Microprocessor and Microcontroller Fundamentals

ELEC 330

Digital Systems Engineering

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Images Courtesy of Ramesh Gaonkar and Delmar Learning

THE CITADEL
DEPARTMENT OF ELECTRICAL & COMPUTER 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

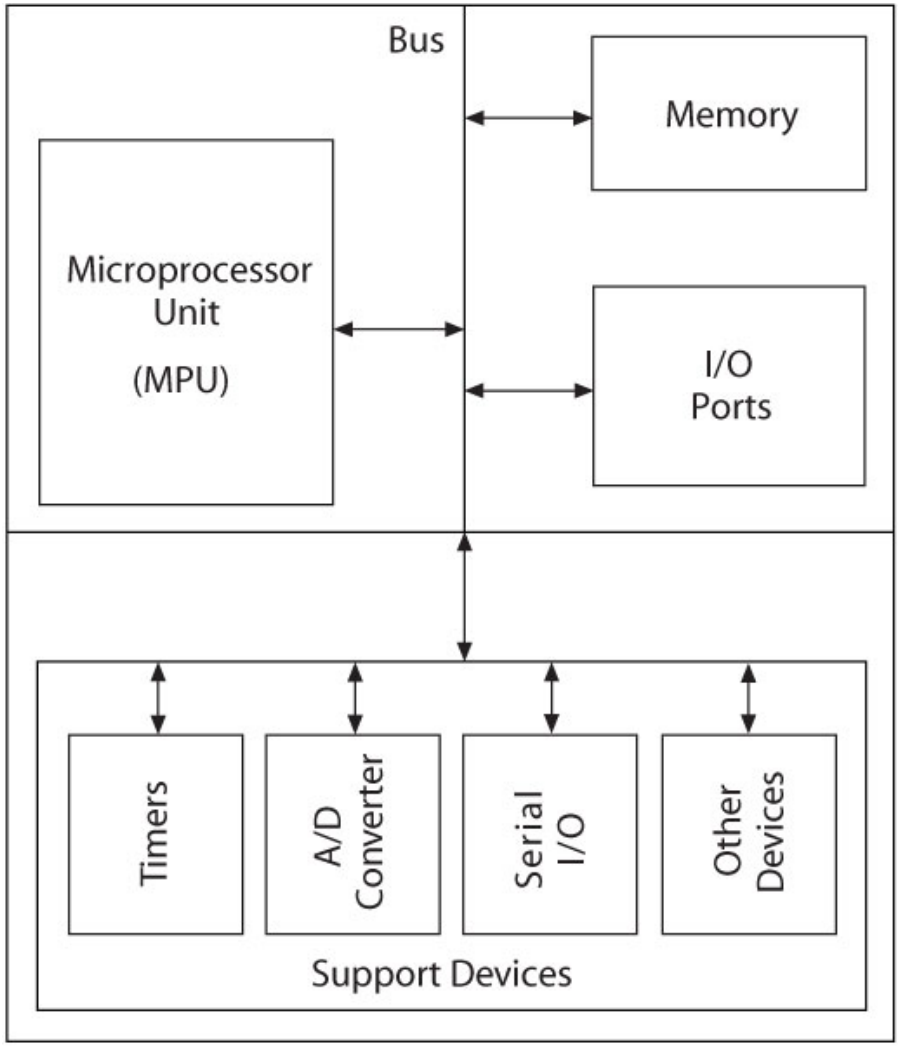
Microcontrollers

- 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

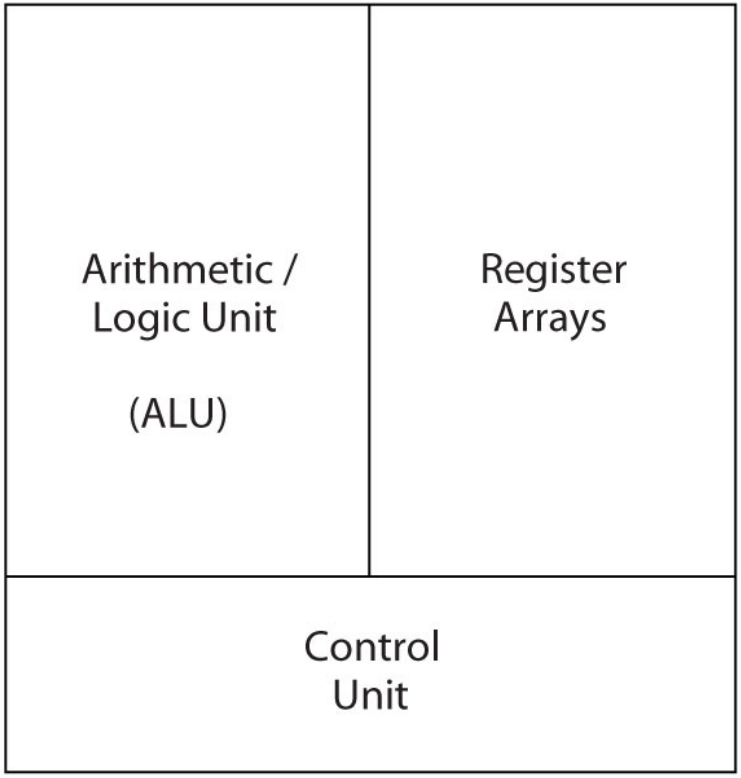
Microcontrollers

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

Block Diagram

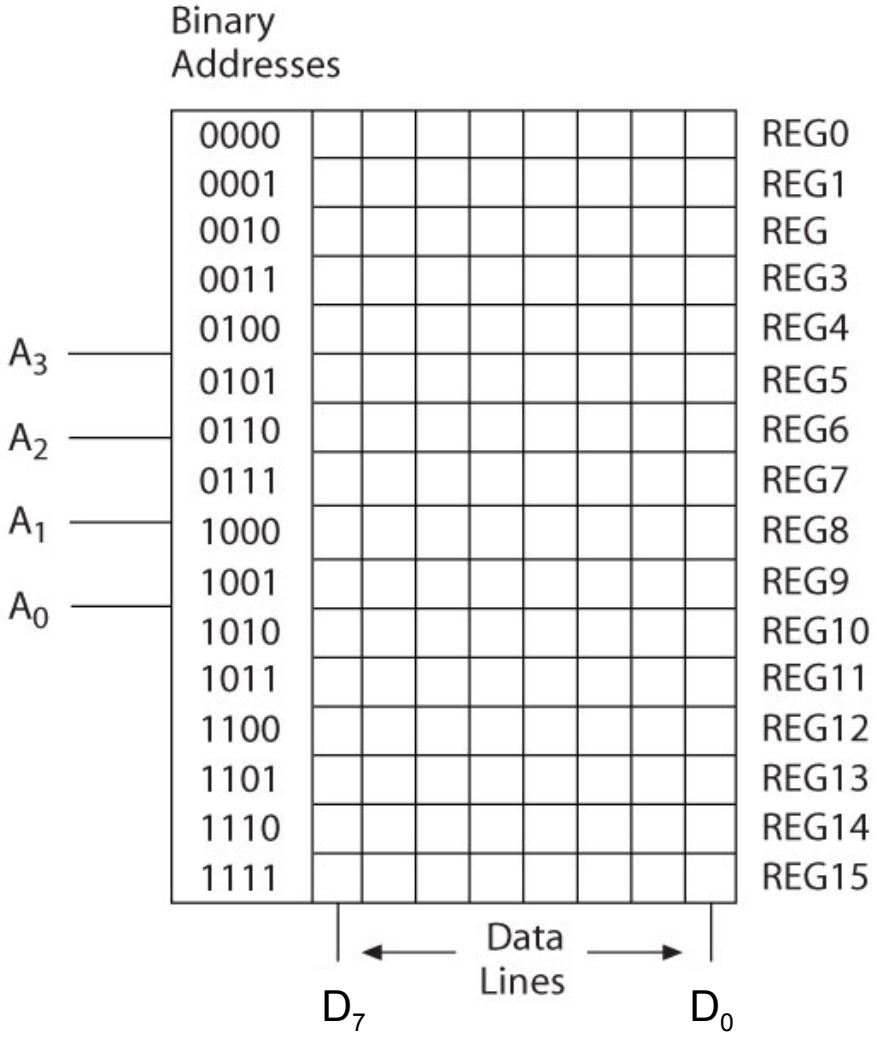


Microprocessor (MPU)



