Unit 1: An overview of computer and Microprocessor

1.1. Brief overview of microprocessor and Microcontroller

Microprocessor:

A microprocessor is a multipurpose, Programmable clock-driven, register based electronic device that read binary instruction from a storage device called memory, accepts binary data as input and processes data according to those instructions and provides results as output.

A µp is a clock driven semiconductor device consisting of electronic circuits manufactured by using either LSI or VLSI technique.

A typical programmable machine can be represented with three components: MPU, Memory and I/O as shown in fig:

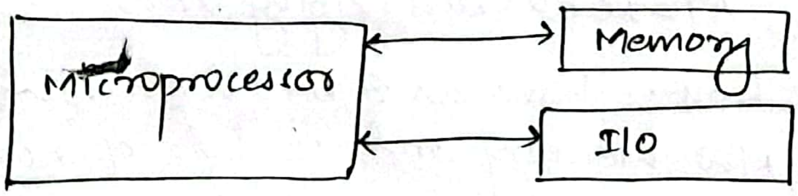


fig: A programmable Machine.

→ These three components work together or interact with each other to perform a given task; thus they comprise a system.

→ The machine (system) represented in above figure can be programmed to turn traffic lights on and off, compute mathematical functions, or keep track of guidance system.

→ The MPU applications are classified primarily in two categories:
- reprogrammable systems
- embedded systems

→ In reprogrammable systems such a micro computers, the µp is for computing and data processing.

→ In embedded systems, the μp is a part of a final product and is not available for reprogramming to end user. A copying machine is a typical example of an embedded system.

MICRO CONTROLLER

→ A single - chip Microcomputers are also known as micro controller.

→ They are used primarily to perform dedicated functions.

→ They are used primarily to perform dedicated functions or as slaves in distributed processing.

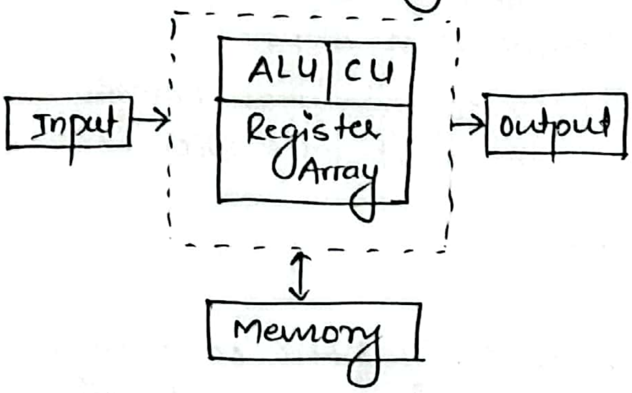
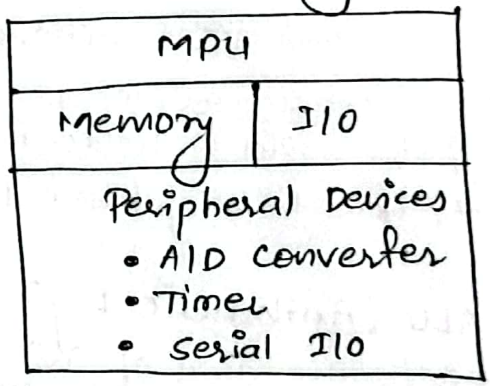
→ generally they include all the essential elements of a computer on a single chip : MPU, R/W memory, ROM and I/O lines.

→ typical examples of the single chip microcomputer are the Intel 8051, AT89C51, AT89C52 and Zilog Z8.

→ Most of the micro controllers have an 8 bit word size, at least 64 bytes of R/W memory and 1K byte of ROM

→ I/O lines varies from 16 to 40.

