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
4. Mathematical Modeling of Dynamic Systems (6 hours)
    - 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

1. Control Systems Engineering, Nise, John Wiley, 2000.

References

1. Modern Control Systems, Richard Dorf, Robert Bishop, Prentice Hall, 2001.
2. Modern Control Engineering, Katsuhiko Ogata, 4th ed., Prentice Hall, 2002.
3. Dynamics of Flight: Stability and Control, B. Etkin, John Wiley and Sons, 1982.
4. Flight stability and Automatic Control, Robert Nelson, McGraw-Hill, 1998.
5. MATLAB programming for Engineers, Stephen Chapman, Brooks/Cole, 2002.

Schedule

2 Lectures per week; 1hour 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.