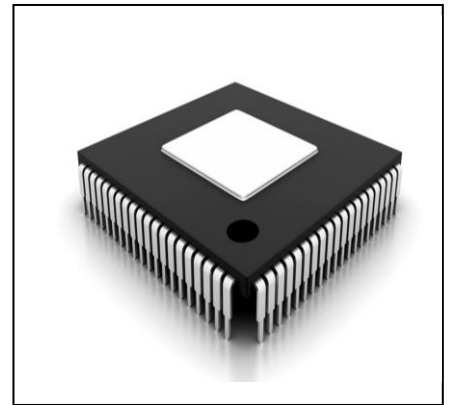


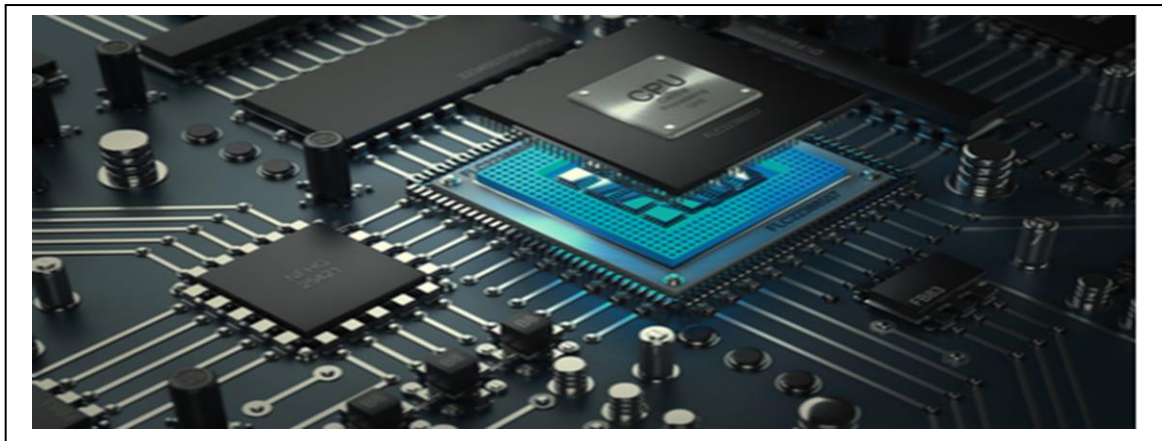
## What Is an Integrated Circuit?

- Integrated circuit or IC or microchip or chip is a microscopic electronic circuit array formed by the fabrication of various electrical and electronic components (resistors, capacitors, transistors, and so on) on a semiconductor material (silicon) wafer, which can perform operations similar to the large discrete electronic circuits made of discrete electronic components. See figure 4.
- Today, we find integrated circuits in every electronics gadget and product
- As all these arrays of components, microscopic circuits and semiconductor wafer material base are integrated together to form a single chip, hence, it is called an integrated circuit or integrated chip .



**Figure 4: Integrated circuit**

## Generations of Microprocessor

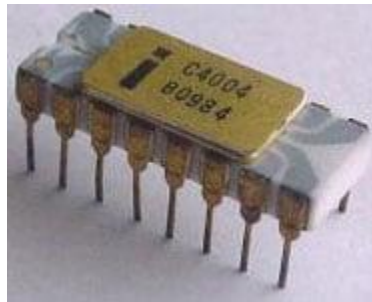


**Figure 5: Microprocessor components**

- A microprocessor is an **integrated circuit IC**, but not all integrated circuits are microprocessors.
- The earliest microprocessor had thousands of transistors on the silicon wafer, but the number has reached billions in the present. The AMD Epyc Rome, which was released in 2019, has over **39 billion transistors in the chip**.
- For most consumers, a microprocessor is often associated with the CPU of a computer. But the usage of microprocessors extends past PCs, smartphones, and laptops. Microprocessors are also developed as graphic processor units (GPU).
- In commercial electronics, microprocessors are fueling the growth of single-board computers, like the Raspberry Pi. And, there's the microcontroller, which is a combination of a microprocessor with memory and I/O peripherals in a single chip
- The microprocessor is **a programmable integrated device that has computing and decision-making capability**.
- The fact that the microprocessor **is programmable means it can be instructed to perform given tasks within its capability**.
- The microprocessor is a **clock-driven semiconductor device consisting of electronic logic circuits**. See figure 5.

