# Sensors in Automation

**(Code : 304195(B))**

**Elective -II**

**Semester VI – Electronics & Telecommunication Engineering**

(Savitribai Phule Pune University)

**Strictly as per the New Choice Based Credit System Syllabus (2019 Course)**
**Savitribai Phule Pune University w.e.f. academic year 2021-2022**


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TechKnowledge™ Publications

PE148A Price ₹ 225/-

(Book Code : PE148A)

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**First Printed in India** : January 2022

**First Edition** : January 2022 **(TechKnowledge Publications)**

This edition is for sale in India, Bangladesh, Bhutan, Maldives, Nepal, Pakistan, Sri Lanka and designated countries in South-East Asia. Sale and purchase of this book outside of these countries is unauthorized by the publisher.

**ISBN :** 978-93-5563-087-2

**Published by :**

**TechKnowledge Publications**

**Head Office :** B/5, First floor, Maniratna Complex, Taware Colony, Aranyeshwar Corner,
Pune - 411 009. Maharashtra State, India

Ph : 91-20-24221234, 91-20-24225678.

Email : info@techknowledgebooks.com,

Website : www.techknowledgebooks.com

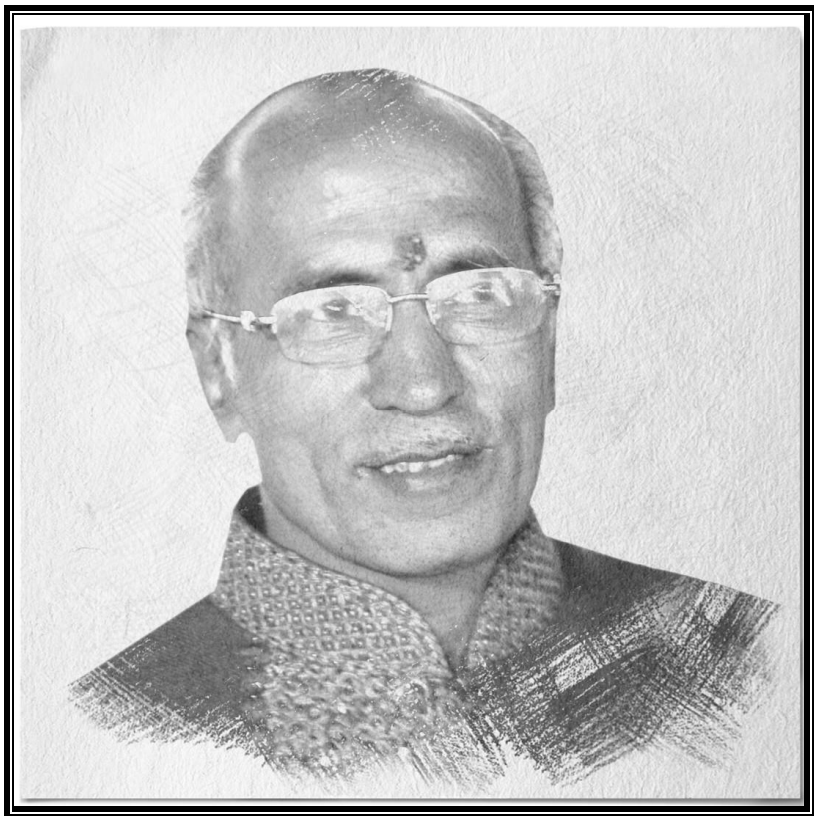
[304195(B)] (FID : PE148) (Book Code : PE148A)

*We dedicate this Publication soulfully and wholeheartedly,*

*in loving memory of our beloved founder director,*

***Late Shri. Pradeepji Lalchandji Lunawat,***

*who will always be an inspiration, a positive force and strong support behind us.*



## *"My work is my prayer to God"*

*- Lt. Shri. Pradeepji L. Lunawat*

*Soulful Tribute and Gratitude for all Your Sacrifices, Hardwork and 40 years of Strong Vision…*

(Book Code : PE148A)

# Syllabus…

**Sensors in Automation : Sem. VI, E & TC Engineering (SPPU)**

| Teaching Scheme : | Credits | Examination Scheme : |
|---|---|---|
| Theory : 03 Hrs/Week | 03 | In-Sem (Theory) : 30 Marks |
| | | End-Sem (Theory) : 70 Marks |

**Prerequisite Courses, if any :** --

1. Basic Electrical Engineering
2. Basic Electronics Engineering

**Companion Course, if any :** Sensors in Automation Lab

**Course Objectives :** To make the students understand about :

1. Concept of Sensors / Transducers and their Static and Dynamic Characteristics.
2. Sensors used in Industry for Temperature and Humidity Measurement.
3. Sensors used for Sensors used for Force, Pressure, Stress and Flow measurements.
4. Sensors used for Displacement and Level Measurement.
5. Applications of Image and Biosensors.
6. Role of Sensors / Transducers in IoT applications.

**Course Outcomes :** On completion of the course, learner will be able to

**CO1 :** Understand the Concepts of Sensors / Transducers, classify and evaluate static and Dynamic Characteristics of Measurement Systems.