Although both μprocessor and micro controllers have been designed for real time applications and they share many common features, they have significant differences which are as follow

Microprocessor	Microcontroller.
1. μP is a silicon chip which includes ALU, register circuit and control circuits.	1. μ-controller is a slicon chip which includes μP, memory and I/O in a single package.
2. General Block diagram: 	2. General Block diagram: 
3. Normally used for general purpose computer as CPU.	3. Normally μ-controllers are used for special purpose (embedded systems). eg. traffic light controller, Printer etc.
4. The performance speed ie. clock speed of μp is higher ranging freq^n from MHz to GHz.	4. The performance speed of μ-controller is relatively slower than that of μp with clock speed from 3-33 MHz.
5. Addition of external RAM, ROM and I/O ports makes these systems bulkier and much more expensive.	5. Has fixed memory and all peripherals are embedded together on a single chip, so are not bulkier and are cheaper than μp.
6. μps are more versatile than μ-controllers as the designers can decide on the amount of RAM, ROM and I/O ports needed to fit the task at hand. eg: 8085, 8086, Motorola 68000.	6. As μ-controllers have already fixed amount of RAM, ROM and I/O ports, so are not versatile as the user cannot change the amount of memory. eg: AT89C51, ATMega

• Computer system components

Every computer is constructed by combining various components which work in an organized manner to perform several operations. The design and arrangement of different components of a computer system is reffered to as computer Architecture. Computer system architecture consists of various components such as:-

i. I/O unit
ii. central processing unit (CPU)
iii. Memory unit

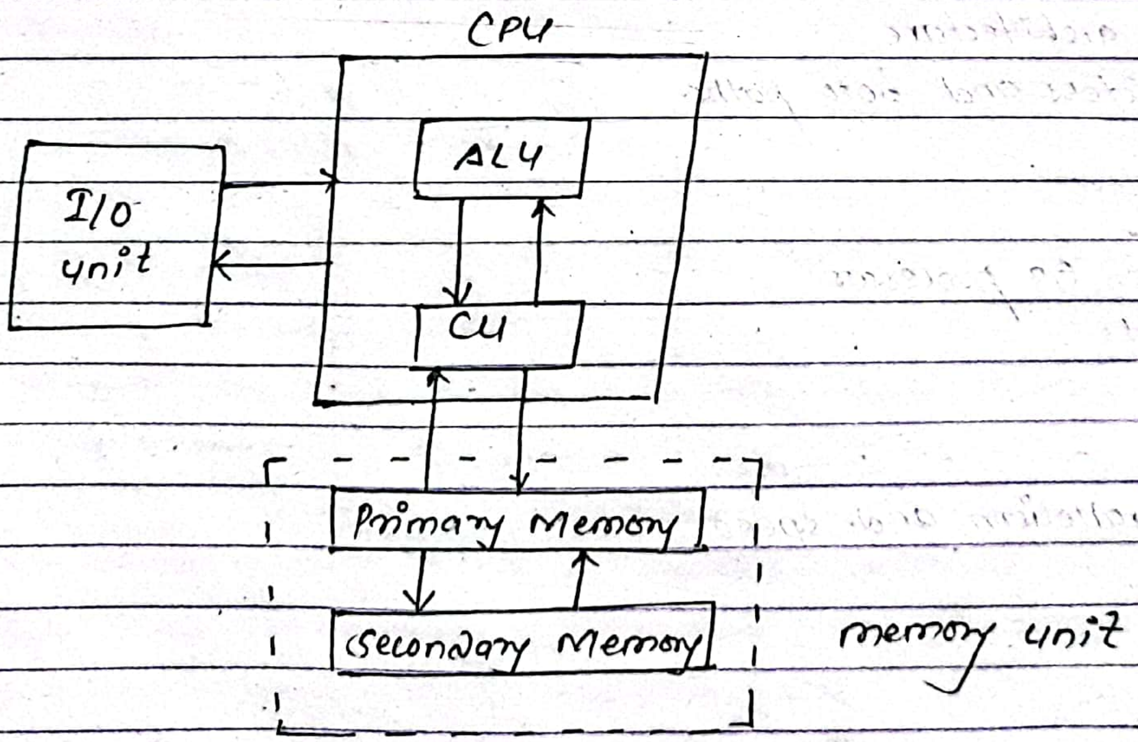


fig: Basic structure/ Architecture of computer system.

i. I/O unit:- I/O unit aids in taking input from the user and make it available to the computer for processing and then finally provide output to the user in understandable form.
In short, I/O unit performs following basic operations.

→ It accepts the list of instructions (input) from user.
→ It converts these instructions and data into a form understandable by the computer and passes it for further processing.
→ It accepts output produced as a result of processing.
→ It converts the received output into user understandable form and presents it to the user.

ii. Central processing unit (CPU):- It is the main unit of the computer. CPU is responsible for controlling internal and external devices and for processing the data.
It has two units:-

→ Arithmetic and Logic Unit (ALU):- ALU is responsible for actual execution of the instructions. All calculations and comparisons are made by this units. It makes the logical decisions as well. ALU can fetch or write data from or into primary memory directly.

