Tutorial T3a
CAD of RF Communication Systems: Techniques and Challenges

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This tutorial will cover verification methods for wireless communication systems, with emphasis on analog and RF functionalities. Modern communication systems combine digital functions (e.g., coding, detection, channel equalization) with analog processing (e.g., filtering, modulation/demodulation), often within a single chip. This diversity of domains makes the verification problem complicated, with the analog RF sections being particularly challenging. Traditional SPICE-like tools for analog verification, though invaluable for general analog design, have some basic inadequacies that limit their application to RF blocks.

We will review the essentials of SPICE's algorithms, discuss their strengths and weaknesses, and look at frequency-domain alternatives to SPICE. We will explain why traditional RF design methodologies are no longer adequate for today's designs. The main body of the tutorial will cover recent techniques and tools for meeting new verification challenges resulting from RF integration. We will present the fundamentals of fast steady-state computation techniques, multi-time simulation methods, mixing/phase noise concepts and algorithms, automated macromodel generation for higher level verification, and methods for crosstalk and digital switching interference prediction. We will conclude by identifying remaining challenges and opportunities. This tutorial will enable engineers to make informed choices of tools and methods for RF design, in addition to providing a foundation in RF CAD algorithms for researchers and tool developers.

Laurence Nagel obtained his BS, MS, and PhD degrees at the University of California at Berkeley, where he developed the well-known SPICE circuit simulation program in 1972. After receiving his doctoral degree, Dr. Nagel joined AT&T Bell Laboratories, where he worked for over 20 years. His activities there included the development of the ADVICE circuit simulator; development of a number of process and device simulation tools and the Kull-Nagel bipolar model; design of analog circuits for submicron NMOS processes; service in the Intellectual Property Division asserting patents and negotiating patent licenses; and managing the development of the Celerity circuit simulation program. Dr. Nagel left Bell Labs in 1994 to join Anadigics, Inc., as Director of CAD. His activities there included the simulation of RF integrated circuits; modeling and characterization of GaAs MESFET device processes; investigating anomalous behavior of GaAs devices; and offering training courses for designers. Dr. Nagel is now an independent consultant.

Jaijeet Roychowdhury obtained his B.Tech. degree from IIT Kanpur in 1987, and his PhD degree from the University of California at Berkeley in 1992. From 1992 to 1995, he was with the CAD Laboratory of AT\&T Bell Laboratories in Allentown, PA; since 1995, he has been with the Communication Sciences Research Division of Lucent Technologies' Bell Laboratories in Murray Hill, NJ. Dr. Roychowdhury has received several international awards for his research on analog and RF verification. Currently, his interests are in multi-time simulation, reduced-order modelling and noise issues in communications design.