UNIT 1
Chapter 1

Microprocessor, microcomputers, and Assembly Language

Microprocessor as CPU

- The block diagram of a computer (Fig1.1a) shows that it has four components: Memory, Input, Output and CPU (Central Processing Unit)
- CPU consists of ALU (Arithmetic Logic Unit) and Control Unit. ALU performs arithmetic & logic operations while Control unit controls the timing of the communication process.
- CPU contains registers to store data. It also contains instruction decoders, counters and control lines.
- To provide control & timing signals to the overall system according to the instructions.

Microprocessor as CPU

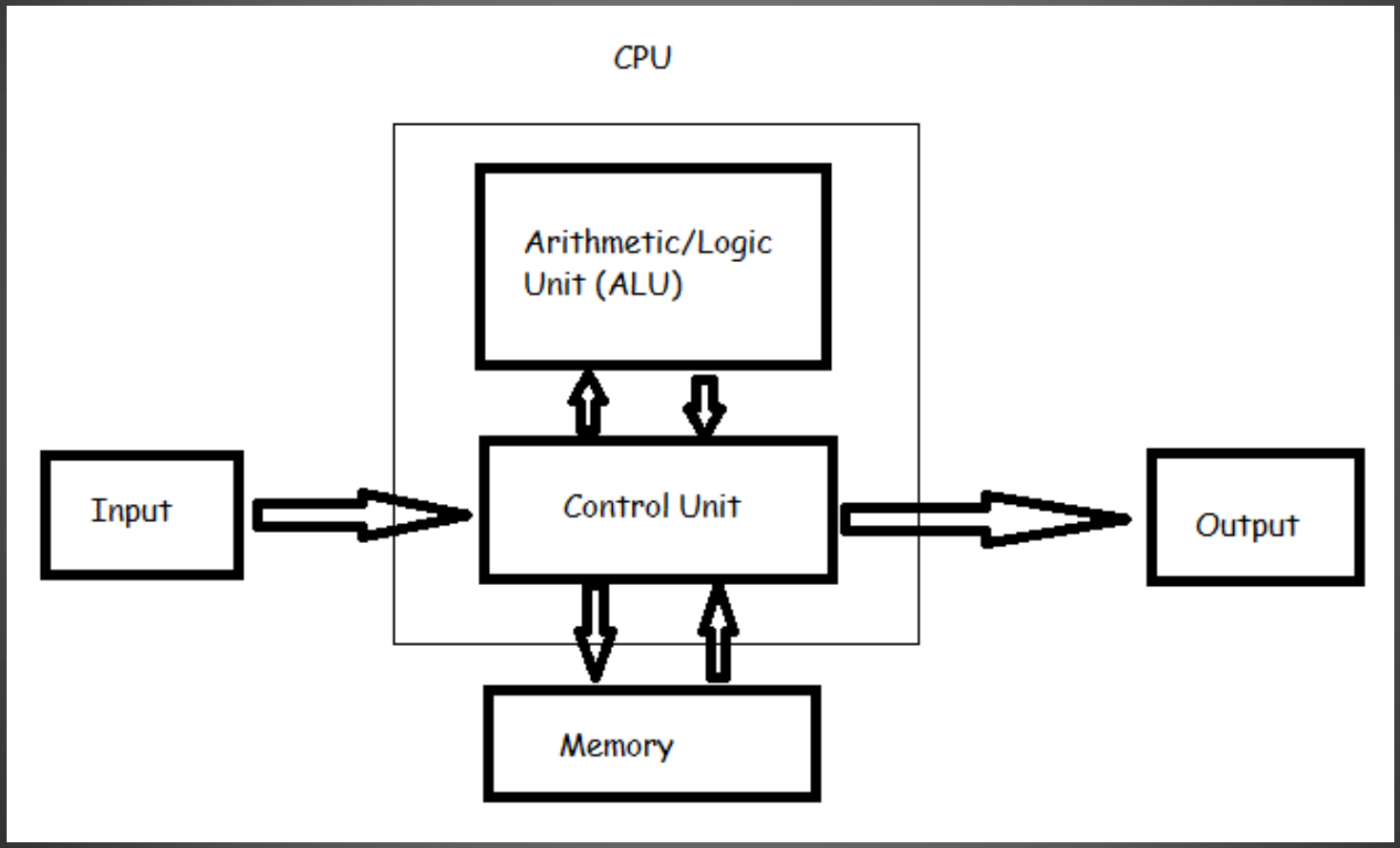


Fig 1.1(a) Traditional Block Diagram of a Computer

Microprocessor as CPU

MPU

