

IEEE

microwave

for the Microwave & Wireless Engineer



MAGAZINE

Volume 20 • Number 3 • March 2019

Completing the Circuit

New Technologies,
New Applications



Editor

Robert H. Caverly, *Villanova University*,
microwave.editor@ieee.org

Assistant Editor

Sharri Shaw, *JWM Consulting LLC*,
microedt@outlook.com

Associate Editors

Nuño Borges Carvalho, *University of Aveiro*,
Portugal, nbcarvalho@ua.pt

Simone Bastioli, *RS Microwave, New Jersey*,
United States sbastioli@rsmicro.com

Ali Darwish, *American University in Cairo*,
Egypt, ali@darwish.org

Christian Fager, *University of Chalmers*,
Sweden, christian.fager@chalmers.se

Mohammad S. Hashmi, *Indraprastha Institute*
of Information Technology, Delhi, India,
mshashmi@iiitd.ac.in

Jianguo Ma, *Guangdong University of*
Technology, China, mjg@gdut.edu.cn

Alfy Riddle, *Kumu Networks, Sunnyside*,
California, alfy@kumunetworks.com

Luca Roselli, *University of Perugia, Italy*,
urlofi@tin.it; luca.roselli@unipg.it

Kamal Samanta, *Sony Europe, United*
Kingdom, kmksamanta@googlemail.com

Almudena Suarez, *University of Cantabria*,
Spain, almudena.suarez@uican.es

Anding Zhu, *University College Dublin*,
Ireland, anding.zhu@ucd.ie

Columns and Departments

MicroBusiness

Fred Schindler,
m.schindler@ieee.org

Health Matters

James C. Lin, *University of Illinois-Chicago*,
lin@uic.edu

Microwave Surfing

Rajeev Bansal, *University of Connecticut*,
rajeev@engr.uconn.edu

Book Reviews

James Chu, *RF Engineering Consultant*,
james.cc.chu@ieee.org

Education Corner

Ramesh Gupta, *Ligado Networks, Reston*,
Virginia, ramesh.gupta@ieee.org

Women in Microwaves

Wenquan Che, *Nanjing University of Science*
and Technology, yeeen_che@163.com

Membership News

Bela Szendrenyi, *Advantest*,
bela.szendrenyi@advantest.com

New Products

Ken Mays, *KMays Technical Services*,
microwave.newproducts@ieee.org

In Memoriam Contributions

Jerry Hausner, j.hausner@ieee.org

Ombuds Officer

Edward C. Niehenke, *Niehenke Consulting*,
e.niehenke@ieee.org

IEEE Periodicals Magazines Department

Mark Gallaher, *Managing Editor*

Janet Dudar, *Senior Art Director*

Gail A. Schnitzer and Bonnie Nani,
Associate Art Directors

Theresa L. Smith, *Production Coordinator*

Felicia Spagnoli, *Advertising Production Manager*

Peter M. Tuohy, *Production Director*

Kevin Lisankie, *Editorial Services Director*

Dawn M. Melley, *Staff Director, Publishing Operations*

Advertising Sales

Mark David, *Director, Business Development—*
Media & Advertising

+1 732 465 6473, fax +1 732 981 1855

Digital Object Identifier 10.1109/MMM.2018.2885628



Volume 20 • Number 3 • March 2019 • ISSN 1527-3342

features

24 Empty SIW Technologies

A Major Step Toward Realizing Low-Cost and Low-Loss Microwave Circuits

Angel Belenguier, Héctor Esteban, Alejandro L. Borja, and Vicente E. Boria

46 Enhancing Satellite Communications

Temperature-Compensated Filters and Their Application in Satellite Technology

Vikrant Singh, Praveen Kumar Ambati, Shilpi Soni, and K. Karthik

64 Solving Resonance Problems in Transitions

End-Launch Connector Considerations for Coaxial-to-Microstrip Transitions

Eric S. Li, Hung-Yi Wu, and Hong-Wei Huang

IMS2018 Student Design Competition winner

76 Meeting the Challenge

Designing, Constructing, Measuring, and Demonstrating a 16-QAM Wireless Transmitter Operating at 963 MHz

Yuan-Chun Lin, Jyun-Yan Lai, Sheng-Fuh Chang, and Janne-Wha Wu

on the cover:

©ISTOCKPHOTO.COM/ASJOS



IEEE prohibits discrimination, harassment, and bullying. For more information, visit <http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html>.

