



**NARSIMHA REDDY ENGINEERING COLLEGE**  
**UGC AUTONOMOUS INSTITUTION**

Maisammaguda (V), Kompally - 500100, Secunderabad, Telangana state, India

Accredited by NBA & NAAC with 'A' Grade

Approved by AICTE

Permanently affiliated to JNTUH

AICTE

**ELECTRONICS SENSORS**

**LECTURE NOTES**

**For**

**IV BTECH I SEM**

**PREPARED BY**

**Mrs K ANURADHA M.TECH (PHD.,)**

**ASSISTANT PROFESSOR**

**DEPARTMENT OF ECE**

**NRCM**

**Narsimha Reddy Engineering College**

*(Approved by NBA & NAAC with A Grade, Approved by AICTE, Affiliated to (JNTUH)  
Maisammaguda, Kompally, Secunderabad, Hyderabad, Telangana 500100*

**[Website: www.nrcmec.org](http://www.nrcmec.org)**

## UNIT I

### SENSORS AND TRANSDUCERS NOTES

#### 1. PRINCIPLES OF SENSORS

##### Definition

A sensor is a device that detects a physical quantity and converts it into a measurable signal, usually electrical.

##### Basic Principle

Physical Quantity → Sensor → Electrical Signal → Processing Unit

##### Functions of a Sensor

- Sensing/Detection
- Signal Conversion
- Signal Transmission
- Measurement and Control

##### Characteristics of an Ideal Sensor

- ✓ High Sensitivity
- ✓ Good Accuracy
- ✓ Fast Response
- ✓ High Reliability
- ✓ Low Cost
- ✓ Good Stability

#### 2. CLASSIFICATION OF SENSORS

##### Based on Energy Requirement

###### Active Sensors

Generate output without external power.

Examples:

- Thermocouple
- Piezoelectric Sensor

###### Passive Sensors

Require external power source.

Examples:

- Strain Gauge
- RTD
- Potentiometer

### **Based on Output**

#### **Analog Sensors**

Provide continuous output.

Examples:

- LVDT
- Thermistor

#### **Digital Sensors**

Provide discrete output.

Examples:

- Optical Encoder
- Digital Temperature Sensor

### **Based on Measured Quantity**

- Temperature Sensors
- Pressure Sensors
- Displacement Sensors
- Flow Sensors
- Humidity Sensors
- Force Sensors

## **3. PARAMETERS OF SENSORS**

### **Static Parameters**

#### **Accuracy**

Degree of closeness to true value.

#### **Precision**

Ability to reproduce same readings.

#### **Sensitivity**

Ratio of output change to input change.

Sensitivity =  $\Delta\text{Output} / \Delta\text{Input}$

### **Resolution**

Smallest detectable input change.

### **Linearity**

Ability to produce proportional output.

### **Repeatability**

Ability to give same output repeatedly.

### **Dynamic Parameters**

#### **Speed of Response**

Time required to reach final value.

#### **Fidelity**

Ability to reproduce input accurately.

#### **Lag**

Delay between input and output.

## **4. CHARACTERISTICS OF SENSORS**

### **Static Characteristics**

- Accuracy
- Precision
- Sensitivity
- Linearity
- Resolution
- Repeatability
- Drift

### **Dynamic Characteristics**

- Speed of Response
- Fidelity
- Dynamic Error
- Time Constant

## **5. ENVIRONMENTAL PARAMETERS (EP)**

Environmental parameters affect sensor performance.

### **Important Environmental Parameters**

#### **Temperature**

Causes drift and measurement errors.

#### **Humidity**

Leads to corrosion and insulation failure.

#### **Vibration**

Produces unwanted signals.

#### **Shock**

May damage sensing elements.

#### **Dust and Contamination**

Reduce accuracy.

#### **Electromagnetic Interference (EMI)**

Creates electrical noise.

#### **Effects**

- Reduced accuracy
- Reduced reliability
- Calibration errors
- Sensor degradation

## **6. CHARACTERIZATION OF ELECTROMECHANICAL SENSORS**

Electromechanical sensors convert mechanical quantities into electrical signals.

