

# Microprocessor and Microcontroller Fundamentals

Digital Systems Engineering



# Admin

- ◆ Course materials available online
- ◆ <http://ece.citadel.edu/hayne/>
  - Students are encouraged to print lecture slides in advance and use them to take notes in class

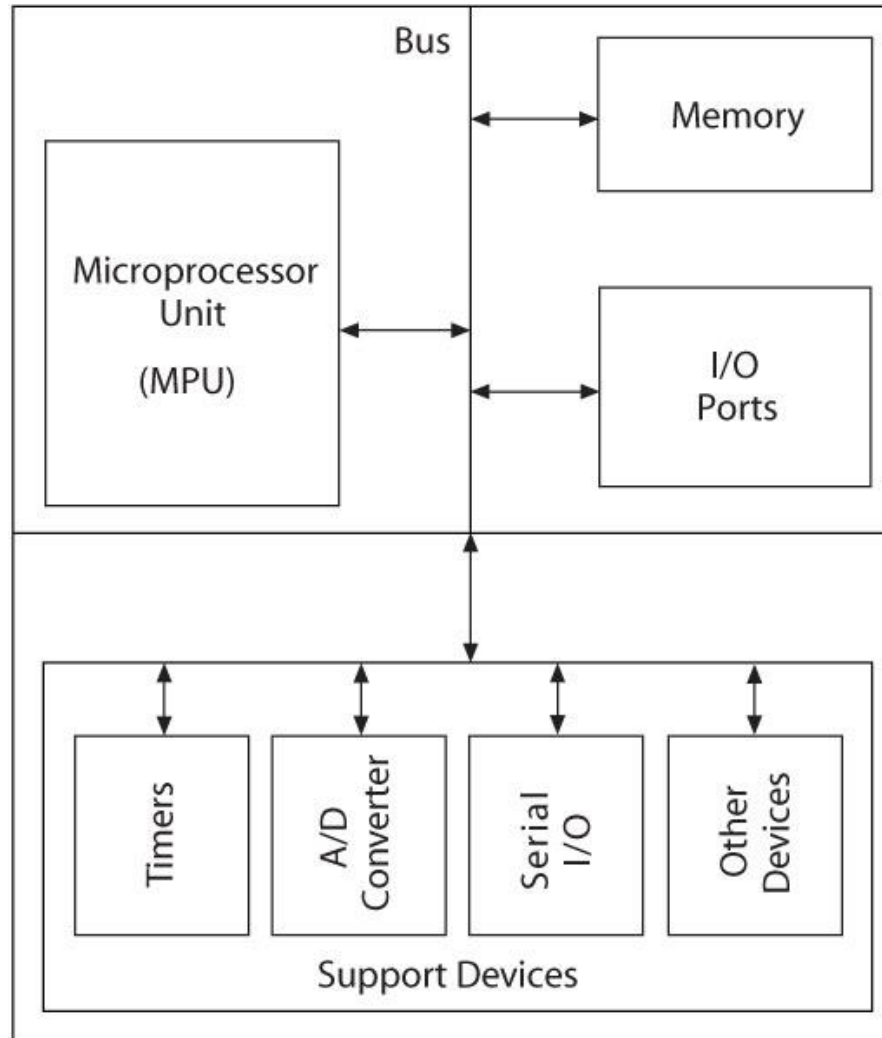
# Microcontrollers

- ◆ Embedded Systems
  - Operations managed behind the scenes by a microcontroller
- ◆ Microcontroller (MCU)
  - Integrated electronic computing device that includes three major components on a single chip
    - Microprocessor (MPU)
    - Memory
    - I/O (Input/Output) ports