**CO2 :** Choose the proper sensor comparing different standards and guidelines for measurements of Temperature and Humidity.

**CO3 :** Choose the proper sensor comparing different standards and guidelines for measurements of Force, Pressure, Stress and Flow

**CO4 :** Choose the proper sensor comparing different standards and guidelines for measurements of Displacement, Vibration, Acceleration and Level

**CO5 :** Explore sensors to profound areas like environmental, Agricultural and bio-medical equipment and sustainability.

**CO6 :** Explore IoT based applications of Sensors and Transducers.

(Book Code : PE148A)

## Course Contents

### Unit I

**Introduction to Sensors &Transducers :**

Concept of sensor, Concept of transducer, Comparison between sensors and transducers , Role of sensors in automation, Broad classification of sensors and transducers, Role of transducer in measurement systems, Block diagram measurement system, **Study of static and dynamic characteristics of measurement systems :** Accuracy, Precision, Reproducibility, Linearity, Repeatability, Resolution, Sensitivity, Range, Span, Dead Zone, Hysteresis, Backlash, **Dynamic characteristics :** Fidelity, Time response and frequency response, **Classification of errors :** Error analysis. Concept and basic principle of working of resistive, capacitive and inductive sensors. **(Refer Chapter 1)**

**Mapping of Course Outcomes for Unit I :**

**CO1 :** Understand the concepts of Sensors / Transducers, classify and evaluate static and Dynamic Characteristics of Measurement Systems.

### Unit II

**Sensors for Temperature and Humidity Measurement :**

**Temperature Measurement :** Units of temperature measurement / Temperature measurement scales ; Celsius scale, Fahrenheit scale, Kelvin scale, Rankine scale - unit conversions, Broad classification of Temperature, Transducers, RTD (e.g. PT-100), Thermocouple, Thermistors, Optical fiber sensors. (Basic principle of working, Selection criteria, Installation and Calibration, Signal conditioning (e.g. Instrumentation amplifier (with AD-620). **DC bridge :** Wheatstone bridges, **AC Bridge :** Wein bridge, Schering bridge, **Signal Conditioning :** 2-Wire, 3-Wire and 4-Wire compensation. **IR Temperature Sensor :** MLX90614 ESF non-contact human body infrared temperature measurement module. **Smart temperature and Solid state sensors :** LM35, AD590 (Only for real time application / implementation in project based learning) **Humidity :** Hygrometer, Soil humidity sensor, Soil hygrometer (DHT11, TI HDC1050). **(Refer Chapter 2)**

**Mapping of Course Outcomes for Unit II :**

**CO3 :** Choose the proper sensor comparing different standards and guidelines for measurements of Temperature and Humidity.

### Unit III

**Sensors for Force, Pressure, Stress and Flow :**

**(Basic principle of working, Selection criteria, Installation and Calibration, Signal conditioning) pressure scales :** Newton, Bar, Pascal, PSI - unit conversions, Absolute, Gauge and Vacuum pressure. **Classification of pressure sensors :** Strain gauge (Load cell using strain gauge), Piezoelectric transducer, Solid state pressure sensors **(IC's like GY-63 MS5611-01BA03 to be discussed)** Differential pressure transducer flow measurement **(Only Mention of basic principle of working, Bernoulli's theorem)**, Orifice, Venturi, Nozzle flow meter **(only Descriptive)**, Pneumatic sensors (Bellows, Diaphragm), Ultrasonic and Hall effect sensors for flow measurement, **Solid state flow sensors : YF-S201, E8FC-25D**, Fiber-optic sensors. **(Refer Chapter 3)**

**Mapping of Course Outcomes for Unit III :**

**CO3 :** Choose the proper sensor comparing different standards and guidelines for measurements of Force, Pressure, Stress and Flow.

**Unit IV**

**Sensors for Displacement, Vibration, Acceleration and Level :**

**(Basic principle of working, Selection criteria, Installation and Calibration, Signal conditioning) Classification of displacement sensors :** Potentiometer, Strain-gauged element, Capacitive element, Differential transformers, Eddy current proximity sensors, Inductive and Capacitive proximity switch, Optical encoders. Pneumatic sensors (**Bellows, Diaphragm**), Hall effect sensors, Accelerometer, Gyroscope and Magnetometer (**ADXL335 / 345**), Electro-optical sensors, Position encoders.

**(Refer Chapter 4)**

**Mapping of Course Outcomes for Unit IV :**

**CO4 :** Choose the proper sensor comparing different standards and guidelines for measurements of Displacement, Vibration, Acceleration and Level.

**Unit V**

**Sensors in Environmental Studies, Bio Sensors :**

Charge-coupled and CMOS image sensors, **Biosensors :** Resonant mirror, Electrochemical, Surface plasmon resonance, Light addressable potentio-metric., pH measurement, CMOS MQ-2 smoke LPG butane hydrogen gas sensor detector module **(MQ-3 alcohol detector gas sensor module MQ 135 air quality / Gas detector sensor module for Arduino data sheet MLX90614 non-contact temperature sensor),** Camera sensor Ultrasonic proximity, Colour sensors, Light sensors like light dependent resistance (LDR), Photo diode, Photo transistors, RFID sensors, e.g. EM-18 module, Applications RFID sensors, MEMS and NEMS sensors. **(Refer Chapter 5)**

**Mapping of Course Outcomes for Unit V :**

**CO5 :** Explore sensors to profound areas like environmental, Agricultural and bio-medical equipment and sustainability.