### **Measured Quantities**

- Displacement
- Force
- Pressure
- Stress
- Velocity

### **Important Characteristics**

- Sensitivity
- Linearity
- Range
- Resolution
- Stability
- Response Time

Examples:

- Potentiometer
- Strain Gauge
- LVDT
- Capacitive Sensors

## 7. RESISTIVE POTENTIOMETER

### Definition

A resistive potentiometer converts displacement into resistance variation.

### Construction

- Resistive Track
- Sliding Wiper
- Terminals

### Working Principle

Movement of wiper changes resistance and output voltage.

Output Voltage:

$$V_o = (x/L)V$$

Where:

x = displacement

L = total length

V = supply voltage

### Advantages

- ✓ Simple
- ✓ Low Cost
- ✓ High Output Signal

### Disadvantages

- ✗ Mechanical Wear
- ✗ Limited Resolution

### **Applications**

- Position Measurement
- Robotics
- Machine Tools

## **8. STRAIN GAUGE**

### **Definition**

A strain gauge measures strain by change in resistance.

### **Principle**

When conductor is stretched:

Length ↑

Area ↓

Resistance increases.

Resistance:

$$R = \rho L/A$$

### **Gauge Factor (GF)**

$$GF = (\Delta R/R)/\epsilon$$

Where:

$\epsilon$  = Strain

### **Applications**

- Stress Measurement
- Load Cells
- Structural Monitoring

## **9. RESISTANCE STRAIN GAUGE**

### **Construction**

- Metallic Foil/Wire
- Insulating Backing
- Adhesive Layer

### **Working**

Mechanical strain changes resistance.

### **Types**

1. Bonded Strain Gauge
2. Unbonded Strain Gauge

### **Advantages**

- ✓ High Accuracy
- ✓ Simple Construction

### **Disadvantages**

- ✗ Temperature Effects
- ✗ Fragile

### **Applications**

- Force Measurement
- Pressure Sensors
- Weight Measurement

## **10. SEMICONDUCTOR STRAIN GAUGES**

### **Principle**

Based on piezoresistive effect.

Resistance changes significantly with strain.

### **Features**

- Very High Sensitivity
- Small Size
- High Gauge Factor

Gauge Factor:  
GF = 50 to 200

(Metallic Gauge GF  $\approx$  2)

### **Advantages**

- ✓ High Sensitivity
- ✓ Compact

### **Disadvantages**

- ✗ Temperature Sensitive
- ✗ Costly

### **Applications**

- Pressure Transducers
- MEMS Devices
- Biomedical Sensors

## **11. INDUCTIVE SENSORS**

### **Definition**

Sensors that work based on change in inductance.

### **Principle**

Inductance:

$$L = (N^2\mu A)/l$$

Change in:

- Number of turns (N)
- Area (A)
- Length (l)
- Permeability ( $\mu$ )

changes inductance.

### **Types**

#### **Self-Inductive Sensors**

Change in self-inductance.

#### **Mutual-Inductive Sensors**

Change in mutual inductance.

Example:

- LVDT

### **Applications**

- Position Measurement
- Thickness Measurement
- Metal Detection

## **12. SENSITIVITY AND LINEARITY OF SENSOR**

### **Sensitivity**

Sensitivity =  $\Delta\text{Output} / \Delta\text{Input}$

Higher sensitivity means greater output change.

### **Linearity**

Indicates how closely output follows a straight-line relation.

### **Importance**

- ✓ Better Accuracy
- ✓ Easier Calibration
- ✓ Reduced Error

### **Ideal Sensor**

High Sensitivity + High Linearity

## **13. CAPACITIVE SENSORS**

### **Definition**

Capacitive sensors operate by change in capacitance.

### **Capacitance Equation**

$$C = \epsilon A/d$$

Where:

C = Capacitance

$\epsilon$  = Permittivity

A = Plate Area

d = Distance