- The traditional diagram of CPU can be replaced by block diagram shown in Fig 1.1(b)
- **A computer with microprocessor as its CPU is known as microcomputer**.
- **MPU** (Microprocessor Unit) is a complete processing unit with necessary control signals.
- Some of the control signals are needed to be generated by using discrete devices to make microprocessor a complete functional unit or MPU

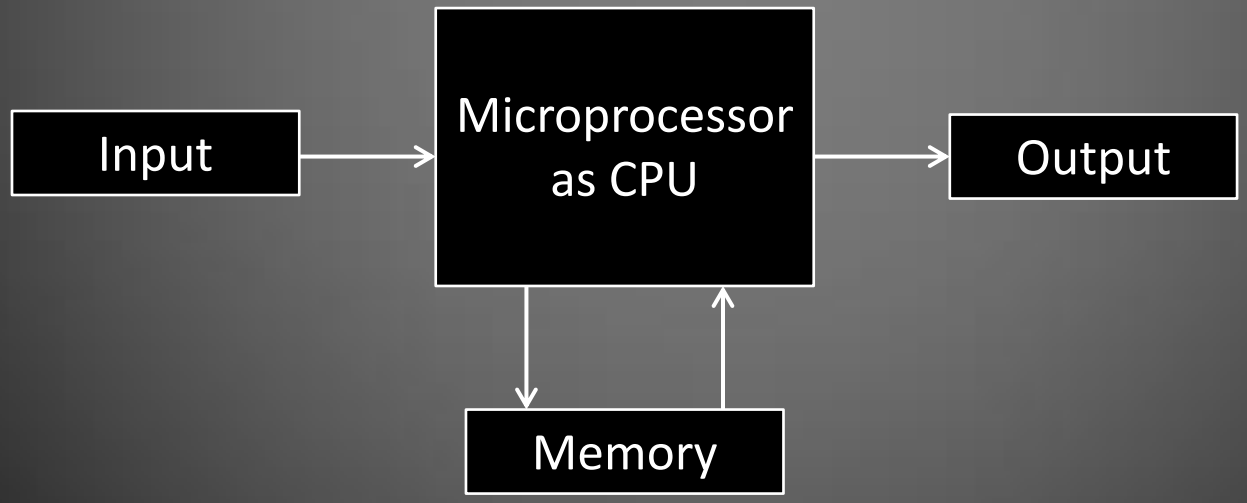


Fig 1.1(b) Block Diagram of a Computer with microprocessor as CPU

MCU

- As semiconductor technology became more advanced, manufacturer place not only MPU but also memory and I/O ports on single chip. This is known as Microcontroller or Microcontroller Unit (MCU).
- A microcontroller is essentially an entire computer on single chip.

