

# Sensors and Actuators

## CM0506 – Small Embedded Systems

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Lecture 8

# What are They?

## Actuators

- Change something in the environment
- Under computer control
- Provide feedback to a process to maintain the predetermined set-points
- Convert electrical signals into physical changes

# What are They?

## Sensors

- Allow sampling of an environment or process variable
- Convert changes in the process under control into electrical signals

# Sensors

Physical quantities measurable:

- Temperature
- Pressure
- Distance/displacement
- Velocity
- Acceleration
- Fluid flow
- Light Intensity
- Voltage
- Current
- Resistance
- Force
- Liquid level
- Torque
- pH
- + many more...

# Switches

- Binary devices
- Normally closed/normally open
- Momentary closure
- Position - closure of contacts - confirm position of mechanical parts
- Human hands - keyboards, etc.
- Conditions - pressure, temperature (thermostats)
- Compressed air switches
- Hydraulics

# Pressure measurement

- Pressure bends an elastic element such as a diaphragm, tube, bellows or piston
- The displacement in turn moves a needle, change an electrical impedance or resistance
- Piezoelectric pressure sensors
- Rapid changes in pressure are difficult to measure - why?
- High pressure transducers are costly

# Temperature

- Expansion of solids, liquids or gases
- Pressure or movement changes can be measured
- Thermocouples - junction between dissimilar metals - generate small voltages
- Other solid state devices are available such as thermistors

# Actuators

**Relays** switch large electrical loads using a small electrical input

**Solenoids** Motion of an iron core in a coil does mechanical work

**Motors** perform mechanical work

- rotation or other through levers
- DC and Stepper



# Relays

- Power switching devices
- Were used in large numbers by PO
- Small current and voltage inputs
- Allow switching of large currents/voltages
- Switch AC or DC
- Multiple contacts - changeover
- Electrical isolation
- Reed relays are sealed in a glass tube
- Opto-isolators - solid state devices - electrical isolation of components

# Motors

- DC motors are employed very widely in industry, appliances, automobiles, etc.
- Used to provide continuous rotation or no rotation - position
- Inexpensive and efficient
- Can use PWM for speed control - noisy
- Geared for more torque

# Stepper Motors

- Digitally controlled
- Discrete positioning
- Useful where accurate control is required
- Lower torque than DC
- Pulses cause the motor to rotate in steps - perhaps  $1.8^{\circ}$  per pulse
- Positional feedback is not required (unless the motor slips)

# Accuracy

**Accuracy** the total of all deviations between a measured value and the actual value - sum of non-linearity, repeatability and hysteresis.

**Non-linearity** the maximum difference in measured value or output from a straight line between calibration points

**Repeatability** the max difference in a measured value or output when a set point is approached multiple times from above or below

**Hysteresis** the max difference in measured value or output when a set value is approached from above, and then below the value.

# Signal Conditioning

- Usually some manipulation of the signals is required between a computer interface and sensors/actuators
- Change in power - power levels in computer interfaces are low
- Voltage levels - e.g., 0-5 v to -2.5-2.5
- Current to voltage and voltage to current
- Requires use of operational amplifiers, etc.

# Part I

## Ananlogue to Digital Conversion

# ADC

## Data acquisition equipment

- ① receives an analogue signal
  - ② it is converted to a voltage
  - ③ in order to transfer to the computer/processor that voltage needs to be **digitised** by an Analogue-to-Digital Converter (ADC)
- An Analogue-to-Digital Converter (ADC) is an electronic circuit which takes as input an analog signal (usually a voltage) and produces a corresponding digital number at the output
  - ADCs (and DACs) are available as modules, integrated circuits or fully integrated inside other components such as microcontrollers