ECE/CS 5780/6780: Embedded System Design

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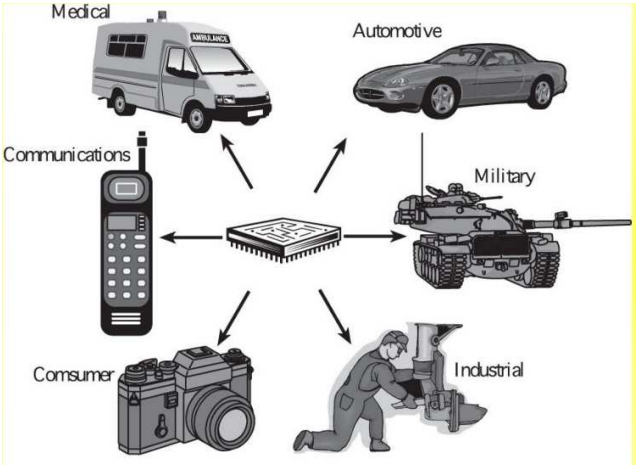
Lecture 1: Microcomputer-Based Systems

Embedded Microcomputer Systems

- An *embedded microcomputer system* is one that includes a microcomputer configured to perform a dedicated application.
- Software is typically fixed into ROM and not user accessible.
- Microcomputer is embedded, or hidden, inside the device.
- Typical automobile contains an average of 10 microcomputers.
- Upscale homes may have as many as 150 microcomputers.
- Average consumer interacts with μ-controllers 300 times/day.

Examples of Embedded Microcomputer Systems



Real Time Interfacing

- Embedded microcomputer systems accept inputs, perform calculations, and generate outputs.
- *Real-time systems* have an upper bound on the time required to perform the input/calculation/output sequence.
- An *interface* is the hardware and software that allow a computer to communicate with its environment.
- In this course, you will learn the various features built into microcomputers to support real-time interfacing.
- This will enable you to design systems that support real-time interfacing for many types of inputs and outputs in both digital and analog form.

Interface and Timing Features of Microcomputers

- Synchronous Serial Peripheral Interface (SPI)
- Asynchronous Serial Communication Interface (SCI)
- Analog-to-digital (ADC) converters
- Fixed periodic rate interrupts
- Computer Operating Properly (COP) protection
- Pulse accumulator for external event counting
- Pulse-width-modulations (PWM) outputs
- Event counter system for advanced timer operations
- Input capture used for period and pulse width measurement
- Output capture used for generating signals and frequency measurement

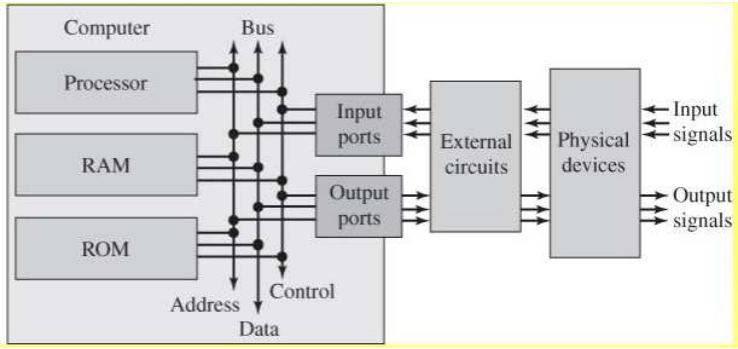
Microcomputer Architectures

Company	Products
Motorola	68HC05, 68HC08, 68HC11, **68HC12**, 68HC16, 68K, MCORE, **Coldfire**, PowerPC
Intel	8051, 80251, 8096, 80296
Philips	8051
Hitachi	H8
NEC	78K
Mitsubishi	740, 7600, 7700, M16C
Siemens	C500, C166, Tricore
Microchip	PIC12, PIC16, PIC17

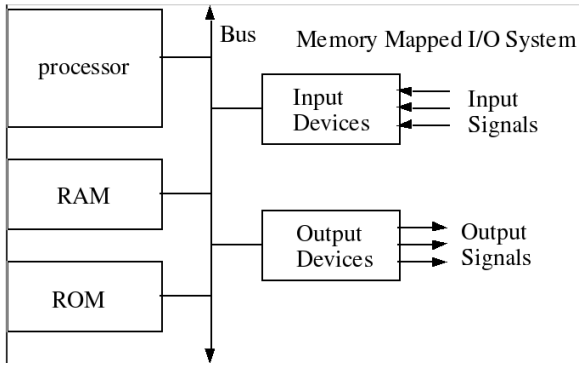
Factors to Consider When Choosing a Microcomputer

- Labor, material, manufacturing, maintenance costs.
- ROM, RAM, and EEPROM size.
- Speed and I/O bandwidth requirements for application.
- 8-,16-, or 32-bit data size.
- Numerical or other special operations required.
- Number of parallel and serial ports needed.
- Timer, PWM, and ADC requirements.
- Package size and environmental issues.
- Second source availability.
- Availability of compilers, simulators, and emulators.
- Power requirements.

