ELECTRONIC SENSORES

K.ANURADHA
Assistant Professor, ECE

Narsimha Reddy Engineering College
(Autonomous)

Secunderabad, Telangana, India

UNIT – I:
Sensors / Transducers

Topics Covered

Principles of Sensors and Transducers
Classification and Characteristics
Electromechanical Sensors
Inductive Sensors
Capacitive Sensors
Quartz Resonator Sensors
Ultrasonic Sensors

Introduction to Sensors

Definition
A sensor is a device that detects a physical quantity and converts it into a measurable signal.
Examples
Temperature Sensor
Pressure Sensor
Proximity Sensor
Light Sensor
Applications
Industrial Automation
Medical Equipment
Robotics
Automotive Systems
Image: Block diagram showing Physical Quantity → Sensor → Electrical Output.


Color Sensor
Touch Sensor
Ultrasonic Sensor
Alcohol Sensor
Humidity Sensor
Air Pressure Sensor
Gyro + Accelero Sensor
Hall Effect Sensor
Soil Sensor
Proximity Sensor
Heartbeat Sensor
Infrared Sensor
IR Receiver
Temp. Sensor
Light Sensors
Load Sensor
Pulse Oximeter
Gas Sensor

Principles of Sensors and Transducers

Working Principle
Sense Physical Quantity
Convert into Electrical Signal
Process Signal
Display/Control
Physical Quantities Measured
Temperature
Pressure
Force
Displacement
Humidity
Light
Diagram: Measurand → Sensor → Signal Conditioning → Output

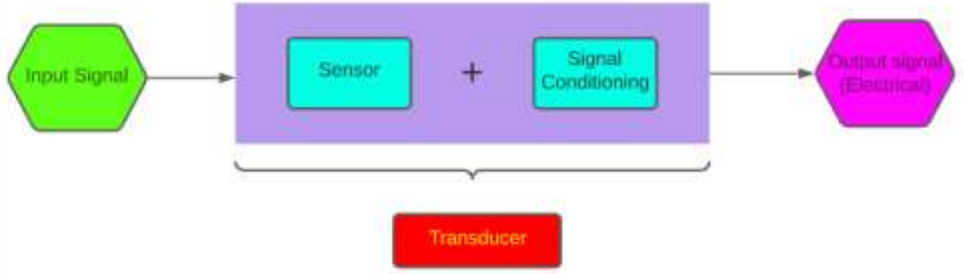


Figure 2: Internal Components of a Transducer

Classification of Sensors

Based on Energy Source

Active Sensors

Generate output without external power.

Thermocouple

Piezoelectric Sensor

Passive Sensors

Require external excitation.

Strain Gauge

RTD

Based on Output

Analog Sensors

Digital Sensors

Sensor Parameters and Characteristics

Sensor Parameters and Characteristics

Static Characteristics

Accuracy

Precision

Sensitivity

Resolution

Linearity

Repeatability

Dynamic Characteristics

Response Time

Bandwidth

Fidelity

Drift

Environmental Parameters (EP)

Factors Affecting Sensor Performance
Temperature
Humidity
Vibration
Shock
Dust
Electromagnetic Interference
Importance
Environmental effects may introduce errors in measurements.
Diagram: Environment → Sensor → Measurement Error

Sensor Characterization

Characterization Process
Determines sensor performance.
Methods
Calibration
Sensitivity Measurement
Error Analysis
Linearity Testing
Benefits
Reliable Measurements
Improved Accuracy

Electromechanical Sensors

Introduction

Convert mechanical quantities into electrical signals.

