Microprocessor Architecture
and
Microcomputer System

Microprocessor Architecture and its operation’s,

Memory,

I/O Devices,

Microcomputer System,

Logic Devices and Interfacing,

Microprocessor-Based System Application.

Microprocessor Architecture and its operation’s

The microprocessor is a programmable digital device, designed with registers, flip-flops, and timing elements. The microprocessor has a set of instructions, designed internally, to manipulate data and communicate with peripherals. This process of data manipulation and communication is determined by the logic design of the microprocessor, called the **architecture.**

slower peripherals. All the various functions performed by the microprocessor can be classified in three general categories:

- Microprocessor-initiated operations
- Internal operations
- Peripheral (or externally initiated) operations

3.1.1 Microprocessor-Initiated Operations and 8085 Bus Organization

The MPU performs primarily four operations:*

1. Memory Read: Reads data (or instructions) from memory.
2. Memory Write: Writes data (or instructions) into memory.
3. I/O Read: Accepts data from input devices.
4. I/O Write: Sends data to output devices.

All these operations are part of the communication process between the MPU and peripheral devices (including memory). To communicate with a peripheral (or a memory location), the MPU needs to perform the following steps:

Step 1: Identify the peripheral or the memory location (with its address).
Step 2: Transfer binary information (data and instructions).
Step 3: Provide timing or synchronization signals.