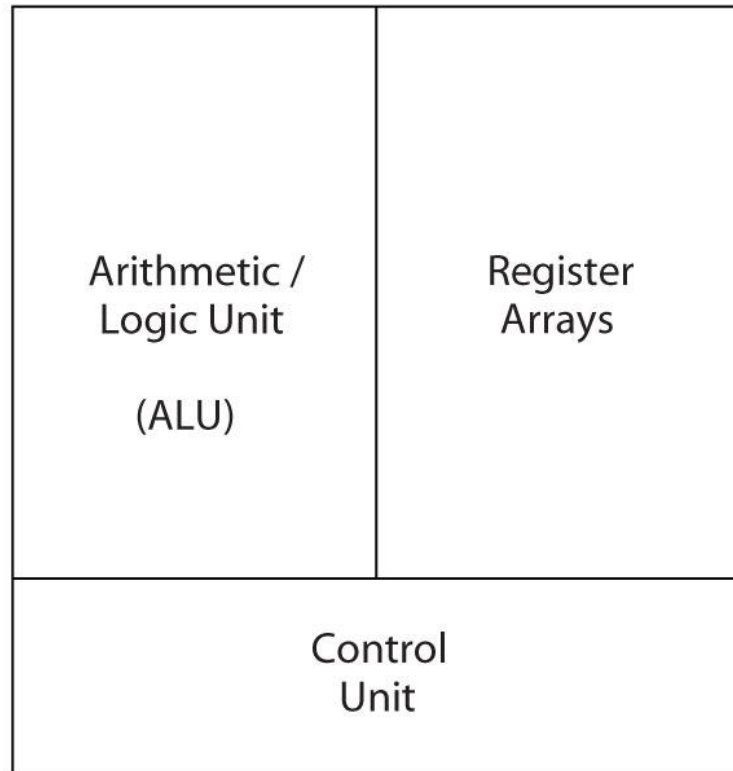
# Microcontrollers

- ◆ Support Devices
  - Timers
  - A/D converter
  - Serial I/O
- ◆ Common communication lines
  - System Bus