IEEE Microwave Theory and Techniques Society

The IEEE Microwave Theory and Techniques Society (MTT-S) is an organization, within the framework of the IEEE, of members with principal professional interests in the field of microwave theory and techniques. All members of the IEEE are eligible for membership in the Society. Information about joining the IEEE or the Society is available on the web, <http://www.ieee.org/> membership.

MTT-S AdCom

The Society is managed by an Administrative Committee (AdCom) consisting of 21 elected members of the Society plus additional ex-officio members as provided in the MTT-S Constitution and Bylaws, which is available on the Web, <http://www.mtt.org>.

Officers

President: Dominique Schreurs
 President-Elect: Alaa Abunjaileh
 Secretary: Sherry Hess
 Treasurer: Gregory Lyons

Elected Members

Scott Barker	Gregory Lyons
Nuño Borges Carvalho	Mohammad Madhian
Maurizio Bozzi	Julio Navarro
Goutam Chattopadhyay	Daniel Pasquet
Wenquan Che	Ajay Poddar
Kamran Ghorbani	Sanjay Raman
Ramesh Gupta	Jose E. Rayas-Sanchez
Rashaunda Henderson	Steven Reising
Amarpal Khanna	Atsushi Sanada
Dietmar Kissinger	Anding Zhu

Ex Officio Members (with vote)

Immediate Past Presidents: Dylan Williams (2017)
 Ke Wu (2016)
 Tim Lee (2015)

Honorary Life Members: John T. Barr IV
 Tatsuo Itoh
 Richard Sparks
 Peter Staecker

IEEE Trans. Microwave Theory & Techniques Coeditors: José Carlos Pedro
 Luca Perregrini

IEEE Microwave & Wireless Components Letters Editor: Thomas Zwick
 IEEE Microwave Magazine Editor: Robert H. Caverly

IEEE Trans. Terahertz Science & Technology Editor: Imran Mehdi

IEEE Journal of Electromagnetics, RF, and Microwaves in Medicine and Biology Editor: J.-C. Chiao

IEEE Journal on Multiscale and Multiphysics Computational Techniques Editor: Costas Sarris

IEEE Microwave Magazine (ISSN 1527-3342) (IEMMF) is published seven times a year by the Institute of Electrical and Electronics Engineers, Inc. Headquarters: 3 Park Avenue, 17th Floor, New York, NY 10016-5997 USA. Responsibility for the contents rests upon the authors and not upon the IEEE, the Society, or its members. IEEE Service Center (for orders, subscriptions, address changes): 445 Hoes Lane, Piscataway, NJ 08854. Telephone: +1 732 981 0060, +1 800 678 4333. Individual copies: IEEE members US\$20.00 (first copy only), nonmembers US\$34.00 per copy. Subscription rates: Subscriptions for Society members are included with membership dues. Nonmember subscription rates available upon request. Copyright and reprint permissions: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limits of U.S. Copyright law for the private use of patrons those articles that carry a code at the bottom of the first page, provided the per-copy fee is paid through the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923 USA. For other copying, reprint, or republication permission, write Copyrights and Permissions Department, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854 USA. Copyright © 2019 by the Institute of Electrical and Electronics Engineers, Inc. All rights reserved. Periodicals postage paid at New York, N.Y., and at additional mailing offices. Ride along enclosed. Postmaster: Send address changes to IEEE Microwave Magazine, IEEE Operations Center, 445 Hoes Lane, Piscataway, NJ 08854 USA. Canadian GST #125634188
 PRINTED IN THE USA

Digital Object Identifier 10.1109/MMM.2018.2885629

columns & departments

6 From the Editor's Desk

■ Robert H. Caverly
Worth the Wait

8 President's Column

■ Dominique Schreurs
Rich in Our Diversity

10 Microwave Surfing

■ Rajeev Bansal
Eye in the Sky

11 MicroBusiness

■ Fred Schindler
Alternating Currents and Pasts

13 Application Notes

■ Hemant Kumar and Girish Kumar
Monopulse Comparators

86 Women in Microwaves

■ Kate A. Remley
Let's Keep Women in Microwaves (But Let's Turn Down the Heat!)

90 In Memoriam

Barry Stuart Perlman

91 Book/Software Reviews

■ James Chu
The Whats, Hows, and Whys of Wireless Networking

93 Education News

■ Ramesh K. Gupta and Michael C. Hamilton
IEEE MTT-S 2018 Webinar Series: Speaker Biographies and Webinar Abstracts

101 New Products

■ Ken Mays

104 Conference Calendar