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

Memory

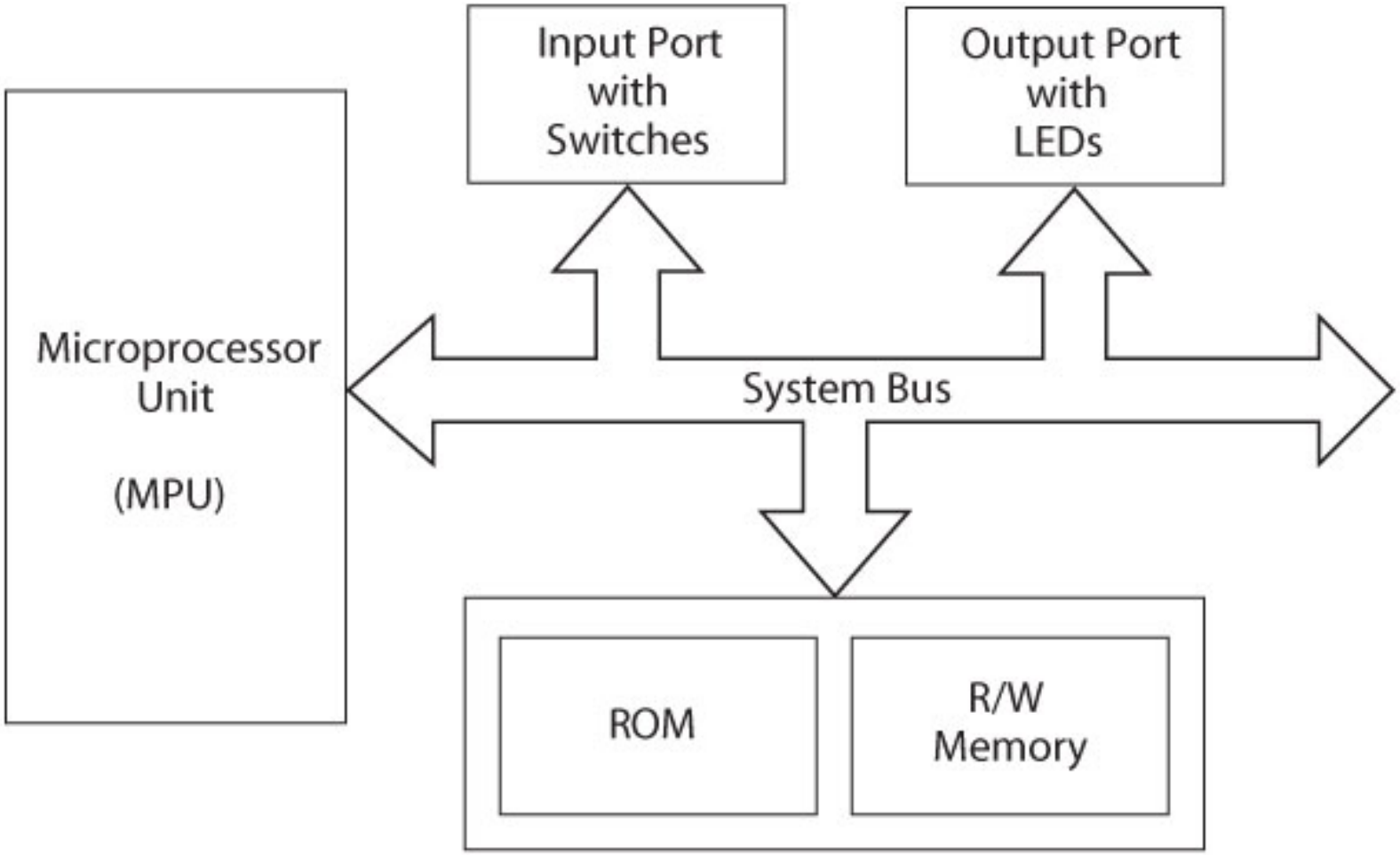


- Storage Device
  - Addresses
  - Registers
- Major Categories
  - Read/Write Memory (R/W)
  - Read-only-Memory (ROM)