# Block Diagram

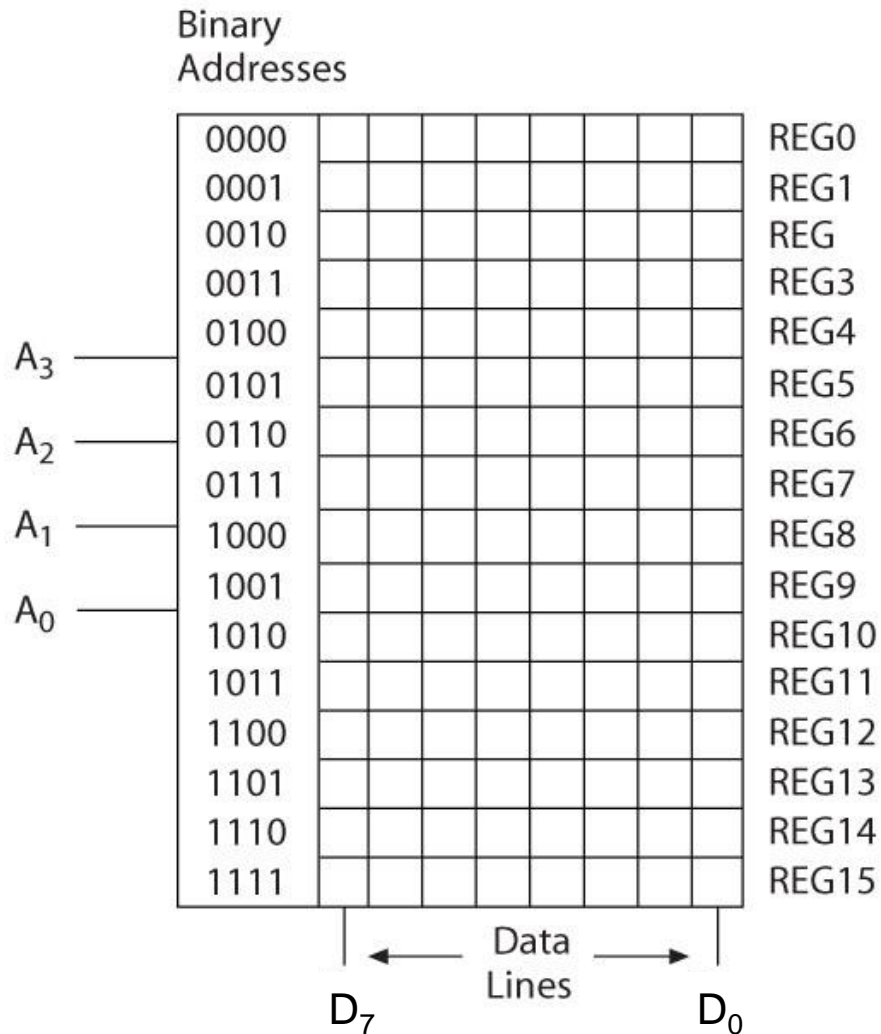


# Microprocessor (MPU)



- ◆ MPU (CPU)
  - Read instructions
  - Process binary data

