# INDUSTRIAL INSTRUMENTATION AND AUTOMATION

**ENEE 351**

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|---|---|---|
| **Lecture** | **: 3** | **Year : III** |
| **Tutorial** | **: 1** | **Part : II** |
| **Practical** | **: 3** | |

**Course Objectives:**

The objective of this course is to provide students with theoretical and practical knowledge of measurement, sensing, control, and industrial automation systems. It develops competency in PLC-based data acquisition and control, along with skills in designing, implementing, and troubleshooting automation systems for industrial applications.

## 1 Automation Overview and Architecture (4 hours)

1.1 Introduction to automation system, industrial communication
1.2 Role of instrumentation and automation in modern industry
1.3 Benefits of automation and evolution of automation strategy
1.4 Functional hierarchy in Automation
1.5 Basic process variables (Temperature, pressure, level, flow, position, speed)
1.6 Overview of measurement chain: Sensor, signal conditioning, controller, actuator, operator interface, supervisory system
1.7 Standards, safety basics and overview of industrial communication layers

## 2 Sensors and Transducers (8 hours)

2.1 Energy sensor classification: Active/passive, contact/non-contact, discrete/ continuous
2.2 Sensor time response: First and second-order responses
2.3 Digital sensors and switches: Limit switches, proximity (Inductive, capacitive), photoelectric sensors (Signal characteristics and interfacing considerations)
2.4 Analog sensors: Resistance temperature detector (RTD), thermocouple, strain gauge, pressure transducer, flow transmitter (Signal ranges and scaling)
2.5 Transducers: Characteristics and choice of the transducer
2.6 Encoders and position/speed transducers: Pulses, quadrature signals, frequency-to-value conversion
2.7 Signal conditioning: Filtering, isolation, amplification, linearization, analog-to-digital basics
2.8 Sensor selection criteria, calibration and accuracy/error sources

**3 Programmable Logic Controllers (PLC) (8 hours)**

3.1 PLC architecture: CPU, Input/output modules, power supply and communication
3.2 Need of PLC for industrial automation
3.3 PLC Programming
   3.3.1 Types of programming language
   3.3.2 Introduction about PLC programming software
   3.3.3 Ladder logic diagram: Instruction, logic function, latching, timer/ counter, multiple outputs, jump and subroutine

**4 PLC Actuators (6 hours)**

4.1 Actuator types: Electrical (Relays, contactors, solenoids), DC/AC motors, stepper/servo basics, proportional valves (General operating principles)
4.2 Digital versus analog actuation and output types (Switching, PWM, 0–10 V)
4.3 Drive and motor interfacing considerations: Relay isolation, contact ratings, protection (Fuses, snubbers, soft starts)
4.4 Safety interlocks, interposing relays and wiring practices
4.5 Closed-loop actuation basics: Sensor feedback, setpoint tracking, stability considerations (PID control)

**5 Human Machine Interface (5 hours)**

5.1 Purpose and role of human machine interfaces (HMI) in automation
5.2 HMI elements: Screens, mimic diagrams, alarms, trends, operator controls and security levels
5.3 Screen design principles: Clarity, ergonomics, alarm management, data validation
5.4 Communication between PLC and HMI; Tag mapping and data scaling
5.5 Recipe handling, logging, and operator workflows

**6 Supervisory Control and Data Acquisition (SCADA) (8 hours)**

6.1 SCADA architecture and components (Remote terminal unit/ PLC level, communication layer, SCADA server, HMI clients)
6.2 Data acquisition, polling strategies and time synchronization
6.3 Alarm management, event logging, historical data and trending
6.4 Network topologies, gateways and basics of industrial protocols and cyber-awareness
6.5 Remote monitoring, supervisory control, and simple reporting

**7 Industrial Applications (6 hours)**

7.1 Typical automation tasks: Sequence control, batching, motor control, material handling, level and flow control

7.2 Process examples: Temperature control loop, pump control and interlocks, conveyor sequencing and safety stops
7.3 Integration examples: Multi-device coordination, HMI/SCADA use-cases and data flows
7.4 Industry 4.0 primer - sensor data, edge acquisition, and supervisory analytics
7.5 Systematic troubleshooting methodology: Observation, isolation, testing, repair and documentation

**Tutorial** **(15 hours)**

1. Sensor selection and calibration problems
2. Ladder logic /structured text exercises: Timers, counters, arithmetic and sequence control
3. HMI screen design critique and alarm handling exercises
4. SCADA polling/archiving and basic alarm-priority design
5. Troubleshooting case studies (Wired/bus faults, signal drift, intermittent I/O, communication fault)

**Practical** **(45 hours)**

1. PLC Hardware Identification and Safety: Identification of I/O terminals, CPU status indicators, and implementation of wiring, grounding, and emergency stop procedures.
2. Digital Input Interfacing: Wiring and verification of digital sensors with PLC inputs, including software debouncing and contact simulation techniques.
3. Analog Input Scaling: Interfacing RTDs and pressure transmitters to determine scaling factors and linearization parameters within the PLC environment.
4. Signal Conditioning Analysis: Evaluation of signal conditioning circuits to determine calibration curves and measurement error correction.
5. Digital Output and Actuator Control: Implementation of relay/contactor actuation using interposing devices for high-load protection.
6. Analog Output and Proportional Control: Programming analog outputs to regulate the speed or position of actuators such as control valves and motors.
7. High-Speed Counter Applications: Utilization of high-speed counting functions for pulse/encoder input handling to determine speed and position.
8. Logic Operations and Sequencing: Development of timer and counter-based logic for process interlocks and permissive conditions.
9. Industrial Process Simulation: Design of state-machine logic for multi-step systems (e.g., conveyor belts or pick-and-place units).
10. Closed-Loop PID Tuning: Implementation of a basic PID control loop in PLC and determination of optimal tuning parameters using real-time feedback.
11. HMI Interface Design: Development of operator screens featuring alarm management, real-time trends, recipe handling and configure PLC tag communication.

12. SCADA System Configuration: Setup of supervisory data acquisition, historical logging, and system troubleshooting through recorded data analysis.

**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 | Mark distribution* |
|---|---|---|
| 1 | 4 | 6 |
| 2 | 8 | 12 |
| 3 | 8 | 10 |
| 4 | 6 | 8 |
| 5 | 5 | 6 |
| 6 | 8 | 10 |
| 7 | 6 | 8 |
| **Total** | **45** | **60** |

* There may be minor deviation in marks distribution.

**References**


1. Patranabis, D. (2012). Principles of industrial instrumentation. Tata McGraw-Hill Education.
2. Lipták, B. G. (2003). Instrument engineers' handbook: Process measurement and analysis (Latest Edition, Vol. 1). CRC Press.
3. Bolton, W. (2015). Programmable logic controllers. Newnes.
4. Petruzella, F. D. (2011). Programmable logic controllers. McGraw-Hill Education.
5. Boyer, S. A. (2010). SCADA: Supervisory control and data acquisition. International Society of Automation.
6. Ogata, K. (2010). Modern control engineering. Prentice Hall.