



Hardware Interface

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Outlines

- Introduction to Embedded / Real Time Systems
 - Polling, Interrupt
- Devices and Interfaces
 - LED
 - DC, Stepped Motors
 - Switch, Sensors, etc

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What's Embedded Systems?

- an ill-defined term
- A special-purpose system designed to perform one or few dedicated functions [embedded systems glossary]
- Optimize for cost, size, reliability, and performance
- Complexity varies from a single micro-controller chip to multiple units
- Personal devices to nuclear power plants controlling

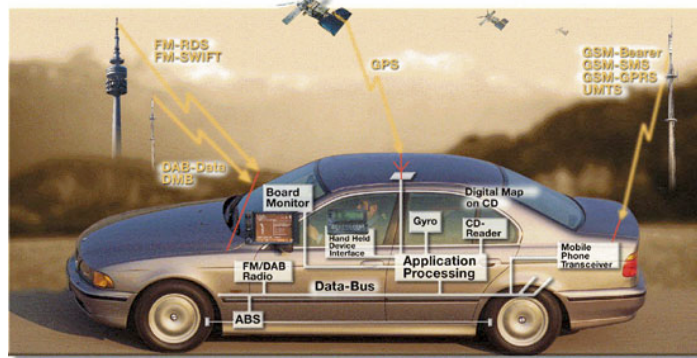
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Examples

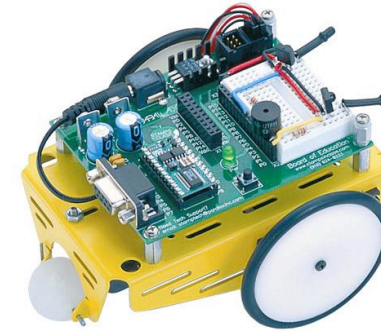
- Process control: food processing, plants
- Office Automation: Printers, Fax, Copier (Xerox)
- Computer Peripherals: Printers, Terminals, Modems
- Communication: Switches, Routers
- Aerospace: Flight Control System, Jet Engine Controls

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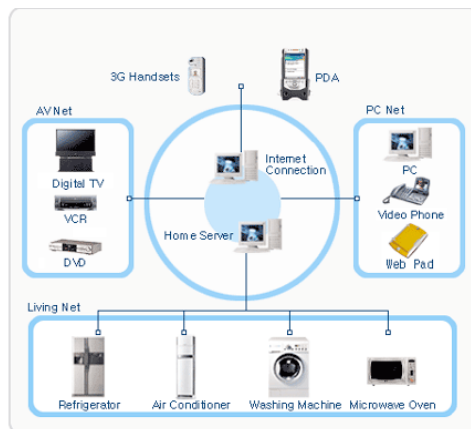
- Automotive: ECU, ABS



- Robots



- Home: Washing machines, Thermostats, Microwave ovens, TV, VCR, DVD, etc



Common Characteristics

- Real-time performance that must be met.
- Built-in to controlled devices
- Software is often called Firmware and is often stored in read-only memory or flash memory

Real-time Systems

- Depends upon logical correctness and time.
- usability (soft real-time systems)
e.g. multimedia video/audio
 - Tasks are performed as fast as possible, but don't have to finish by specific times.
- safety (hard real-time systems)
e.g. Engine Control Unit
 - Tasks have to be performed not only correctly, but also on time.
- can have both hard and soft requirements.

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Pitfalls

- hard versus soft real-time does not necessarily relate to the length of time available
 - A system may overheat if a cooling system is not functioning in 5 minutes --- hard
 - A network packet may drop buffered data if it is not processed in 0.1 sec. --- soft
- High Performance <> real time
 - Examples ?
 - Chess-Playing Programs ?

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Software Models

- Foreground/Background Systems
(aka. super-loops)
- Real-Time OS (aka. Real-Time kernel)
 - Non-preemptive (Cooperative Multitasking)
 - Preemptive

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Super loop in C

```
void main(void)
{
    initialise();
    superloop();
}

void superloop(void)
{
    while(1)
    {
        task1();
        task2();
        task3();
        ...
    }
}
```

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Foreground/ Background

- Super-loops
- Foreground (ISR) handles Asynchronous events.
- Background handles task level.
- Critical operations in ISR

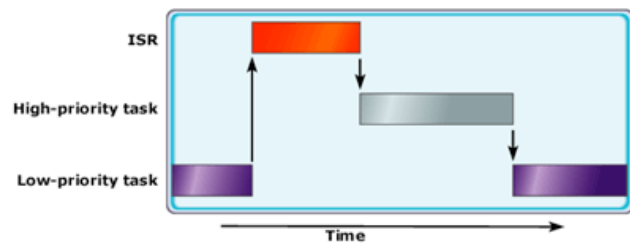
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Real-time O.S.

- Tasks (with priorities)
- Non-Preemptive Kernels
 - Each task has to explicitly give up control of the CPU.
- Preemptive Kernels
 - Use priority as a criteria.

