Microprocessor

Semester: II
Course Code: CSC162
Nature of the Course: Theory + Lab
Full Marks: 60 + 20 + 20
Pass Marks: 24 + 8 + 8

Course Description: This course contains fundamental concepts of Microprocessor operations, basic I/O interfaces and Interrupts operations.

Course Objectives: The course objective is to introduce the operation, programming and application of microprocessor.

Unit 1
Introduction

Syllabus

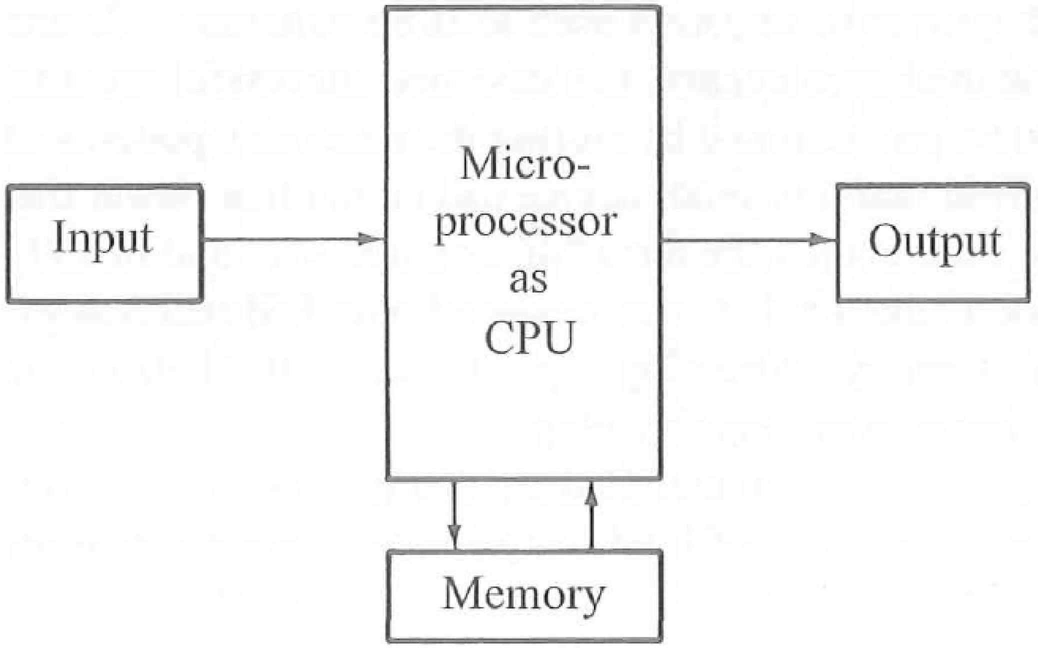
- ❖ Definition of microprocessor and its application
- ❖ Evolution of microprocessor, Von Neumann and Harvard architecture
- ❖ Components of microprocessor
  - ❑ Microprocessor: Arithmetic and Logic Unit (ALU), Control Unit (CU), Registers
  - ❑ Memory
  - ❑ Input / Output
- ❖ System Bus: Data , Address and Control Bus
- ❖ Microprocessor with Bus Organization

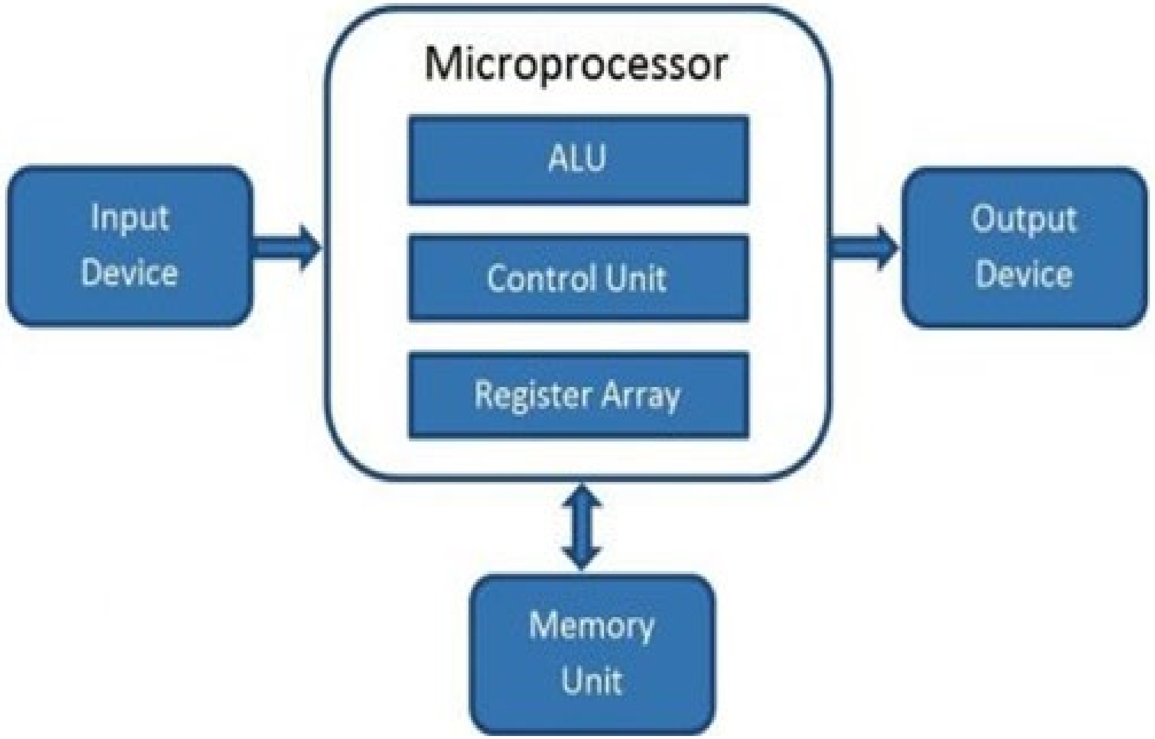
Microprocessor

- Computer's Central Processing Unit (CPU) built on a single Integrated Circuit (IC) is called a microprocessor. A digital computer with one microprocessor which acts as a CPU is called microcomputer.
- Microprocessor is a **programmable**, **multipurpose**, **clock -driven**, **register-based** electronic device that reads binary instructions from a storage device called **memory**, accepts binary data as input and processes data according to those instructions and provides results as output.
- The microprocessor contains millions of tiny components like transistors, registers, and diodes that work together.
- Sometimes, microprocessor is written as **μP**.

  (**μ** is pronounced as **Mu**)

Microprocessor





Applications of Microprocessor

Microprocessors are versatile and widely used in a variety of applications across different industries. Some of the common applications of microprocessors are

- **Consumer Electronics:** Microprocessors are used in a wide range of consumer electronics, including smartphones, TVs, digital cameras, video game consoles, and home appliances such as washing machines, refrigerators, and microwaves.
- **Automotive:** Microprocessors are used in modern vehicles to control various systems such as the engine, transmission, and braking systems. They also provide functionalities like GPS, infotainment systems, and driver assistance systems.
- **Medical:** Microprocessors are used in medical devices such as pacemakers, insulin pumps, and blood glucose meters to monitor and control the health of patients.
- **Industrial Control Systems:** Microprocessors are used in industrial control systems such as SCADA (Supervisory Control and Data Acquisition) systems, programmable logic controllers (PLCs), and robotics to control and monitor various processes.

Applications of Microprocessor

- **Aerospace and Defense:** Microprocessors are used in aerospace and defense systems such as avionics, radar systems, and missile guidance systems.
- **Communication:** Microprocessors are used in communication systems such as modems, routers, and switches to process and transmit data.
- **Security:** Microprocessors are used in security systems such as access control systems and surveillance cameras to process and store data.
- **Education:** Microprocessors are used in educational kits and toys to teach programming and electronics to children.
- **Entertainment:** Microprocessors are used in gaming consoles and virtual reality systems to provide immersive gaming experiences.

Overall, microprocessors have become an integral part of modern technology, and their applications continue to expand as technology advances.

