Introduction to Sensors

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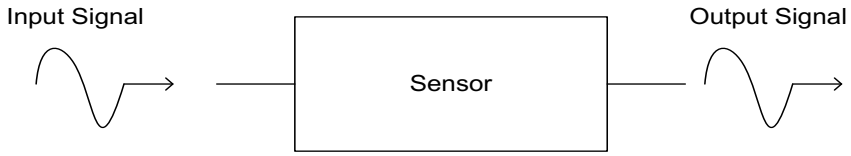
Overview

- What are Sensors?
- Detectable Phenomenon
- Physical Principles – How Do Sensors Work?
- Need for Sensors
- Choosing a Sensor
- Sensor Descriptions
  - Temperature Sensor
  - Accelerometer
  - Light Sensor
  - Magnetic Field Sensor
  - Ultrasonic Sensor
  - Photogate
  - CO_2 Gas Sensor

What are Sensors?

- American National Standards Institute (ANSI) Definition
  - A device which provides a usable output in response to a specified measurand



- A sensor acquires a physical parameter and converts it into a signal suitable for processing (e.g. optical, electrical, mechanical)

- A transducer
  - Microphone, Loud Speaker, Biological Senses (e.g. touch, sight,…ect)

Detectable Phenomenon

Stimulus	Quantity
Acoustic	Wave (amplitude, phase, polarization), Spectrum, Wave Velocity
Biological & Chemical	Fluid Concentrations (Gas or Liquid)
Electric	Charge, Voltage, Current, Electric Field (amplitude, phase, polarization), Conductivity, Permittivity
Magnetic	Magnetic Field (amplitude, phase, polarization), Flux, Permeability
Optical	Refractive Index, Reflectivity, Absorption
Thermal	Temperature, Flux, Specific Heat, Thermal Conductivity
Mechanical	Position, Velocity, Acceleration, Force, Strain, Stress, Pressure, Torque

Physical Principles

- Amperes's Law
  - A current carrying conductor in a magnetic field experiences a force (e.g. galvanometer)
- Curie-Weiss Law
  - There is a transition temperature at which ferromagnetic materials exhibit paramagnetic behavior
- Faraday's Law of Induction
  - A coil resist a change in magnetic field by generating an opposing voltage/current (e.g. transformer)
- Photoconductive Effect
  - When light strikes certain semiconductor materials, the resistance of the material decreases (e.g. photoresistor)

Need for Sensors

- Sensors are omnipresent. They embedded in our bodies, automobiles, airplanes, cellular telephones, radios, chemical plants, industrial plants and countless other applications.

- Without the use of sensors, there would be no automation !!
  - Imagine having to manually fill Poland Spring bottles

Choosing a Sensor

Environmental Factors	Economic Factors	Sensor Characteristics
Temperature range	Cost	Sensitivity
Humidity effects	Availability	Range
Corrosion	Lifetime	Stability
Size		Repeatability
Overrange protection		Linearity
Susceptibility to EM interferences		Error
Ruggedness		Response time
Power consumption		Frequency response
Self-test capability		

Temperature Sensor

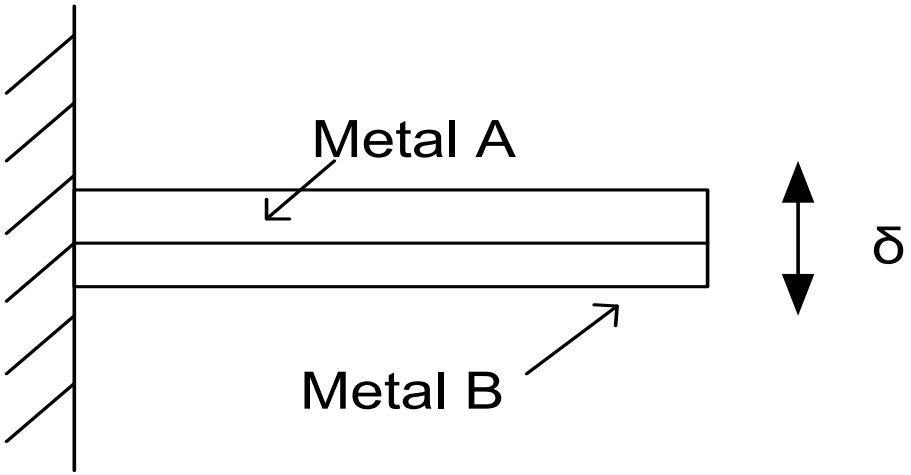
- Temperature sensors appear in building, chemical process plants, engines, appliances, computers, and many other devices that require temperature monitoring

- Many physical phenomena depend on temperature, so we can often measure temperature indirectly by measuring pressure, volume, electrical resistance, and strain

Temperature Sensor

- Bimetallic Strip

$$L = L_0[1 + \beta(T - T_0)]$$



- Application
  - Thermostat (makes or breaks electrical connection with deflection)

Temperature Sensor

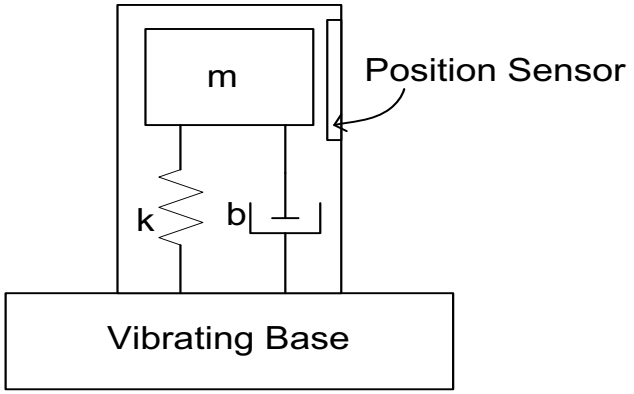
- Resistance temperature device.