# Memory



- ◆ Storage Device

- Addresses
- Registers

- ◆ Major Categories

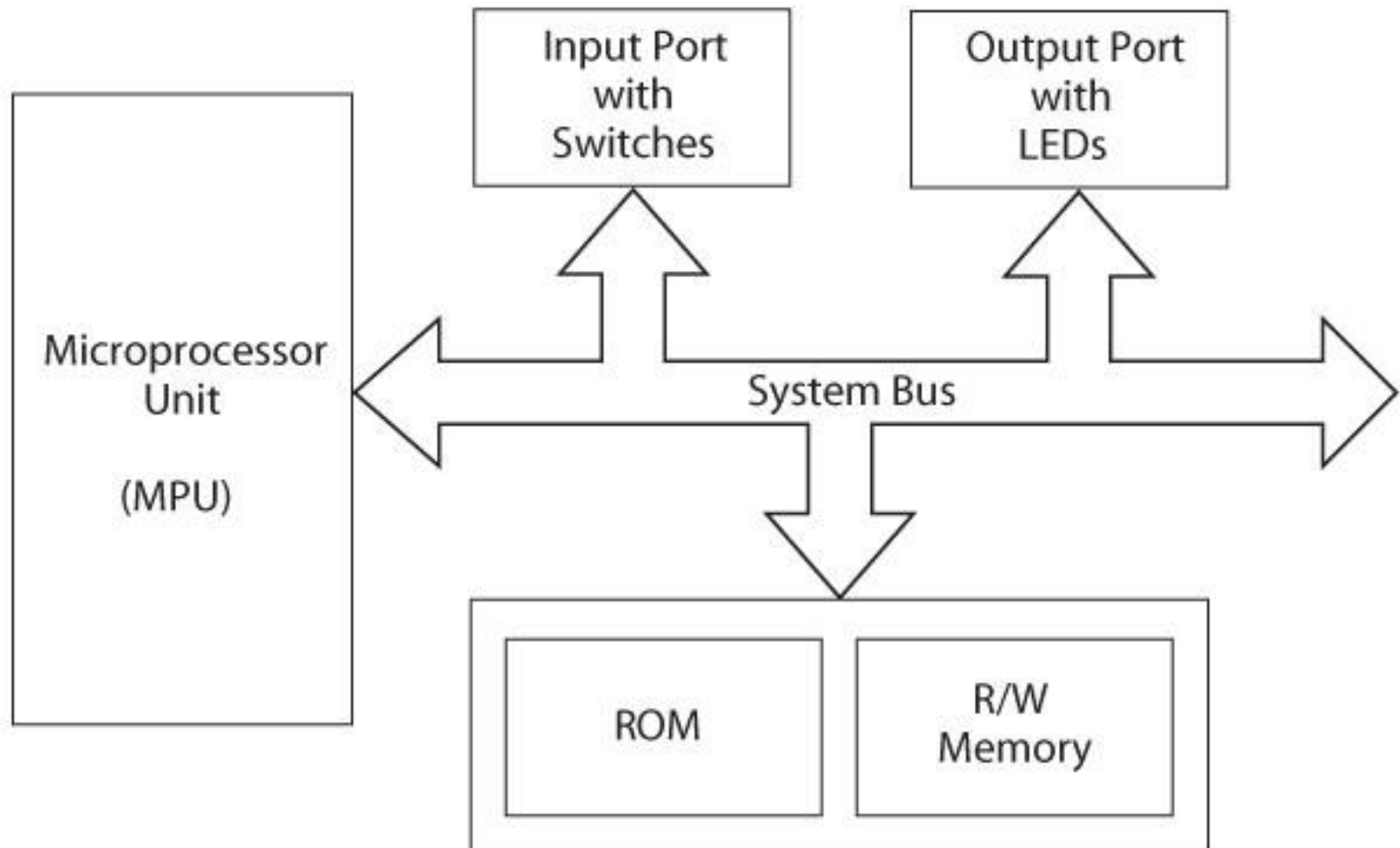
- Read/Write Memory (R/W)
- Read-only-Memory (ROM)