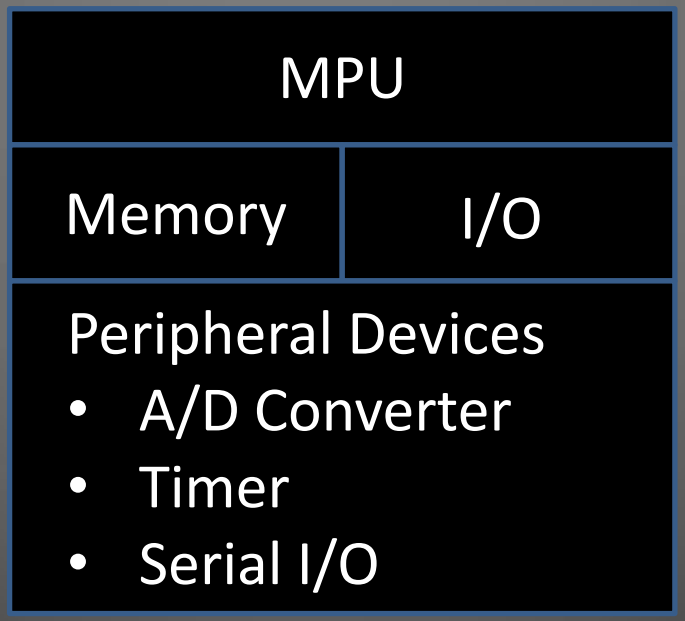


Fig 1.1(b) Block Diagram of a Microcontroller

Organization of Microprocessor-Based System

- A microcomputer is an example of microprocessor based system.
- It includes Microprocessor, I/O (input/output) and Memory (RAM and ROM).
- These components are organized around a common path called **Bus**.
- The Microprocessor is a component of Microcomputer where functions of CPU are performed by microprocessor.
- The term Peripheral is used for input/output devices.

Microprocessor

- It is a semiconductor, multipurpose, programmable logic device that reads binary instruction from storage device called memory, accepts binary data as input & processes the data according to the instructions & provides result as output
- It can be viewed as an integrated circuit, that contains processing capabilities of large computers.

- The electronic logic circuits in microprocessor is capable of performing various computing functions. These electronic circuits are manufactured by using a LSI (Large Scale Integration) or VLSI (Very Large Scale Integration) technique.

Microprocessor

- Microprocessor is roughly divided into 3 parts as shown in fig 1.2. – Arithmetic Logic Unit (ALU), Register Array and Control Unit

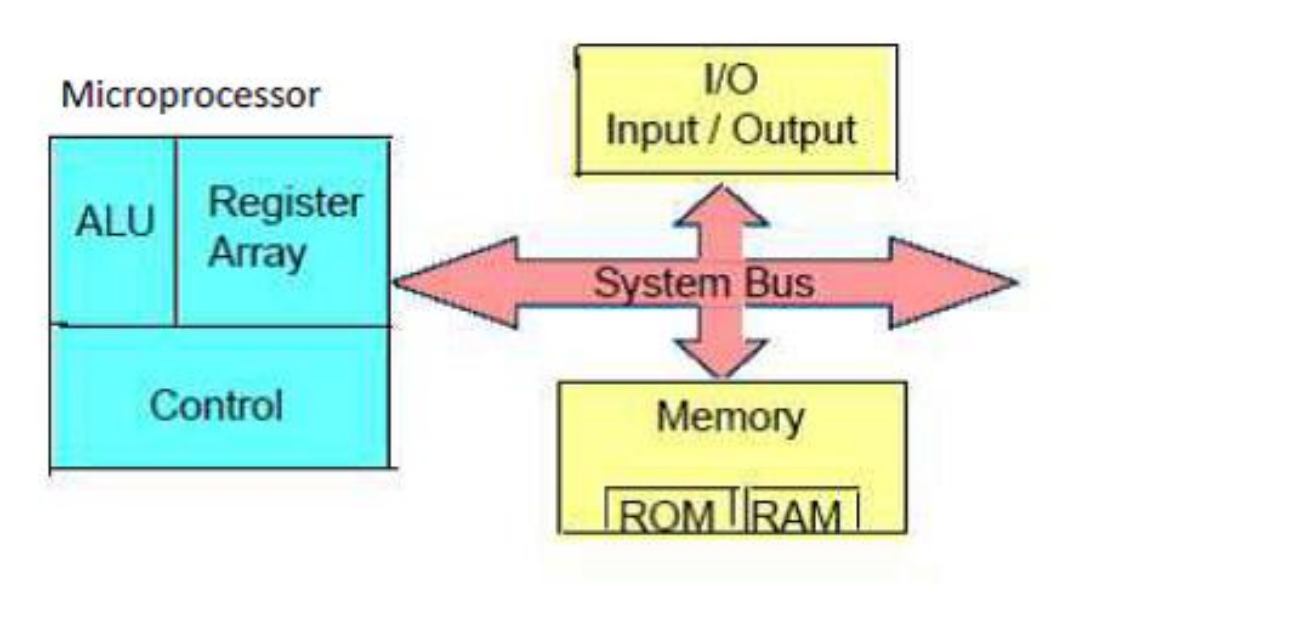


Fig 1.2 (b) Block diagram of a Microprocessor- based System with Bus Architecture

