Sensors & Sensing

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Sensors: Introduction

- Device which can sense change or detect an event and send the information to other electronics devices for meaningful analysis, feedback, processing, transmission etc.
- Sensor convert one form of signal into another more usable form.
- Examples
  - Light sensor
  - Tactile sensor
  - Chemical sensor
  - Temperature

Different Type of Sensor

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Sensors

Signals → Sensors → Readable Signal

- Motion
- Chemical
- Electrical parameters
- Light
- Temperature

- Electrical
- Perceivable

- Every living being is capable of sensing

Displacement Sensors

- Displacement $\longrightarrow$ Change in Electrical Parameter
- Example: Strain Gauge

$$R = \rho L / A$$

$$GF = \frac{\left(\frac{\delta R}{R_g}\right)}{\epsilon}$$

Displacement Sensors

- Displacement → Change in Electrical Parameter
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  - Advantages:
    - Simple
    - Low-cost
    - Proportional
  - Problems:
    - Low signal strength
    - Resistance of the gauge can change due to temperature
    - If the wires connecting the strain gauge to the signal conditioner are not protected against humidity, corrosion can occur, leading to parasitic resistance
  - Typically deployed in a Wheatstone bridge arrangement

Accelerometer

- Acceleration ⟶ Capacitance
- Example: Comb shaped capacitor

$$C = \epsilon A / d$$

Accelerometer

- Acceleration → Capacitance

Rotation sensing

Rotation → Frequency

- AC alternator
- Higher the speed, higher is f

- Flow sensor / Anemometers

Rotation → Frequency

Flow → Temperature change due to cooling

What is the need?

- Device which can sense change or detect an event and send the information to other electronics devices for meaningful analysis, feedback, processing, transmission etc.
- Sensor convert one form of signal into another more usable form.
- Examples
  - Light sensor
  - Tactile sensor
  - Chemical sensor
  - Temperature

Sensor operation – flow sensors

Sensor operation – temperature

- Thermocouples
- Temperature dependant (TDR) resistan
- Thermodiode and Thermotransistor

Sensor operation – light

- Phototransistors,
- Photoresistors
- Photodiodes

Sensor operation – gas sensors

Chemical ——————— Resistance change

Sensor operation – microbe sensors

Chemical
Biological

Mechanical frequency

Plasmonic Resonance Sensor

e sensed

f the

magnitude

Sensor selection

- Range—Difference between the maximum and minimum value of the sensed parameter
- Resolution—The smallest change the sensor can differentiate
- Accuracy—Difference between the measured value and the true value
- Precision—Ability to reproduce repeatedly with a given accuracy
- Sensitivity—Ratio of change in output to a unit change of the input
- Zero offset—A nonzero value output for no input

Sensor selection

- Non Linearity—Percentage of deviation from the best-fit linear calibration curve
- Zero Drift—The departure of output from zero value over a period of time for no input
- Response time—The time lag between the input and output
- Operating temperature—The range in which the sensor performs as specified
- Deadband—The range of input for which there is no output
- Signal-to-noise ratio—Ratio between the magnitudes of the signal and the noise at the output

Sensor system

- Sensor system consists of a sensor and the readout circuitry
- Normally, the output from a sensor requires post processing of the signals before they can be fed to the controller
- The sensor output may have to be amplified, filtered, linearized, digitized, range quantized, and isolated so that the signal can be accepted by a typical controller
- All the electronics are integrated into one microcircuit and can be directly interfaced with the controllers

Sensor calibration!

- The sensor manufacturer usually provides the calibration curves. If the sensors are stable with no drift, there is no need to recalibrate
- However, often the sensor may have to be recalibrated after integrating it with a signal conditioning system
- This essentially requires that a known input signal is provided to the sensor and its output recorded to establish a correct output scale
- If the sensor is used to measure a time-varying input, dynamic calibration becomes necessary
  - Use of sinusoidal inputs is the most simple and reliable way of dynamic calibration
  - However, if generating sinusoidal input becomes impractical (for example, temperature signals) then a step input can substitute for the sinusoidal signal
  - The transient behavior of step response should yield sufficient information about the dynamic response of the sensor