ECE 411: Control Systems

IN

Signals and Systems

- Understand basic signals: impulses, steps, sinusoids, exponentials
- Understand both real and complex valued signals, particularly exponentials
- Perform basic signal manipulations: scaling, translation, reflection, time shift
- Decompose signals into basic elements (steps, ramps, etc.)
- Understand basic concepts of Linear Time-Invariant (LTI) Single-Input-Single-Output (SISO) systems
- Apply principle of superposition

Transform Methods

- Analyze signals via Fourier Transform (forward and inverse using tables) for frequency content
- Understand properties of Fourier Transform, especially time-domain convolution versus frequency domain multiplication
- Analyze causal signals via one-sided Laplace Transform (forward and inverse tables)
- Understand properties of Laplace Transform, especially time-domain convolution versus frequency domain multiplication AND final value theorem for steady state analysis

Linear Systems

- Understand basic concepts for SISO LTI systems, including linearity, time-invariance, memory, causality, stability
- Manipulate and solve ordinary differential equations (ODEs)
- Compute transfer functions
- Compute time domain convolution
- Switch between the above system representations (ODE, transfer function, and convolution representation (via impulse response))

Pre-requisites

- ECE 312 with a minimum grade of C

Concepts:

- Open and Closed-Loop Systems
- Performance in both Time and Frequency Domain
- Transient and Steady State Response
- Connections between Time-Domain, Frequency Domain, and Pole/Zero Location in both Open and Closed-Loop
- Nyquist Stability Criterion
- Stability Margins (Gain and Phase) and their relation to Nyquist and Bode Plots
- Pole/Zero Location and the Effects of Feedback (root locus plots)
- Controller Design via classical methods
- Integral action and PID controllers
- State Space approaches

Applications:

- Stability and performance analysis for open and closed loop systems
- Feedback controller design

Tools:

- Complex Algebra and Analysis
- Ordinary Differential Equations
- Laplace and Fourier Transforms
- MATLAB and Simulink, plus Toolboxes (control, signal processing, symbolic)
- Graphical Techniques (Bode plots, Nyquist plots, root locus plots)

OUT

Classical Closed-Loop Analysis

- Compute steady state performance for close-loop systems via final value theorem
- Understand concept and utility of integral action
- Understand concepts of time-constant, damping ratio and natural frequency
- Compute transient response parameters (overshoot, rise time, settle time), impulses, step, and ramp response
- Compute stability margins via Nyquist/Bode analysis
- Check stability via Routh test
- Check for stability via Nyquist/Bode plots
- Check for stability via root locus plot
- Understand connection between open and closed loop
- Understand connections between Time-Domain, Frequency Domain, and Pole/Zero Location

State Space Representation

- Switch between state space system representation and ODE, transfer function, impulse response
- Construct state and simulation diagrams (for implementation)
- Solve systems of state space equations
- Understand connection between system poles and state matrix eigenvalues

Controller Design

- Design lag, lead, and lag-lead controllers
- Design PI, PD, and PID controllers
- Design controllers using Nyquist/Bode plots and root locus approaches
- Design controllers using analytic approach

Computer Aided Tools

- Perform all calculations above by hand (for simple systems)
- Perform all calculations above in MATLAB, including command-line and GUI based tools (ltiview, sisotool)
- Write custom m-files for controller analysis and design
- Develop Simulink models for analysis and simulation

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