Microprocessor

- Arithmetic/Logic Unit: Performs arithmetic operations like addition, subtraction and logic operations like AND, OR, EX-OR etc.
- Register Array: Consists of various registers (B,C,D,E,H,L). These registers are used to store the data temporarily during the execution and are accessible to the user through instructions.
- 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 memory and peripherals.

Functions of Microprocessor

- To fetch, decode & execute the instructions in proper order.
- To transfer data from one block to another block or from one block to I/O lines
- To give proper response to different external interrupts according to their priority.
- To provide control & timing signals to the overall system according to the instructions

Memory

Memory stores binary information (instructions and data) and provides that information to microprocessor whenever necessary. The memory block shown in fig 1.2 has two sections – Random Access Memory (RAM), Read Only Memory (ROM).

- ROM:
  - It is used to store programs that do not need alterations.
  - The monitor program of a single-board microcomputer is stored in ROM.
  - This program interprets the information entered through the keyboard and provides equivalent binary digits to the microprocessor.
  - Programs stored in ROM can only be read and cannot be altered.

Memory

- RAM:
  - It is also known as Read Write Memory (RWM) or User Memory.
  - It is used to store user programs and data.
  - The information stored in this memory can be easily read and altered.

Input / Output

- The input devices such as keyboard, switches etc transfer binary information from the outside world to the microprocessor.
- The output devices like LED, LCD, CRT etc transfer the information from microprocessor to outside world

System Bus

- It is the communication path between the microprocessor and peripherals.
- It is a group of wires to carry bits.
- All the peripherals share the same bus, but the microprocessor communicates with only one peripheral at a time. The timing is provided by the control unit of the microprocessor.

How does the microprocessor work?

- Assume that program and data are already entered in RAM.
- When the µp is given a command to execute the program, it reads and executed one instruction at a time and finally sends the result to the output.
- The µp fetches the first instruction from its memory, decodes it and executes the instruction.
- This sequence of the of fetch, decode and execute is continued until the µp comes across an instruction to stop.
- During the entire process the µp uses system bus to fetch binary instruction and data from memory. It uses registers to store data temporarily and computing function is done by ALU.
- Finally, it sends out the result in binary using same bus lines to seven segment display.

Microprocessor Instruction Set and Computer Languages

- The microprocessor communicates and operates in the binary numbers 0 and 1, called bits
- Each microprocessor has its own binary words, meanings and language.
- The word length is defined by number of bits the microprocessor recognizes and processes at a time.
- Word length may range from 4 bits for small microprocessor based systems to 64 bits for high-speed large computers. (for 8085 microprocessor word length is 8 bits).

Bit, Nibble, Byte

1 Nibble = 4 Bits

1 Byte = 2 Nibbles

1 Bytes = 8 Bits

Machine Language, Assembly Language & High level language

- Each machine has its own set of instructions based on the design of its CPU or microprocessor. To communicate with computer, one must give instructions in binary code known as machine language.
- But as it is difficult to write programs in Binary, programmers can write programs in assembly language also called low level language.
- But again the programs written in assembly language are not transferable from one machine to another. Hence programmers use high level language like C, C++, BASIC etc.

8085 Machine Language

- 8085 microprocessor has word length of 8-bits. That means its instruction is designed by using various combinations of these 8 bits.
- For Example:

0111 0110 is a code used for Halt the microprocessor.

- 8085 microprocessor use such 246 different binary codes.
- Since is difficult to enter the binary data without errors hence for convenience these instructions are written in hexadecimal code and entered in a single-board microcomputer by using Hex-keyboard.