# Input/Output (I/O)

- ◆ Input Devices
  - Switches and Keypads
  - Provide binary information to the MPU
- ◆ Output devices
  - LEDs and LCDs
  - Receive binary information from the MPU



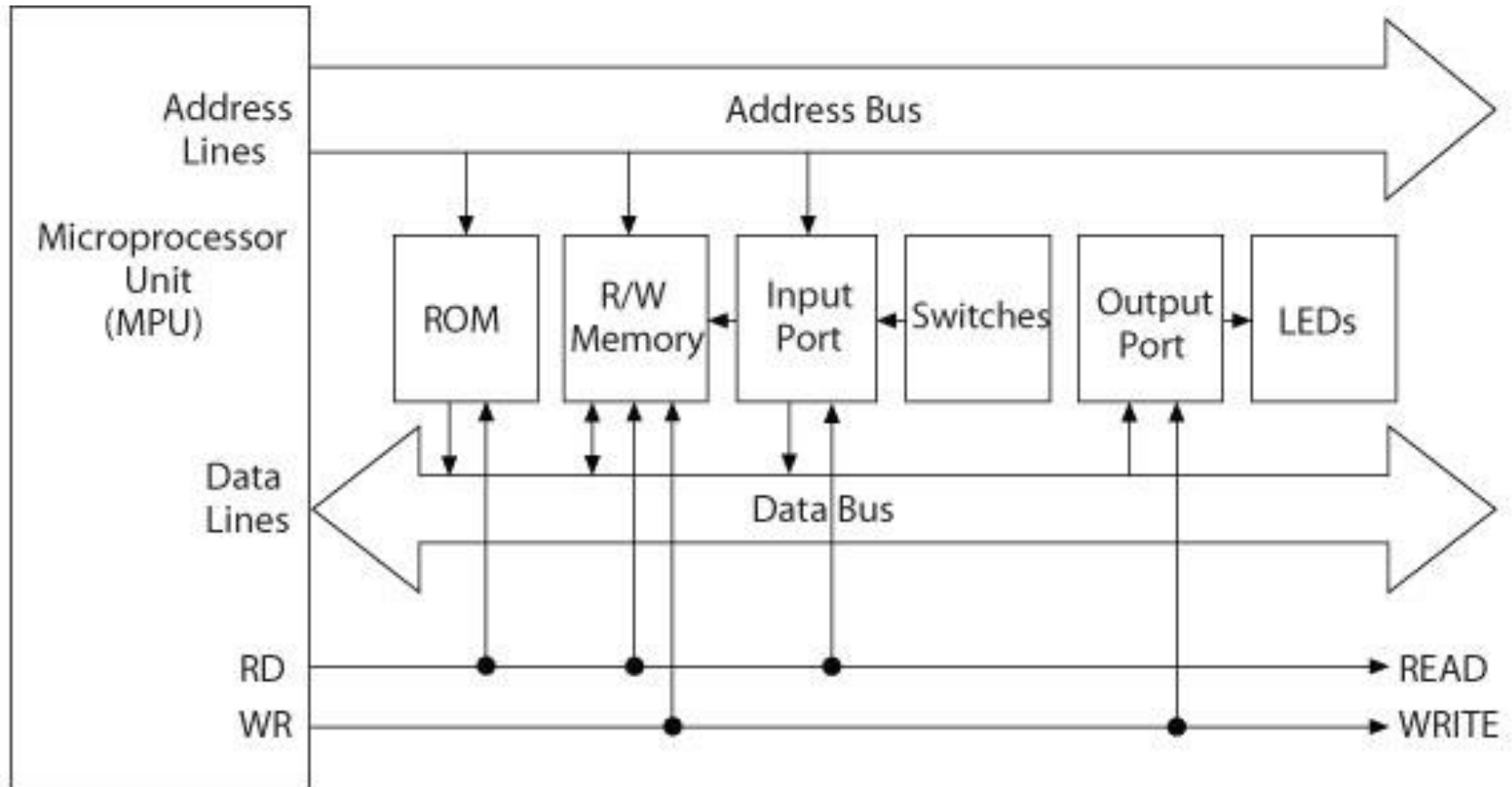
# Microprocessor-Based Systems



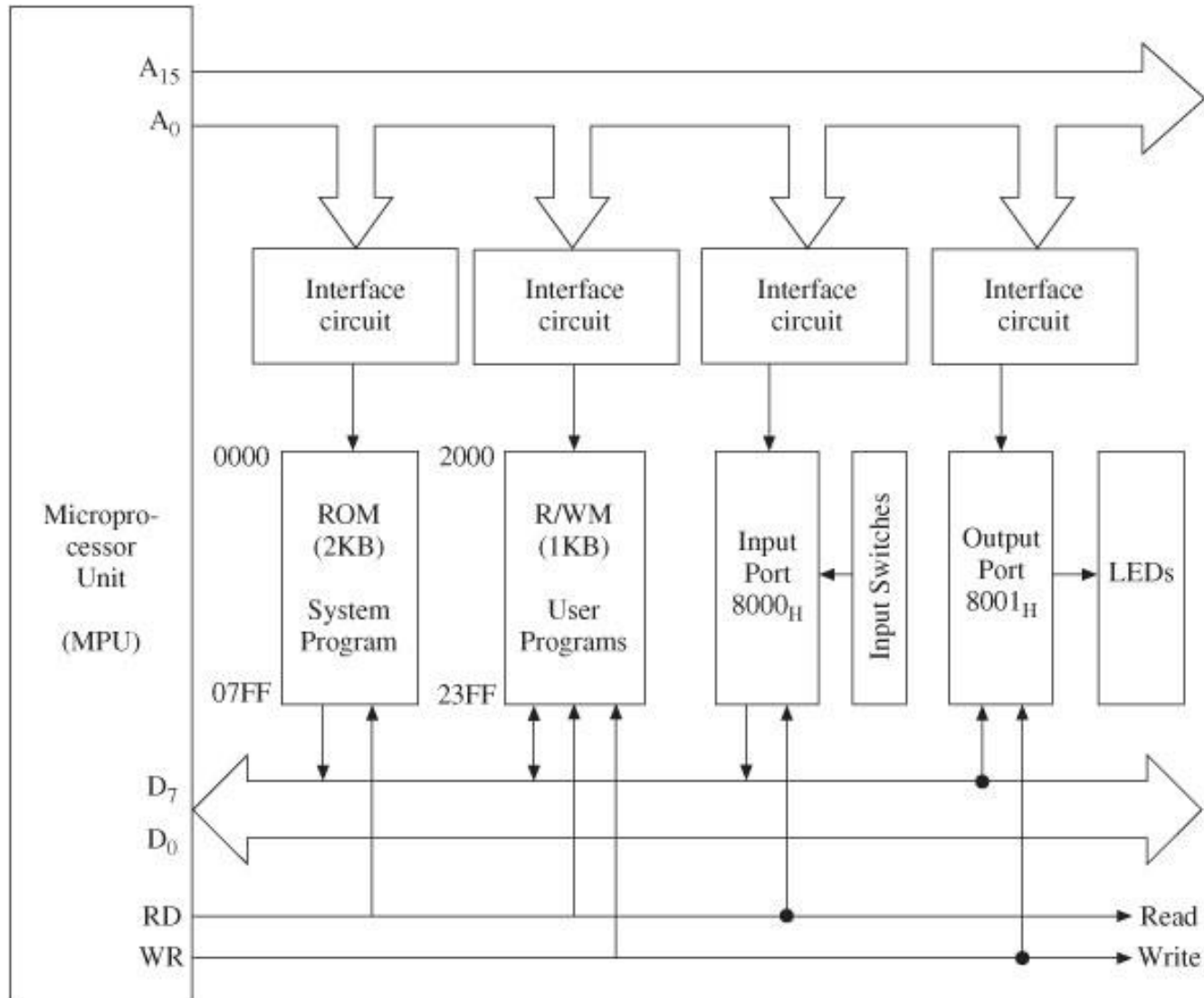
# Microprocessor Architecture

- ◆ MPU communicates with Memory and I/O using the System Bus
  - Address bus
    - Unidirectional
    - Memory and I/O Addresses
  - Data bus
    - Bidirectional
    - Transfers Binary Data and Instructions
  - Control lines
    - Read and Write timing signals

# Microprocessor-Based System



# Example Microprocessor System



# Software

## ◆ Machine Language

- Binary Instructions
- Difficult to decipher and write
  - Error-prone
- All programs converted into machine language for execution

Instruction	Hex	Mnemonic	Description	Processor
10000000	80	ADD B	Add reg B to Acc	Intel 8085
00101000	28	ADD A, R0	Add Reg R0 to Acc	Intel 8051
00011011	1B	ABA	Add Acc A and B	Motorola 6811

# Software

- ◆ Assembly Language
