ECE 480
Sensors

Types of Sensors
  - Light
  - Pressure
  - Temperature
  - Direction-Compass
  - Magnetic Field
  - Location
  - Acceleration
  - Motion/Displacement
  - Time Interval
Light Sensing

Common types:
- Photoconductor
- Photodiode
- Phototransistor

Photoconductor: (Light sensitive semiconductor resistor)

\[ I = I_0 \left( \exp\left(\frac{eV}{kT}\right) - 1 \right) - I_\lambda \]

\( I_\lambda \) is proportion to the light level

Responsivity: example (1 A/W)

Example Circuits for Photodiodes
Simpliest:

Reverse Bias the diode:

![Diagram of diode circuit](image1)

![Graph of Vout vs Light Level](image2)
Phototransistor

The npn or pnp transistor has no base connection. The light absorbed provides the base current.

Responsivity typically 100-1000 A/W

Typical circuit:
Pressure Sensors

Most pressure sensors work by sensing the deflection of a membrane.

\[ C = \varepsilon A / t \]
Temperature Sensors

Common Types:
- Thermocouple
- Thermistors
- IC Temperature Sensors- Analog and digital
- Optical temperature sensors

Thermocouples

The junction between two dissimilar metals generates a small voltage. The voltage is on the order of 50µV/C. Widest temperature range: -270C to 2500 C

Example:

![Thermocouple Circuit Diagram]

Thermistors

Thermally sensitive semiconductor resistor.

Example sensitivity is -4%/C

Typical ranges: -30 C to 100 C
- accuracy: 0.1-1.0 degrees C

Example Thermistor Circuit
IC Temperature Sensors- Analog

Example 1: Two Terminal Temperature Sensor
LM135/LM335: Viewed as a zener diode with the voltage set by the temperature. 10 mV/K

AD590: Viewed as a constant current course with the current proportion to the temperature: 1µA/C

LM 20: Low power

IC Temperature Sensors- Digital

TC74: Digital Thermal Sensor- Used I²C-serial port

LM 74: SPI Digital Temperature Sensor
Serial Communications Protocols for between chip communication

I$^2$C: Inter Integrated Circuit
2 wires
SDA and SCL signals
Each chip can have its own address

SPI/Microwire/QSPI
3 wires
SI/O Slave I/O
SC Slave Clock
CS chip select (no address)
Position/Proximity/Rotation Sensors

Reflective Object Sensor

Example: QRB1133

Blocked Beam Optical Sensor

Ultrasonic Transducer

Ultrasonic transducers can be used to sense if an object is present at a certain distance, the level of a liquid in a tank, the flow of a liquid (via doppler effect), and presence of bubbles in a flow system. Parameters: beam angle, sensitivity, sound level, frequency
Rotational Position- Optical Encoder:

Sensors the rotation a shaft: sensitivity can range from dividing the circle into 2 to 1000's of division.

Example: MAS50
**Magnetic Field Sensing**

**Hall Effect Sensor**
- Used to detect rotating speed: say of a motor
- Used to detect position

Example: See spec sheet of 2 wire CMOS Hall Effect Sensor HAL55x

**Electronic Compass**

Example: See Specification Sheet for VECTOR 2X

**Position Sensing**

Example: GPS unit

**Acceleration Sensing**

Example: ADXL150-