System Bus – wires connecting memory & I/O to microprocessor

– Address Bus

• Unidirectional

• Identifying peripheral or memory location

– Data Bus

• Bidirectional

• Transferring data

– Control Bus

• Synchronization signals

• Timing signals

• Control signal

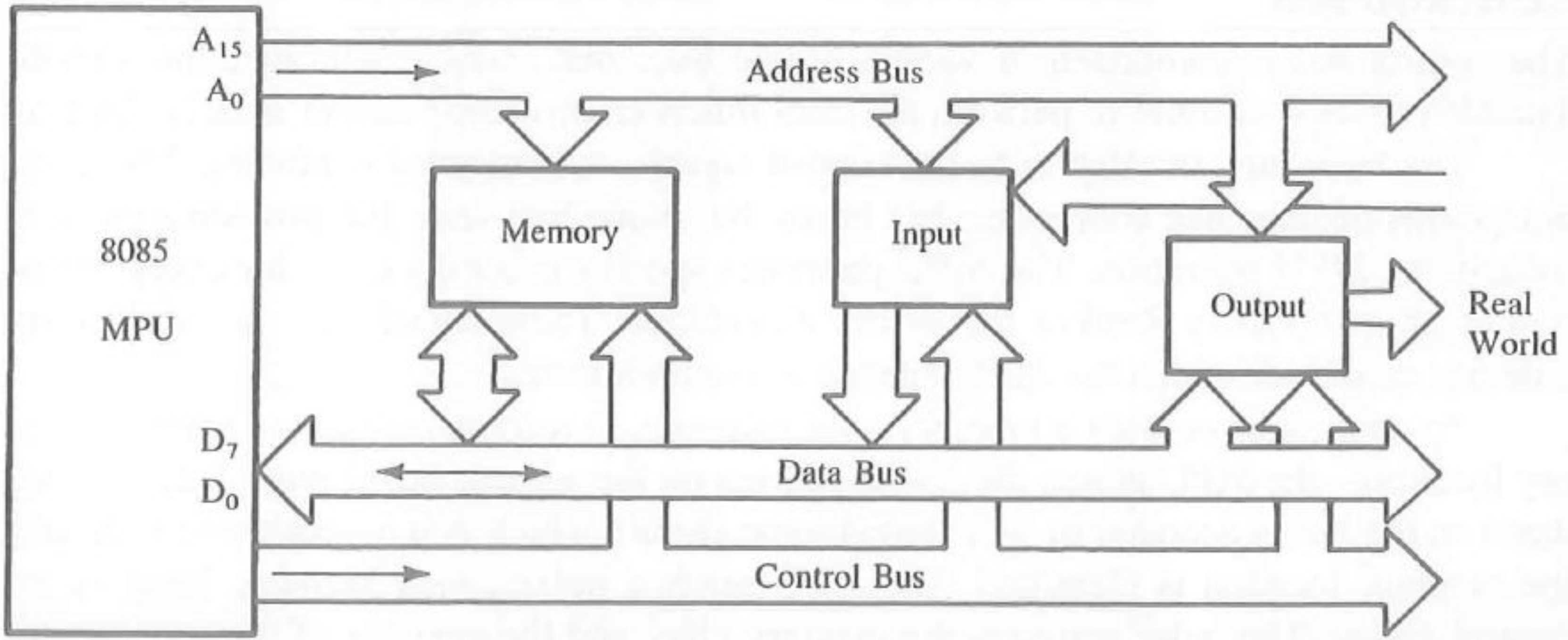


FIGURE 3.1
The 8085 Bus Structure

ADDRESS BUS

The address bus is a group of 16 lines generally identified as A_0 to A_{15}. The address bus is **unidirectional:** bits flow in one direction—from the MPU to peripheral devices. The MPU uses the address bus to perform the first function: identifying a peripheral or a memory location (Step 1).

In a computer system, each peripheral or memory location is identified by a binary number, called an **address,** and the address bus is used to carry a 16-bit address. This is sim-

DATA BUS

The data bus is a group of eight lines used for data flow (Figure 3.1).* These lines are **bidirectional**—data flow in both directions between the MPU and memory and peripheral devices. The MPU uses the data bus to perform the second function: transferring binary information (Step 2).

The eight data lines enable the MPU to manipulate 8-bit data ranging from 00 to FF ($2^8 = 256$ numbers). The largest number that can appear on the data bus is 11111111 (255_{10}). The 8085 is known as an 8-bit microprocessor. Microprocessors such as the Intel 8086, Zilog Z8000, and Motorola 68000 have 16 data lines; thus they are known as 16-bit microprocessors. The Intel 80386/486 have 32 data lines; thus they are classified as 32-bit microprocessors.

CONTROL BUS

The control bus is comprised of various single lines that carry synchronization signals. The MPU uses such lines to perform the third function: providing timing signals (Step 3).

The term **bus,** in relation to the control signals, is somewhat confusing. These are not groups of lines like address or data buses, but individual lines that provide a pulse to indicate an MPU operation. The MPU generates specific control signals for every operation (such as Memory Read or I/O Write) it performs. These signals are used to identify a device type with which the MPU intends to communicate.

3.1.2 Internal Data Operations and the 8085 Registers

The internal architecture of the 8085 microprocessor determines how and what operations can be performed with the data. These operations are:

1. Store 8-bit data.
2. Perform arithmetic and logical operations.
3. Test for conditions.
4. Sequence the execution of instructions.
5. Store data temporarily during execution in the defined R/W memory locations called the stack.