Evolution of Microprocessors

- We can categorize the microprocessor according to the generations or according to the size of the microprocessor as follows;

First Generation (4 - bit Microprocessors)

- ❖The first generation microprocessors were introduced in the year 1971-1972 by Intel Corporation. It was named **Intel 4004** since it was a 4-bit processor.
- ❖It was a processor on a single chip. It could perform simple arithmetic and logical operations such as addition, subtraction, Boolean OR and Boolean AND.
- ❖It had a control unit capable of performing control functions like fetching an instruction from storage memory, decoding it, and then generating control pulses to execute it.

Second Generation(8–bit Microprocessor)

- ❖The second generation microprocessors were introduced in 1973 again by Intel.
- ❖It was a first 8 - bit microprocessor which could perform arithmetic and logic operations on 8-bit words. It was Intel 8008, and another improved version was Intel 8088.

Third Generation(16 - bit Microprocessor)

- The third generation microprocessors, introduced in 1978 were represented by Intel's 8086, Zilog Z800 and 80286, which were 16 - bit processors with a performance like minicomputers.

Fourth Generation(32-bit Microprocessors)

- Several different companies introduced the 32-bit microprocessors, but the most popular one is the Intel 80386.

Fifth Generation (64-bit Microprocessors)

- ❖From 1995 to now we are in the fifth generation. After 80856, Intel came out with a new processor namely Pentium processor followed by Pentium Pro CPU, which allows multiple CPUs in a single system to achieve multiprocessing.
- ❖Other improved 64-bit processors are Celeron, Dual, Quad, Octa Core, i3, i5, i7, i9 processors.

Historical Perspective

Intel Microprocessors: Historical Perspective

Processor	Year of Introduction	Number of Transistors	Initial Clock Speed	Address Bus	Data Bus	Addressable Memory
4004	1971	2,300	108 kHz	10-bit	4-bit	640 bytes
8008	1972	3,500	200 kHz	14-bit	8-bit	16 K
8080	1974	6,000	2 MHz	16-bit	8-bit	64 K
8085	1976	6,500	5 MHz	16-bit	8-bit	64 K
8086	1978	29,000	5 MHz	20-bit	16-bit	1 M
8088	1979	29,000	5 MHz	20-bit	8-bit*	1 M
80286	1982	134,000	8 MHz	24-bit	16-bit	16 M
80386	1985	275,000	16 MHz	32-bit	32-bit	4 G
80486	1989	1.2 M	25 MHz	32-bit	32-bit	4 G
Pentium	1993	3.1 M	60 MHz	32-bit	32/64-bit	4 G
Pentium Pro	1995	5.5 M	150 MHz	36-bit	32/64-bit	64 G
Pentium II	1997	8.8 M	233 MHz	36-bit	64-bit	64 G
Pentium III	1999	9.5 M	650 MHz	36-bit	64-bit	64 G
Pentium 4	2000	42 M	1.4 GHz	36-bit	64-bit	64 G

*External 8-bit and internal 16-bit data bus

Evolution of Microprocessors: INTEL Series

Intel Microprocess				
Name	**Year**	**Transistors**	**Clock speed**	**Data width**
8080	1974	6,000	2 MHz	8 bits
8085	1976	6,500	5 MHz	8 bits
8086	1978	29,000	5 MHz	16 bits
8088	1979	29,000	5 MHz	8 bits
80286	1982	134,000	6 MHz	16 bits
80386	1985	275,000	16 MHz	32 bits
80486	1989	1,200,000	25 MHz	32 bits
Pentium	1993	3,100,000	60 MHz	32/64 bits
Pentium II	1997	7,500,000	233 MHz	64 bits
Pentium III	1999	9,500,000	450 MHz	64 bits
Pentium IV	2000	42,000,000	1.5 GHz	64 bits
Pentium IV "Prescott"	2004	125,000,000	3.6 GHz	64 bits
Intel Core 2	2006	291 million	3 GHz	64 bits
Pentium Dual Core	2007	167 million	2.93 GHz	64 bits
Intel 64 Nchalem	2009	781 million	3.33 GHz	64 bits

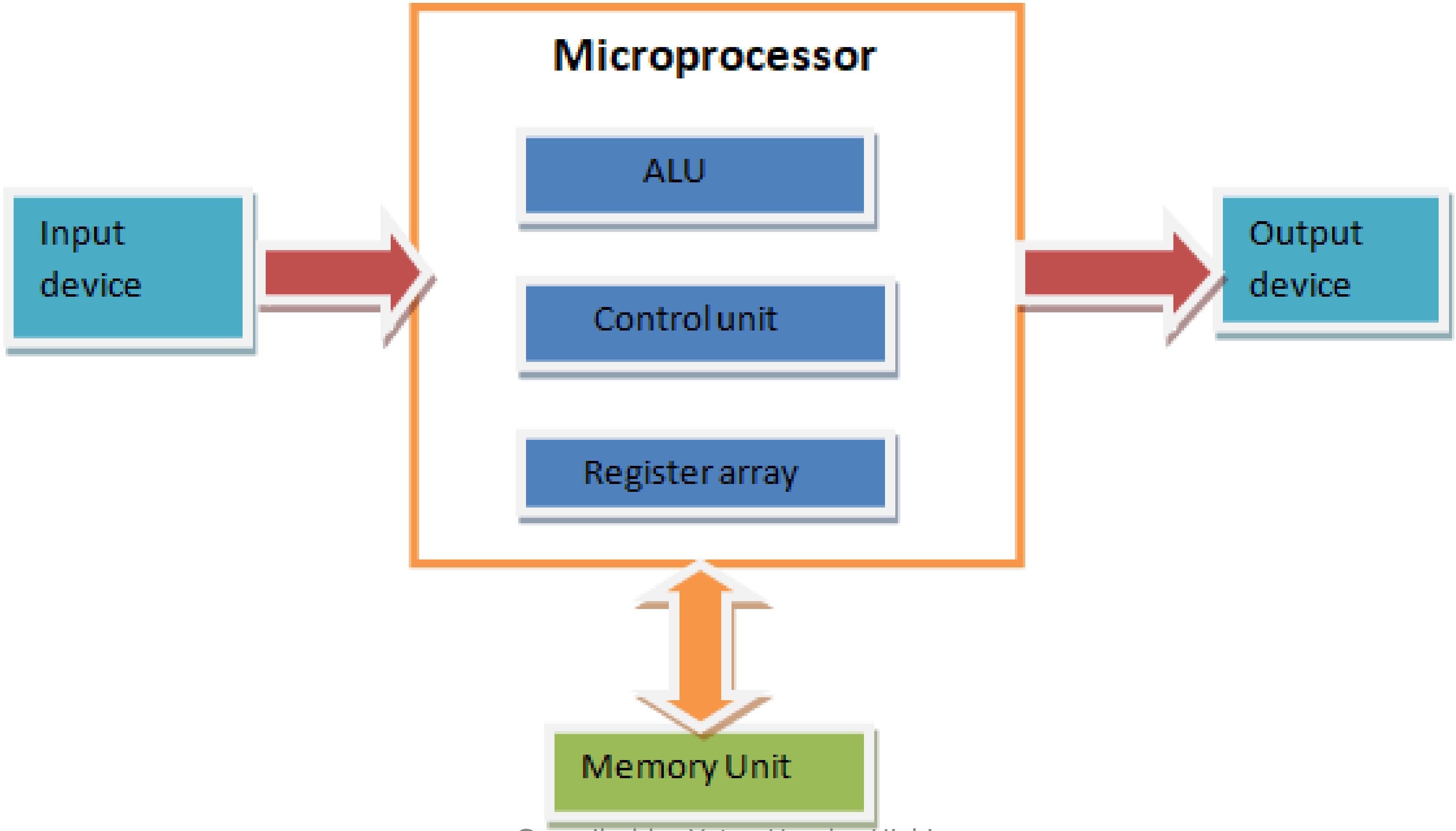
Important Intel Microprocessors

Manufacturer	Processor	Date of introduction	Number of transistors	Process	Area [mm^2]
Intel	Intel4004	1971	2,300	10 μm	12
	Intel8008	1972	3,500	10 μm	14
	Intel8080	1974	4,400	6 μm	20
	Intel8085	1976	6,500	3 μm	20
	Intel8086	1978	29,000	3 μm	33
	Intel80286	1982	134,000	1.5 μm	44
	Intel80386	1985	275,000	1.5 μm	104
	Intel80486	1989	1,180,235	1 μm	173
	Pentium	1993	3,100,000	0.8 μm	294
	Pentium Pro	1995	5,500,000	0.5 μm	307
	Pentium II	1997	7,500,000	0.35 μm	195
	Pentium III	1999	9,500,000	0.25 μm	128
	Pentium 4	2000	42,00,000	180 nm	217
	Itanium 2 McKinely	2002	220,000,000	180 nm	421
	Core 2 Duo	2006	291,000,000	65 nm	143
	Core i7 (Quad)	2008	731,000,000	45 nm	263
	Six-Core Core i7	2010	1,170,000,000	32 nm	240
	Six-Core Core i7/8-Core Xeon E5	2011	2,270,000,000	32 nm	434
	8-Core Itanium Poulson	2012	3.100,000,000	32 nm	544