Applications

Industrial Automation

Robotics

Aerospace

Medical Equipment

Types

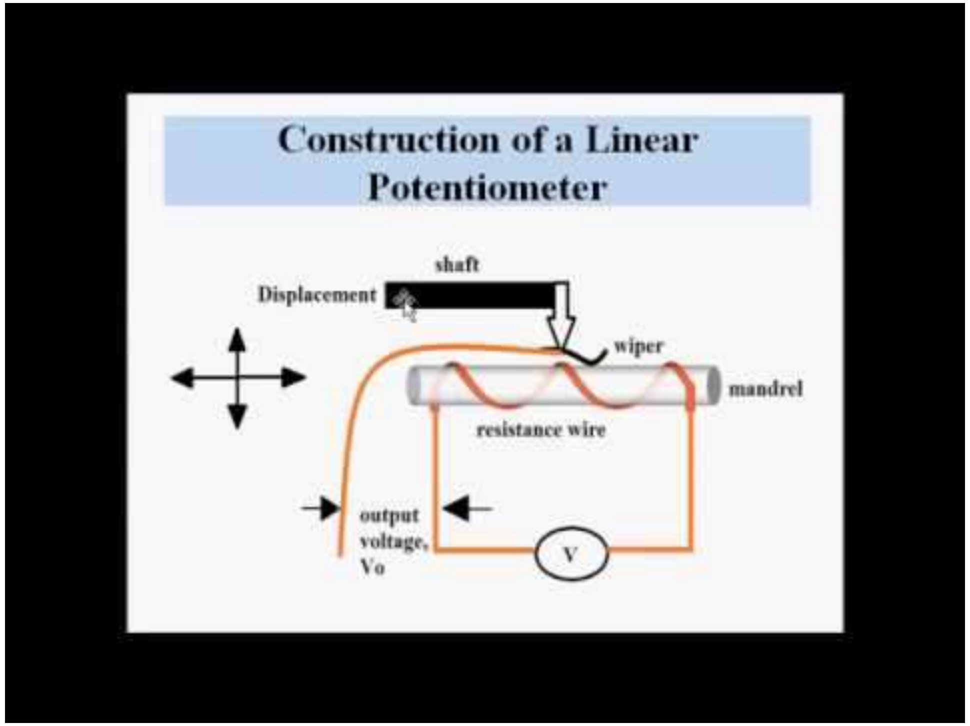
Potentiometers

Strain Gauges

Inductive Sensors

Resistive Potentiometer

Principle
Resistance changes with displacement.
Construction
Resistive Element
Sliding Contact (Wiper)
Output Voltage
Vo=xLVsV_o=\frac{x}{L}V_sVo=LxVs
Where:
x = displacemen
L = total length
Applications
Position Measurement
Servo Systems
Diagram: Linear Potentiometer



Strain Gauge

Definition
Measures strain produced by applied force.
Working Principle
Resistance changes when stretched or compressed.
Gauge Factor
GF=ΔR/RεGF=\frac{\Delta R/R}{\varepsilon}GF=εΔR/R
Applications
Load Cells
Structural Monitoring

Resistance Strain Gauge

Construction
Metallic Foil/Grid
Backing Material
Adhesive
Advantages
High Accuracy
Easy Installation
Limitations
Temperature Sensitivity
Diagram: Foil Strain Gauge Structure

Semiconductor Strain Gauges

Principle
Piezoresistive Effect
Features
Very High Sensitivity
Small Size
Advantages
Gauge Factor 50–200
Disadvantages
Temperature Dependence
Fragile
Applications
Pressure Sensors
MEMS Devices

Inductive Sensors

Introduction

Operate based on change in inductance.

Principle

L=N2μAlL=\frac{N^2\mu A}{l}L=lN2μA

Where:

N = Number of Turns

μ = Permeability

A = Area

l = Magnetic Path Length

Applications

Displacement Measurement

Position Detection

Sensitivity and Linearity of Inductive Sensors

Sensitivity and Linearity of Inductive Sensors

Sensitivity

Output change per unit input.

S=ΔOutputΔInputS=\frac{\Delta Output}{\Delta Input}S=ΔInputΔOutput

Linearity

Ability to produce proportional output.

Graph: Ideal vs Actual Output

Types of Inductive Sensors

Self-Inductance Type

Measures inductance variation directly.

Mutual Inductance Type

Based on coupling between coils.

LVDT

Linear Variable Differential Transformer

Advantages

High Accuracy

Frictionless Operation

Diagram: LVDT Construction

Capacitive Sensors

Principle

Capacitance changes due to:

Area Variation

Distance Variation

Dielectric Variation

Capacitance Equation

C=εAdC=\frac{\varepsilon A}{d}C=dεA

Applications

Pressure Sensors

Touch Screens

Electrostatic Transducer

Working Principle
Uses electrostatic force between charged plates.
Advantages
High Sensitivity
Low Power Consumption
Applications
Microphones
MEMS Sensors
Diagram: Parallel Plate Electrostatic Transducer

force/Stress Sensors Using Quartz Resonators

Principle
Based on Piezoelectric Effect.
Quartz Crystal Characteristics
High Stability
High Accuracy
Fast Response
Applications
Force Measurement
Stress Monitoring
Diagram: Quartz Resonator Sensor

Ultrasonic Sensors

Principle

Uses ultrasonic waves (>20 kHz).

Working

Transmit Ultrasonic Pulse

Receive Echo

Measure Time Delay

Distance Formula

d=vt2d=\frac{vt}{2}d=2vt

Where:

v = Sound Velocity

t = Echo Time

Applications

Robotics

Obstacle Detection

Level Measurement