→ Control unit (CU):- This unit is responsible for the generation of control signals that looks after the action for each and every component of the CPU and peripherals.
It directs and controls the activities of all internal and external devices.

iii. Memory unit:- This unit is responsible for the storage of data whether it be temporary or permanent. There are basically two types of memory:-

→ primary memory:- Primary memory is generally used for temporary storage of data during processing. primary memory are quite fast as compared to secondary memory and hence they directly interact with the processor.
eg: RAM, cache memory.

→ Secondary memory:- Secondary memory is generally used for storing data permanently or for future use. They interact with primary memory. They are ~~exp~~ comparatively slower so they do not get the privillage of interacting with processor directly.

1.3. Architecture of computer:

The general architecture of microcomputer systems is shown below:

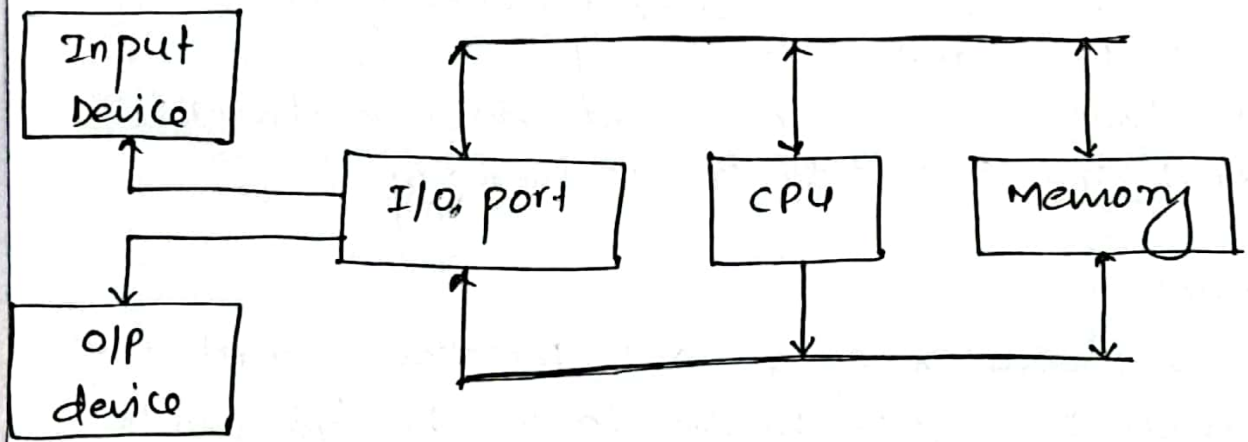


Fig: Block diagram of a simple microcomputer.

→ fig shows a block diagram for a simple microcomputer.

→ The major parts are the CPU, Memory and I/O

→ Connecting these parts are three sets of parallel lines called buses.

→ The three buses are address bus, data bus and the control bus.

1) Address Bus:

→ The address bus consists of 16, 20, 24 or 32 parallel signal lines.

→ On these lines the CPU sends out the address of the memory locations that is to be written to or read from.

→ The no. of memory locations that the CPU can address is determined by the number of address lines.

→ If the CPU has N address lines, then it can directly address 2^N memory locations ie. CPU with 16 address lines can address 2^{16} or 65536 memory locations.

MEMORY CALCULATIONS

→ 2^{10} = 1K (Kilo)
→ 2^{20} = 1M (Mega)
→ 2^{30} = 1G (Giga)
→ 2^{40} = 1T (Tera)

b) Data Bus:
→ The data Bus consists of 8, 16 or 32 parallel signal lines.
→ The data bus lines are bi-directional.
→ This means that the CPU can read data in from memory or it can send data out to memory.

c) Control Bus:
→ The control bus consists of 4 to 10 parallel signal lines.
→ The CPU sends out signals on the control bus to enable the output of addressed memory devices or port devices.
→ Typical control bus signals are Memory Read, Memory write, I/O Read and I/O write.

All other components are same that are explained in previous topics.

1.4. Applications of Microprocessor and Microcontroller.

Microprocessor's Applications:

1. Microcomputer
2. Industrial control
3. Robotics
4. Traffic Lights
5. washing machines
6. Microwave oven
7. security systems
8. on Board systems.