Other Important Microprocessors

MIPS	R2000	1986	110,000	2.0 μm	80
	R3000	1988	150,000	1.2 μm	56
	R4000	1991	1,200,000	0.8 μm	213
	R10000	1994	2,600,000	0.5 μm	299
	R10000	1996	6,800,000	0.35 μm	299
	R12000	1998	7,1500,000	0.25 μm	229
IBM	POWER3	1998	15,000,000	0.35 μm	270
	POWER4	2001	174,000,000	180 nm	412
	POWER4+	2002	184,000,000	130 nm	267
	POWER5	2004	276,000,000	130 nm	389
	POWER5+	2005	276,000,000	90 nm	243
	POWER6+	2009	790,000,000	65 nm	341
	POWER7	2010	1.200,000,000	45 nm	567
	POWER7+	2012	2.100,000,000	32 nm	567

Components of Microprocessor



Components of Microprocessor

The functions of various components of a microprocessor-based system can be summarized as follows:

1. **The Microprocessor**
   - reads instruction from memory.
   - communicates with all peripherals (memory and I/Os) using the system bus.
   - controls the timing of information flow.
   - performs the computing tasks specified in a program.
2. **The Memory**
   - stores the binary information, called instructions and data.
   - provides the instructions and data to the microprocessor on request.
   - stores results and data for the microprocessor.

Components of Microprocessor

3. **The input device**
   - ❑ enters data and instructions under the control of a program such as a monitor program.
4. **The output device**
   - ❑ accepts data from the microprocessor as specified in a program.
5. **The bus**
   - ❑ carries bits between the microprocessor and memory and I/Os.

How Does the Microprocessor Work?

- ❖Assume that a program and data are already entered in the R/W memory. (How to write and execute a program will be explained later.)
- ❖The program includes binary instructions to add given data and to display the answer at the seven-segment LEDs.
- ❖When the microprocessor is given a command to execute the program, it reads and executes one instruction at a time and finally sends the result to the seven-segment LEDs for display.
- ❖This process of program execution can best be described by comparing it to the process of assembling a radio kit.
- ❖The instructions for assembling the radio are printed in a sequence on a sheet of paper. One reads the first instruction, then picks up the necessary components of the radio and performs the task.

How Does the Microprocessor Work?

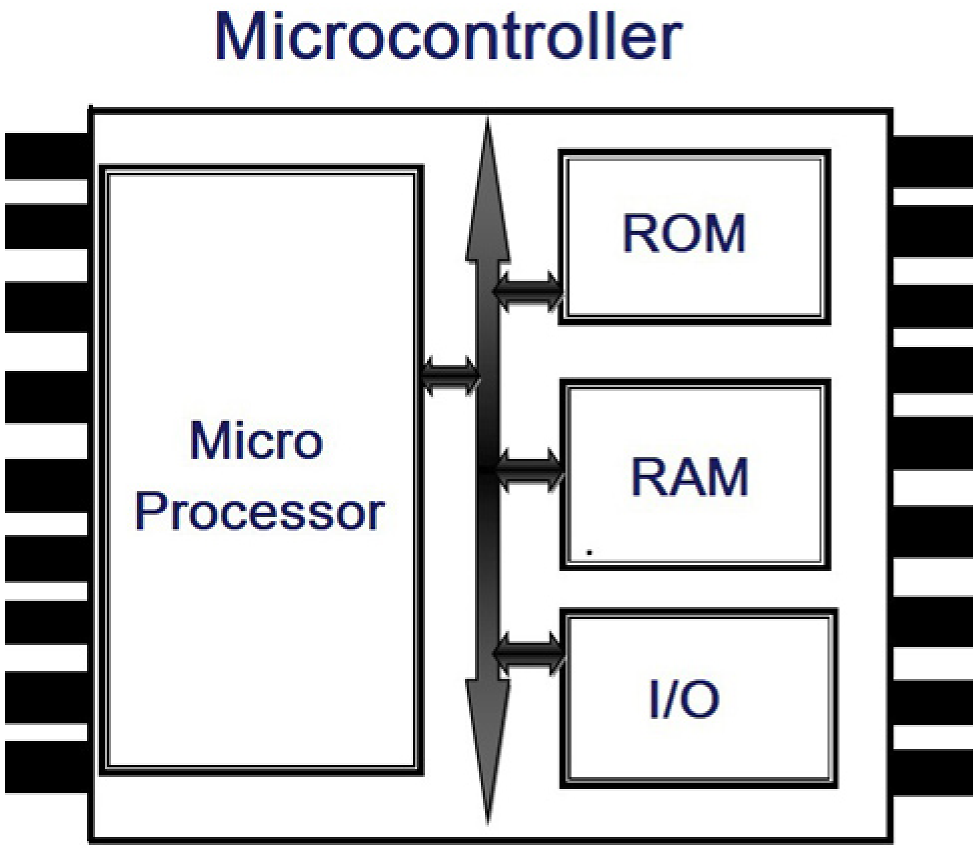
- ❖The sequence of the process is read, interpret, and perform.
- ❖The microprocessor works the same way. The instructions are stored sequentially in the memory.
- ❖The microprocessor fetches the first instruction from its memory sheet, decodes it, and executes that instruction. The sequence of fetch, decode, and execute is continued until the microprocessor comes across an instruction to stop.
- ❖During the entire process, the microprocessor uses the system bus to fetch the binary instructions and data from the memory.
- ❖It uses registers from the register section to store data temporarily, and it performs the computing function in the ALU section. Finally, it sends out the result in binary, using the same bus lines, to the seven-segment LEDs.

Features of 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.

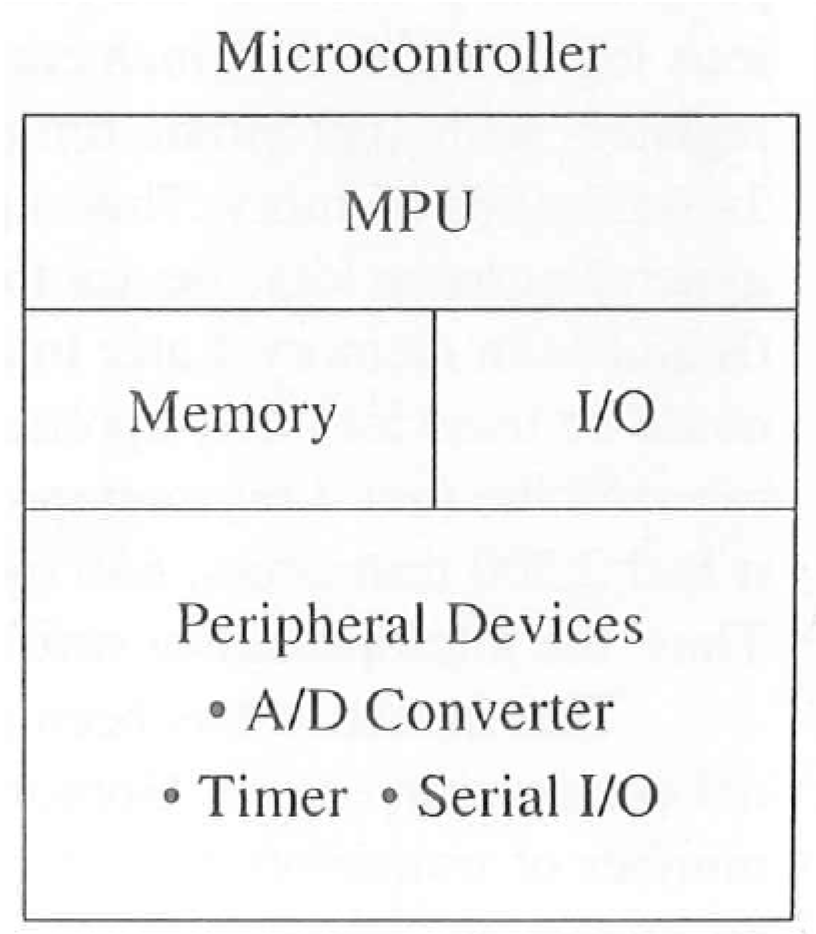
Microcontroller

- ❖A microcontroller is a compact integrated circuit designed to govern a specific operation in an embedded system.
- ❖ A typical microcontroller includes a processor, memory and input/output (I/O) peripherals on a single chip.
- ❖Sometimes referred to as an embedded controller or microcontroller unit (MCU), microcontrollers are found in vehicles, robots, office machines, medical devices, mobile radio transceivers, vending machines and home appliances, among other devices.