8085 Assembly language

- Even though the instructions can be written in Hex code still for programmer it is still difficult to understand a program written in hexadecimal numbers. Therefore symbolic code is used for each instruction, this code is called mnemonics
- For Example:

0111 0110 is a code used for Halt the microprocessor.
In Hex Code it is written as 76H
Mnemonic for this code is 'HLT' which can be entered using ASCII keyboard

- **Assembler is a software that translates the mnemonics into corresponding binary machine codes.**

Writing and Executing Assembly Language Program

- Write the program i.e., instructions in mnemonics.
- Find the hexadecimal code for each instruction by searching through the opcode sheet
- Enter (load) the program in user memory (RAM) in a sequential order by using hex keyboard as input device.
- Execute the program.
- The answer will be displayed on seven segment display.

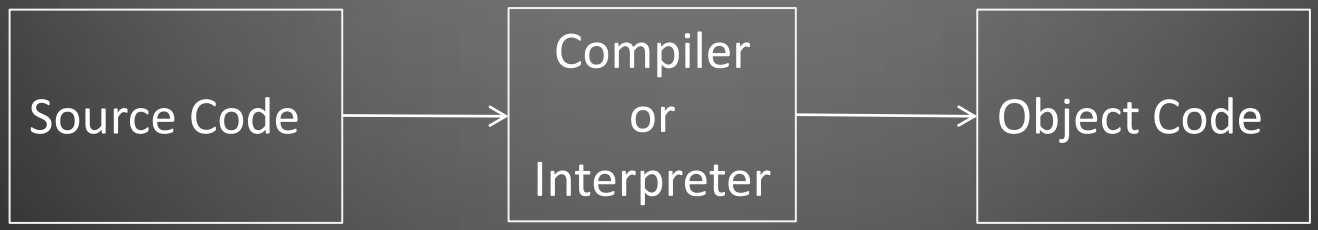
This process is called hand assembly. This procedure is used in single board microcomputer and suited for small programs

Writing and Executing Assembly Language Program

- We can also enter the program in a computer using ASCII keyboard and an assembler.
- Assembler is a program that translates the mnemonics entered by ASCII keyboard into the corresponding binary machine codes.

High Level Languages

- These programming languages are machine independent.
- Example: BASIC, FORTRAN, PASCAL, C, C++, Java etc.
- Instructions written in these languages are known as statements (Syntax) and not mnemonics.
- Compiler is a software that translates program written high level language to corresponding binary machine language called object code.



Operating Systems

- The interaction between hardware and software is managed by a set of programs called an Operating System of a computer.
- The computer transfers information constantly between memory and various peripherals such as printer, keyboard and video monitor. It also stores programs on disk
- The operating system is responsible for storing information on disk and communication between computer and peripherals.

From Large Computers to Single Chip Microcontroller

Difference between Microprocessor and Microcontroller

- Microprocessor is a silicon chip representing CPU which is capable of performing arithmetic and logical operations according to a pre-defined set of instructions.
- Microcontroller is a highly integrated chip containing CPU, special and general purpose registers, timer and interrupt control units and I/O ports.
- In short Microcontroller contains microprocessor along with I/O ports, timer and memory all inside one chip.

Large Computers

- These are large, general purpose, multiuser, multitasking computers designed to perform complex scientific and engineering calculations and handle the records for large corporations or government agencies.
- These computers can be broadly classified into Mainframes and Supercomputers. Mainframes are further classified according to their sizes.
- Mainframes are high speed computers with word length ranging from 32 to 64 bits. They are capable of addressing megabytes of memory and handling all types of peripherals and a large number of users.
- Supercomputers are high performance, high speed computers which are used in research in global climate and high energy physics.

Medium-Size Computers

- In 1960s, these computers were designed to meet the needs of small colleges, the manufacturing problems in small factories and the data processing tasks of medium-size business.
- These computers were slower and smaller in memory capacity than Mainframes.
- These computers are referred to minicomputers.

