CONTROL SYSTEM AND AUTOMATION
ENEE 307

Lecture : 3 | **Year : III**
Tutorial : 1 | **Part : I**
Practical : 3/2

Course Objectives:
The objective of this course is to provide the principles and practices of control systems and automation. It covers fundamental concepts such as component modeling, system transfer functions and responses, performance specifications, and compensation design. The course emphasizes the analysis and design of control systems with a focus on their practical application in industrial automation and real-world physical processes.

1 Control System Background (2 hours)

- 1.1 History of control system and its importance
- 1.2 Control system: Characteristics and basic features, components and variables
- 1.3 Types of control system and their comparison

2 Component Modeling (5 hours)

- 2.1 Review of Laplace transform
- 2.2 Differential equation and transfer function notations, characteristics equation, concept of poles and Zero
- 2.3 Modeling of mechanical components: Mass, spring and damper, moment of inertia (Linear and rotational)
- 2.4 Modeling of electrical components: Inductance, capacitance, resistance, DC and AC motor, transducers and operational amplifiers, electric circuit and Transfer functions
- 2.5 Electric circuit analogies: Force-voltage and force-current
- 2.6 Linearized approximations of non-linear characteristics

3 System Transfer Function and Response (10 hours)

- 3.1 Block diagram algebra and system reduction techniques
- 3.2 Signal flow graphs and Mason’s gain formula
- 3.3 Time response analysis
  - 3.3.1 Types of test signals: Impulse, step, ramp, parabolic
  - 3.3.2 Time response analysis of first order system
  - 3.3.3 Time response analysis of second order system (Step)
  - 3.3.4 Transient response specifications: Rise time, peak time, delay time, settling time, maximum overshoot and steady state error

3.4 Static error coefficients and steady state error
3.5 P, I,D,PI, PD, PID controller and derivative feedback controller

4 Stability (4 hours)

4.1 Introduction of stability and causes of instability
4.2 Characteristic equation, root location and stability
4.3 Routh-Hurwitz (R-H) stability criterion
4.4 Setting loop gain using Routh-Hurwitz (R-H) criterion
4.5 Relative stability analysis from complex plane axis shifting

5 Root Locus and Frequency Response Techniques (10 hours)

5.1 Introduction of root locus
5.2 Relationship between root loci and time response of systems
5.3 Rules for manual calculation and construction of root locus
5.4 Stability concept from root locus
5.5 Frequency domain characterization of the system
5.6 Relationship between real and complex frequency response
5.7 Stability analysis in frequency domain: Gain margin, phase margin
5.8 Nyquist plot and criterion for stability analysis

6 Performance Specifications and Compensation Design (4 hours)

6.1 Compensation technique and compensator
6.2 Application of root locus and frequency response on control system design
6.3 Lead, lag cascade compensation design from Root locus methos
6.4 Concept of lead-lag compensator

7 Industrial Automation (10 hours)

7.1 Sensors and transducers used in industrial automation.
7.2 Principles of measurement and control; Process variables and control loops
7.3 Programming languages and concepts for PLCs
7.4 Ladder logic programming and relay-based control
7.5 Timers, counters, and arithmetic functions in PLCs
7.6 HMI design and integration with PLCs
7.7 Basics of industrial communication protocols (Modbus, Profibus)
7.8 Ethernet and TCP/IP in industrial automation
7.9 SCADA architecture and components
7.10 HMI development for SCADA systems
7.11 Real-time data acquisition and historical trending

Tutorial **(15 hours)**

1. Modeling exercises of mechanical/electrical system and analogy
2. Block diagram model development and reduction, SFG exercise
3. Time response exercise of first order and second order system and steady state error and PID
4. R-H criterion and relative stability numerical, root locus plot
5. Polar and Nyquist plot, Bode plotting and stability analysis in frequency domain
6. Compensator design exercises from Root locus and Bode plot approach for lead and lag compensator
7. Simulation and programming exercises on PLC-based process control including sensor input handling, ladder logic development, timer/counter functions, HMI visualization, and SCADA data monitoring in a simulated industrial automation environment

Practical **(22.5 hours)**

1. Study of open loop and closed mode for DC motor and familiarization with different components in DC motor control module.
2. Determination of gain and transfer function of different control system components
3. Study the effects of feedback on gain and time constant for closed loop speed control system and position control system
4. Determination of frequency response of first order and second order system and to get transfer function
5. Simulation of closed loop speed control system and position control system and verification
6. Simulation of Motor control and Monitoring using PLC, HMI, and SCADA

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	5	8
3	10	12
4	4	4
5	10	12
6	4	8
7	10	12
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Ogata, K. (2009). Modern Control Engineering. Pearson
2. Kuo, B. C. (2015). Automatic Control System. Willey India.

3. Nagrath, I.J., Gopal, M. (2021) Modern Control Engineering. New Age International.
4. Hassan, S. (2013). Automatic Control System. Arihant.
5. Akande, O. (2023). Industrial Automation from Scratch: A hands-on guide to using sensors, actuators, PLCs, HMIs, and SCADA to automate industrial processes. Packt Publishing.
6. AlMadhoun, A. S. (2025). PLC SCADA for Beginners: Understanding and Implementing Industrial Automation Systems. Apress.