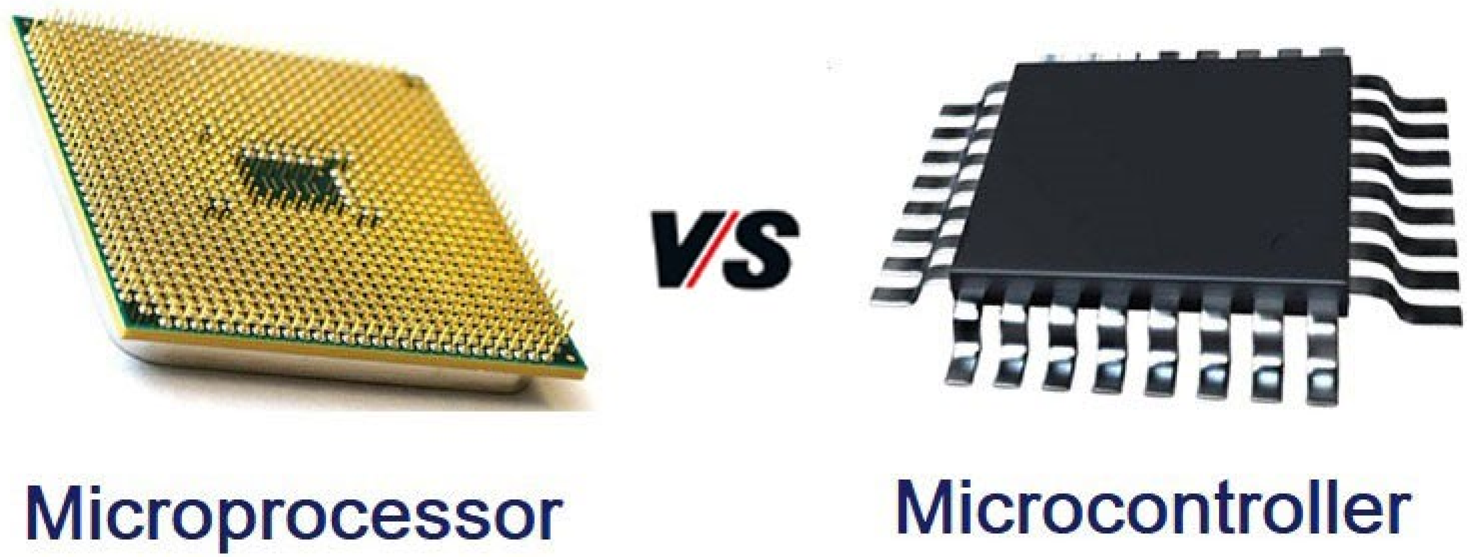


Microcontroller

- ❖SINGLE-CHIP MICROCOMPUTERS (MICROCONTROLLERS)
- ❖These microcomputers are designed on a single chip, which typically includes a microprocessor, 256 bytes of R/W memory, from 1K to 8K bytes of ROM, and several signal lines to connect I/Os. These are complete microcomputers on a chip; they are also known as microcontrollers. They are used primarily for such functions as controlling appliances and traffic lights. Typical examples of these microcomputers include such chips as the Zilog Z8, Intel MCS 51 series, Motorola 68HCI 1, and the Microchip Technology PIC family



Microprocessor Versus Microcontroller



MICROPROCESSOR	MICROCONTROLLER
A component that performs the instructions and task involved in computer processing	A compact integrated circuit designed for a specific operation in an embedded system
Used for applications that require intensive processing	Used for an application that performs a particular task
Memory, IO ports, timers, etc. are connected to the CPU externally	CPU and all other elements are integrated into a single chip or a board
Microprocessor based applications perform multiple tasks. Therefore, it requires more memory	Performs a single task. Therefore, it does not require more memory and IO ports
Has a high clock speed	Has a lower clock speed
32bit or 64bit	8 bit, 16bit or 32bit
Uses USB, UART, and high- speed Ethernet as the peripheral interfaces	Uses 12C, UART and SPI for the peripheral interfaces
Consumes more power	Consumes less power
Cost more	Cost less
Larger	Smaller
Used by personal computers and laptops	Used by microwave ovens and washing machines

Microprocessor Vs. Microcontroller

Microprocessor	Microcontroller
Microprocessor is the heart of Computer system.	Micro Controller is the heart of an embedded system.
It is only a processor, so memory and I/O components need to be connected externally	Micro Controller has a processor along with internal memory and I/O components.
Memory and I/O has to be connected externally, so the circuit becomes large.	Memory and I/O are already present, and the internal circuit is small.
You can’t use it in compact systems	You can use it in compact systems.
Cost of the entire system is high	Cost of the entire system is low
Due to external components, the total power consumption is high. Therefore, it is not ideal for the devices running on stored power like batteries.	As external components are low, total power consumption is less. So it can be used with devices running on stored power like batteries.
Most of the microprocessors do not have power saving features.	Most of the microcontrollers offer power-saving mode.

Microprocessor Vs. Microcontroller

Microprocessor	Microcontroller
It is mainly used in personal computers.	It is used mainly in a washing machine, MP3 players, and embedded systems.
Microprocessor has a smaller number of registers, so more operations are memory-based.	Microcontroller has more register. Hence the programs are easier to write.
Microprocessors are based on Von Neumann model	Micro controllers are based on Harvard architecture
It is a central processing unit on a single silicon-based integrated chip.	It is a byproduct of the development of microprocessors with a CPU along with other peripherals.
It has no RAM, ROM, Input-Output units, timers, and other peripherals on the chip.	It has a CPU along with RAM, ROM, and other peripherals embedded on a single chip.
It uses an external bus to interface to RAM, ROM, and other peripherals.	It uses an internal controlling bus.
Microprocessor-based systems can run at a very high speed because of the technology involved.	Microcontroller based systems run up to 200MHz or more depending on the architecture.
It's used for general purpose applications that allow you to handle loads of data.	It's used for application-specific systems.
It's complex and expensive, with a large number of instructions to process.	It's simple and inexpensive with less number of instructions to process.