Microcomputers

- 4-bit and 8-bit microprocessors became available in mid 1970s
- Initial applications were in area of machine control and instrumentation. But with time applications were extended in almost all the areas like video games, word processing and small business applications.
- Early microcomputers were designed around 8-bit microprocessors. Since then 16, 32, 64-bit microprocessors such as Intel Pentium series, Intel Core i3, i5, i7 and the power PC series have been introduced and recent computers are designed around these microprocessors.
- Present day microcomputers can be classified into 4 groups: Personal / Business Computers (Laptops, desktops), workstations, single board and single chip microcomputers (microcontrollers).

Microcomputers

Personal Computers

- These microcomputers are single user systems used for business accounts, word processing, legal and medical record keeping, personal finance, accessing internet resources (e-mail, web search) etc. Also known as PC (Personal Computers)
- A typical PC includes 64-bit processor (Intel i3 core), $GB of system memory (RAM), a hard disk with storage capacity 500GB, LCD video monitor, a CD ROM/ DVD drive, 4 to 6 USB ports to connect flash memory drives, keyboard, mouse and speakers etc.
- Frequently used programs and application programs are stored on hard disk while flash drive is generally used for user programs and to make back up copies.
- These are further classified according to their size, weight and portability. They are desktop, laptop and notebook (tablet)

Microcomputers

Workstations

- High performance cousins of personal computers.
- Used in engineering and scientific applications such as Computer Aided Design (CAD), Computer Aided Engineering (CAE), Computer Aided Manufacturing (CAM). They generally include system memory and storage memory in GB and high resolution screen.
- Workstations are designed around RISC (Reduced Instruction Set Computing) processors.
- Faster and more efficient than personal computers.

