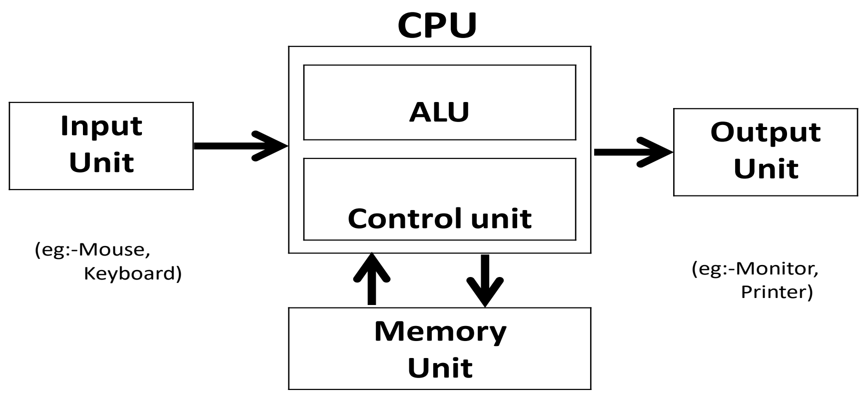
Disadvantages of microprocessors:

1. Overheating occurs due to overuse
2. Performance depends on the size of the data
3. Large board size than microcontrollers
4. Most microprocessors do not support floating-point operations

1.2.1. Basic CPU Structure: CU, ALU and MU

- A computer organization describes the functions and design of the various units of a digital system.
- A general-purpose computer system is the best-known example of a digital system. Other examples include telephone switching exchanges, digital voltmeters, digital counters, electronic calculators and digital displays.
- Computer architecture deals with the specification of the instruction set and the hardware units that implement the instructions.
- Computer hardware consists of electronic circuits, displays, magnetic and optic storage media and also the communication facilities.
- Functional units are a part of a CPU that performs the operations and calculations called for by the computer program.
- Functional units of a computer system are parts of the CPU (Central Processing Unit) that performs the operations and calculations called for by the computer program. A computer consists of five main components namely, Input unit, Central Processing Unit, Memory unit Arithmetic & logical unit, Control unit and an Output unit.

BLOCK DIAGRAM OF DIGITAL COMPUTER:



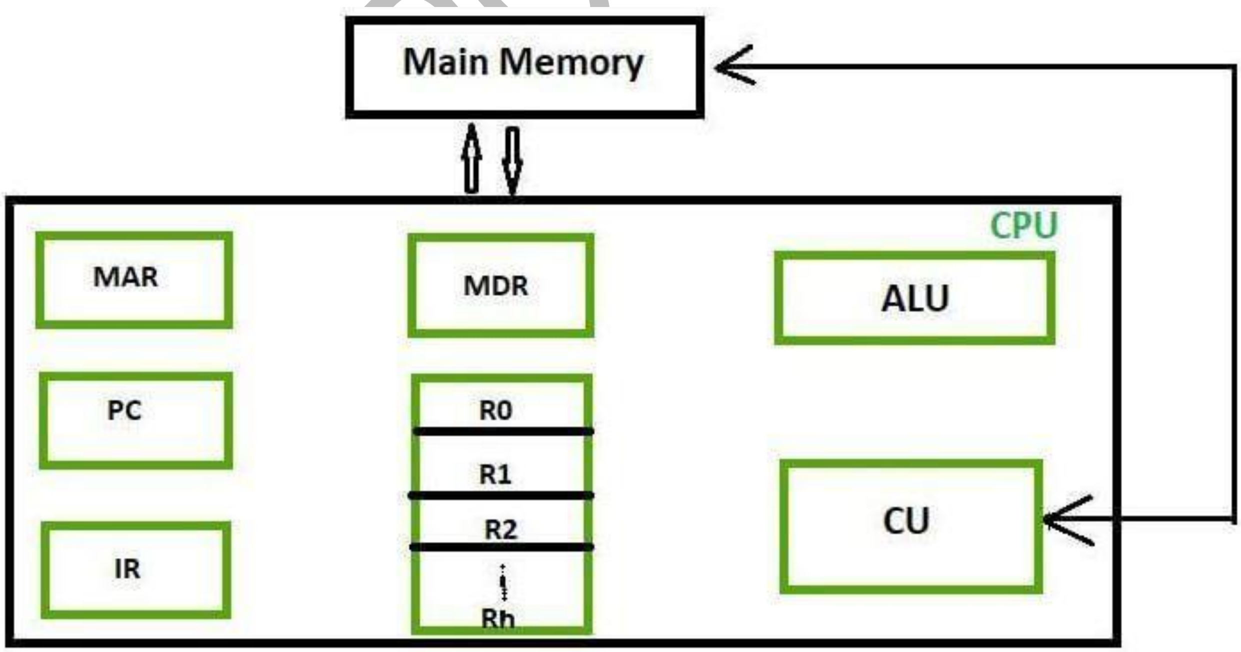
- **Input unit**
  - Input units are used by the computer to read the data.
  - The most commonly used input devices are keyboards, mouse, joysticks, trackballs, microphones, etc.
- **Central processing unit**
  - Central processing unit commonly known as CPU can be referred to as an electronic circuitry within a computer that carries out the instructions given by a computer program by performing the basic arithmetic, logical, control and input/output (I/O) operations specified by the instructions.
- **Memory unit**
  - The Memory unit can be referred to as the storage area in which programs are kept which are running, and that contains data needed by the running programs.
  - The Memory unit can be categorized in two ways namely, primary memory and secondary memory.
  - It enables a processor to access running execution applications and services that are temporarily stored in a specific memory location.
- **Arithmetic & logical unit**
  - Most of all the arithmetic and logical operations of a computer are executed in the ALU (Arithmetic and Logical Unit) of the processor. It performs arithmetic operations like addition,

subtraction, multiplication, division and also the logical operations like AND, OR, NOT operations.