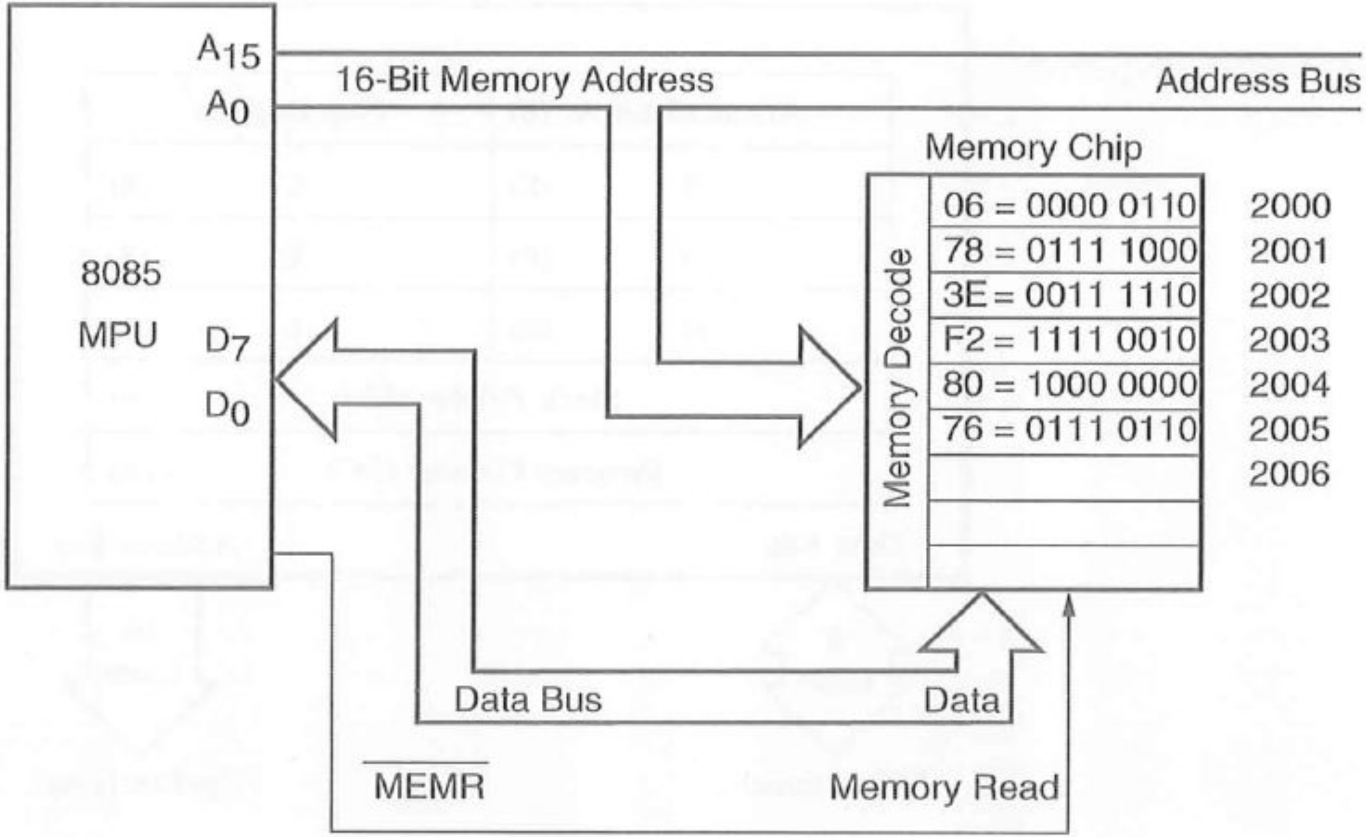
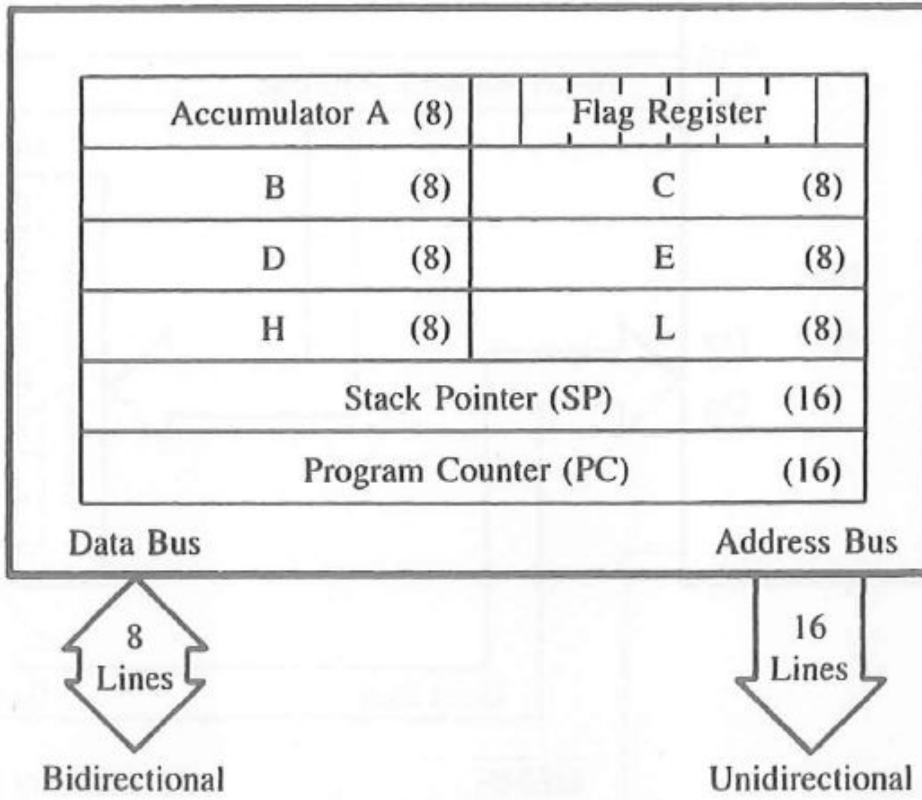


