Title: Linear Control Systems

Code Number: EE3203

Credit Hours: 3 (3+1)

Prerequisites: NS1204 Complex Variables & Transforms,

EE2101 Electrical Network Analysis, EE2201 Signals and Systems

Semester: 5th

Course Objectives

The course will enable students to:

1. Analyze control systems using frequency and time-domain modeling techniques, including the use of transfer functions and state-space representations.
2. Evaluate the stability and performance of linear systems using methods such as Routh-Hurwitz criterion, root locus techniques, and frequency response techniques
3. Design compensators, including lead-lag and PID controllers, to enhance the transient and steady-state performance of control systems.
4. Demonstrate control systems using physical hardware setups to analyze their transient and steady state responses and validating theoretical models with experimental data.
5. Perform modeling, simulation, and analyzing control systems utilizing software tools.

Contents

Unit 1: Introduction to Control System

1. Introduction to control system and its performance parameters
2. Open loop and closed loop control system
3. Objectives for analyzing and designing control system

Unit 2: Modeling in the Frequency Domain

1. System models
2. Transfer function modeling
3. Developing transfer functions using Laplace Transform of Electrical Circuits,
4. Translational and rotational mechanical systems
5. Demonstrate the transfer function of DC motor

Unit 3: Modelling in the Time domain

1. Time-domain modeling
2. State variables, state equations and output equations
3. State Space representation to model electrical and mechanical systems
4. Carry out conversion of a transfer function to state space model
5. Carry out conversion of a state space model to transfer function

Unit 4: Reduction of Multiple Sub-Systems

1. Block diagram reduction for sub systems
2. Different configurations used in reduction
3. Signal Flow Graphs
4. Mason's rule to simplify signal flow graph to single transfer function

Unit 5: Transient Response of a System

1. System response using Pole Zero Diagram
2. Transient response of first order Systems
3. Transient response of Second Order Systems
4. Transient response of Under damped second order systems

Unit 6: Stability of Linear System

1. Stability of a linear system
2. Difference between stability of linear and non-linear systems
3. Routh-Hurwitz criterion to check stability of a linear system
4. Analyzing the stability of a linear systems
5. Analysis of special stability cases

Unit 7: Steady State Errors

1. Steady State Errors
2. Steady State errors for unity feedback systems
3. System types based on integrators and analyzing the steady-state error using these types.

Unit 8: Root Locus Techniques

1. Root locus
2. Rules to sketch root locus and analyze the system stability

Unit 9: Frequency Response Techniques

1. Bode plot and Nyquist plot to sketch frequency response of a system
2. Analyzing the system stability using Nyquist criterion of stability

Unit 10: Compensator Design

1. Designing Lead-Lag compensators to improve the transient and steady- state error of a system
2. Designing a PID controller to improve the transient and steady-state error of a system

Lab Work Outline:

In this lab, students will explore both hardware and software aspects of linear control systems. Hardware experiments include DC motor speed and position control, frequency response analysis, and stability tests using root locus plots. Software tasks involve Matlab/Simulink for modeling, simulating, and designing PID controllers, conducting frequency response and Bode plot analysis, and generating root locus plots. The lab integrates hardware and software for real-time control system implementation and advanced control strategies, offering a comprehensive hands-on learning experience.

Teaching-Learning Strategies:

The pedagogical approach to this course relies on face-to-face teaching in a university classroom environment. The lectures are delivered using multimedia support and on white board. Students are engaged and encouraged to solve real world problems using computer-aided tools.

Assignments/Types and Number with calendar:

A minimum of four assignments to be submitted before the written exams for each term.

Assessment and Examinations:

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2.	Sessional Assessment	25%	It is continuous assessment. It includes classroom participation, attendance, assignments and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Recommended Books:

1. Norman S. Nise, Control Systems Engineering, 6th Ed. 2016.
2. Richard C. Dorf and Robert H. Bishop, Modern Control Systems, 13th Ed. 2016.
3. K. Ogata, Modern Control Engineering, 5th Ed.