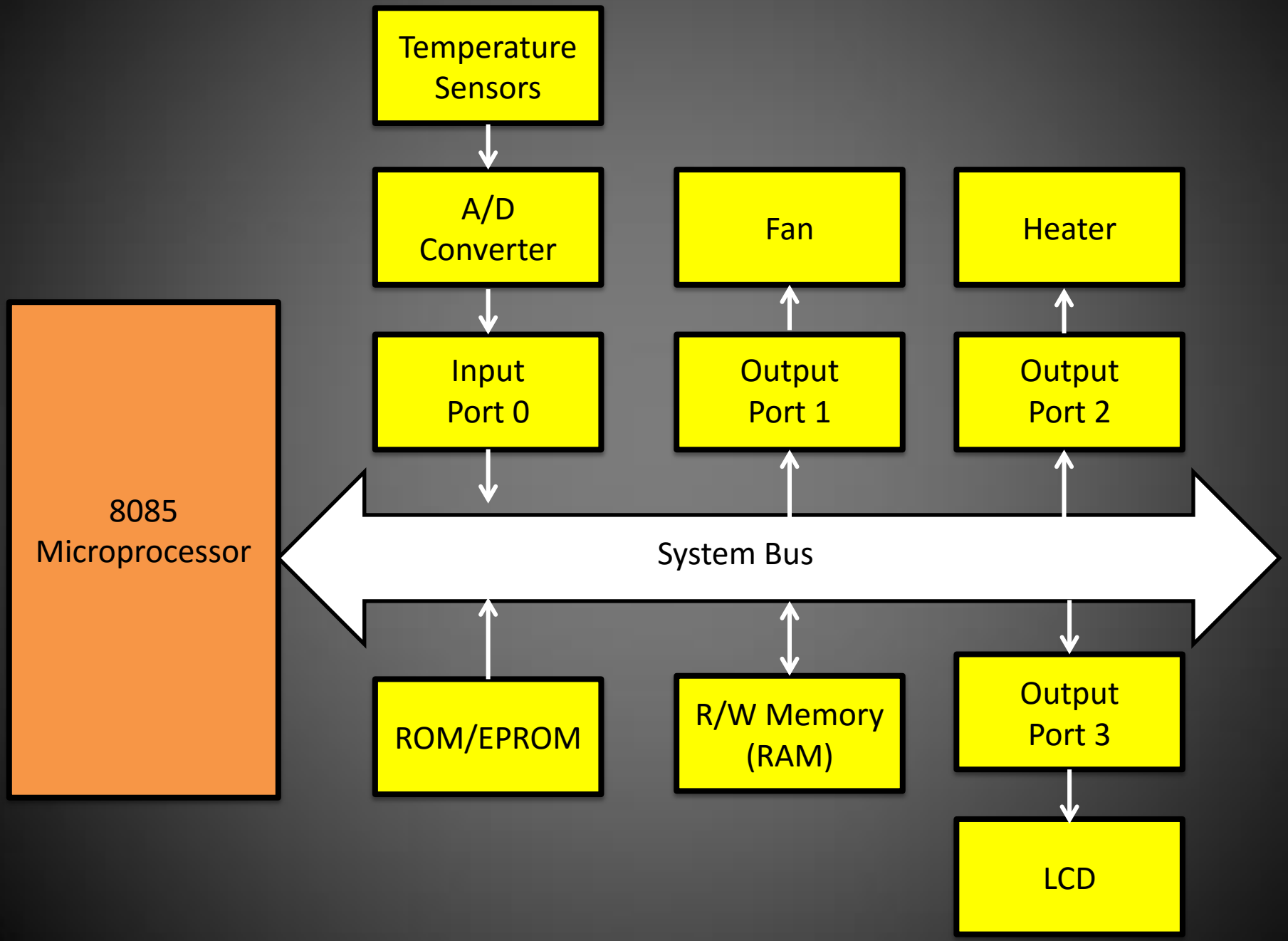
Microcomputers

Single Board Microcomputers

- Primarily used in college laboratories and for industrial purpose.
- They can also be a part of some large system.
- These microcomputers include an 8 or 16-bit microprocessor, from 256 bytes to 8K bytes of user memory, a Hex keyboard and seven segment display.
- The interaction between the microprocessor, memory and I/O is looked after by a program called Monitor Program.
- The monitor program is in charge of the system. It monitors the keyboard inputs, interpret those keys, stores programs in memory, sends output to system display and enable execution of user programs.

Application: Microprocessor Controlled Temperature System (MCTS)

MCTS


Temperature Sensors
A/D Converter
Fan
Heater
8085 Microprocessor
Input Port 0
Output Port 1
Output Port 2
System Bus
ROM/EPROM
R/W Memory (RAM)
Output Port 3
LCD

MCTS

System Hardware

- In addition to microprocessor and memory, we need various input and output devices.
- The system needs temperature sensors as an input device to sense room temperature and three output devices – a fan, a heater and an LCD panel for display.

Microprocessor

- The processor will read binary instruction from memory and execute those instructions continuously.
- It will read temperature, display it at the LCD panel and turn on/off the fan and heater based on temperature.

MCTS

System Hardware

Input

- We need a device that can translate temperature (heat energy) to equivalent electrical signal. The device that converts one form of energy to another is known as transducer.
- We use temperature sensor for this purpose. It generates a voltage signal that is proportional to temperature.
- But this voltage is analog and microprocessor deals only with digital data. So we need A/D (Analog to Digital) converter It converts analog signal to equivalent 8-bit binary data.
- A/D converter is connected to input port and this port will be assigned a binary address. Microprocessor reads this digital signal from input port.

MCTS

Output

- Fan, heater, LCD (Liquid Crystal Display) are connected to microprocessor using latches called output ports.
- **Fan** : Output device at Port 1, tuned on by µp when the temperature reaches a set higher limit.
- **Heater** : Output device at Port 2, tuned on by µp when the temperature reaches a set lower limit.
- **LCD** : Output device at Port 3. It is made of crystal material placed between two plates in the form of matrix. It can display letters, decimal digits or graphic characters. It is used to display temperature.

MCTS

System Software

- The program that runs the system is called system software.
- Generally the entire program is divided into sub-stacks and written as independent modules. It is stored in ROM (or EPROM).
- When the system is reset, the µp reads the binary instruction from ROM and continues in sequence to execute the program.