There are five generations of this processor that mainly include the following.

- **First Generation Microprocessor: 4 – bit microprocessor** introduced in 1971 – 1972 by Intel Corporation. **Intel 4004** was able to perform only addition/subtraction operation on 4 bit at once. The 4004 used 4-bit bus for transferring, 12-bit addresses, 8-bit instructions and 4-bit data word. See figure 6.



**Figure 6: Intel 4004 Mp**

- **Second Generation Microprocessor:** The second-generation processors are 8 – bit microprocessor introduced in 1973 by Intel. It was **Intel 8008**, and another improved version was **Intel 8088, Intel 8080, INTEL 8085** .
- **Third Generation Microprocessor:** The third-generation processors are 16 – bit microprocessor introduced in 1978. Represented by **Intel's 8086, Zilog Z800 and 80286, which were 16 -bit processors**
- **Fourth Generation Microprocessor:** The fourth-generation processors are 32 – bit microprocessors.
- **Fifth Generation Microprocessor:** The fifth-generation processors are 64 – bit microprocessor.

## List of Terms Used in a Microprocessor

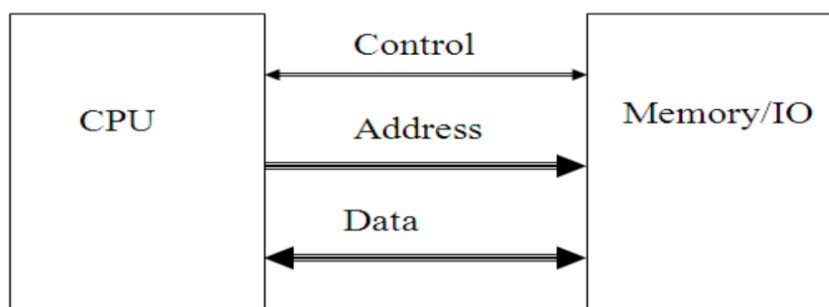
Here is a list of some of the frequently used terms in a microprocessor –

- **Instruction Set** – It is the set of instructions that the microprocessor can understand and given to the microprocessor. The instruction set acts as an interface between the software and hardware.
- **Bus** - The bus is used for the transmission of data, address and control information. This transmission occurs in different elements of the microprocessor. The bus in this is basically of three types which are **data bus, a control bus, and address bus**.
- **Bandwidth** – It is the number of bits processed in a single instruction.
- **Clock Speed** – It determines the number of operations per second the processor can perform. It is expressed in **megahertz (MHz)** or **gigahertz (GHz)**.It is also known as **Clock Rate**.
- **Word Length** – It depends upon **the (number of bits) of internal data bus, registers, ALU**, etc. An 8-bit microprocessor can process 8-bit data at a time. The word length ranges from 4 bits to 64 bits depending upon the type of the microcomputer. A processor with longer word length is more powerful and can process data at a faster speed as compared to processor with shorter word length.

- **Data Types** – The microprocessor has multiple data type formats like binary, BCD, ASCII, signed and unsigned numbers.

