Guest Editorial for the Special Issue on Multifunction Antennas and Antenna Systems

Over the last decade, there has been an increased interest and demand for wireless communication and radar systems that provide expanded functionality. This functionality includes adaptability and reconfigurability, increased integration combined with superior electrical performance, reliability, low cost, and low weight. The need for such systems has paved the way for the gradual development of RF front ends that can incorporate as many of these system characteristics as possible. Since RF front ends consist of both the RF electronic components (e.g. filter, amplifiers, mixers, oscillators etc.) and antennas, the above desired characteristics need to be developed either on an individual basis or at a sub-system or system level.

Currently, multifunctional high-frequency systems depend on the co-existence of several antennas and RF components on the same or a neighboring platform. As the number of antenna systems on individual platforms grows, so do the problems of co-site interference, cost, maintainability, reliability, and weight. One solution to this situation is to provide multiple functions from each antenna aperture and its associated circuitry. Given the wide and various requirements from different applications in commercial and military settings, multifunction antennas can take many forms. Some antennas, with the help of RF MEMS, solid state switches or other developing technologies, can change their operating frequencies, bandwidths, or radiation patterns. Others may operate over several frequency bands simultaneously or operate over a wide band instantaneously. Some of these antennas are suitable for implementation in portable devices, while others are restricted to use in array settings. Supporting circuitry and systems for antennas also require new approaches to account for antenna functionality and meet system operational goals. For example, filters and amplifiers that operate over different frequency bands or provide good matching to a multifunctional antenna system are needed. These circuits and antennas can constitute an RF front end that is intelligent and aware of its environment. Capable to alter its response under different conditions or stimuli, the system can then achieve a highly reliable communication link whenever and wherever needed, as well as make efficient utilization of the radio spectrum. Cognitive radio is a commercial system that could incorporate such an intelligent and multifunctional RF front end, in which software can dictate the operation of the RF front end in different bands or across various communication standards. For a military platform, a multifunctional RF front end could lead to one system capable of handling all functions of communications, sensing, navigation and counter-measures.

The goals of this Special Issue are twofold. The first goal is to highlight current research and development efforts to create the antennas and associated circuitry for future multifunction wireless systems. These efforts include using new design approaches, novel tunable or reconfigurable materials, RF MEMS and micromachining techniques, and other emerging technologies. The second goal is to stimulate further research in these and other technologies that may be relevant for antenna systems of the future.

The papers contained in the pages that follow demonstrate a range of different approaches to a diverse set of application areas and usage scenarios. They represent only a fraction of what may be accomplished when we, as a scientific community, re-examine limitations established by tradition, outdated assumptions, and artificially imposed restrictions and instead open our imaginations to new echelons of antenna and system performance.

The papers of this Special Issue are organized into four main categories. These areas:

1) Wideband or frequency reconfigurable antennas;
2) Unique antenna structures that deliver both frequency and pattern reconfigurability;
3) Pattern reconfigurable antennas;
4) Components of multifunctional antenna systems.

Papers in the first category include a broad range of antenna topologies (planar, aperture, horn) and frequency bands (UHF to 35 GHz) that can provide either simultaneous or switched operation for numerous functions. The second category encompasses unique antenna structures that deliver both frequency and pattern reconfigurability using a number of different reconfiguration mechanisms, including varactors and diodes as well as photoconducting and RF MEMS switches. The third paper category consists of pattern reconfigurable antennas, with an emphasis on the integration of RF MEMS switches. Finally, papers in the fourth category describe some critical components of multifunctional systems, such as reconfigurable circuitry and packaging associated with antennas that enable additional system adaptability for a range of situations.

We would like to express our thanks to the IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION Editor-in-Chief, Dr. Trevor Bird, for supporting this project, to all authors that responded to this Special Issue's Call for Papers, and to all the Reviewers for their priceless service and promptness in returning the reviews. The Reviewers are as follows:

- Pierre Blondy
- Ricky Chair
- Kai Chang
- Christos Christodoulou
- Joseph Colburn
- Franco De Flaviis
- Mircea Dragoman
- Lucas Feldner

Digital Object Identifier 10.1109/TAP.2006.870155

- Miguel Ferrando
- Spartak Gevorgian
- Roland Gilbert
- Charles Goldsmith
- Xun Gong
- Christophe Granet
- David Jackson
- Shyh-Kang Jeng
- Rolf Judaschke
- Kiersten Kerby
- Kai-Fong Lee
- RongLin Li
- Stuart Long
- Jui-Han Lu
- A. Matsui
- James McLean
- Kathleen Melde
- Hiroaki Miyashita
- Ananda Mohan
- Louis Nagy
- Dev Palmer
- Dimitrios Peroulis
- Andrew Peterson
- Ronald Pogorzelski
- George Ponchak
- Sudhakar Rao
- Banmali Rawat
- Rafael Rodriguez Solis
- Roberto Rojas
- Edward Rothwell
- James Schaffner
- Tom Weller
- John Volakis
- Douglas Werner
- Kin-Lu Wong

In closing, we hope that this Special Issue will inspire the interest and imagination of readers to contribute in this emerging and important research area.