  - Machine instructions represented in mnemonics
  - One-to-one correspondence
  - Efficient execution and use of memory
  - Machine-specific

# Software

- ◆ High-Level Languages
  - BASIC, C, and C++
  - Written in statements of spoken languages
  - Machine independent
  - Easy to write and troubleshoot
  - Larger memory and less efficient execution

# Data Format (8-bit)

- ◆ Unsigned Integers
  - All eight bits represent the magnitude of a number
    - Bit7 to Bit0
  - Range  $00_{\text{H}}$  to  $\text{FF}_{\text{H}}$  ( $0_{10}$  to  $255_{10}$ )



# Data Format (8-bit)

## ◆ Signed Integers

### ■ 2's Complement

- Bit7 is sign bit

■ Positive numbers:  $00_{\text{H}}$  to  $7F_{\text{H}}$  ( $0_{10}$  to  $127_{10}$ )

■ Negative numbers:  $80_{\text{H}}$  to  $FF_{\text{H}}$  ( $-1_{10}$  to  $-128_{10}$ )

# Data Format (8-bit)

- ◆ Binary Coded Decimal Numbers (BCD)
  - 8-bit number divided into two groups of four
    - Each group represents a decimal digit from 0 to 9
  - $A_H$  through  $F_H$  are invalid
  - Example:  $0010\ 0101_{\text{BCD}} = 25_{10}$

