ECE 4413 / AME 4383

Control Systems Engineering

Instructor: Sesh Commuri

Prerequisites
ECE: ECE3793
AME: AME2533, MATH3113

Syllabus

1. Introduction to Control Systems (1 hours)
   - What is control?
   - Open Loop versus Closed Loop Control
   - Examples of Control Systems
     i. Speed Control (Watts Speed Governor)
     ii. Robot Control
     iii. Flight Control

2. Elements of Computer Control (1 hours)
   - Sensors
   - Actuators
   - Servo Amplifiers and Computers in Control
   - Control Requirements (Bandwidth, Settling Time, Cost Considerations)

3. Review of Mathematical Concepts (3 hours)
   - Laplace Transforms
   - Inverse Laplace Transforms
   - Solution of LTI Differential Equations
   - Basic MATLAB Operations

   - Transfer Functions and Impulse-Response Functions
   - Concept of Poles and Zeros
   - Modeling of Sensors
   - Modeling of Actuators
   - Block Diagram Representation of Systems
   - Simplification of Block Diagrams
   - State-Space Representation of Systems
   - Eigenvalues and Eigenvectors
   - Axes Systems and Notation, Translation, Rotation
   - Robot Modeling (Planar 2-DOF)
   - Aircraft Modeling
     i. Longitudinal Dynamics
        ➢ Longitudinal Characteristic Equation
        ➢ Short-period pitching oscillation
        ➢ Phugoid Mode
     ii. Lateral Dynamics
        ➢ Lateral Direction Characteristic Equation
        ➢ Roll-Subsidence Mode
        ➢ Spiral Mode
        ➢ Dutch-Roll Mode
5. Transient and Steady-State Response Analysis (12 hours)
   - First-Order Systems
   - Second-Order Systems
   - Third-Order Systems
   - Response Characteristics Using MATLAB
   - Steady-State Errors in Unity Feedback Systems
   - Effects of P-I-D Control Actions on System Performance
   - Handling Qualities of Aircraft
     i. Longitudinal Flying Qualities
     ii. Lateral-Direction Flying Qualities
     iii. The influence of Feedback

6. Frequency Response Analysis (9 hours)
   - Bode Diagrams and Plotting using MATLAB
   - Polar Plots and Plotting using MATLAB
   - Nyquist Stability Criteria
   - Stability Analysis
   - Relative Stability
   - Experimental Determination of Transfer Functions

7. Compensator Design (6 hours)
   - Lead Compensation
   - Lag Compensation
   - Lag-Lead Compensation

8. Discrete-Time Control (3 hours)
   - Difference Equations
   - Z transforms
   - Stability Analysis in Z Domain
   - Implementation of Digital Controllers

9. Practical PID Control (3 hours)
   - Tuning Rules for PID Controllers
   - Integrator Anti-Windup Control
   - Real-Time Considerations

   Exams (3 hours)

Total = 47 hours

Recommended Text

References

Schedule
2 Lectures per week; 1 hour 15 minutes per Lecture.

Assessment Methods Used
5 Assignments contributing to 10% of the final grade.
4 Quizzes contributing to 10% of the final grade.
1 Term Project contributing 20% of final grade.
2 Mid-Term Exams contributing to 30% each of the final grade (best of two).
1 Final Exam (Comprehensive) contributing to 30% of the final grade.