**Unit VI**

**Latest trends in Sensors Applications :**

Basic concept of data acquisition systems (Block diagram understanding), Basic concept of IoT, Sensor interface in IoT systems. **Case study 1 :** IoT based agriculture / greenhouse systems. (Block diagram) **(Mention of optical sensors, Electro-chemical sensors, Mechanical sensors, Dielectric soil moisture sensors, Air flow sensors may be considered) Case study 2 :** IoT based healthcare systems. (Block diagram) **(Mention of ECG module, Temperature, Humidity, Accelerometer, Oxygen level, Heart rate sensors) Case Study 3 :** IoT based automobile sector (Engine management system) **(Mention of fuel level, Ignition, Exhaust sensors)** **(Refer Chapters 6)**

**Mapping of Course Outcomes for Unit VI :**

**CO6 :** Explore IoT based applications of Sensors and Transducers.

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**Unit I**



**Syllabus :** Concept of sensor, Concept of transducer, Comparison between sensors and transducers , Role of sensors in automation, Broad classification of sensors and transducers, Role of transducer in measurement systems, Block diagram measurement system, **Study of static and dynamic characteristics of measurement systems :** Accuracy, Precision, Reproducibility, Linearity, Repeatability, Resolution, Sensitivity, Range, Span, Dead Zone, Hysteresis, Backlash, **Dynamic characteristics :** Fidelity, Time response and frequency response, **Classification of errors :** Error analysis. Concept and basic principle of working of resistive, capacitive and inductive sensors.

**Unit II**



**Syllabus : Temperature Measurement :** Units of temperature measurement / Temperature measurement scales ; Celsius scale, Fahrenheit scale, Kelvin scale, Rankine scale - unit conversions, Broad classification of Temperature, Transducers, RTD (e.g. PT-100), Thermocouple, Thermistors, Optical fiber sensors. (Basic principle of working, Selection criteria, Installation and Calibration, Signal conditioning (e.g. Instrumentation amplifier (with AD-620). **DC bridge :** Wheatstone bridges, **AC Bridge :** Wein bridge, Schering bridge, **Signal Conditioning :** 2-Wire, 3-Wire and 4-Wire compensation. **IR Temperature Sensor :** MLX90614 ESF non-contact human body infrared temperature measurement module. **Smart temperature and Solid state sensors :** LM35, AD590 (Only for real time application / implementation in project based learning) **Humidity :** Hygrometer, Soil humidity sensor, Soil hygrometer (DHT11, TI HDC1050).

**Unit III**



**Syllabus : (Basic principle of working, Selection criteria, Installation and Calibration, Signal conditioning) pressure scales :** Newton, Bar, Pascal, PSI - unit conversions, Absolute, Gauge and Vacuum pressure. **Classification of pressure sensors :** Strain gauge (Load cell using strain gauge), Piezoelectric transducer, Solid state pressure sensors **(IC's like GY-63 MS5611-01BA03 to be discussed)** Differential pressure transducer flow measurement **(Only Mention of basic principle of working, Bernoulli's theorem)**, Orifice, Venturi, Nozzle flow meter **(only Descriptive)**, Pneumatic sensors (Bellows, Diaphragm), Ultrasonic and Hall effect sensors for flow measurement, **Solid state flow sensors : YF-S201, E8FC-25D**, Fiber-optic sensors.

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**Syllabus :** Charge-coupled and CMOS image sensors, **Biosensors :** Resonant mirror, Electrochemical, Surface plasmon resonance, Light addressable potentio-metric., pH measurement, CMOS MQ-2 smoke LPG butane hydrogen gas sensor detector module **(MQ-3 alcohol detector gas sensor module MQ 135 air quality / Gas detector sensor module for Arduino data sheet MLX90614 non-contact temperature sensor),** Camera sensor Ultrasonic proximity, Colour sensors, Light sensors like light dependent resistance (LDR), Photo diode, Photo transistors, RFID sensors, e.g. EM-18 module, Applications RFID sensors, MEMS and NEMS sensors.

**Syllabus :** Basic concept of data acquisition systems (Block diagram understanding), Basic concept of IoT, Sensor interface in IoT systems. **Case study 1 :** IoT based agriculture / greenhouse systems. (Block diagram) **(Mention of optical sensors, Electro-chemical sensors, Mechanical sensors, Dielectric soil moisture sensors, Air flow sensors may be considered) Case study 2 :** IoT based healthcare systems. (Block diagram) **(Mention of ECG module, Temperature, Humidity, Accelerometer, Oxygen level, Heart rate sensors) Case Study 3 :** IoT based automobile sector (Engine management system) **(Mention of fuel level, Ignition, Exhaust sensors)**

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