ECE 5604 Computer-Aided Design and Analysis of Communication Systems

Return to course list

ECE 5604 Computer-Aided Design and Analysis of Communication Systems (3C)

Simulation techniques for communication systems operating in random environments. Simulation models for stochastic signals and system components including coders, decoders, modulators, non-linear amplifiers, bit and carrier synchronizers, equalizers and receivers. Techniques for modeling time-varying channels. Monte Carlo simulation, semi-analytic simulation and variance reduction techniques applied to the analysis, design and performance evaluation of communication systems.

What is the reason for this course?

Basic courses in both analog and digital communication theory only consider highly idealized communication systems since, because of the stochastic nature of the communications channel, it is only these systems that are analytically tractable. These idealized systems are characterized by linear models and AWGN (additive, white Gaussian noise) channels. Because of both the complexity of modern communications systems, and the stochastic environment in which modern systems are required to operate, some level of computer support is almost always needed for the design, analysis and performance evaluation of these systems. This computer support almost always takes the form of simulation. Properly developed simulations provide the communications engineer with tools necessary for gaining insight into the behavior of complex systems and for using simulation as an effective design, analysis and performance evaluation tool. An understanding of the underlying concepts of stochastic simulation allows one to apply the proper ‚Äúsanity checks‚Äù to simulation results so the user can have confidence in the simulation results and use the results effectively in the system design process. Many graduate students in communications, as well as in other areas of electrical and computer engineering, use simulation in the development of their thesis and dissertation projects. This course directly supports those activities.

Typically offered: Fall. Program Area: Communications.

Prerequisites: 4624, 4634, STAT 4714. Co: 5605.

Why are these prerequisites or corequisites required?

In order for students to understand stochastic simulation and the application of stochastic simulation techniques to the design and analysis of communication systems, students must have a background in statistics (STAT 4714), basic communications (4634), and digital signal processing (4624). The student must also have good programming skills. ECPE 5605 is a co-requisite because it provides basic knowledge of stochastic process paralleled with class material.

Department Syllabus Information:

Major Measurable Learning Objectives:

- determine the necessary sampling rates for required signal-to-aliasing error ratios for different pulse shapes

Spring 2010 textbook list

The Spring 2010 ECE textbook list is available online for students.

Current Prerequisites & Course Offering

For current prerequisites for a particular course, and to view course offerings for a particular semester, see the Virginia Tech Course Timetables.

- develop simulation models for non-linear systems, time-varying systems, systems with memory and for systems involving feedback
- represent band-pass stochastic signals using low-pass direct/quadrature models and to develop efficient software structures and simulations based on these models
- design noise generators based on congruence algorithms or PN sequence generators that satisfy given probability density function or power spectral density requirements
- develop simulation models of key communication system components such as coders, modulators and transmitters, carrier and symbol synchronizers, and receivers
- develop simulation models for channels that involve not only thermal noise but also fading, multipath, and interference
- develop Monte Carlo simulations of basic communication systems and to use the resulting simulations to parameterize and enhance system performance.
- to partition design and analysis problems into a set of problems that are analytically tractable and into a set of problems requiring some level of computer support and to develop efficient simulations combining these problem sets (semi-analytic simulations).

Course Topics

Topic	Percentage
Introduction to Simulation Methodologies (Motivation, basic techniques)	2%
Review of Digital Communication System Concepts (Basic modulation, ML and MAP receivers, signal space, Euclidean distance and error probability, union bound)	6%
Sampling, Pulse Shaping and Discrete System Theory (Sampling, ailiasing and finite wordlength effects, the z-transform and discrete system theory)	4%
Filter Models and Efficient Simulation Techniques (IIR and FIR structures, discrete integration, the bi-linear z-transform, noise bandwidth of discrete-time structures)	8%
Signal and System Representations (Hilbert transforms, analytic signals, complex envelopes, direct/quadrature representations of systems, direct/quadrature represetnations of random bandpass signals, simulation structures of bandpass systems)	10%
A Noiseless Case Study ‚Äö?Ñ?¨ The Phase Locked Loop (PLL architectures, component models, modeling errors and approximations, performance characterization for both tracking (linear) and acquisition (non-linear) operation)	6%
Noise Generation and Modeling (Congruence algorithms, PN sequence generators, testing uniform number generators, mapping to target probability density functions, mapping to target power spectral densities)	8%
Graphical Simulation Products (Signal constellations, D/Q signal plots and eye diagrams, phase-plane plots, probability density function estimation and histograms, power spectral density estimation)	8%
Fundamentals of Monte Carlo Estimation (Parameter estimation, point and interval estimates, biased and un-biased estimates, consistent estimates)	4%
Monte Carlo Simulation of Communication Systems (Binary systems, M-ary systems, simulation architecture, interpretation of simulation results and sanity checking)	8%
Semi-Analytic Simulation Techniques (Motivation, simulation architecture, methodology)	8%
Simulation Techniques for Non-linear and Time-Varying Systems (Complex envelope memoryless systems, AM/AM	12.

Course Topics

Topic	Percentage
conversion, AM/PM conversion, time-varying system models)	8%
Advanced Channel Models	10%
Variance Reduction Techniques	10%