

ECE-1777: Computer Methods for Circuit Simulation

Instructor: Farid N. Najm, (416) 946-5175, f.najm@utoronto.ca, office in LP-484D.

Web Site: www.eecg.utoronto.ca/~najm

Prerequisites:

ECE-212 and Math-298, or equivalent (Circuit theory, matrices and linear algebra).

Other useful background: linear systems, numerical analysis, computer programming.

General Description: Circuit simulation is a very commonly used technique for analysis and verification of electronic and electric circuits, ranging from integrated circuits and microelectronics to power distribution networks and power electronics. It is both an established art and an important area of further research. This course covers the theoretical background for modern circuit simulation, as well as the numerical techniques that are at the core of typical circuit simulators.

<u>Topic</u>	<u>Topical Outline</u>	<u>Reading</u>	<u>Assignment(s)</u>
I. Introduction			
01.	Circuit Simulation		
II. Network Equations			
02.	Elements and Networks		
03.	Topological Constraints		
04.	Cycle Space and Bond Space		
05.	Formulation of Linear Algebraic Equations		
06.	Formulation of Linear Dynamic Equations		
III. Solution of Linear Algebraic Equations			
07.	Direct Methods		
08.	Indirect/Iterative Methods		
09.	Partitioning Techniques		
10.	Sparse Matrix Techniques		
IV. Solution of Nonlinear Algebraic Equations			
11.	Formulation of Nonlinear Network Equations		
12.	Solution Techniques		
13.	Application to Circuit Simulation		
V. Solution of Differential Equations			
14.	Formulation of Differential Network Equations		
15.	Solution Techniques		
16.	Application to Circuit Simulation		
VI. Conclusion			
17.	Circuit Simulation		

Grading: The course mark will be based on 8 homework assignments, 3 computer projects, a mid-term exam, and a final exam.

Textbook: none required, but two are recommended:

- L. T. Pillage, R. A. Rohrer, and C. Visweswaraiiah, *Electronic Circuit and System Simulation Methods*, McGraw Hill, NY, 1995 [ISBN: 978-0-07-134770-9].
- J. Vlach and K. Singhal, *Computer Methods for Circuit Analysis and Design*, 2nd Ed., Van Nostrand Reinhold Co., NY, 1994, reprint: Kluwer Academic Publishers, Norwell, MA, 2003 [ISBN: 0-442-01194-6].

Other References:

- L. O. Chua and P-M. Lin, *Computer-Aided Analysis of Electronic Circuits: Algorithms and Computational Techniques*, Prentice-Hall Inc., Englewood Cliffs, NJ, 1975 [ISBN: 0-13-165415-2].
- W. J. McCalla, *Fundamentals of Computer-Aided Circuit Simulation*, Kluwer Academic Publishers, Norwell, MA, 1988 [ISBN: 0-89-838248-3].
- K. S. Kundert, J. K. White, and A. L. Sangiovanni-Vincentelli, *Steady-State Methods for Simulating Analog and Microwave Circuits*, Kluwer Academic Publishers, Norwell, MA 1990 [ISBN: 0-79-239069-5].
- T. A. Davis, *Direct Methods for Sparse Linear Systems*, SIAM, Philadelphia, PA, 2006 [ISBN: 0-89871-613-6].
- I. S. Duff, A. M. Erisman, and J. K. Reid, *Direct Methods for Sparse Matrices*, Oxford University Press, New York, NY, 1986 [ISBN: 0-19-853421-3].
- N. J. Higham, *Accuracy and Stability of Numerical Algorithms*, 2nd Ed., SIAM, Philadelphia, PA, 1996 [ISBN: 0-89871-521-0].
- G. H. Golub and C. F. Van Loan, *Matrix Computations*, 2nd Ed., The John Hopkins University Press, 1989 [ISBN: 0-8018-3772-3].
- R. A. Horn and C. R. Johnson, *Matrix Analysis*, Cambridge University Press, New York, NY, 1985 [ISBN: 0-521-30586-1].
- R. A. Horn and C. R. Johnson, *Topics in Matrix Analysis*, Cambridge University Press, New York, NY, 1991 [ISBN: 0-521-30587-X].
- R. G. Bartle, *The Elements of Real Analysis*, 2nd Ed., John Wiley & Sons, New York, NY, 1976 [ISBN: 0-471-05464-X].
- J. E. Dennis, Jr. and R. B. Schnabel, *Numerical Methods for Unconstrained Optimization and Nonlinear Equations*, SIAM, Philadelphia, PA, 1996 [ISBN: 0-89871-364-1].
- U. M. Ascher and L. R. Petzold, *Computer Methods for Ordinary Differential Equations and Differential-Algebraic Equations*, SIAM, Philadelphia, NJ, 1998 [ISBN: 0-89-871412-5].
- J. D. Lambert, *Numerical Methods for Ordinary Differential Systems: The Initial Value Problem*, John Wiley & Sons Ltd., Chichester, UK, 1991 [ISBN: 0-471-92990-5].
- L. F. Shampine, *Numerical Solution of Ordinary Differential Equations*, Chapman & Hall, NY, 1994 [ISBN: 0-412-05151-6].
- A. Berman and R. J. Plemmos, *Nonnegative Matrices in the Mathematical Sciences*, SIAM, Philadelphia, PA, 1994 [ISBN: 0-89871-321-8].
- Y. Saad, *Iterative Methods for Sparse Linear Systems*, 2nd Ed., SIAM, Philadelphia, PA, 2003 [ISBN: 0-89871-534-2].
- A. Ralston and P. Rabinowitz, *A First Course in Numerical Analysis*, 2nd Ed., Dover Publications, Inc., Mineola, NY, 2001 [ISBN: 0-486-4145-X].
- R. L. Burden and J. D. Faires, *Numerical Analysis*, 8th Ed., Thomson Books/Cole, Belmont, CA, 2005 [ISBN: 978-0-534-39200-0].
- J. Ogrodzki, *Circuit Simulation Methods and Algorithms*, CRC Press, Boca Raton, FL, 1994 [ISBN: 0-8493-7894-X].
- G. Dahlquist and Å. Björck, *Numerical Methods in Scientific Computing*, Vol. I, SIAM, Philadelphia, PA, 2008 [ISBN: 978-0-898716-44-3].
- D. A. Calahan, *Computer-Aided Network Design*, Revised Edition, McGraw-Hill, Inc., New York, NY, 1972 [ISBN: 07-009601-5].