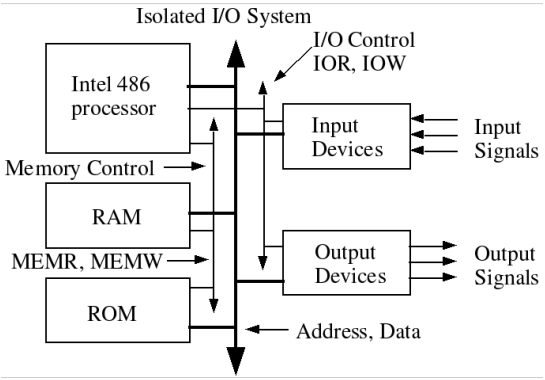
Basic Components of a Computer System



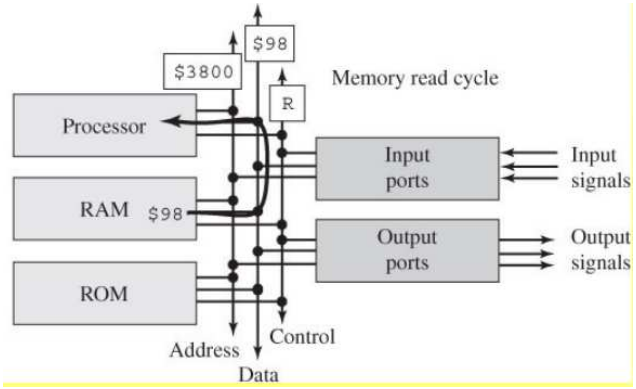
Memory-Mapped Computer System



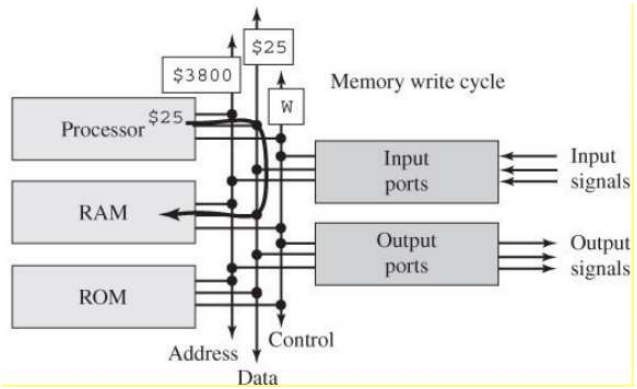
Isolated I/O Computer System



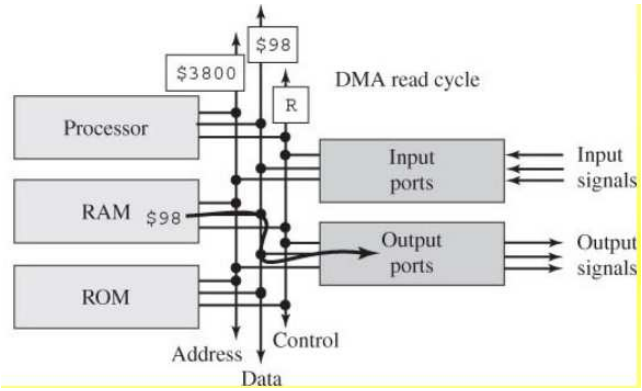
Memory Read Cycle



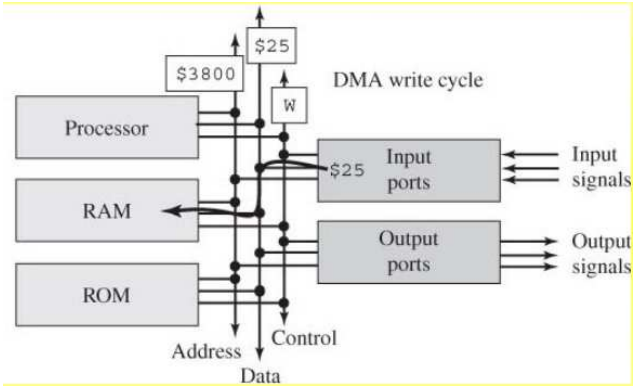
Memory Write Cycle



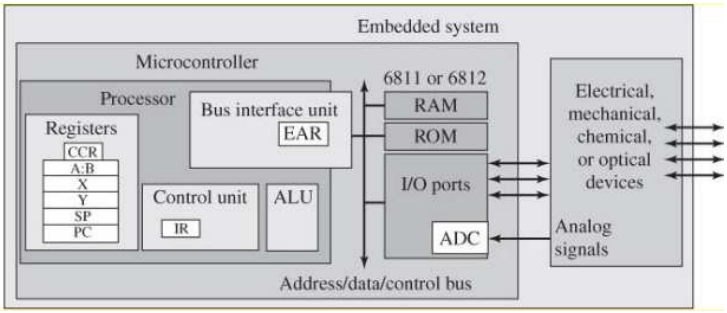
DMA Read Cycle



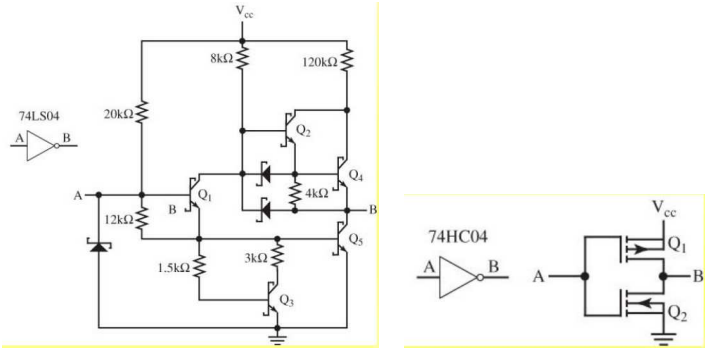
DMA Write Cycle



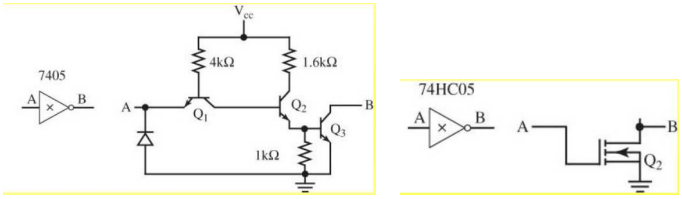
Basic Components of an Embedded Microcomputer System



