

IEEE

microwave

for the Microwave & Wireless Engineer 

MAGAZINE

Volume 17 • Number 8 • August 2016

RF/Microwave Design

Endless Possibilities



Editor

Alfy Riddle, *Kumu Networks*,
microwave.editor@ieee.org

Assistant Editor

Sharri Shaw, *NIST*, microedt@nist.gov

Associate Editors

Robert H. Caverly, *Villanova University*,
Pennsylvania, United States
robert.caverly@villanova.edu

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

Ana Collado, *CTTC, Barcelona, Spain*,
ana.collado@cttc.cat

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

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

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

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

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

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

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

Columns and Departments

MicroBusiness

Fred Schindler, *RF Micro Devices*,
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, *Southern Polytechnic State*
University, Georgia, jchu@spsu.edu

Education Corner

Ramesh Gupta, *Lightsquared, Washington*,
D.C., ramesh.gupta@ieee.org

Membership News

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

New Products

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

In Memoriam Contributions

John T. Barr IV, j.barr@ieee.org

Ombuds Officer

Ed Niehenke, *Niehenke Consulting*,
e.niehenke@ieee.org

IEEE Periodicals Magazines Department

Mark Gallaher, *Managing Editor*

Janet Dudar, *Senior Art Directors*

Gail A. Schnitzer and Mark Morrissey,
Associate Art Director

Theresa L. Smith, *Production Coordinator*

Felicia Spagnoli, *Advertising Production Manager*

Peter M. Tuohy, *Production Director*

Dawn M. Melley, *Editorial Director*

Fran Zappulla, *Staff Director, Publishing Operations*

Advertising Sales

Mark David, *Sr. Manager Advertising*
& Business Development

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

Digital Object Identifier 10.1109/MMM.2016.2563299



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

IEEE
microwave
MAGAZINE

for the Microwave & Wireless Engineer

Volume 17 • Number 8 • August 2016 • ISSN 1527-3342

features

28 **No Noise Is Good Noise**

Noise Matching, Noise Canceling, and Maybe a Bit of Both for Wide-Band LNAs

Leonid Belostotski

41 **Doherty Goes Digital**

Digitally Enhanced Doherty Power Amplifiers

Ramzi Darraji, Pedram Mousavi, and Fadhel M. Ghannouchi

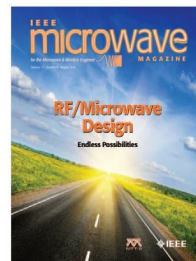
52 **Making Meta Better**

The Synthesis of New-Shaped Periodic Artificial Structures Suitable for Metamaterial Behavior Characterization

M. Jasim Uddin, M. Habib Ullah, T.A. Latef, W.N.L. Mahadi, and M.T. Islam

on the cover:

IMAGE LICENSED BY INGRAM PUBLISHING



IEEE Microwave Theory and Techniques Society

The 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

<i>President:</i>	Ke Wu
<i>President-Elect:</i>	Dylan Williams
<i>Secretary:</i>	Maurizio Bozzi
<i>Treasurer:</i>	Alaa Abunjaileh

Elected Members

Alaa Abunjaileh	Sergio Pacheco
Silvio Barbin	George Ponchak
Tom Brazil	Sanjay Raman
Ramesh Gupta	James Rautio
Rashaunda Henderson	Jose E. Rayas-Sanchez
Wei Hong	Steve Reising
Arne Jacob	Magdalena Salazar-Palma
Shiban Koul	Atsushi Sanada
Joy Laskar	Dominique Schreurs
Tim Lee	Michael Steer
Gregory Lyons	Dylan Williams
Mohammad Madihian	Ke Wu

Ex Officio Members (with vote)

<i>Immediate Past Presidents:</i>	Tim Lee (2015)
	Robert Weigel (2014)
	Madhu Gupta (2013)
	Nick Kolias (2012)

<i>Honorary Life Members:</i>	Tatsuo Itoh
	Richard Sparks
	Peter Staecker

<i>IEEE Trans. Microwave Theory & Techniques Coeditors:</i>	Jenshan Lin
	Dominique Schreurs

<i>IEEE Microwave & Wireless Components Letters Editor:</i>	N. Scott Barker
<i>IEEE Microwave Magazine Editor:</i>	Alfy Riddle
<i>IEEE Trans. Terahertz Science & Technology Editor:</i>	Jan Stake

IEEE Microwave Magazine (ISSN 1527-3342) (IEMMF) is published monthly 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\$32.00 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 © 2016 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.2016.2563300

columns & departments

- 6 From the Editor's Desk** ■ Alfy Riddle
Diving Deep
- 10 President's Column** ■ Ke Wu
A Community of Special Interest Groups That Matter
- 20 Microwave Surfing** ■ Rajeev Bansal
The Annual Quiz
- 23 Health Matters** ■ James C. Lin
Transcranial Magnetic Stimulation Therapy for Depression and Psychiatric Disorders
- 25 MicroBusiness** ■ Fred Schindler
Something Different
- 59 Application Notes**
■ Ulrich L. Rohde and Anisha M. Apte
Everything You Always Wanted to Know About Colpitts Oscillators
- 77 Book/Software Reviews**
■ James Chu
A Comprehensive Survey of Electrostatic Discharge Protection
■ Alfy Riddle
Recently Published Books
- 82 Awards** ■ Daniela Andrei and Kiran Rajmohan
The IEEE MGA Young Professionals Achievement Award Winner—Tushar Sharma
- 84 Education News** ■ Giovanni Crupi, Roger Kaul, Changzhi Li, and Ramesh K. Gupta
The 2016 MTT-S Graduate Student Fellowship Awards
- 90 Conference Report**
■ Jon Martens
ARFTG—The Microwave Measurements Technical Organization
■ Dhananjay Jahagirdar and Mohammad Madihian
IMaRC2015 Hosted in Hyderabad, India
- 94 New Products**
■ Ken Mays, Editor
New Products
- 101 Conference Calendar**