- **Control unit**
  - The control unit is a component of a computer's central processing unit that coordinates the operation of the processor. It tells the computer's memory, arithmetic/logic unit and input and output devices how to respond to a program's instructions.
  - The control unit is also known as the nerve center of a computer system.
- **Output Unit**
  - The primary function of the output unit is to send the processed results to the user. Output devices display information in a way that the user can understand.
  - Output devices are pieces of equipment that are used to generate information or any other response processed by the computer. These devices display information that has been held or generated within a computer.
  - The most common example of an output device is a monitor.

1.2.2. Various Registers used in CPU & its applications:

❖ **AC, DR, AR, PC, MAR, MBR, IR**



Sr No	Name	Symbol	Description
1	Accumulator	AC	An accumulator is the most often utilized register, and it is used to store information taken from memory.
2	Data Register	DR	Holds memory operand
3	Address Register	AR	Holds address for the memory
4	Program Counter	PC	These registers are utilized in keeping the record of a program that is being executed or under execution. These registers consist of the memory address of the next instruction to be fetched. PC points to the address of the next instruction to be fetched from the main memory when the previous instruction has been completed successfully. Program Counter (PC) also functions to count the number of instructions. The incrementation of PC depends on the type of architecture being used. If we use a 32-bit architecture, the PC gets incremented by 4 every time to fetch the next instruction.
5	Memory Address Register	MAR	Address location of memory is stored in this register to be accessed later. It is called by both MAR and MDR together
6	Memory Buffer Register	MBR	MBR - Memory buffer registers are used to store data content or memory commands used to write on the disk. The basic functionality of these is to save called data from memory. MBR is very similar to MDR
7	Instruction Register	IR	Instruction registers hold the information about to be executed. The immediate instructions received from the system are fetched and stored in these registers. Once the instructions are stored in registers, the processor starts executing the set instructions, and the PC will point to the next instructions to be executed

1.3.1. Types of Buses used in CPU : Common / Shared Bus v/s Dedicated Bus

Serial Bus v/s Parallel Bus

- **What is Bus?**

In computer architecture, a bus is a communication system that transfers data between components inside a computer, or between computers.

- **Common / Shared Bus v/s Dedicated Bus**

Dedicated Bus– assigned to a single function (e.g. address bus) or a physical subset of components (e.g. I/O bus connects all I/O modules).

Common Bus – a bus can be used for both addresses and data. In this case, an address valid control line is needed to determine whether the data is an address or data. Time multiplexing is using the same lines for multiple purposes.

- **Serial V/S Parallel Bus:**

Parallel Bus:

A parallel bus is a communication method that transmits multiple bits of data simultaneously using multiple wires or channels. Each bit of the data word is transmitted on a separate wire, allowing for faster transfer of data compared to a serial bus. In a parallel bus, all the data bits, along with control and address information, are transmitted together in parallel.

Advantages of Parallel Bus

1. Faster Data Transfer: Parallel buses can transmit multiple bits simultaneously, resulting in faster data transfer rates. This makes them suitable for applications that require high-speed data transmission, such as video processing, image rendering, and high-performance computing.
2. Simplicity of Implementation: Parallel bus interfaces are relatively straightforward to implement, as they involve connecting the appropriate number of wires between the transmitting and receiving devices. This simplicity can be advantageous in certain applications where ease of implementation is a priority.

Serial Bus:

A serial bus, on the other hand, is a communication method that transmits data sequentially, one bit at a time, over a single wire or channel. The data bits are sent in a continuous stream, with additional control and address information included within the data stream.

Advantages of Serial Bus

1. Simplified Wiring: Serial buses require fewer wires or channels compared to parallel buses since data is transmitted sequentially. This simplifies the wiring and reduces the complexity of

the system, making it suitable for applications with space constraints or limited available connectors.

2. Longer Distance Transmission: Serial buses are better suited for long-distance data transmission, as they are less susceptible to signal degradation and interference. This makes them ideal for applications that require data transmission over extended distances, such as networking, telecommunications, and serial communication protocols.

Serial vs Parallel

- A parallel link transmits several streams of data simultaneously along multiple channels (e.g., wires, printed circuit tracks, or optical fibers); whereas, a serial link transmits only a single stream of data.
- Serial links can be clocked considerably faster than parallel links in order to achieve a higher data rate.
- Serial is cheaper to implement than parallel.
- A serial connection requires fewer interconnecting cables (e.g., wires/fibers) and hence occupies less space.
- Many ICs have serial interfaces, as opposed to parallel ones so that they have fewer pins and are therefore less expensive.
- A parallel bus is and always has been widely used within integrated circuits.
- Parallel buses were commonly used in earlier system buses, whereas serial buses are prevalent in modern computers.
- When data is sent using parallel data transmission, multiple data bits are transmitted over multiple channels at the same time.
- Parallel transmission can transfer data faster, it requires more transmission channels than serial transmission.
- Parallel is easier to program.
- Parallel buses have a relatively large number of wires bundled together that enable data to be transferred in parallel. This increases the throughput, or rate of data transfer, between the peripheral and computer. SCSI buses are parallel buses.
- Serial buses are used for long-distance communication. Eg, Computer to the computer. Parallel buses are used for short distance. Eg, computer to a printer.
- Serial Transmission is full duplex as the sender can send as well as receive the data whereas, Parallel Transmission is half duplex since the data is either sent or received.
- Serial transmission cables are thinner, longer and economical in comparison with the Parallel Transmission cables.