FIGURE 3.2
Memory Read Operation

FIGURE 3.3
The 8085 Programmable Registers



3.1.3 Peripheral or Externally Initiated Operations

External devices (or signals) can initiate the following operations, for which individual pins on the microprocessor chip are assigned: Reset, Interrupt, Ready, Hold.

- ☐ Reset: When the reset pin is activated by an external key (also called a reset key), all internal operations are suspended and the program counter is cleared (it holds 0000H). Now the program execution can again begin at the zero memory address.
- ☐ Interrupt: The microprocessor can be interrupted from the normal execution of instructions and asked to execute some other instructions called a **service routine** (for example, emergency procedures). The microprocessor resumes its operation after completing the service routine (see Chapter 12).
- ☐ Ready: The 8085 has a pin called READY. If the signal at this READY pin is low, the microprocessor enters into a Wait state. This signal is used primarily to synchronize slower peripherals with the microprocessor.
- ☐ Hold: When the HOLD pin is activated by an external signal, the microprocessor relinquishes control of buses and allows the external peripheral to use them. For example, the HOLD signal is used in Direct Memory Access (DMA) data transfer (see

Memory

Memory is an essential component of a microcomputer system; it stores binary instructions and data for the microprocessor. There are various types of memory, which can be classified in two groups: prime (or main) memory and storage memory. In the last chapter, we discussed briefly two examples of prime memory: Read/Write memory (R/WM) and Read-Only memory (ROM). Magnetic tapes or disks can be cited as examples of stor-