JOHN PAPAPOLYMEROU, *Guest Editor*
Georgia Institute of Technology
School of Electrical and Computer Engineering
Atlanta, GA 30332 USA

JENNIFER T. BERNHARD, *Guest Editor*
University of Illinois at Urbana-Champaign
Department of Electrical and Computer Engineering
Urbana, IL 61801 USA

John Papapolymerou (S'90–M'99–SM'04) received the B.S.E.E. degree from the National Technical University of Athens, Athens, Greece, in 1993, and the M.S.E.E. and Ph.D. degrees from the University of Michigan, Ann Arbor, in 1994 and 1999, respectively.

From 1999 to 2001, he was a faculty member at the Department of Electrical and Computer Engineering of the University of Arizona, Tucson, and during summers 2000 and 2003, he was a Visiting Professor at The University of Limoges, France. From 2001 to 2005 he was an Assistant Professor at the School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, where he is currently an Associate Professor. His research interests include the implementation of micromachining techniques and MEMS devices in microwave, millimeter-wave and THz circuits and the development of both passive and active planar circuits on semiconductor (Si/SiGe, GaAs) and organic substrates (LCP, LTCC) for System-on-a-Chip (SOC)/ System-on-a-Package (SOP) RF front ends. He has authored or coauthored over 120 publications in peer reviewed journals and conferences.

Dr. Papapolymerou received the 2004 Army Research Office (ARO) Young Investigator Award, the 2002 National Science Foundation (NSF) CAREER award, the best paper award at the 3rd IEEE International Conference on Microwave and Millimeter-Wave Technology (ICMMT2002), Beijing, China and the 1997 Outstanding Graduate Student Instructional Assistant Award presented by the American Society for Engineering Education (ASEE), The University of Michigan Chapter. His student also received the best student paper award at the 2004 IEEE Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems, Atlanta, GA. He currently serves as the Vice-Chair for Commission D of the US National Committee of URSI and as an Associate Editor for IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION. During 2004 he was the Chair of the IEEE MTT/AP Atlanta Chapter.

Jennifer T. Bernhard (S'89–M'95–SM'01) was born on May 1, 1966, in New Hartford, NY. She received the B.S.E.E. degree from Cornell University, Ithaca, NY, in 1988,. While at Cornell, she was a McMullen Dean's Scholar and participated in the Engineering Co-op Program, working at IBM Federal Systems Division in Owego, New York. She received the the M.S. and Ph.D. degrees in electrical engineering from Duke University, Durham, NC, in 1990 and 1994, respectively, with support from a National Science Foundation Graduate Fellowship.

During the 1994–95, academic year she held the position of Postdoctoral Research Associate with the Departments of Radiation Oncology and Electrical Engineering, Duke University, where she developed RF and microwave circuitry for simultaneous hyperthermia (treatment of cancer with microwaves) and magnetic resonance imaging thermometry. At Duke, she was also an organizing member of the Women in Science and Engineering (WISE) Project, a graduate student-run organization designed to improve the climate for graduate women in engineering and the sciences. From 1995 to 1999, she was an Assistant Professor in the Department of Electrical and Computer Engineering, University of New Hampshire, Durham, where she held the Class of 1944 Professorship. In 1999 and 2000, she was a National Aeronautics and Space Administration-American Society for Engineering Education (NASA-ASEE) Summer Faculty Fellow at the NASA Glenn Research Center, Cleveland, OH. From 1999 to 2003, she was an Assistant Professor in the Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign (UIUC), where since 2003, she has held the position of Associate Professor. She is also a UIUC College of Engineering Willett Faculty Scholar and a Research Associate Professor in UIUC's Micro and Nanotechnology Laboratory and the Coordinated Science Laboratory. Her industrial experience includes work as a Research Engineer with Avnet Development Laboratories and, more recently, as a private consultant for members of the wireless communication and sensors community. She is also a member of the editorial board of *Smart Structures and Systems*. Her research interests include reconfigurable and wideband microwave antennas and circuits, wireless sensors and sensor networks, high speed wireless data communication, electromagnetic compatibility, and electromagnetics for industrial, agricultural, and medical applications.

Prof. Bernhard is a Member of Tau Beta Pi, Eta Kappa Nu, Sigma Xi, ASEE, and URSI Commissions B and D. She received the NSF CAREER Award in 2000. She and her students received the 2004 H. A. Wheeler Applications Prize Paper Award from the IEEE Antenna and Propagation Society for their paper published in the March 2003 issue of the IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION. From 2001 to 2005, she served as an Associate Editor for IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS. Since 2001, she has served as an Associate Editor for IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION. She is serving as an Elected Member of the IEEE Antennas and Propagation Society's Administrative Committee from 2004 to 2006.