Microprocessor Vs. Microcontroller

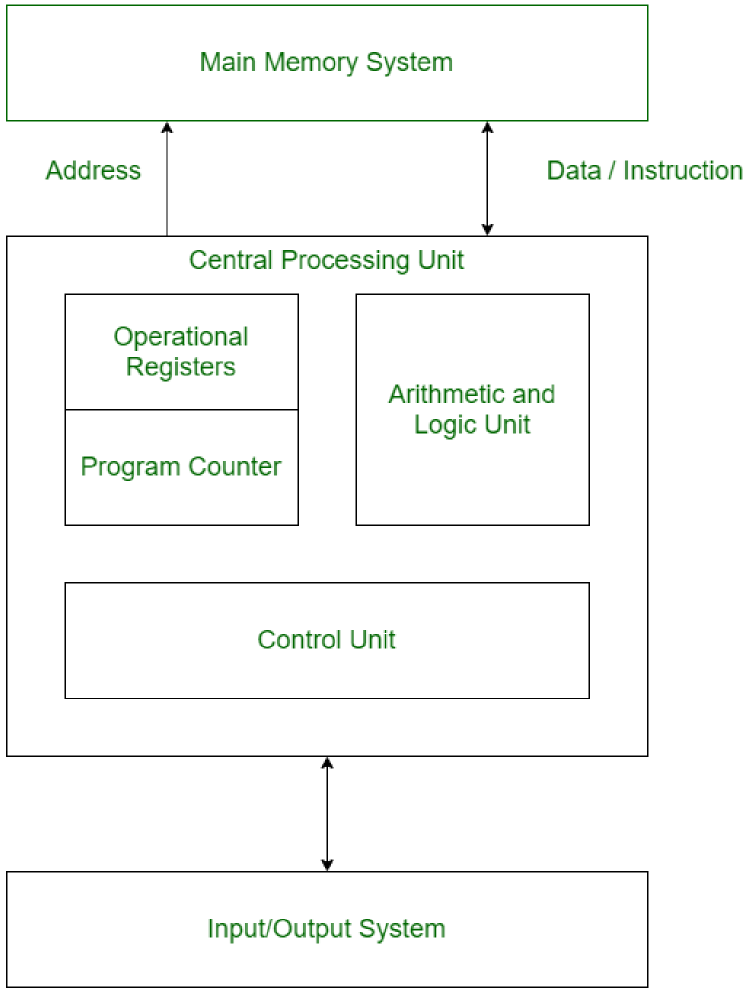
	Microprocessor	**Microcontroller**
Application	It used where intensive processing is required. It is used in personal computers, laptops, mobiles, video games, etc.	It used where the task is fixed and predefined. It is used in the washing machine, alarm, etc.
Structure	It has only the CPU in the chip. Other devices like I/O port, memory, timer is connected externally. The structure of the microprocessor is flexible. Users can decide the amount of memory, the number of I/O port and other peripheral devices.	CPU, Memory, I/O port and all other devices are connected on the single chip. The structure is fixed. Once it is designed the user cannot change the peripheral devices.
Clock speed	The clock speed of the microprocessor is high. It is in terms of the GHz. It ranges between 1 GHz to 4 GHz.	The clock speed of the microcontroller is less. It is in terms of the MHz. it ranges between 1 MHz to 300 MHz.
RAM	The volatile memory (RAM) for the microprocessor is in the range of the 512 MB to 32 GB.	The volatile memory (RAM) for the microcontroller is in the range of 2 KB to 256 KB.
ROM	The hard disk (ROM) for the microprocessor is in the range of the 128 GB to 2 TB.	The hard drive or flash memory (ROM) is in the range of the 32 KB to 2 MB.
Peripheral interface	The common peripheral interface for the microprocessor is USB, UART, and high-speed Ethernet.	The common peripheral interface for the microcontroller is I2C, SPI, and UART.
Programming	The program for the microprocessor can be changed for different applications. The programming of the microprocessor is difficult compared to the microcontroller.	The program for the microcontroller is fixed once it is designed.
Bit size	It is available in 32-Bit and 64-bit.	It is available in 8-bit, 16-bit, and 36-bit.
Cost	The cost of the microprocessor is high compared to the microcontroller.	It is cheaper.
Power consumption	The power consumption for the microprocessor is high.	The power consumption for the microcontroller is less.
Size	The overall size of the system is large.	The overall size of the system is small.

Computer Architecture

- ❖Computer architecture comprises rules, methods, and procedures that describe the execution and functionality of the entire computer system.
- ❖In general terms, computer architecture refers to how a computer system is designed using compatible technologies.

Von-Neumann Architecture(Neumann Model or Princeton Architecture)

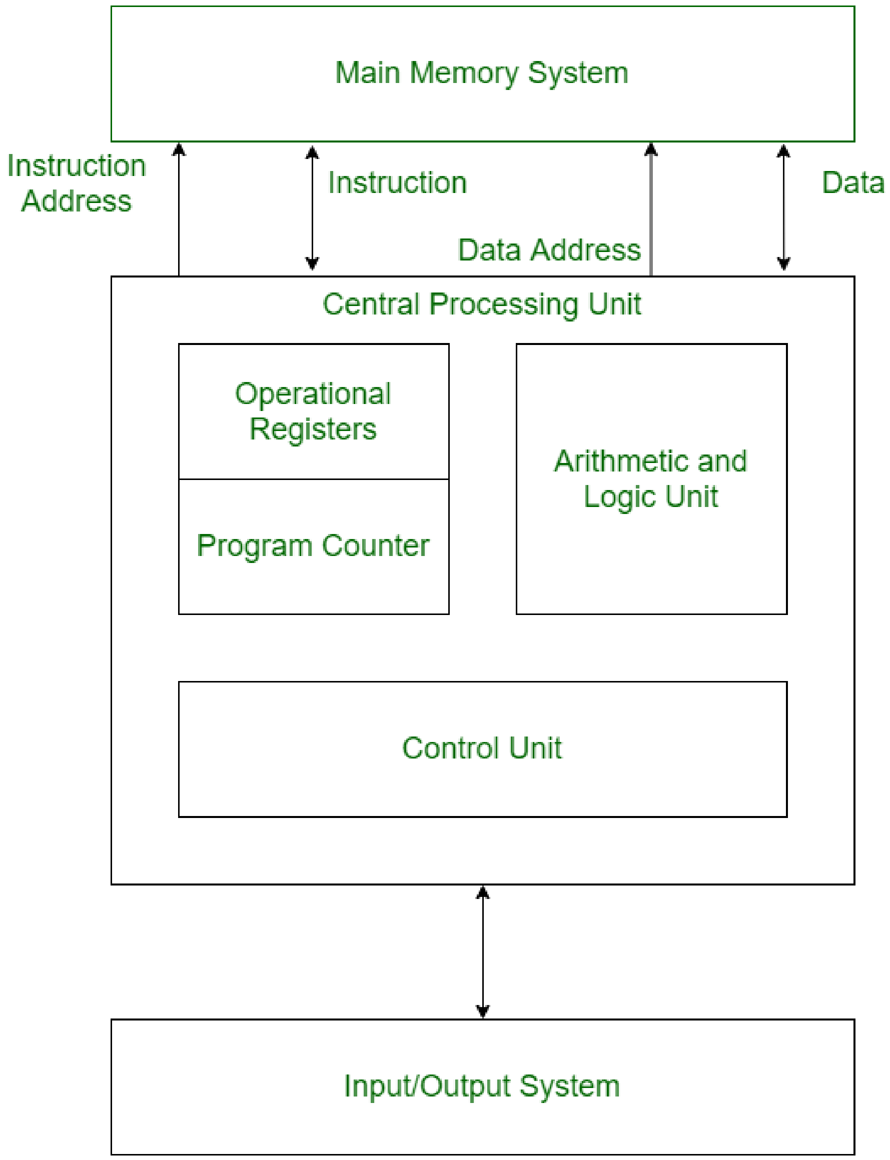
- Von Neumann Architecture is a digital computer architecture whose design is based on the concept of stored program computers where program data and instruction data are stored in the same memory.
- This architecture was designed by the famous mathematician and physicist John Von Neumann in 1945.
- It is used in personal computers and small computers.



Von Neumann Architecture

Harvard Architecture

- Harvard Architecture is the digital computer architecture whose design is based on the concept where there are separate storage and separate buses (signal path) for instruction and data.
- It was basically developed to overcome the bottleneck of Von Neumann Architecture.
- It is used in micro controllers and signal processing.



