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

<table>
<thead>
<tr>
<th>Company</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorola</td>
<td>68HC05, 68HC08, 68HC11, <strong>68HC12</strong>, 68HC16, 68K, MCORE, <strong>Coldfire</strong>, PowerPC</td>
</tr>
<tr>
<td>Intel</td>
<td>8051, 80251, 8096, 80296</td>
</tr>
<tr>
<td>Philips</td>
<td>8051</td>
</tr>
<tr>
<td>Hitachi</td>
<td>H8</td>
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<tr>
<td>NEC</td>
<td>78K</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>740, 7600, 7700, M16C</td>
</tr>
<tr>
<td>Siemens</td>
<td>C500, C166, Tricore</td>
</tr>
<tr>
<td>Microchip</td>
<td>PIC12, PIC16, PIC17</td>
</tr>
</tbody>
</table>
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
### 74HC245 Tristate Driver

[Diagram of 74HC245 Tristate Driver]

### Input Ports

[Diagram of Input Ports]

### Readable Output Port

[Diagram of Readable Output Port]

### Bidirectional Ports

[Diagram of Bidirectional Ports]

### Fanout Requirements

<table>
<thead>
<tr>
<th>Family</th>
<th>$I_{OH}$</th>
<th>$I_{OL}$</th>
<th>$I_{HI}$</th>
<th>$I_{IL}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard TTL</td>
<td>0.4mA</td>
<td>16mA</td>
<td>40µA</td>
<td>1.6mA</td>
</tr>
<tr>
<td>Schottky TTL</td>
<td>1mA</td>
<td>20mA</td>
<td>50µA</td>
<td>2mA</td>
</tr>
<tr>
<td>Low-power Schottky TTL</td>
<td>0.4mA</td>
<td>4mA</td>
<td>20µA</td>
<td>0.4mA</td>
</tr>
<tr>
<td>High-speed CMOS</td>
<td>4mA</td>
<td>4mA</td>
<td>1µA</td>
<td>1µA</td>
</tr>
<tr>
<td>MC9S12C32</td>
<td>10mA</td>
<td>10mA</td>
<td>1µA</td>
<td>1µA</td>
</tr>
</tbody>
</table>

- For transistor-transistor logic (TTL) logic:
  \[ \text{fan out} = \min \left( \frac{I_{OH}}{I_{HI}}, \frac{I_{OL}}{I_{IL}} \right) \]

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

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LED and Switch Interfaces

\[ R \leq \frac{(+5 - V_{out})}{I_{out}} \]

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