Applications of Microcontroller:

1. Light sensing and controlling devices.
2. Temperature sensing and controlling devices.
3. Fire detection and safety devices.
4. Industrial instrumentation devices
5. Process control devices.
6. "

- On the basis of methods of storing programs and data, we can categorize the computing machines as:
    1. Fixed Program Machines, and
    2. Stored Program Machines

1. **Fixed Program Machines:**

- The earliest computing machines had fixed programs.
- These machines were programmed by setting switches and inserting patch leads to route data and to control signals between various functional units.
- Changing the program of a fixed-program machine requires rewiring, restructuring, or redesigning the machine.
- "Reprogramming", when it was possible at all, was a laborious process, starting with flowcharts and paper notes, followed by detailed engineering designs.
- For example- ENIAC [Electronic Numerical Integrator and computer]

2. **Stored Program Machines:**

- A stored-program machine is one which stores program instructions and data in electronic memory.
- The program stored in this machine can be easily reprogrammed.
- Von Neumann machine is one of the best example of Stored Program Machine or Stored Program Computer.

Von Neumann & Harvard Architecture:

Von Neumann Architecture:

- It is also called as Stored Program Computer.
- This architecture was first founded by John Von Neumann in 1945 A.D.
- This describes a design architecture for an electronic digital computer with parts consisting of a processing unit containing an arithmetic logic unit and processor registers, a control unit containing an instruction register and program counter, a memory to store both data and instructions, external mass storage, and input and output mechanisms.
- Intel 8085 microprocessor follows this architecture.

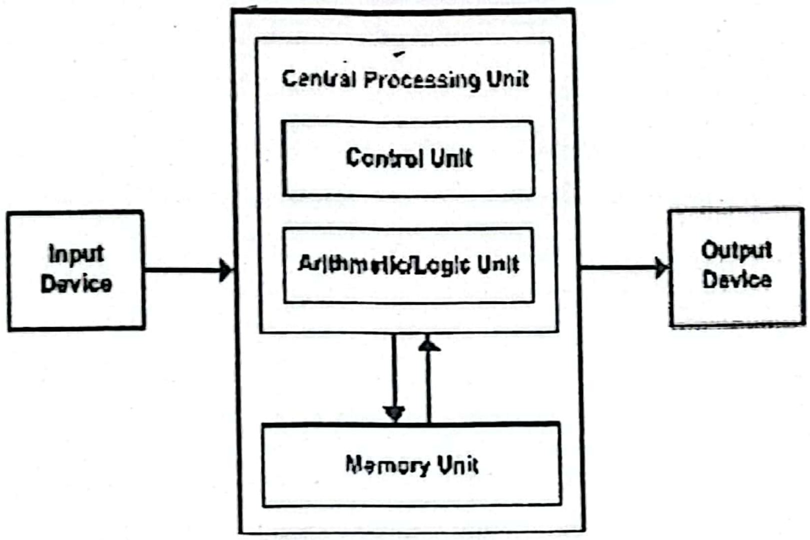


Fig. Von Neumann Architecture

Memory Unit:

- Both data and instructions are stored in single electronic memory unit , so it is easy to read/write data and instructions
- Instruction fetch and a data operation cannot occur at the same time because they share a common bus.

Control Unit (CU):

- This unit consists of Instruction Register and Program Counter.
- It helps for instruction interpretation and program execution to control the overall functioning of the whole system.

Arithmetic/Logic Unit (ALU):

- Performs various arithmetic and Logic Operations.

Input/output Devices:

- These devices help to provide external communication of the system with the user.

Advantages of Von Neumann Architecture:

- Holds instructions as easy as data.
- Efficient use of memory.
- Ease of loading program from memory.

Disadvantages of Von Neumann Architecture:

- Data can overwrite instructions as uses same memory location for storing both data and instructions, so special hardware precaution is needed.
- Data and instructions follow the same path to get the processor, so system is slow (called limited bandwidth).

Harvard Architecture:

- First founded by Harvard Hathaway Aiken in 1944 A.D. while designing microprocessor.
- It is also a stored-program system but has one dedicated set of address and data buses for reading data from and writing data to memory, and another set of address and data buses for fetching instructions.