Harvard Architecture

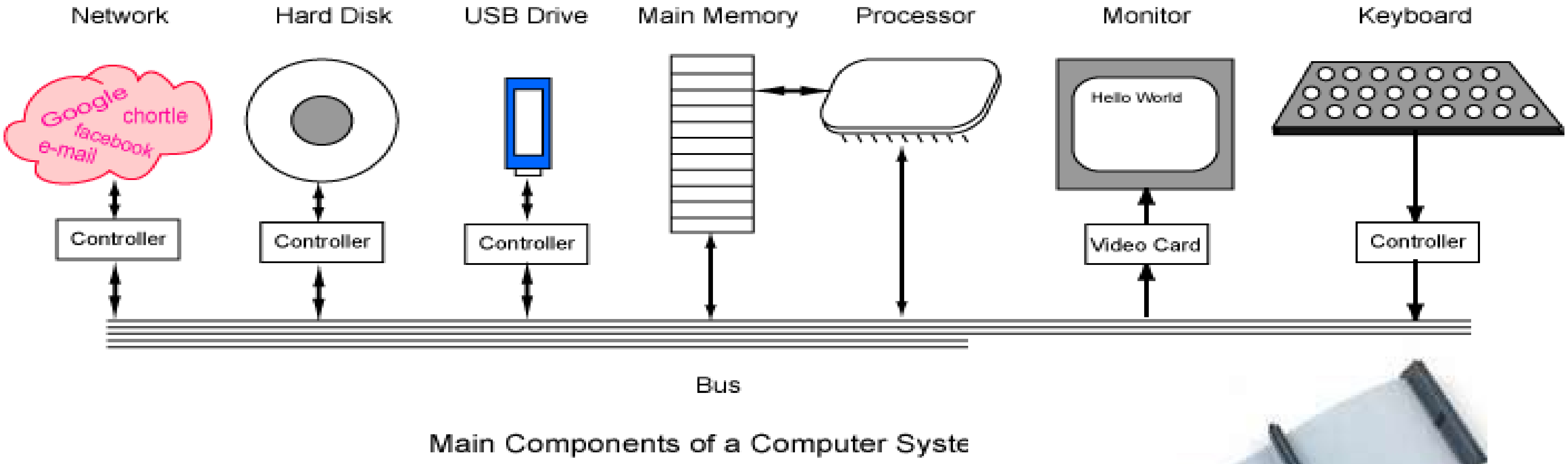
Comparison Between Harvard and Von-Neumann Architecture

VON NEUMANN ARCHITECTURE	HARVARD ARCHITECTURE
It is a theoretical design based on the stored-program computer concept.	It is a modern computer architecture based on the Harvard Mark I relay- based computer model.
It uses same physical memory address for instructions and data.	It uses separate memory addresses for instructions and data.
Processor needs two clock cycles to execute an instruction.	Processor needs one cycle to complete an instruction.
Simpler control unit design and development of one is cheaper and faster.	Control unit for two buses is more complicated which adds to the development cost.
Data transfers and instruction fetches cannot be performed simultaneously.	Data transfers and instruction fetches can be performed at the same time.
Used in personal computers, laptops, and workstations.	Used in microcontrollers and signal processing.

Bus Organization

- A bus organization is a group of conducting wires which carries information, all the peripherals are connected to microprocessor through the bus. A system bus is nothing just a group of wires to carry bits.
- The MPU (Micro Processing Unit) performs primarily four operations:
  - Memory Read: Read data (or instructions) from memory.
  - Memory Write: Write data (or instructions) into memory.
  - I/O Read: Accepts data from I/P devices.
  - I/O Write: Sends data to O/P devices.

Bus Organization



Bus Organization

- *The diagram to represent the bus organization of 8085 microprocessor is given below:-*

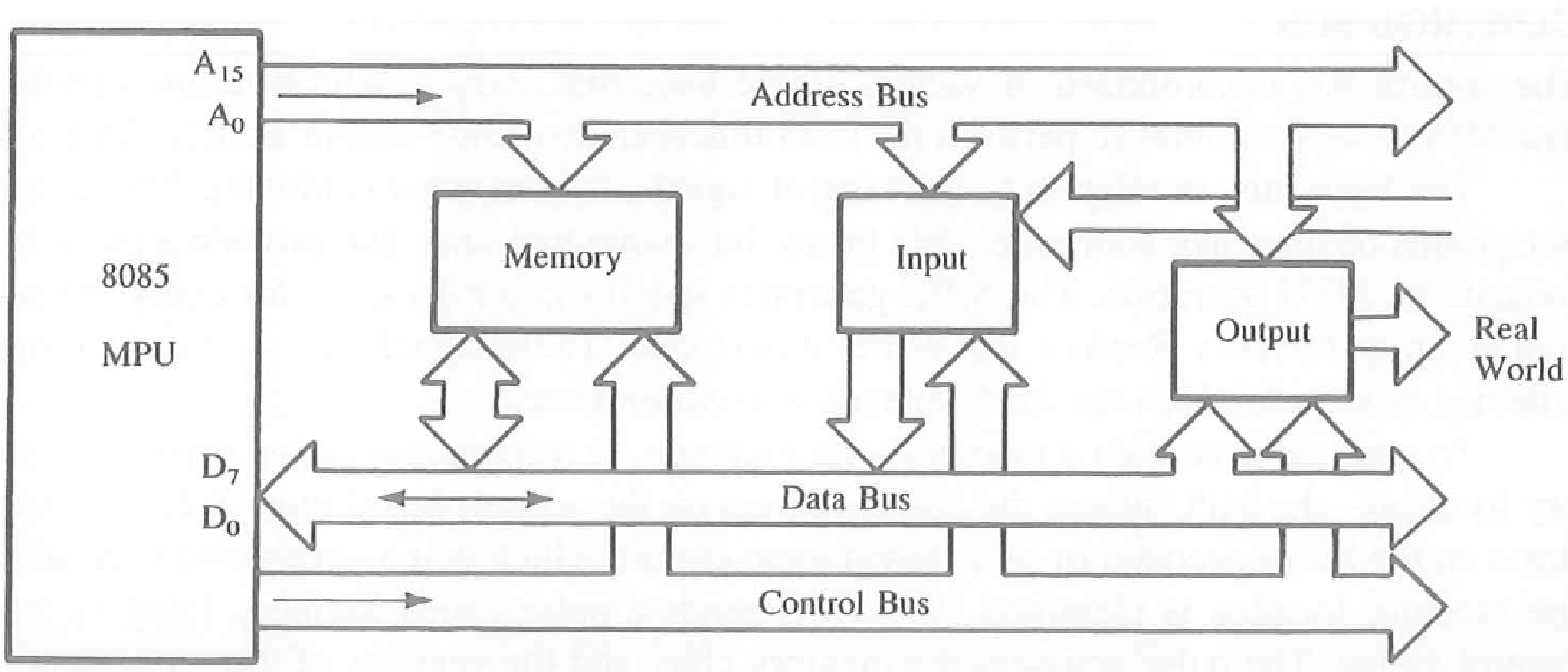


Figure: The 8085 Bus Structure

Bus Organization

❖ Types of Bus in the microprocessor are:
1) Address Bus
2) Data Bus
3) Control Bus

Bus Organization

❖ **Address Bus:**

- ❑ The address bus carries information about the location of data in the memory.
- ❑ The addresses bus is unidirectional because of data flow in one direction, from the microprocessor to memory or from the microprocessor to input/out devices.
- ❑ Length of Address bus of 8085 microprocessor is 16 bit (That is, four hexadecimal digits), ranging from 0000H to FFFF H.
- ❑ The microprocessor 8085 can transfer maximum 16-bit address which means it can address 65,536 different memory location i.e., 64KB memory.
- ❑ Address Bus is used to perform the first function, identifying a peripheral or a memory location.

Bus Organization

❖ **Data Bus:**

- ❑ The data bus allows data to travel between the microprocessor (CPU) and memory (RAM).
- ❑ The data bus is bidirectional because of data flow in both directions, from the microprocessor to memory or input/output devices and from memory or input/output devices to microprocessors.
- ❑ Length of Data bus of 8085 microprocessor is 8 bit (that is, two hexadecimal Digits, ranging from 00H to FF H.
- ❑ The data bus is used to perform the second function, transferring binary information.

Bus Organization

❖**Control Bus:**

❑The control bus carries the control signals to control all the associated peripherals, the microprocessor uses control bus to process data, that is what to do with selected memory location signals are:-

a) Memory read
b) Memory write
c) I/O read
d) I/O write

Address Bus

- ❖ Address bus is used to carry the memory or I/O device address to which the data is to be transferred.
- ❖ It is a group of conducting wires which carries address only
- ❖ Address bus is unidirectional because data flow in one direction, from microprocessor to memory or from microprocessor to Input/output devices (That is, Out of Microprocessor).
- ❖ The maximum address capacity is equal to two to the power of the number of lines present ($2^{\text{address lines}}$).

