ECE 312: Linear Systems Analysis II

IN

Signals

- Understand standard test signals in continuous-time and discrete-time and their connections via sampling
- Understand periodicity and compute the period of a periodic signal
- Understand energy and power and compute them

Fourier Analysis

- Understand frequency harmonics and spectrum, and bandwidth of signals
- Compute Fourier transforms and Fourier series for standard signals
- Understand the impact of elementary transformations on the spectrum of a signal

LTI Systems

- Understand causality, stability, and their connections with impulse response
- Understand linearity and time invariance
- Understand convolution and compute the response of an LTI system to an arbitrary input
- Understand complex exponentials as eigenfunctions of LTI systems
- Understand frequency response of an LTI system and compute magnitude and phase spectra
- Understand the interplay between time domain and frequency domain analyses of LTI systems

Sampling

- Understand Shannon-Nyquist sampling theorem
- Understand the consequences of aliasing
- Specify anti-aliasing filter and sampling rate for alias-free A/D conversion

Simulation

- Analyze systems in time and frequency domain using MATLAB and/or Simulink tools

Pre-requisites

- ECE 311 with a C or higher

Concepts:

- Laplace transform and its use in analyzing continuous-time LTI systems
- Connection between Laplace transform and Continuous-time Fourier transform
- z-transform and its use in analyzing discrete-time LTI systems
- Connection between z-transform and discrete-time Fourier transform
- Transfer functions, poles, and zeros of continuous-time and discrete-time LTI systems
- Connection between transfer functions, frequency response, impulse response, and ODE representations of continuous-time and discrete-time LTI systems
- Connection between stability and causality and pole locations
- Block diagram representation and series and parallel interconnection of continuous-time and discrete-time LTI systems
- Analog filters, including Butterworth and Chebyshev filters
- Design of digital IIR filters via bilinear transform
- Connection between the spectrum of a continuous-time signal and the Fourier transform of its samples
- Amplitude modulation (AM) and frequency modulation (FM)
- Thermal noise, autocorrelation, and power spectral density of WSS random processes
- Analysis of noise through LTI system

Applications:

- Communication
- Signal Processing
- Control
- Circuits
- Optics

Tools:

- MATLAB - Optional

OUT

Laplace Transform for LTI Systems

- Calculate Laplace transforms and inverse Laplace transforms for standard signal-transform pairs
- Understand the difference between Laplace transform and Continuous-time Fourier transform and their connection
- Derive the transfer function of a continuous-time LTI system from its ODE representation and vice versa
- Derive the response of a continuous-time LTI system to an input using Laplace transform
- Understand the impact of poles and zeros of the transfer function on stability, causality, and the behavior of an LTI system

Z-transforms for LTI Systems

- Calculate z transforms and inverse z transforms for standard signal-transform pairs
- Understand the difference between z transform and Discrete-time Fourier transform and their connection
- Derive the transfer function of a discrete-time LTI system from its ODE representation and vice versa
- Derive the response of a discrete-time LTI system to an input using z transform
- Understand the impact of poles and zeros of the transfer function on stability, causality, and the behavior of an LTI system

Filtering and Modulation

- Analyze and design first- and second-order analog filters
- Analyze and design Butterworth and Type-I Chebyshev filters
- Derive IIR digital filters from analog filters via bilinear transform
- Understand the basics of AM and FM radio

From CTFT to FFT and Back

- Understand the connection between an FFT computed from samples and the spectrum of the corresponding continuous-time signal
- Understand the impact of finite observation time on spectrum estimation

Noise Through LTI Systems

- Understand WSS processes, autocorrelations, and power spectral densities
- Determine the autocorrelation and power spectral density at the output of an LTI system in response to white noise
- Understand the relation between bandwidth, noise power, and signal-to-noise ratio

Revised 4/2019