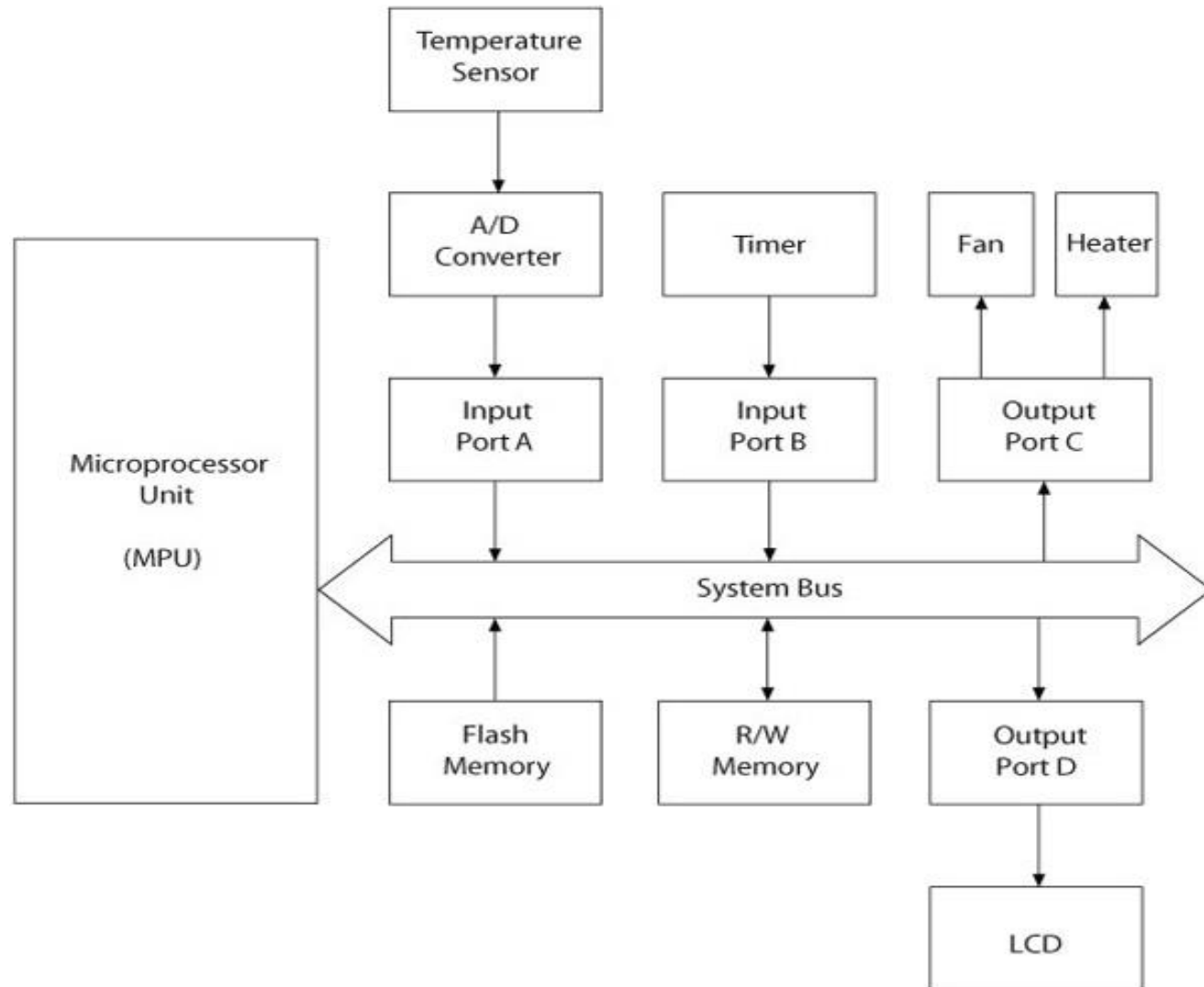
# Data Format (8-bit)

- ◆ American Standard Code for Information Interchange (ASCII)
  - 7-bit alphanumeric code with 128 combinations ( $00_{\text{H}}$  to  $7\text{F}_{\text{H}}$ )
  - Represents English alphabet, decimal digits from 0 to 9, symbols, and commands

# MPU-Based Systems

- ◆ System hardware
  - Discrete components
    - Microprocessor, Memory, and I/O
  - Components connected by buses
    - Address, Data, and Control
- ◆ System software
  - Group of programs that monitors the functions of the entire system