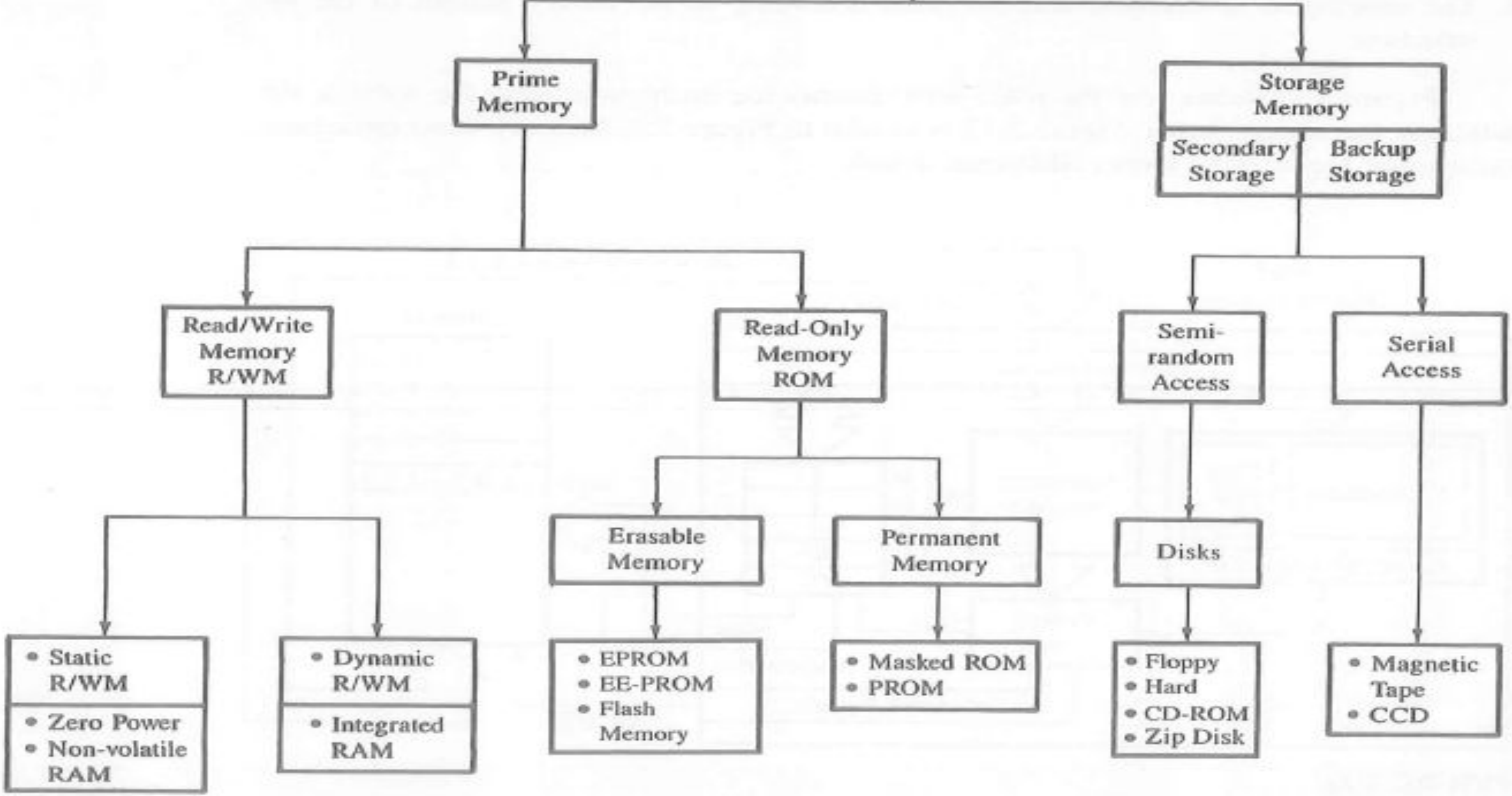


FIGURE 3.13
Memory Classification

INPUT AND OUTPUT (I/O) DEVICES

Input/output devices are the means through which the MPU communicates with "the outside world." The MPU accepts binary data as input from devices such as keyboards and A/D converters and sends data to output devices such as LEDs or printers. There are two different methods by which I/O devices can be identified: one uses an 8-bit address and the other uses a 16-bit address. These methods are described briefly in the following sections.

The microprocessor cannot do anything by itself therefore, It needs to be linked with memory, extra peripherals, or IO devices. This linking is called Interfacing.

The interfacing of the I/O devices in 8085 can be done in two ways :

1. Memory-Mapped I/O Interfacing :

In this kind of interfacing, we assign a memory address that can be used in the same manner as we use a normal memory location.

2. I/O Mapped I/O Interfacing :

A kind of interfacing in which we assign an 8-bit address value to the input/output devices which can be accessed using IN and OUT instruction is called I/O Mapped I/O Interfacing.

Features	Memory Mapped IO	IO Mapped IO
Addressing	IO devices are accessed like any other memory location.	They cannot be accessed like any other memory location.
Address Size	They are assigned with 16-bit address values.	They are assigned with 8-bit address values.
Instructions Used	The instruction used are LDA and STA, etc.	The instruction used are IN and OUT.
Cycles	Cycles involved during operation are Memory Read, Memory Write.	Cycles involved during operation are IO read and IO writes in the case of IO Mapped IO.

Registers Communicating	Any register can communicate with the IO device in case of Memory Mapped IO.	Only Accumulator can communicate with IO devices in case of IO Mapped IO.
Space Involved	2^{16} IO ports are possible to be used for interfacing in case of Memory Mapped IO.	Only 256 I/O ports are available for interfacing in case of IO Mapped IO.
IO/M` signal	During writing or read cycles (IO/M` = 0) in case of Memory Mapped IO.	During writing or read cycles (IO/M` = 1) in case of IO Mapped IO.
Control Signal	No separate control signal required since we have unified memory space in the case of Memory Mapped IO.	Special control signals are used in the case of IO Mapped IO.