## Microprocessor Buses

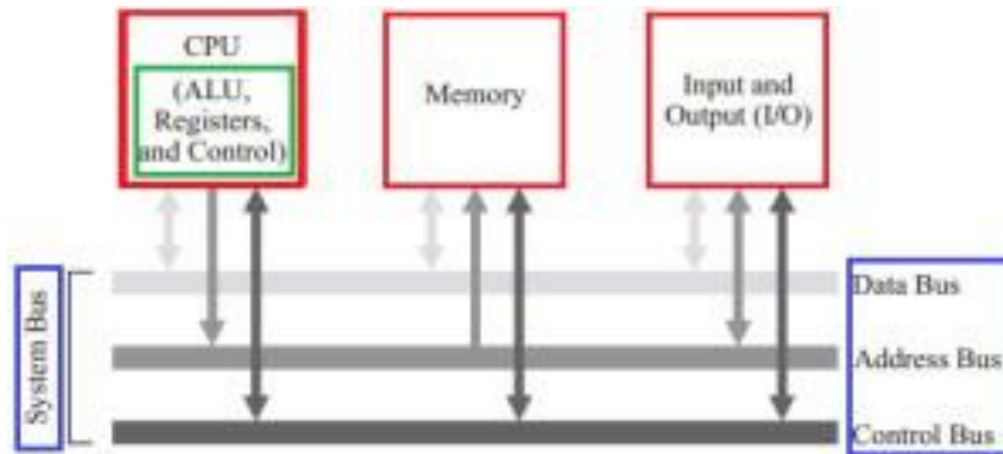
The system bus connects the various units to facilitate the exchange of information. It further consists of data, address, and control buses to perform data exchanging properly. Three buses for microprocessors allow *data*, *addresses* and *instructions* to be moved. See figure 7 and figure 8.



**Figure 7: Microprocessor Busses**

1. **The data bus:** It is a *bi-directional bus* that connects the CPU, memory, and the other hardware devices on the motherboard. The number of wires in the bus affects the speed at which data can travel between hardware components. For example an 8-wire bus can move 8 bits at a time, which is a full byte. A 16-bit bus transfer 2 bytes, and a 32-bit bus can transfer 4 byte at a time because each wire can transfer 1 bit of data at a time.
2. **The address bus:** It is a *one-directional bus* that connects only the CPU and RAM and carries only *memory address*. The address bus used by the MP to specify the number of locations (words) in memory. For example if the address bus of a MP is 16 lines then it has  $2^{16}$  unique locations in memory

3. **The control bus:** It is a *bi-directional bus* used by MP to coordinates its operations and carrying *control signal* (either write signal or read signal). Also control bus can carrying timing signals.



**Figure 8: An overview of Microprocessor Architecture**

- **The Central processing unit:** consists of one or more arithmetic logic units (ALU), registers, and a control unit. Based on the registers also the generations of the microprocessor can be classified.

A microprocessor consists of *general-purpose* and a *special type of registers* to execute instructions and to store the address or data while running the program.

The ALU computes all arithmetic as well as logic operations on data and specifies the size of microprocessors like 16 bit or 32 bit.

- **The Memory unit:** holds the program as well as data and is divided into a processor, primary and secondary memory.
- **The Input and output unit:** interfaces the I/O peripheral devices to the microprocessor for accepting and sending information.

## Introduction to Basic Input Output System (BIOS)

- ✚ The BIOS software is built into the PC, and is the first code run by a PC when powered on.
- ✚ When the PC starts up, the first job for the BIOS is to initialize and identify system devices such as the video display card, keyboard and mouse, hard disk drive, optical disc drive and other hardware.
- ✚ The BIOS locates boot loader software and loads and executes that software, giving it control of the PC. This process is known as booting, or booting up.
- ✚ BIOS software is stored on a non-volatile ROM chip on the motherboard (it is often called a ROM BIOS). This ensures that the BIOS will always be available and will not be damaged by disk failures.
- ✚ Because RAM is faster than ROM, though, many computer manufacturers design systems so that the BIOS is copied from ROM to RAM each time the computer is booted, this is known as shadowing.
- ✚ Many modern PCs have a flash BIOS, which means that the BIOS has been recorded on a flash memory chip, which can be updated if necessary.

