Guest Editorial
Microwave Computer-Aided Design

THE INCREASING complexities of modern microwave and millimeter-wave components, circuits, and systems, particularly in monolithic integrated circuit form, have made the use of computer-aided design tools necessary for microwave and millimeter-wave engineers. Some of the CAD programs for microwave circuits have been around for almost two decades, and have reached a certain level of maturity. Most of the earlier CAD tools were developed primarily for the design of hybrid MIC's and have been used extensively for that purpose. However, a recent spurt of interest in monolithic microwave integrated circuits has brought out the need for a new generation of more accurate CAD tools. There are several reasons for this increased demand for accuracy in the design software. First, the limited post fabrication adjustment capability available in hybrid MIC's is absent altogether in the monolithic fabrication. As the repeated experimental iterations are prohibitively costly and time consuming, the ideal CAD software's aim is an ability to design a circuit that will meet the specifications on the first attempt! Another major change in the design philosophy is caused by the smaller physical size of GaAs monolithic circuits. In order to increase the yield to reduce the cost, it is desirable to pack the monolithic circuits in as small an area as possible. This causes an increased proximity coupling between various parts of the circuit. Adequate ways for modeling and analyzing the effects of these couplings need to be incorporated in the design software. Electromagnetic analysis problems to account for couplings via substrate and/or package modes are not trivial.

Keeping the timely interest in the microwave CAD development in mind, the MTT Technical Committees on CAD (MTT-1) and on Microwave Field Theory (MTT-15) cosponsored a workshop on "Trends in Microwave CAD" in conjunction with the 1986 International Microwave Symposium at Baltimore. The program consisted of talks by seven speakers. These talks were tutorial presentations on the state of the art in various aspects of microwave CAD such as CAD for monolithic circuits, linear and nonlinear MESFET models, numerical techniques for characterization of passive structures, nonlinear circuit design, and CAD for microstrip antennas. This workshop was followed by a more specialized workshop on "Nonlinear CAD and Modeling," held in conjunction with the 1987 International Microwave Symposium at Las Vegas. In view of the overwhelming response to these two workshops, another specialized workshop on "CAD-Oriented Characterization of Discontinuities in Microstrip Lines" is being planned in conjunction with the 1988 MTT Symposium in New York.

Ideas for this Special Issue emerged from the discussions following the 1986 CAD workshop in Baltimore. The Special Issue is being cosponsored by three of the MTT Technical Committees: MTT-1, MTT-6 (Microwave and Millimeter-Wave Integrated Circuits), and MTT-15. In addition to the open solicitation of articles for the Special Issue, all of the speakers in the 1986 workshop were invited to contribute to the issue. The response to the Call for Papers for this issue has been very encouraging. In all, 66 papers were received. Of these, 27 contributions are being published here. Some other acceptable papers could not be included because the reviews of their revised versions could not be completed before the printer's deadline for the issue. These papers will appear in the regular issues of the MTT TRANSACTIONS.

Research efforts in computer-aided design techniques span three major aspects of CAD, namely, modeling, analysis, and optimization. This Special Issue includes interesting contributions in all three areas. The first paper is an invited review of the CAD approach for the design of MMIC's. Several features of the new generation of CAD tools are described in this paper. Papers in the area of modeling for CAD appear in three sections: modeling of active devices, modeling of transmission structures, and modeling of passive components and circuits. A section on active devices consists of four papers: two on FET models (one of these being an invited review), one on large-signal HEMT characteristics, and one on planar Schottky diodes. Modeling of transmission structures is a fairly mature research area. However, the four papers included indicate continued interest and some new directions. The topics discussed in this section are modeling of lossy and dispersive lines, the finite-element method for lossy dielectric waveguides, and modeling of superconducting striplines. The largest number of papers in this issue are in the area of modeling of passive components. Seven contributions in this section include modeling of microstrip–slotline crossover transition, models for spiral inductors, model for lossy radial stubs, two papers on modeling arbitrarily shaped microstrip structures, design of circular waveguide papers, and arbitrarily shaped coaxial discontinuities. Intensive research efforts are currently in progress in the areas of nonlinear microwave circuit analysis. The four papers in this section comprise an invited review article on nonlinear microwave CAD techniques, a paper on the harmonic balance method applied to almost-periodic circuits, a paper on frequency-domain nonlinear circuit analysis, and one on the design of MESFET power amplifiers. Analysis of passive microwave circuits is perhaps the most developed aspect of microwave CAD. However, the four

papers in this section represent only a sample of current research efforts. We have articles on admittance matrix analysis of waveguide circuits, generalized scattering matrix analysis of *E*-plane filters, sensitivity analysis for yield, and time-domain analysis for cascaded microwave circuits. A section on the optimization method consists of an invited review of the state of the art and a paper on efficient optimization with integrated gradient approximations. CAD techniques are also being used on surface acoustic wave circuits, and we have included a paper on the development of a SAW filter CAD system.