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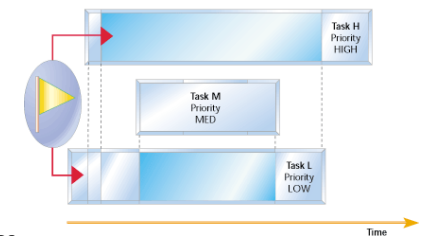
Preemption



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Priority Inversions

- Two solutions
 - priority inheritance
 - priority ceilings (no need for semaphore)



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Devices and Interface

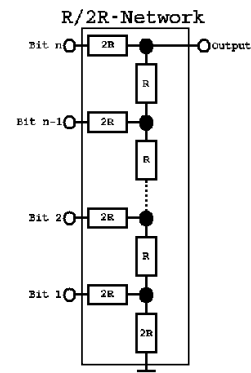
- Digital vs. Analog
- What is Digital?
 - On/Off
- What is Analog?
 - Fuzzy?
- How to connect Digital to Analog Device?

POP Quiz

- Label the following item as Digital or Analog
 - Temperature
 - luminous of light
 - Picture/Color
 - Voice
 - What else?

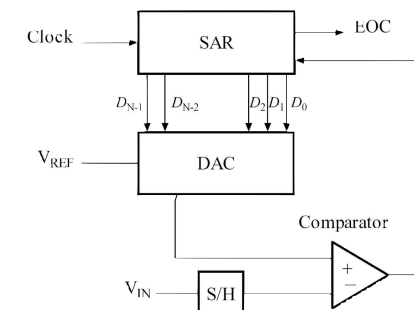
Analog Output?

- On/Off
- Color / Pictures
- Steps / Levels
- Digital-to-Analog-Converter



Analog Input

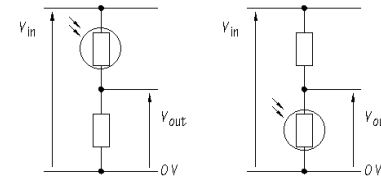
- Analog-to-Digital Converter
- PIC 16F877 has build-in A2D



What is Sensors?

- A device that convert the information into voltage, current (usually resistance).
- Light
 - LDR (Light Dependent Resistor)
 - Photo Diode, Photo Transistor
- Temperature
 - Thermistor, Thermocouple, Infrared Sensor

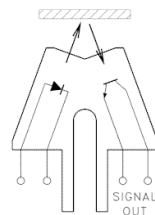
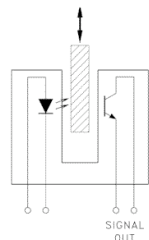
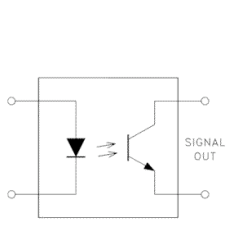
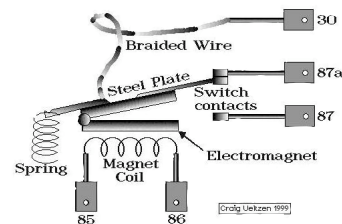
LDR



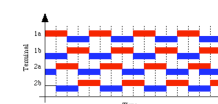
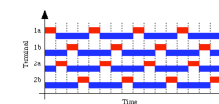
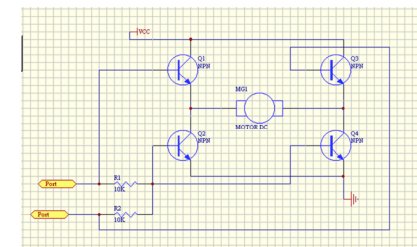
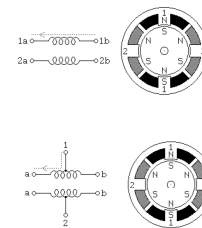
$$V_{out} = \frac{R_{bottom}}{R_{bottom} + R_{top}} \times V_{in}$$

Interface between Different Voltages

- Relay
- Transistor
- Optoisolator



Driving DC Motor/Steps Motor



How about other devices?

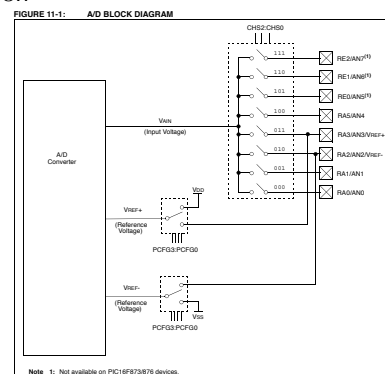
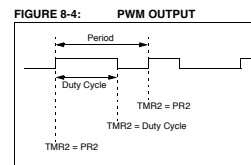
- Microphone
- TV
- Speaker
- Monitors
- Motion Sensor
- (You name it)
- Angle
- Speed
- Power

Resources

- <http://www.epanorama.net/links/automation.html>
- Several interface and circuit books

PIC 16F877

- Pulse Width Modulation
- Synchronous Communication
- 10 Bit A2D (8 channels)
- Interrupts



Question ?