E.g. 8085 has 16 - address lines

$\therefore$ Maximum address capacity $=> 2^{16} = 65536$ bytes

Address Bus

- ❖ Length of Address Bus of 8085 microprocessor is 16 Bit (That is, Four Hexadecimal Digits), ranging from 0000 H to FFFF H, (H denotes Hexadecimal).
- ❖ The microprocessor 8085 can transfer maximum 16 bit address which means it can address 65, 536 different memory location.
- ❖ The Length of the address bus determines the amount of memory a system can address.
- ❖ Such as a system with a 32-bit address bus can address 2^{32} memory locations.
- ❖ If each memory location holds one byte, the addressable memory space is 4 GB.
- ❖ However, the actual amount of memory that can be accessed is usually much less than this theoretical limit due to chipset and motherboard limitations.

Data Bus

- ❖ Data bus is used to transfer data between the microprocessor and other components such as memory and I/O devices.
- ❖ It is used to carry data to or from the memory or input/output devices.
- ❖ It is a group of conducting wires which carries Data only.
- ❖ Data bus is bidirectional because data flow in both directions, from microprocessor to memory or Input/Output devices and from memory or Input/Output devices to microprocessor
- ❖ Each wire of data bus is used to transfer the data corresponding to a single bit of binary data.

E.g. 8085 has 8 - data lines

$\therefore$ 8085 is known as 8-bit processor

Data Bus

- Length of Data Bus of 8085 microprocessor is 8 Bit (That is, two Hexadecimal Digits), ranging from 00 H to FF H. (H denotes Hexadecimal)
- When it is write operation, the processor will put the data (to be written) on the data bus
- When it is read operation, the memory controller will get the data from specific memory block and put it into the data bus.
- The width of the data bus is directly related to the largest number that the bus can carry, such as an 8 bit bus can represent 2 to the power of 8 unique values, this equates to the number 0 to 255.
- A 16 bit bus can carry 0 to 65535.

Control Bus

- ❖ It is a group of conducting wires, which is used to generate timing and control signals to control all the associated peripherals, microprocessor uses control bus to process data, that is what to do with selected memory location.
- ❖ The control bus is used to carry control signals between the microprocessor and other components such as memory and I/O devices.
- ❖ It is used to transmit commands to the memory or I/O devices for performing specific operations.
- ❖ Some control signals are Memory read, Memory write , I/O Read, I/O Write and Opcode fetch etc.
- ❖ Control Bus is a bidirectional bus.

Microprocessor-Based System with Bus Architecture

❖**ALU (Arithmetic/Logic Unit)** – It performs such arithmetic operations as addition and subtraction, and such logic operations as AND, OR, and XOR, etc. Results are stored either in registers or in memory.

❖**Register Array** – It consists of various registers identified by letters such as B, C, D, E, H, L, etc. These registers are used to store data and addresses temporarily during the execution of a program.

❖**Control Unit** – The control unit provides the necessary timing and control signals to all the operations in the microcomputer. It controls the flow of data between the microprocessor and memory and peripherals.

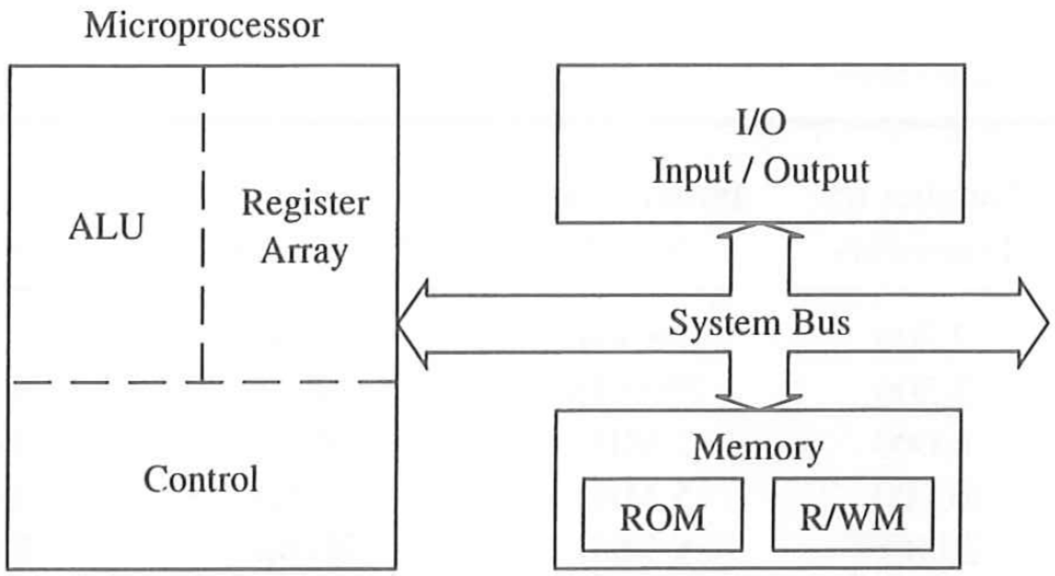


Figure: Microprocessor-Based System with Bus Architecture

Microprocessor-Based System with Bus Architecture

- **Input** – The input section transfers data and instructions in binary from the outside world to the microprocessor. It includes such devices as a keyboard, switches, a scanner, and an analog-to-digital converter.
- **Output** – The output section transfers data from the microprocessor to such output devices as LED, CRT, printer, magnetic tape, or another computer.
- **Memory** – It stores such binary information as instructions and data, and provides that information to the microprocessor. To execute programs, the microprocessor reads instructions and data from memory and performs the computing operations in its ALU section. Results are either transferred to the output section for display or stored in memory for later use.
- **System bus** – It is a communication path between the microprocessor and peripherals. The microprocessor communicates with only one peripheral at a time. The timing is provided by the control unit of the microprocessor.

Microprocessor – Controlled Temperature System (MCTS)

❖ Microprocessor – controlled temperature system is used to
   i. Read the temperature in a room
   ii. Display the temperature at LCD/LED panel
   iii. Turn-on a fan if the temperature is above the limit.
   iv. Turn-on a heater if the temperature is below the limit.

❖ This system has a temperature sensor as an input device to sense room temperature and three output devices: a fan, a heater and display panel.