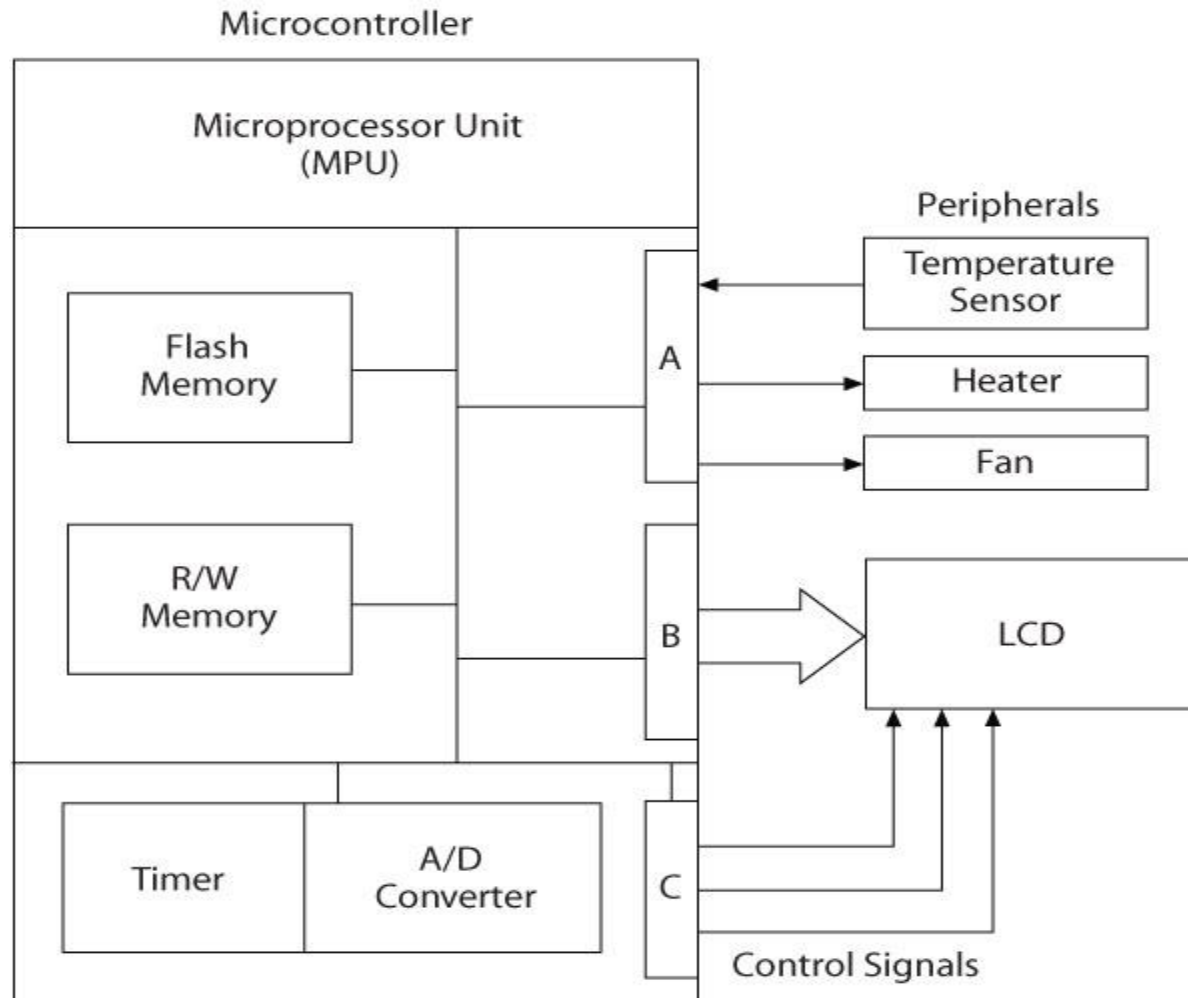
# MPU-Based System



# MCU-Based Systems

- ◆ Microprocessor, memory, I/O ports, and support devices on a single chip
- ◆ Buses generally not available to a system designer
- ◆ I/O ports generally multiplexed and can be programmed to perform different functions

# MCU-Based System



# Computer Architectures

- ◆ Princeton versus Harvard Architecture
- ◆ CISC versus RISC processors
- ◆ Microprocessors and Microcontrollers