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

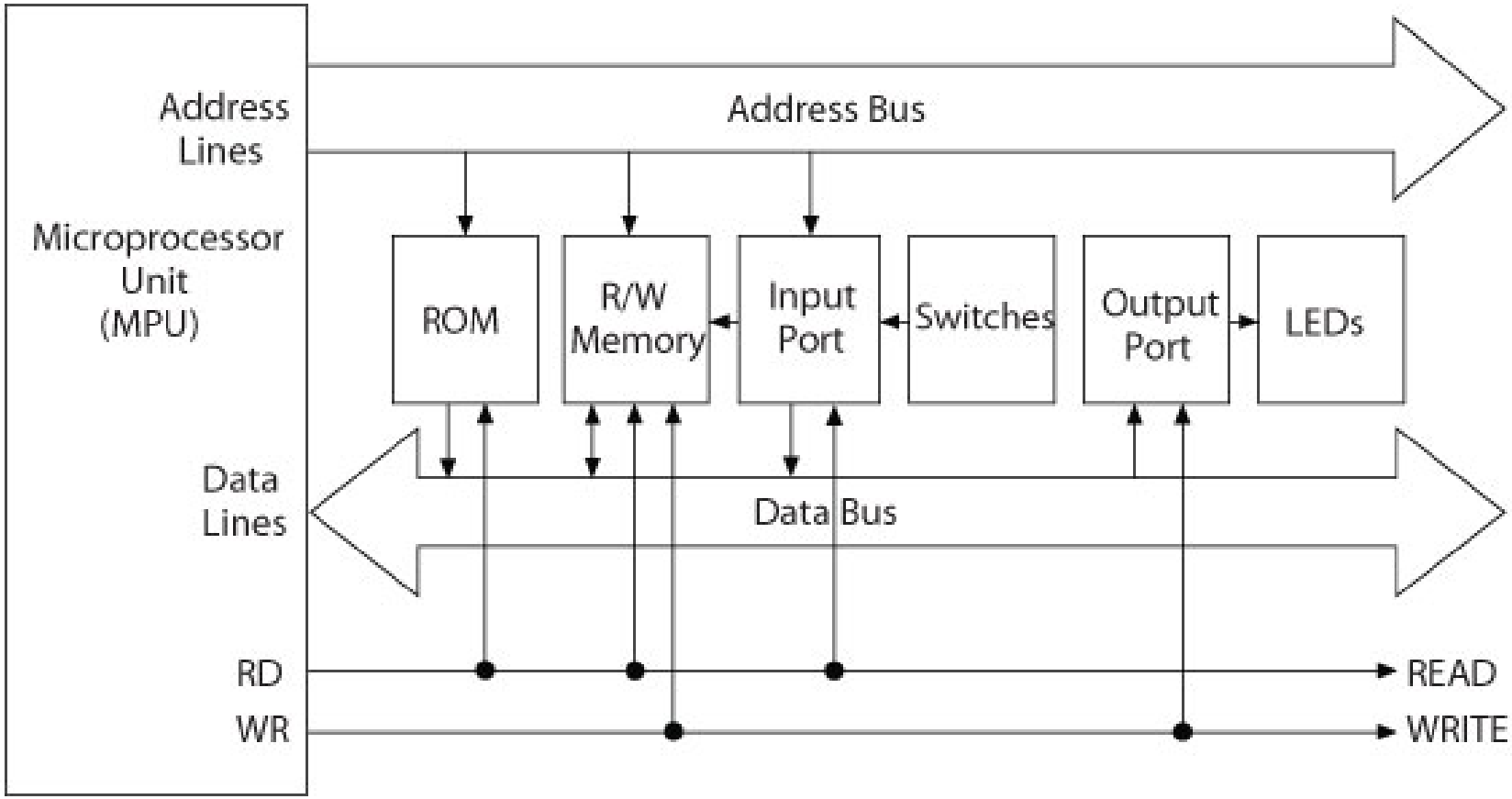
Microprocessor-Based Systems



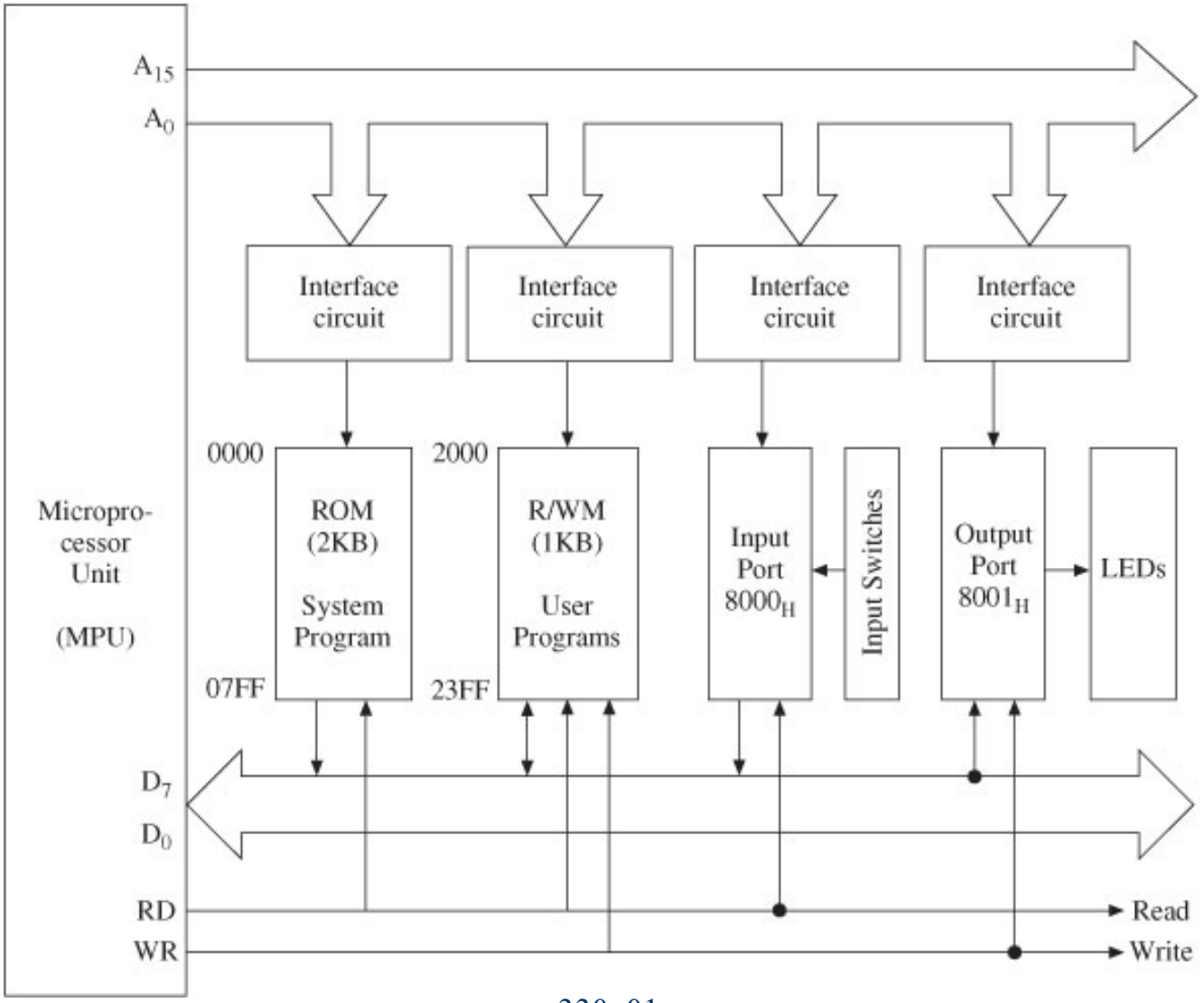
Microprocessor Architecture

- 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_H to FF_H (0_{10} to 255_{10})

Data Format (8-bit)