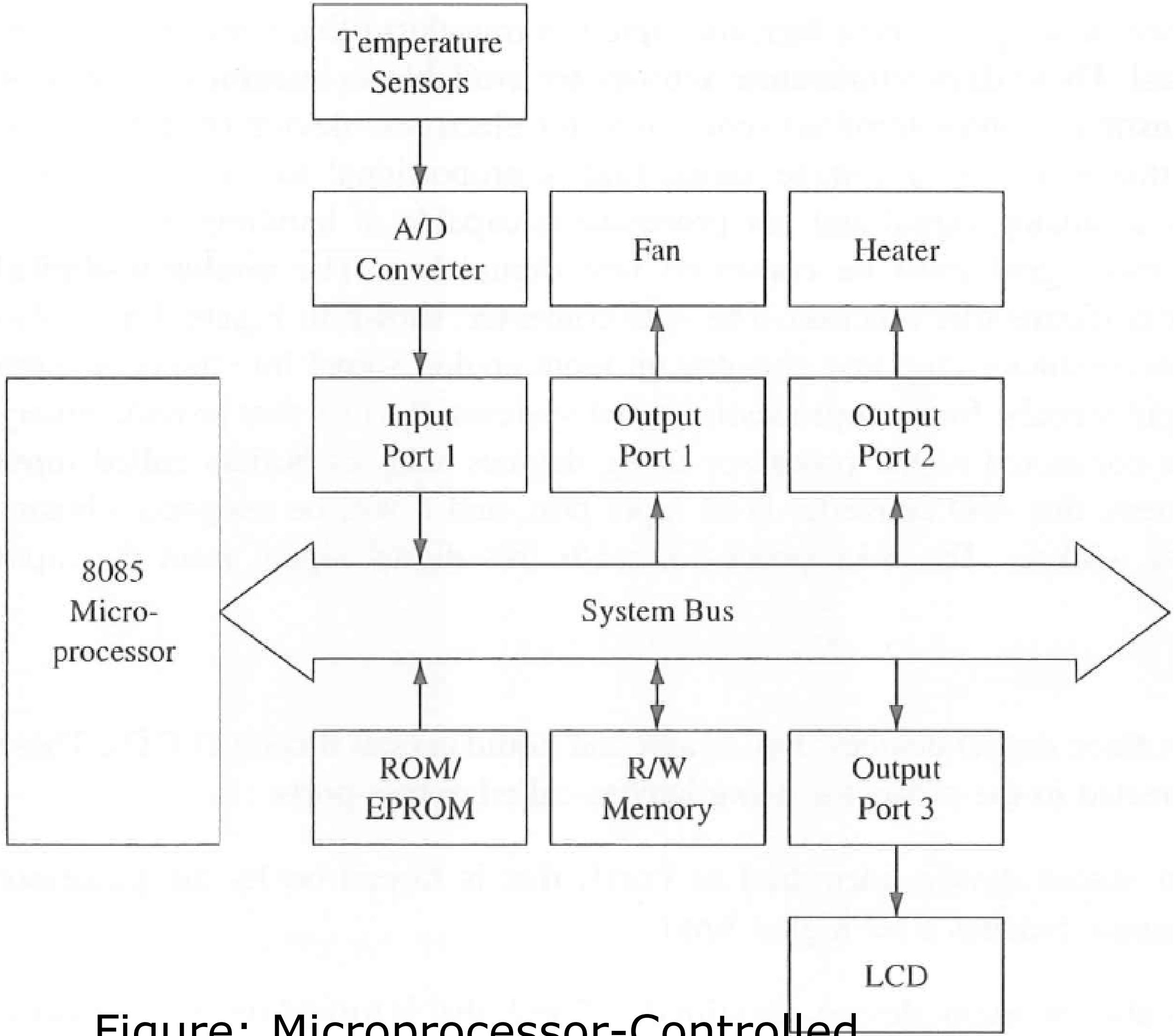
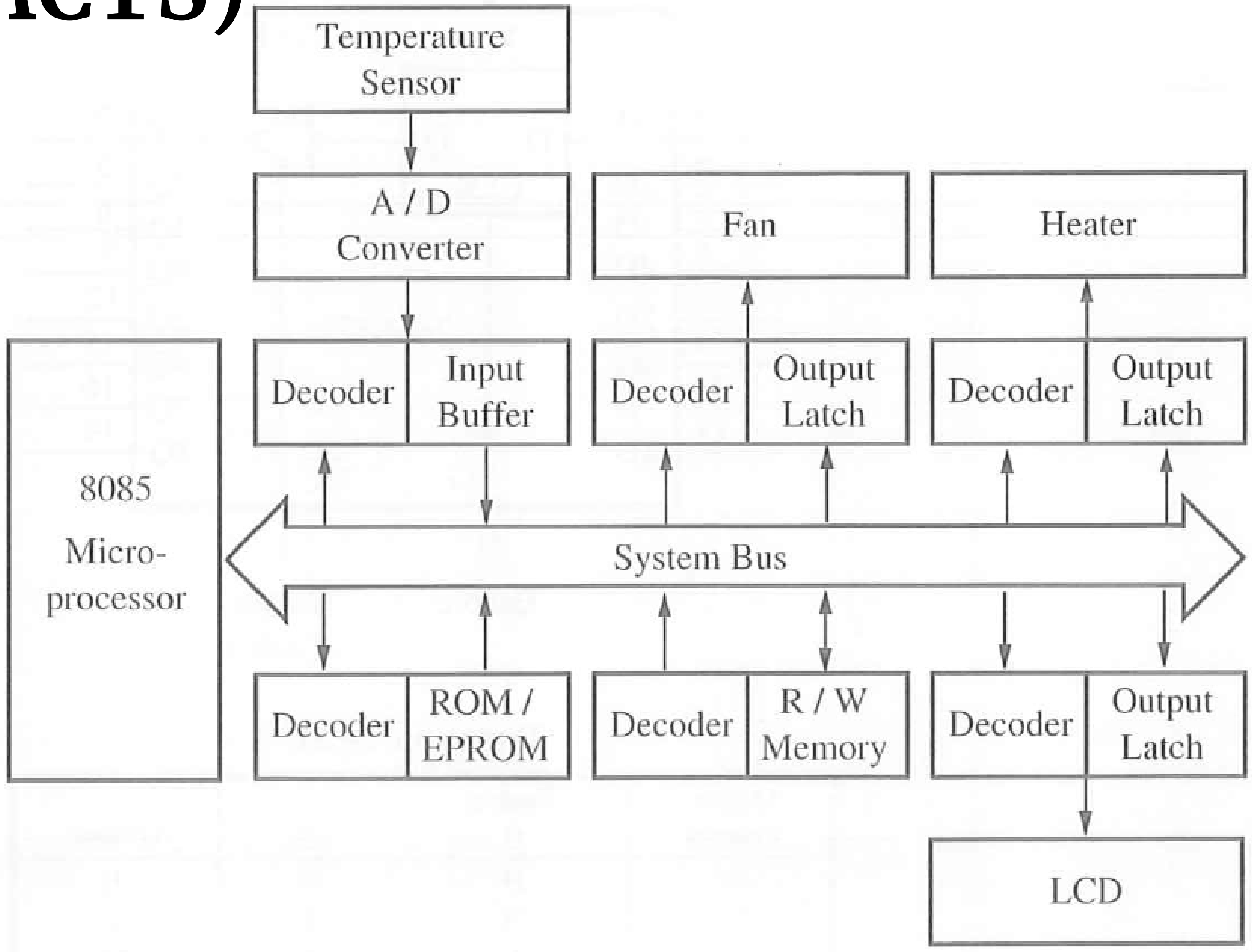


Figure: Microprocessor-Controlled Temperature System (MCTS)

Microprocessor – Controlled Temperature System (MCTS)



Microprocessor - Controlled Temperature System (MCTS)

❖ Microprocessor

- ❑ Fig shows an 8085/8086 processor with a system bus; The processor will read the binary instructions from memory and execute those instructions continuously. It will read the temperature, display it at the LCD display panel, and turn on/off the fan and the heater based on the temperature.

❖ Memory

- ❑ The system includes two types of memory ROM and R/W memory.
- ❑ ROM (read-only memory) will be used to store the program, called the monitor program, that is responsible for providing the necessary instructions to the processor to monitor the system. This will be a permanent program stored in ROM and will not be altered.
- ❑ The R/W (read-write) memory is needed for temporary storage of data.

Microprocessor – Controlled Temperature System (MCTS)

❖Input

- ❑In this system, we need a device that can translate temperature (measurement of heat) into an equivalent electrical signal
- ❑ a device that translates one form of energy into another form is called a transducer.
- ❑A temperature sensor is a three terminal semiconductor electronic device (a chip) that generates a voltage signal that is proportional to the temperature.
- ❑However, this is an analog signal and our processor is capable of handling only binary bits. Therefore, this signal must be converted into digital bits. The analog to digital converter (ADC) performs that function.
- ❑The ADC is an electronic semiconductor chip that converts an input analog signal into the equivalent eight binary output signals.
- ❑In microprocessor based systems, devices that provide binary inputs (data) are connected to the processor using devices such as buffers called input ports.
- ❑In this system, this ADC is an input port, and it will be assigned a binary number called an address. The microprocessor reads this digital signal from the input port.

Microprocessor - Controlled Temperature System (MCTS)

- **Output**
  - Fig shows three output devices: fan, heater and liquid crystal display (LCD). These devices are connected to the processor using latches called output ports.
  - Fan is an output device, identified as Port 1 , that is turned on by the processor when the temperature reaches a set higher limit.
  - Heater is also an output device, identified as Port 2, that is turned on by the processor when the temperature reaches a set lower limit.
  - LCD is made of crystal material placed between two plates in the form of a dot matrix or segments. It can display letters, decimal digits, or graphic characters. The LCD will be used to display temperatures.
- **System Software (Programs)**
  - The program that runs the system is called a monitor program or system software.
  - Generally, the entire program is divided into subtasks and written as independent modules, and it is stored in ROM (or EPROM).
  - When the system is reset, the microprocessor reads the binary command (instruction) from the first memory location of ROM and continues in sequence to execute the program.

Micron

- ❖A unit of length equal to one millionth of a meter.
- ❖It is denoted by **μ**(Mu).
- ❖For Example:
  - ❑If we pluck a hair from the head, it is very thin. But a hair is more than 2000 times wider than a transistor on a microprocessor.
  - ❑Wires between transistors are even thinner. They're more than 4000 times thinner than a hair.
  - ❑A hair is about 100 microns in diameter. That means, a transistor is just 0.045 microns wide.

End of Unit 1

Thank You