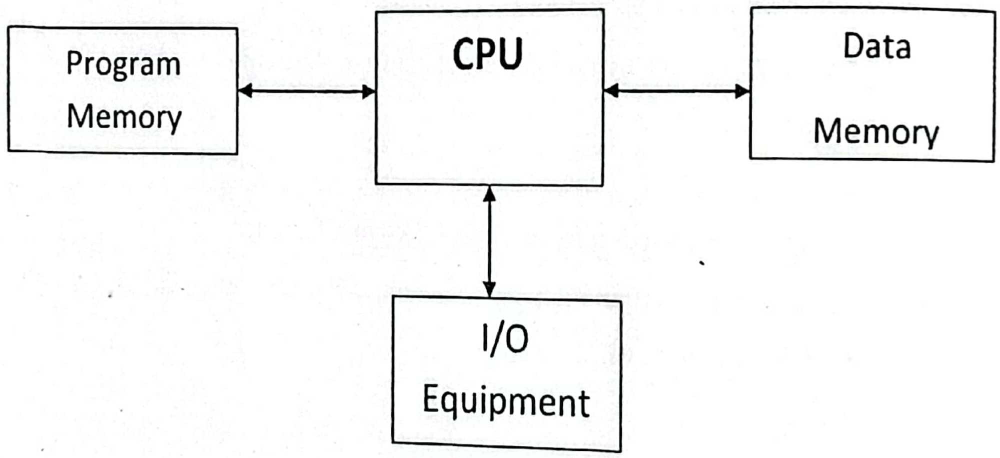


Fig. Harvard Architecture

- In this architecture, memory for storing program and data are separate, so it is faster than Von Neumann Architecture.
- For example, DSP (Digital Signal Processor) uses this architecture.
- Operations of all parts are similar to that of Von-Neumann Architecture.

Advantages of Harvard Architecture:

- The program and data memory are stored in different memory, thus preventing from overwrite.
- Separate dedicated bus system for program and data, so the data transfer is much faster (sufficient bandwidth).

Disadvantages of Harvard Architecture:

- Inefficient use of memory, because if there is large size of program and less size of data, then data memory can't store program, so overloading of one memory may occur while having enough space in other memory.
- Greater Cost because two memory are used and memory are costlier.
- Appropriate methods for storing data and program would have to be developed.

Concept of Fetch, Decode and Execution:

Most modern processors work on fetch-decode-execute principle. The fetch-decode-execute cycle is also called as **instruction cycle**. When a set of instructions is to be executed, the instructions and data are loaded into main memory (RAM), determine what actions the instructions require and carries out those actions. This cycle is repeated continuously by Central Processing Unit (CPU) from bootup to when computer is shut down. The execution of an instruction by a processor is divided into 3 parts as explained below:

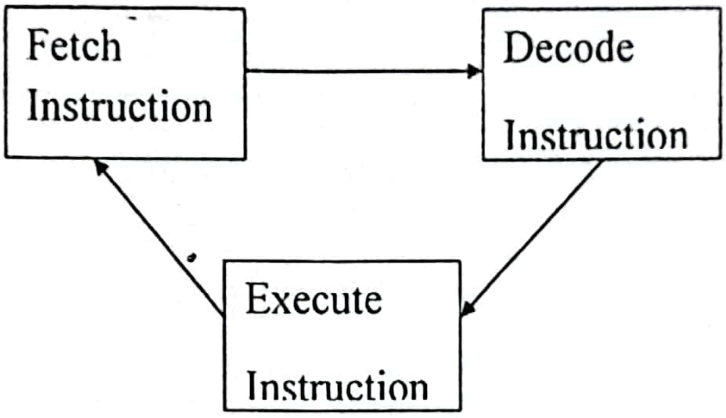


Fig. Fetch-Decode-Execute Cycle

1. **Fetch the instruction:**
   - In the first step, the processor fetches the instruction from memory and it is transferred to Instruction Register(IR)
2. **Decode the instruction:**
   - During this cycle, the encoded instruction present in the Instruction Register (IR) is interpreted by the decoder.
3. **Execute the instruction:**
   - The control unit of CPU passes the decoded information as a sequence of control signals to the relevant function units of CPU to perform the actions required by the instructions such as – reading values from the register, passing them to the ALU to perform mathematical or logical functions on them and writing the result back to the register.