- Signed Integers
  - 2's Complement
    - Bit7 is sign bit
  - Positive numbers: 00_H to $7F_H$ (0_{10} to 127_{10})
  - Negative numbers: 80_H to FF_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: $0010\ 0101_{BCD} = 25_{10}$

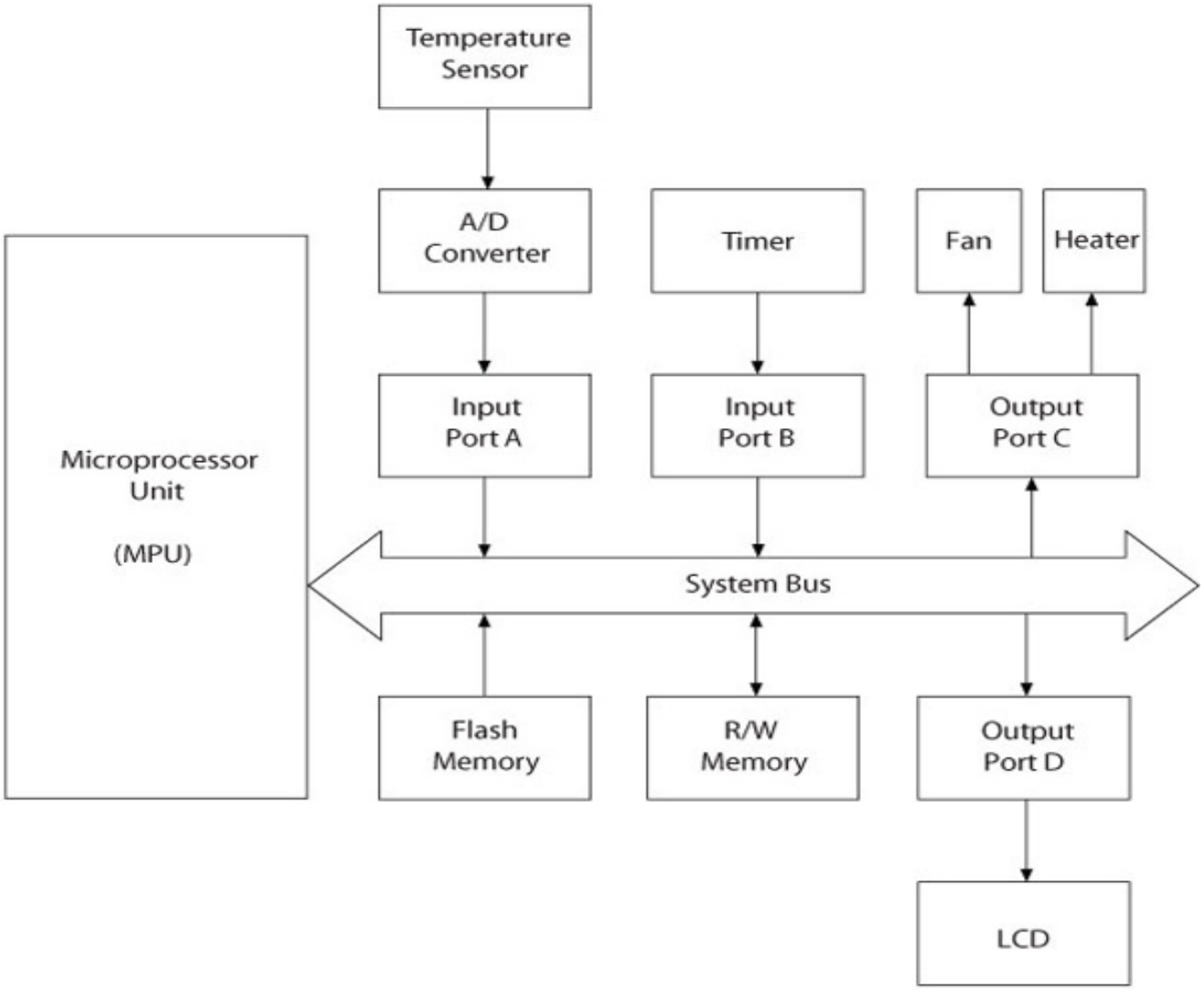
Data Format (8-bit)