$$R = R_0[1 + \alpha(T - T_0)]$$

$$R = R_0 e^{\gamma\left[\frac{1}{T} - \frac{1}{T_0}\right]}$$

Accelerometer

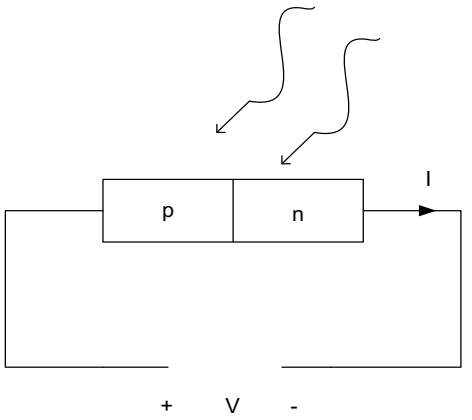
- Accelerometers are used to measure along one axis and is insensitive to orthogonal directions
- Applications
  - Vibrations, blasts, impacts, shock waves
  - Air bags, washing machines, heart monitors, car alarms
- Mathematical Description is beyond the scope of this presentation. See me during lunch if interested



Light Sensor

- Light sensors are used in cameras, infrared detectors, and ambient lighting applications

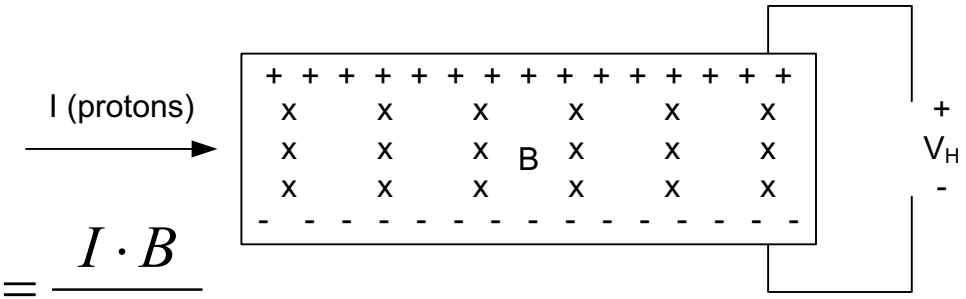
- Sensor is composed of photoconductor such as a photoresistor, photodiode, or phototransistor



Magnetic Field Sensor

- Magnetic Field sensors are used for power steering, security, and current measurements on transmission lines

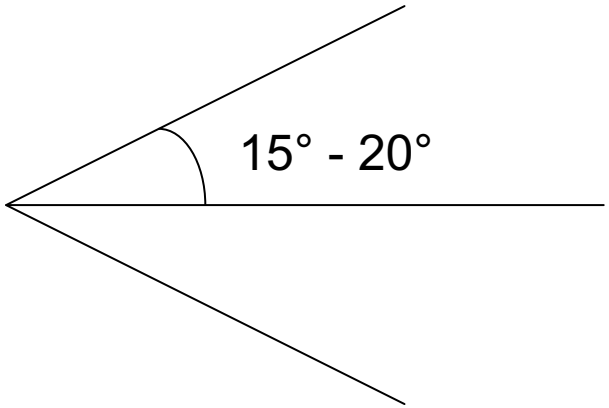
- Hall voltage is proportional to magnetic field



$$V_H = \frac{I \cdot B}{n \cdot q \cdot t}$$

Ultrasonic Sensor

- Ultrasonic sensors are used for position measurements
- Sound waves emitted are in the range of 2-13 MHz
- **So**und **N**avigation **A**nd **R**anging (SONAR)
- **Ra**dio **D**ection **A**nd **R**anging (RADAR) – ELECTROMAGNETIC WAVES !!

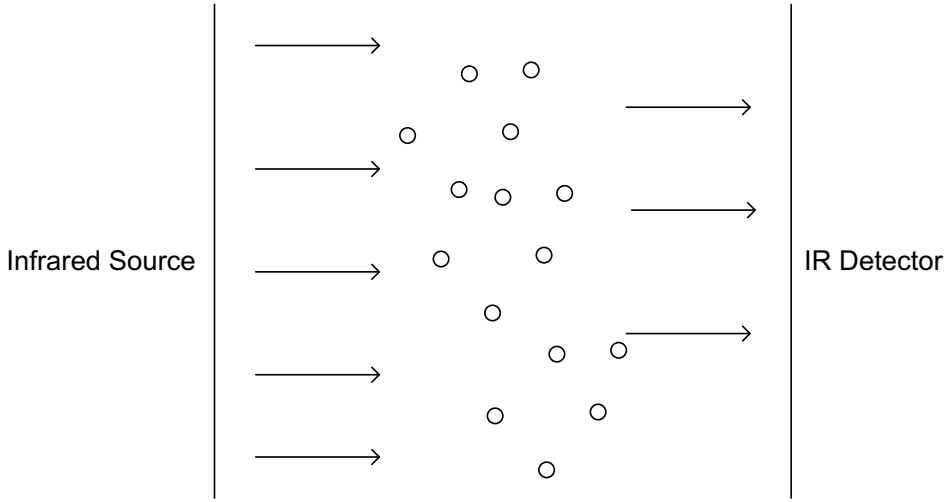


Photogate

- Photogates are used in counting applications (e.g. finding period of period motion)
- Infrared transmitter and receiver at opposite ends of the sensor
- Time at which light is broken is recorded

CO_2 Gas Sensor

- CO_2 sensor measures gaseous CO_2 levels in an environment
- Measures CO_2 levels in the range of 0-5000 ppm
- Monitors how much infrared radiation is absorbed by CO_2 molecules



Thank You