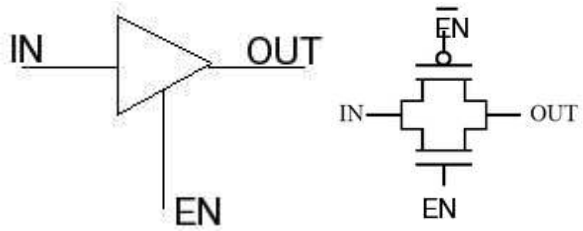
Transistor Implementations



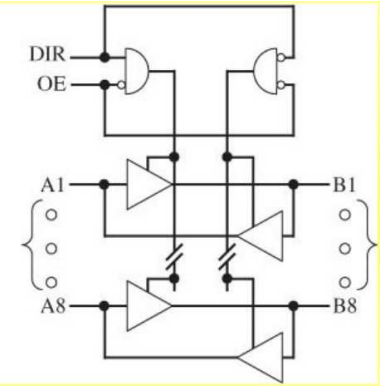
Open-Collector Gates



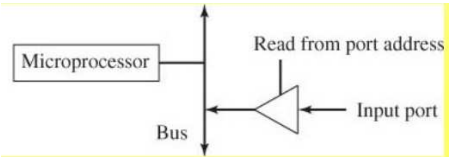
Tristate Logic

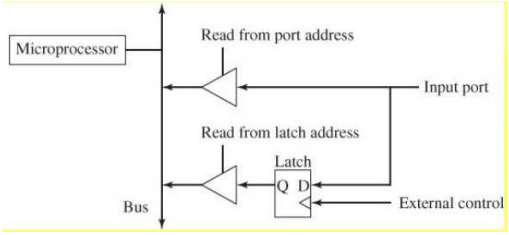


74HC245 Tristate Driver

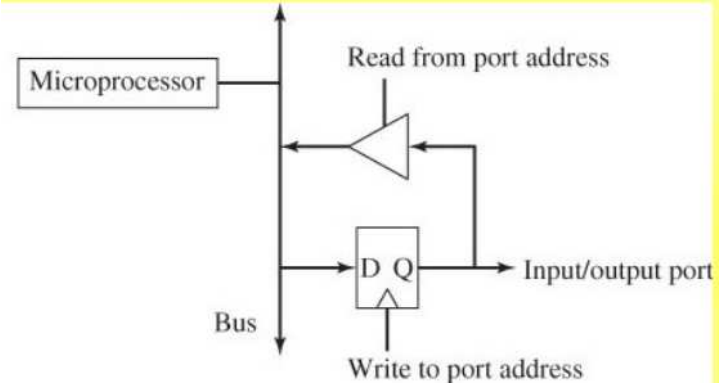


Input Ports

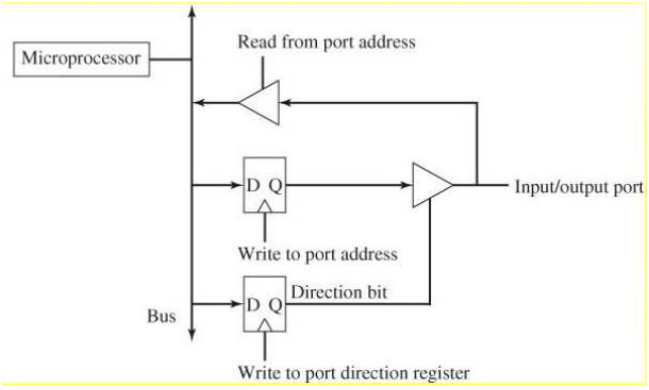




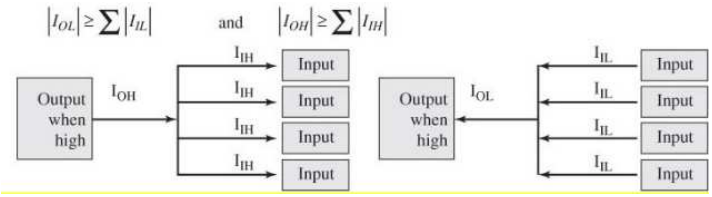
Readable Output Port



Bidirectional Ports



Fanout Requirements



I/O Currents

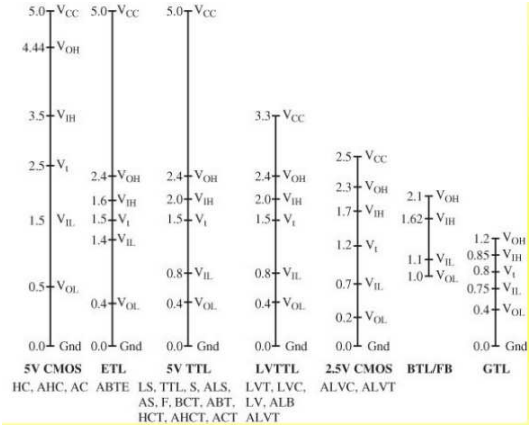
Family	I_{OH}	I_{OL}	I_{IH}	I_{IL}
