ECE 412: Digital Control and Digital Filters

IN

Transform Methods

- Can analyze causal signals via one-sided Z Transform (forward and inverse using tables)
- Understand properties of Z Transform, especially time-domain convolution versus frequency domain multiplication AND final value theorem for steady state analysis
- Understand use and properties of Discrete-Time Fourier Transform for frequency content of digital signals, particularly time domain convolution versus frequency domain multiplication
- Understand concept of aliasing for discrete-time frequency response

Linear Systems

- Can manipulate and solve ordinary difference equations (ODEs)
- Can compute via (pulse) transfer functions
- Can compute time domain convolution
- Can switch between the above system representation (ODE, transfer function, and convolution representation (via impulse response))

Control Systems

- Understand Nyquist/Bode and Root Locus plots and their relation to stability analysis
- Can analyze system stability and compute stability margins (gain and phase)
- Can analyze closed-loop system steady state and transient response using classical tools (Routh/Nyquist/Bode/Root Locus/Final Value Theorem
- Can design Lag, Lead, Lag-Lead, PI, PD, PID controllers
- Can formulate and solve state space systems, and switch to other representation (transfer function)
- Can utilize Matlab and Simulink for controller analysis, simulation, and design

Filters

- Understand basic filtering concepts
- Can design standard analog filters

Pre-requisites:

- ECE 411

Concepts:

- Sampling and reconstruction for signals and systems
- Nyquist sampling rate and aliasing
- Sampled data control systems
- Zero order hold equivalence
- 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
- Bilinear and impulse invariant transformations
- IIR and FIR digital filters

Applications:

- Stability and performance analysis for open and closed loop digital and sampled-data systems
- Digital feedback controller design
- Numerical approximation and mappings from continuous to discrete-time
- Digital filter design

Tools:

- Complex Algebra and Analysis
- Ordinary Difference Equations
- Series and sequences
- Z Transform and starred transform (and Discrete Time Fourier Transform)
- Matlab and Simulink, plus Toolboxes (control, signal processing, symbolic)
- Graphical Techniques (Bode plots, Nyquist plots, root locus plots

OUT

Classical Closed-Loop Analysis

- Can compute zero order hold equivalent system
- Can map sampled data to equivalent digital system
- Understand mappings from s-plane to z-plane
- Can compute steady state performance for closed-loop systems via final value theorem
- Can compute transient performance parameters
- Can compute stability margins via Nyquist/Bode analysis
- Can check stability via Routh/Jury test, Nyquist/Bode plots, and/or root locus plot

State Space Representation

- Can switch between state space system representation and ODE, (pulse) transfer function, pulse response
- Can construct state and simulation diagrams (for implementation)
- Can solve system of state space equations

Controller Design

- Can design lag, lead, and lag-lead controllers, PI, PD, and PID controllers
- Can design controllers using Nyquist/Bode, root locus, and analytic approaches
- Can design controllers via mapping from continuous time
- Can design controllers via direct digital design

Filter Design

- Can design Butterworth, Chebyshev, Elliptic, and Bessel filters
- Can design low pass, high pass, band pass, and band stop filters
- Can design filters via mapping from continuous time
- Understand basic concepts of IIR, FIR filters
- Understand basic approaches to direct digital design

Computer Aided Tools

- Can perform all calculations above by hand (for simple systems)
- Can perform all above calculations in Matlab
- Can develop Simulink models for analysis and simulation

As of 12/9/08