Electronic Components - Sensors Cheatsheet

A quick reference guide to various electronic sensors, their principles of operation, common types, and applications. This cheat sheet covers a broad range of sensors used in modern electronics.

Introduction to Sensors

Sensor Fundamentals

Definition: A sensor is a device that detects and responds to some type of input from the physical environment.

Transduction: Sensors convert a physical quantity (e.g., temperature, pressure, light) into an electrical signal (e.g., voltage, current).

Key Characteristics:

- **Sensitivity:** The smallest change in input that a sensor can detect.
- **Accuracy:** How close the sensor's reading is to the actual value.
- **Precision:** The repeatability of a sensor's readings.
- **Resolution:** The smallest increment a sensor can measure.

Common Output Signals:

- **Voltage:** 0-5V, 0-10V
- **Current:** 4-20mA
- **Digital:** I2C, SPI, UART

Calibration: The process of adjusting a sensor's output to match known standards, improving accuracy.

Response Time: The time it takes for a sensor to respond to a change in the input signal.

Drift: Gradual change in sensor output over time, even with a constant input.

Sensor Categories

Physical Sensors	Measure physical properties like temperature, pressure, acceleration, etc.
Chemical Sensors	Detect specific substances in gases or liquids (e.g., gas sensors, pH sensors).
Optical Sensors	Detect light or other electromagnetic radiation (e.g., photodiodes, light sensors).
Biosensors	Detect biological substances (e.g., glucose sensors).
Acoustic Sensors	Detect sound waves or vibrations (e.g., microphones, ultrasonic sensors).
Image Sensors	Capture visual information (e.g., cameras).

Temperature Sensors

Thermocouples

Principle:	Seebeck effect - a temperature difference creates a voltage.
Types:	Type K (Chromel-Alumel), Type J (Iron-Constantan), Type T (Copper-Constantan).
Range:	-200°C to +1350°C (depending on type).
Pros:	Wide temperature range, rugged.
Cons:	Low sensitivity, requires cold junction compensation.
Applications:	Industrial temperature monitoring, furnaces, ovens.

Resistance Temperature Detectors (RTDs)

Principle:	Resistance changes with temperature.
Types:	Pt100, Pt1000 (Platinum RTDs are common).
Range:	-200°C to +850°C.
Pros:	High accuracy and stability.
Cons:	Slower response time, more expensive than thermocouples.
Applications:	Precision temperature measurements, HVAC systems.

Thermistors

Principle:	Semiconductor device with resistance highly dependent on temperature.
Types:	NTC (Negative Temperature Coefficient), PTC (Positive Temperature Coefficient).
Range:	-100°C to +300°C.
Pros:	High sensitivity, low cost.
Cons:	Non-linear response, less stable than RTDs.
Applications:	Temperature compensation, over-current protection.

Pressure Sensors

Strain Gauge Pressure Sensors

Principle:	Strain gauges measure the deformation of a diaphragm caused by pressure.
Types:	Bonded, unbonded, piezoresistive.
Range:	Varies widely depending on the design.
Pros:	Good accuracy, robust.
Cons:	Can be temperature sensitive, requires signal conditioning.
Applications:	Industrial pressure monitoring, automotive pressure sensors.

Capacitive Pressure Sensors

Principle:	Pressure changes the distance between capacitor plates, altering capacitance.
Range:	Typically low to medium pressure ranges.
Pros:	High sensitivity, low power consumption.
Cons:	Sensitive to temperature changes, complex signal conditioning.
Applications:	Medical devices, consumer electronics.
Types:	Differential, absolute, gauge.

Piezoresistive Pressure Sensors

Principle:	Change in resistance of a semiconductor material due to applied pressure.
Range:	Wide range of pressure measurements.
Pros:	High sensitivity, small size.
Cons:	Temperature sensitivity, non-linearity.
Applications:	Automotive, industrial control, medical devices.
Types:	Silicon, polysilicon.

Light Sensors

Photodiodes

Principle:	Semiconductor diode that generates current when exposed to light.
Types:	PIN, avalanche.
Range:	UV to IR spectrum.
Pros:	Fast response, high sensitivity.
Cons:	Temperature sensitive, requires amplification.
Applications:	Light detection, optical communication.

Phototransistors

Principle:	Light controls the current flow between collector and emitter.
Range:	Visible light spectrum.
Pros:	Higher gain than photodiodes.
Cons:	Slower response time, temperature sensitivity.
Applications:	Light-activated switches, object detection.
Types:	NPN, PNP.

Light Dependent Resistors (LDRs)

Principle:	Resistance decreases as light intensity increases.
Range:	Visible light spectrum.
Pros:	Simple, low cost.
Cons:	Slow response time, non-linear, less accurate.
Applications:	Street lights, camera light meters.
Materials:	Cadmium sulfide (CdS), others.