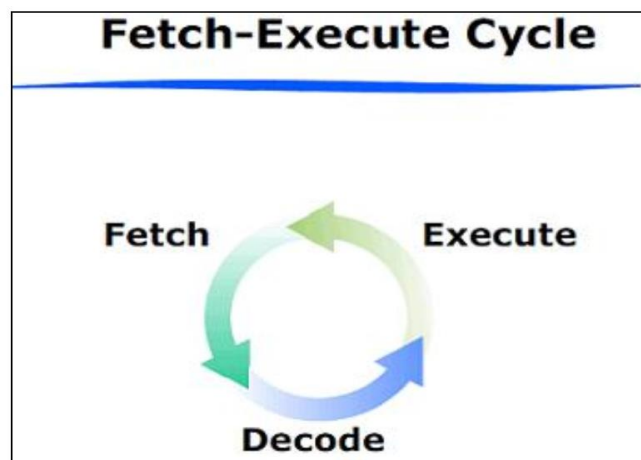
## How does a Microprocessor Work?

- ✚ A computer can only do what the programmer has told it to do, in the form of a program.
- ✚ A program is just a sequence of very simple commands that lead the computer to solve some problem.

- ✚ Once the program is written and debugged, the computer can execute the instructions very fast, and always do it the same, every time, without a mistake.
  - ✚ The microprocessor itself is usually a single integrated circuit (IC).
  - ✚ Most microprocessors (MPU), or very small computers, have much the same commands or instructions that they can perform.
  - ✚ In a typical MPU, there are commands to move data around, do simple math (add, subtract, multiply, and divide), bring data into the micro from the outside world, and send data out of the micro to the outside world.
- ✚ A microprocessor executes a program by repeatedly cycling through following three basic steps: **Fetch, Decode, and then Execute**, see figure 9
- Initially, **the instructions are stored in the memory in a sequential order.** The microprocessor fetches those instructions from the memory,
  - then **decodes it and executes those instructions till STOP instruction is reached.**
  - Later, **it sends the result in binary to the output port.** Between these processes, the register stores the temporarily data and ALU performs the computing functions.

***NOT: The power of the given microprocessor is measured in terms of bits.***

- The processor executes the instruction using the following steps:
- This sequence is continued until all instructions are performed.



**Figure 9: Workflow of instructions execution**

## Instructions Execution

A microprocessor executes a collection of machine instructions that tell the processor what to do. Based on the instructions, a microprocessor does three basic things:

- ✚ Using its ALU (Arithmetic/Logic Unit), a microprocessor can perform mathematical operations like addition, subtraction, multiplication and division. Modern microprocessors contain complete floating-point processors that can perform extremely sophisticated operations on large floating-point numbers.
- ✚ A microprocessor can move data from one memory location to another.
- ✚ A microprocessor can make decisions and jump to a new set of instructions based on those decisions.

This is about as simple as a microprocessor gets. This microprocessor has:

- An **address bus** (that may be 8, 16, 32 or 64 bits wide) that sends an address to memory
- A **data bus** (that may be 8, 16, 32 or 64 bits wide) that can send data to memory or receive data from memory
- An **RD (read) and WR (write) line** to tell the memory whether it should set or get the addressed location
- A **clock line** that lets a clock pulse sequence the processor
- A **reset line** that resets the program counter to zero (or whatever) and restarts execution

## Features of a Microprocessor

Here is a list of some of the most prominent features of any microprocessor –

- **Cost-effective** – The microprocessor chips are available at low prices and results its low cost.
- **Size** – The microprocessor is of small size chip, hence is portable.
- **Low Power Consumption** – Microprocessors are manufactured by using metaloxide semiconductor technology, which has low power consumption.
- **Versatility** – The microprocessors are versatile as we can use the same chip in a number of applications by configuring the software program.
- **Reliability** – The failure rate of an IC in microprocessors is very low, hence it is reliable.

## Applications of Microprocessors:

The application of microprocessors is increasing day by day. Some of the applications are:

- ❖ Analytical scientific instruments
- ❖ Smart terminals
- ❖ Standalone electronics cash system
- ❖ Electronic games
- ❖ Vending and dispensing machines
- ❖ Market scales
- ❖ Traffic light controls
- ❖ Home heating and lighting controls
- ❖ Security & fire alarm system
- ❖ Computer aided instruction
- ❖ On line control of lab instrumentation
- ❖ Desktop computers
- ❖ Optical character recognition
- ❖ I/O terminal for computers
- ❖ Medical instrumentation
- ❖ Data communication processing