Micro-Computer System

The address lines A_{15}–A_0 are used to address memory, and the low-order address bus A_7–A_0 is used to identify the input and the output. The data bus D_7–D_0 is bidirectional and common to all the devices. The four control signals generated by the MPU are connected to different peripheral devices, as shown in Figure 3.15.

The MPU communicates with only one peripheral at a time by enabling the peripheral through its control signal. For example, to send data to the output device, the MPU places the device address (output port number) on the address bus, data on the data bus, and enables the output device using the control signal $\overline{\text{IOW}}$ (I/O Write). The output device latches and displays data if the output device happens to be LEDs. The other pebus drivers increase the current driving capacity of the buses, the decoder decodes the address to identify the output port, and the latch holds data output for display. These devices are called **interfacing devices.** The interfacing devices are semiconductor chips that are needed to connect peripherals to the bus system. Before we discuss interfacing concepts, we will review these interfacing devices.

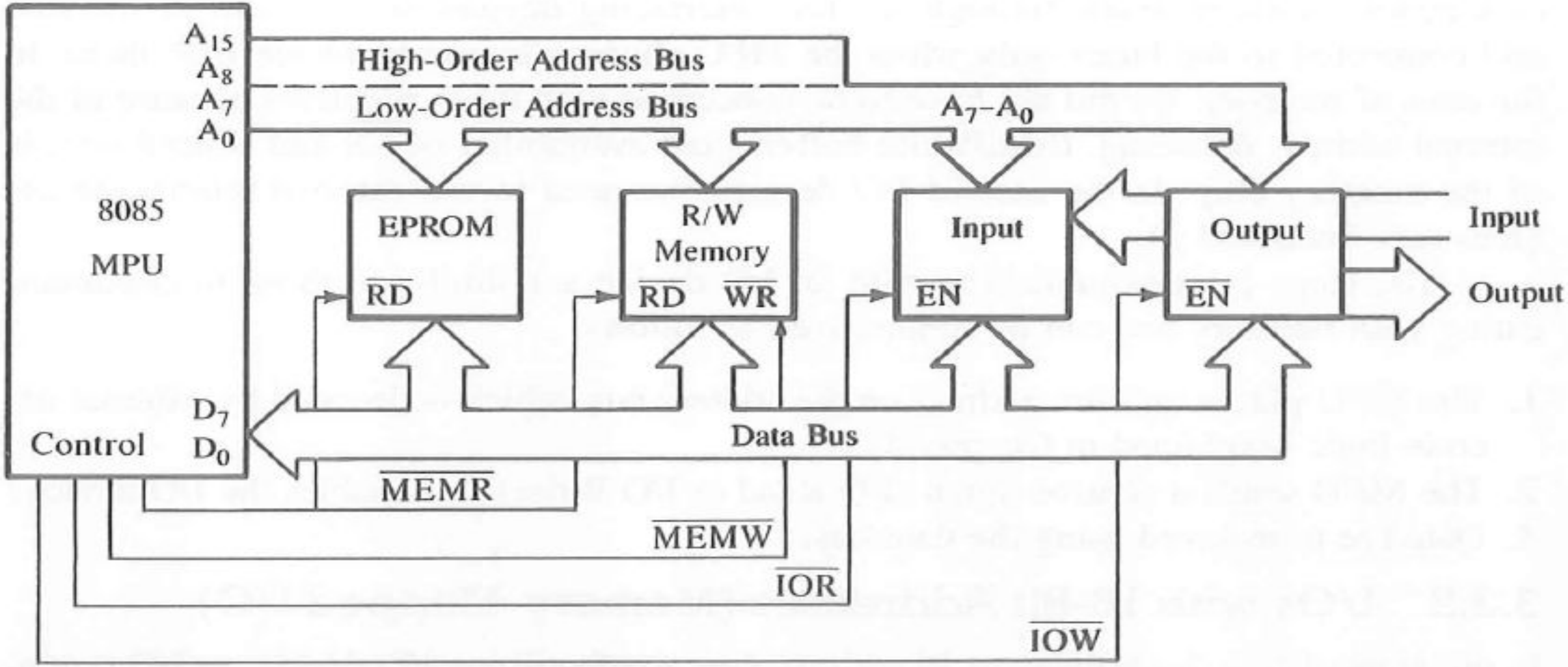


FIGURE 3.15
Example of a Microcomputer System

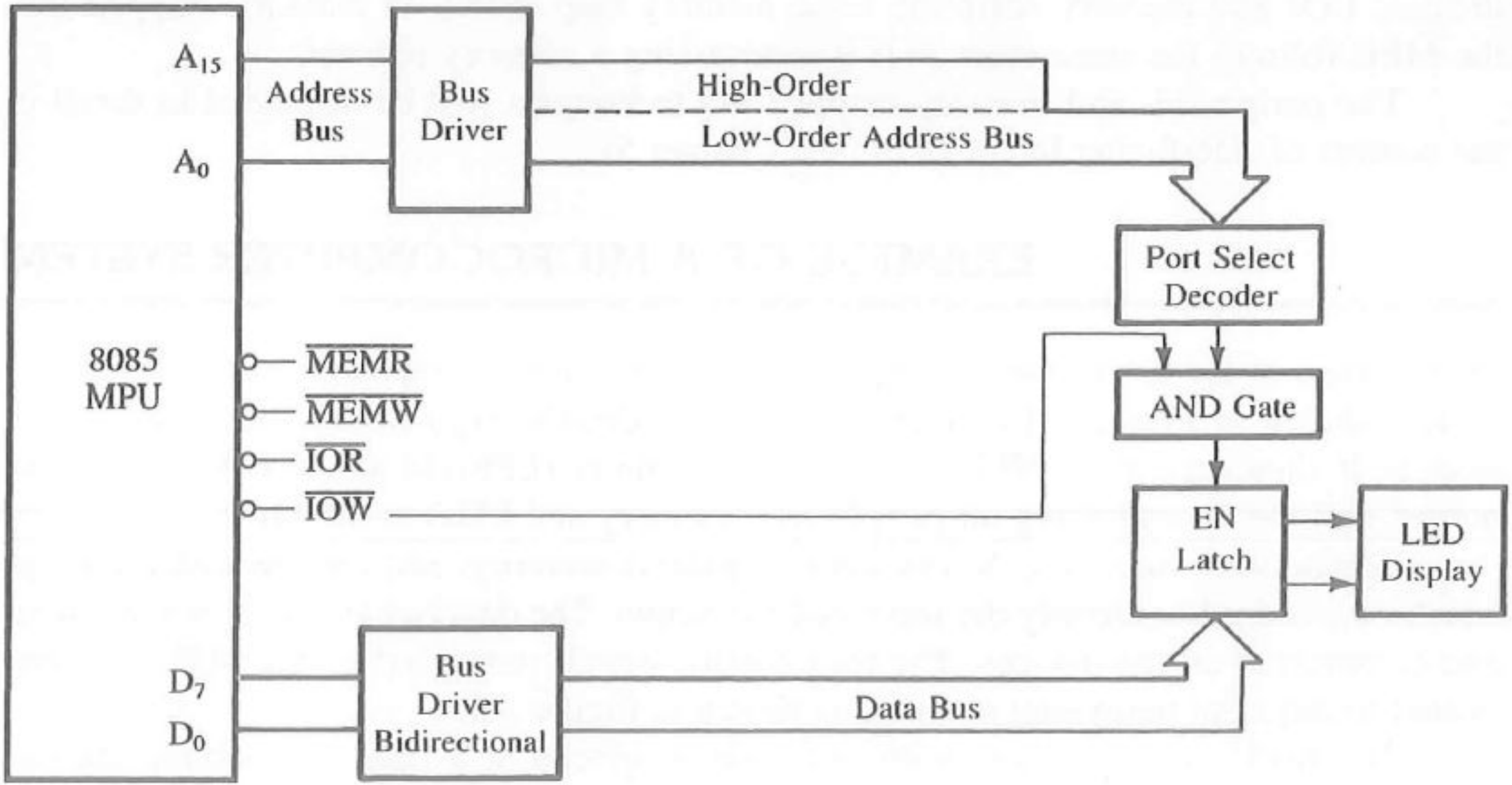


FIGURE 3.16
The Output Section of the Microcomputer System Illustrated in Figure 3.15

Logic Devices for Interfacing

- Tri-Sate Devices
- Buffer
- Decoder
- Encoder

Microprocessor-Based System Application.(MCTS)

- Figure 3.28 includes three output devices (fan, heater, and LCD) and one input device, and they are connected to the address and data bus through interfacing devices such as latches and a buffer. A binary address is assigned to each of these interfacing devices, and the microprocessor sends data through these latches when asked through an OUT instruction.