As guest editors we have enjoyed working to bring about this issue. We would like to express appreciation to the large number of authors and reviewers whose efforts have made this publication possible. The names of the reviewers are listed below.

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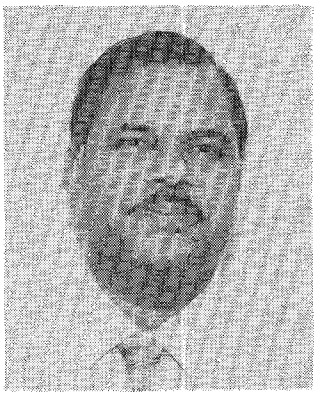
TATSUO ITOH
Guest Editors



Kuldip C. Gupta (M'62–SM'74) received the B.S. and M.S. degrees in electrical communication engineering from the Indian Institute of Science, Bangalore, India, in 1961 and 1962, respectively, and the Ph.D. degree from Birla Institute of Technology and Science, Pilani, India, in 1969.

Dr. Gupta has been at the University of Colorado since 1983, initially as a Visiting Professor and later as a Professor. Earlier, he had a long stay (since 1969) at the Indian Institute of Technology, Kanpur, where he had been a Professor in Electrical Engineering since 1975. On leave from IITK, he has been a Visiting Professor at the University of Waterloo, Canada; at the Ecole Polytechnique Federale de Lausanne, Switzerland; at the Technical University of Denmark (Lyngby); at the Eidgenossische Technische Hochschule, Zurich; and at the University of Kansas, Lawrence. From 1971 to 1979 he was the Coordinator for the Phased Array Radar Group of the Advanced Center for Electronics Systems at the Indian Institute of Technology.

Dr. Gupta's current research interests are in the area of computer-aided design techniques for microwave and millimeter-wave integrated circuits and integrated antennas. He is author or coauthor of four books: *Microwave Integrated Circuits* (Wiley Eastern, 1974; Halsted Press of John Wiley, 1974), *Microstrip Lines and Slotlines* (Artech House, 1979), *Microwaves* (Wiley Eastern 1979; Halsted Press of John Wiley, 1980; Editorial Limusa Mexico, 1983), and *CAD of Microwave Circuits* (Artech House, 1981; Chinese Scientific Press, 1986). Also, he has contributed chapters to the forthcoming *Handbook of Microstrip Antennas* (Peter Peregrinus) and the *Handbook of Microwave and Optical Components* (John Wiley). Dr. Gupta has published over 100 research papers and holds one patent in the microwave area.

Dr. Gupta is a Fellow of the Institution of Electronics and Telecommunication Engineers (India). He is on the MTT-S Technical Committee on CAD, the Editorial Board for the MTT-S TRANSACTIONS, and the Technical Program Committee for MTT-S International Symposia.

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Tatsuo Itoh (S'69–M'69–SM'74–F'82) received the Ph.D. degree in electrical engineering from the University of Illinois, Urbana, in 1969.

From September 1966 to April 1976, he was with the Electrical Engineering Department, University of Illinois. From April 1976 to August 1977, he was a Senior Research Engineer in the Radio Physics Laboratory, SRI International, Menlo Park, CA. From August 1977 to June 1978, he was an Associate Professor at the University of Kentucky, Lexington. In July 1978, he joined the faculty at the University of Texas at Austin, where he is now a Professor of Electrical and Computer Engineering and Director of the Electrical Engineering Research Laboratory. During the summer of 1979, he was a guest researcher at AEG-Telefunken, Ulm, West Germany. Since September 1983, he has held the Hayden Head Centennial Professorship of Engineering at the University of Texas. Since September 1984, he has been the Associate Chairman for Research and Planning in the Electrical and Computer Engineering Department.

Dr. Itoh is a member of the Institute of Electronics and Communication Engineers of Japan, Sigma Xi, and Commissions B and D of USNC/URSI. He served as the Editor of IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES for 1983–1985. He serves on the Administrative Committee of the IEEE Microwave Theory and Techniques Society. Dr. Itoh is a Professional Engineer registered in the state of Texas.