INSTRUMENTATION
ENEX 252

Lecture	: 4
Tutorial	: 1
Practical	: 3/2

Year : II
Part : II

Course Objectives:
The objective of this course is to provide comprehensive understanding on methods and instrument for a wide range of measurement problems used in instrumentation system. It also covers application of transducers in the microprocessor, microcontroller and their interfacing to design instrumentation system.

1 Introduction **(2 hours)**

1.1 Analog and digital instrument: Definition, block diagram, characteristics
1.2 Microprocessor-based systems: Open vs closed loop, benefits, features and applications in instrumentation design
1.3 Microcomputer on instrumentation design

2 Theory of Measurement **(6 hours)**

2.1 Static performance parameters: Accuracy, precision, sensitivity, resolution and linearity
2.2 Dynamic performance parameters: Response time, frequency response and bandwidth
2.3 Error in measurement
2.4 Statistical analysis of error in measurement
2.5 Measurement of resistance (Low, medium and high)
2.6 DC / AC bridge (Wheatstone bridge, Maxwell's bridge, Schering bridge)

3 Transducer **(8 hours)**

3.1 Transducer, workflow of a transducer in typical system, transducer classification
3.2 Sensor and its working principle (Resistive, capacitive and piezoelectric), generation of sensor, classification of sensor (Analog sensor, digital sensor)
3.3 Types of sensors (Electrical sensor, chemical sensor, biological sensor, acoustic sensor, optical sensor and other motion sensor), characteristic of sensors
3.4 Actuator, classification of actuators (Hydraulic, pneumatic, electric and mechanical), characteristic of actuator

4 Interfacing of Instrumentation System (14 h...

4.1 Microprocessor and microcontroller and their selection criteria, applications

4.2 The PPI 8255 and interfacing of peripherals (LED, 7 segment, dip switch, ... bit ADC, 8/10-bit DAC using mode 0 and mode1) with 8085 microprocessor

4.3 Microcontrollers (Atmega328, STM32): Architecture, pin configuration, and their application

4.4 Sensor/Actuator interfacing with Atmega328P (Arduino): Analog and digital sensors, implementation of communication protocols, interrupt based interfacing

5 Connectivity Technology in Instrumentation System (6 hours)

5.1 Wired and wireless communication system

5.2 Wired connectivity: UART, I2C, SPI, CAN

5.3 Wireless sensor network and its technology

5.4 RF modem, Bluetooth, WI-FI, NFC, ZIGBEE and LORA

5.5 Thermal management: Heat dissipation technique, heat sink

5.6 Data acquisition system (Data loggers, data archiving and storage), cloud based data acquisition system

6 Circuit Design (4 hours)

6.1 Converting requirement into design, reliability and fault tolerance

6.2 High-speed design: Bandwidth, decoupling, crosstalk, impedance matching

6.3 PCB design: Component placement, trace routing, signal integrity, and ground loops

6.4 Noise and noise coupling mechanism, noise prevention, filtering, ferrite beads, decoupling capacitors, and ESD & its prevention

7 Software for Instrumentation Application (6 hours)

7.1 Overview of software engineering

7.2 Types of software

7.3 Software development life cycle (SDLC), software process models (Waterfall model, prototype model, incremental model, agile model)

7.4 Software reliability vs hardware reliability

7.5 Software bugs, software testing, different levels of testing

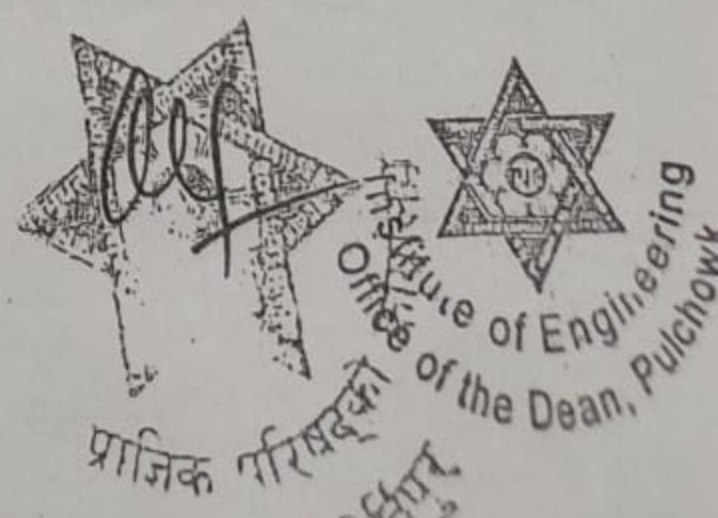
8 Electrical Equipment (6 hours)

8.1 Voltmeter and ammeter: Types and working principle

8.2 Energy meter: Types and working principle

8.3 Frequency meter: Types and working principle

8.4 Wattmeter: Types and working principle



(14 hours)
and

9 **Latest Trends** (3 hours)

9.1 Internet of things (IoT): Simple architecture, characteristics, advantages
9.2 Smart sensors
9.3 Important of cloud computing in instrumentation system
9.4 Instrumentation in industry 4.0/5.0

10 **Application of Modern Instrumentation System** (5 hours)

10.1 Instrumentation for power station including all electrical and non-electrical parameters
10.2 Instrumentation for wire and cable manufacturing and bottling plant
10.3 Instrumentations for a beverage manufacturing and bottling plant
10.4 Instrumentations required for a biomedical application such as a medical clinic or hospital
10.5 Instrumentation system design using a processor (Microprocessor, microcontroller or others)

Tutorial (15 hours)

1. Understanding the fundamentals of Op-amps is essential since they are central to analog instrumentation.
2. Learn how to filter, amplify, and modify analog signals for signal conditioning
3. How ADCs and DACs work and how to select the right one for your application
4. Interfacing of ADC on any application of your interest
5. Application for the protocol UART, I2C, SPI in Adriano
6. Design a simple temperature sensing system using a thermistor or thermocouple, op-amp, and analog display.
7. Explain the generation of PWM signals in ATmega328P for controlling things like motor speed or LED brightness.

Practical (22.5 hours)

1. Measurement and accuracy testing: Analog and digital meters
2. Use of LabVIEW, Proteus, MATLAB or others for modeling instrumentation systems
3. Use of resistive, capacitive & inductive transducers / sensors / actuators
4. Review of assembly programming and simple I/O interfacing with 8085 and 8255
5. Interfacing of LEDs, seven segment display and motors
6. Interfacing of ADC and DAC

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Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	2	4
2	6	5
3	8	6
4	14	12
5	6	6
6	4	4
7	6	6
8	6	6
9	3	5
10	5	6
Total	60	60

* There may be minor deviation in marks distribution.

References

1. Hall, D. V., (1999). Microprocessor and Interfacing, Programming and Hardware. Tata McGraw Hill
2. Goankar, R. S., (2000). Microprocessor Architecture, Programming and Application with 8085. Prentice Hall
3. Fowler, K. R., (1996). Electronic Instrument Design: Architecting for the Life Cycle. Oxford University Press, Inc.
4. Sawhney, A. K., (1998). A Course in Electronic Measurement and Instrumentation. Dhanpat Rai and Sons.
5. Gupta, J. B., (2008). A Course in Electrical and Electronics Measurement and Instrumentation, Kataria and Sons.
6. DE Silva C. W., Sensors and Actuators: Control System Instrumentation. CRC Press Taylor and French Group Boca Raton London New York.
7. Misra, S., Roy, C. and Mukherjee, A., (2020). Introduction to Industrial Internet of Things and Industry 4.0. CRC Press.

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