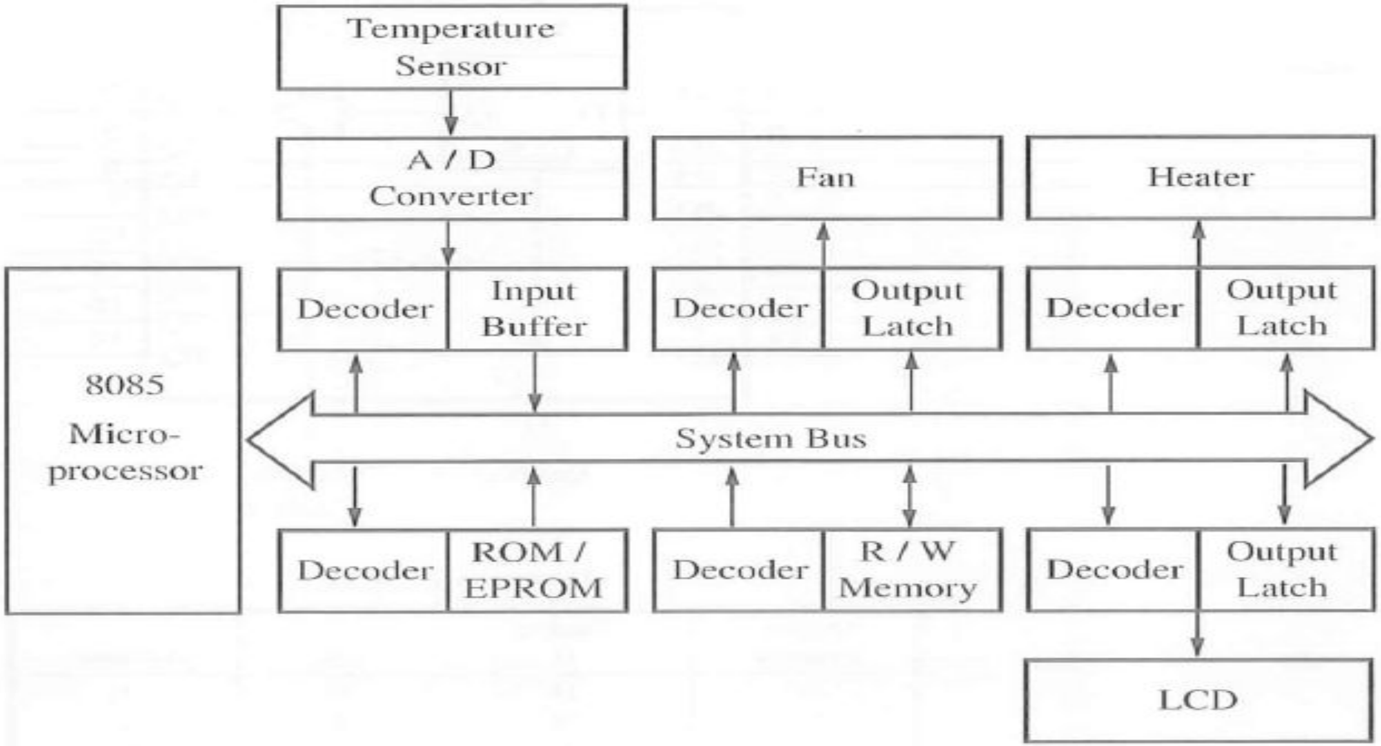


FIGURE 3.28

Microprocessor-Controlled Temperature System (MCTS) with Interfacing Devices