Standard TTL	0.4mA	16mA	40μA	1.6mA
Schottky TTL	1mA	20mA	50μA	2mA
Low-power Schottky TTL	0.4mA	4mA	20μA	0.4mA
High-speed CMOS	4mA	4mA	1μA	1μA
MC9S12C32	10mA	10mA	1μA	1μA

- For *transistor-transistor logic* (TTL) logic:

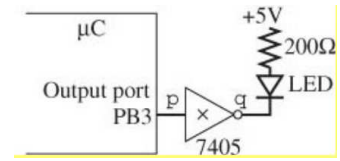
$$\text{fan out} = \text{minimum}((I_{OH}/I_{IH}),(I_{OL}/I_{IL}))$$

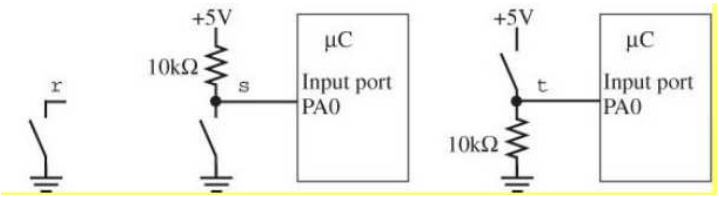
- For *complementary metal-oxide semiconductor* (CMOS) logic, fan out is determined by *capacitive loading* and desired *slew rates*.

Voltage Thresholds



LED and Switch Interfaces





$$R \leq (+5 - V_{out})/I_{out}$$