- American Standard Code for Information Interchange (ASCII)
  - 7-bit alphanumeric code with 128 combinations (00_H to $7F_H$)
  - 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

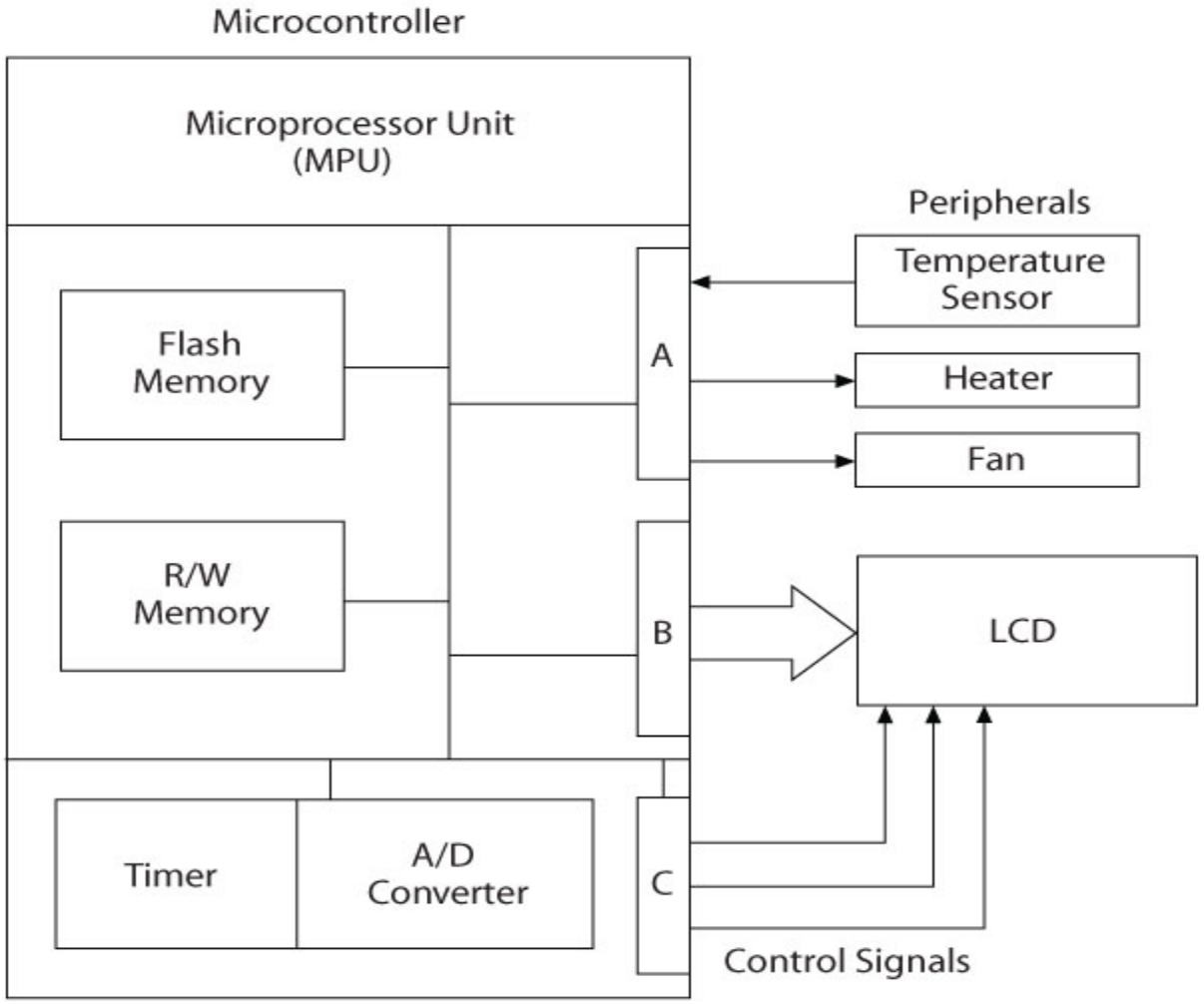
MPU-Based System



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