ELEC5508 / ELG6358

Advanced Methods for Simulation of Large-Scale Circuits and Systems

Fall Term

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Course Web-site: **Elec5508 Fall Term 2024 link in Carleton Brightspace**

Analog circuit simulators form the backbone of the rapidly growing semiconductor industry, enabling the designers to design and validate large scale circuits prior to fabrication. If not designed and validated properly, the resulting fabricated chip may become inoperable, or they can distort an analog signal such that it fails to meet specifications. Since extra iterations in the VLSI design cycle are extremely costly, properly designed analog circuit simulators and their understanding become very important for both the developers of CAD tools as well as to the designers of these circuits/systems. This course is intended for both the developers and users of CAD tools and circuit/system designers. The application of the course material spans a wide spectrum of engineering fields.

Course Objectives and Overview

1) To understand the modules and fundamentals of Analog Circuit Simulators such as SPICE (or equivalent ones such as HSPICE, SPECTRE, ELDO, etc.).
2) To become conversant with various analysis methods such as frequency domain analysis and time-domain analysis, as applicable to linear and nonlinear circuits.
3) To design and build prototype analog circuit simulators.
4) To understand model-order reduction techniques to facilitate efficient simulation of large-scale analog VLSI circuits
5) To understand the issues and limitations that designers face while using analog circuit simulators.

Course Content

The first part of the course covers the basic principles of circuit simulation. The second part focuses on advanced analysis techniques. Following is a broad outline of the materials proposed to be covered in this course:

Frequency-Domain:

- *Modified-Nodal Analysis*
- *LU decomposition, Sparse techniques*
- *Stability and Passivity*

Linear Time-Domain:

- *Solution of Large-Scale Differential Equations*
- *Multi-step methods*
- *Numerical stability*

Model-Order Reduction:

- *Moments matching*
- *Pade' approximation*
- *Asymptotic Waveform Evaluation*
- *Projection Techniques*
- *QR decomposition*
- *Krylov subspace*
- *Arnoldi algorithm*
- *Passivity preservation*

Nonlinear Time-Domain:

- *Jacobian matrix,*
- *Newton's iterations*

Multiport MOR

- *Macromodelling*
- *Recursive convolution*
- *Block Arnoldi*

Grading:

80% Assignments
20% Final Exam

Pre-requisites:

Familiarity with the basic concepts in circuit theory, analysis and design, linear algebra and calculus.

References:

(1) Computer Methods for Circuit Analysis & Design
J. Vlach and K. Singhal, Van Nostrand Reinhold 1983/ 1994

(2) Electronic Circuit and Simulation Methods
L. Pillage, R. Rohrer, C. Visweswariah, McGraw-Hill 1995

(3) Circuit Simulation
F. Najm, Wiley, 2010.

(4) Asymptotic Waveform Evaluation and Moment Matching for Interconnect Analysis
Eli Chiprout and Michel Nakhla, Kluwer Academic Publisher 1994

(5) IC Interconnect Analysis:
M. Celik, L. Pileggi and A. Odabasioglu, Kluwer Academic Publisher 2004

(6) Simulation of High-Speed Interconnects:
R. Achar & M. Nakhla, Proceedings of the IEEE, May 2001

+ **Handouts**