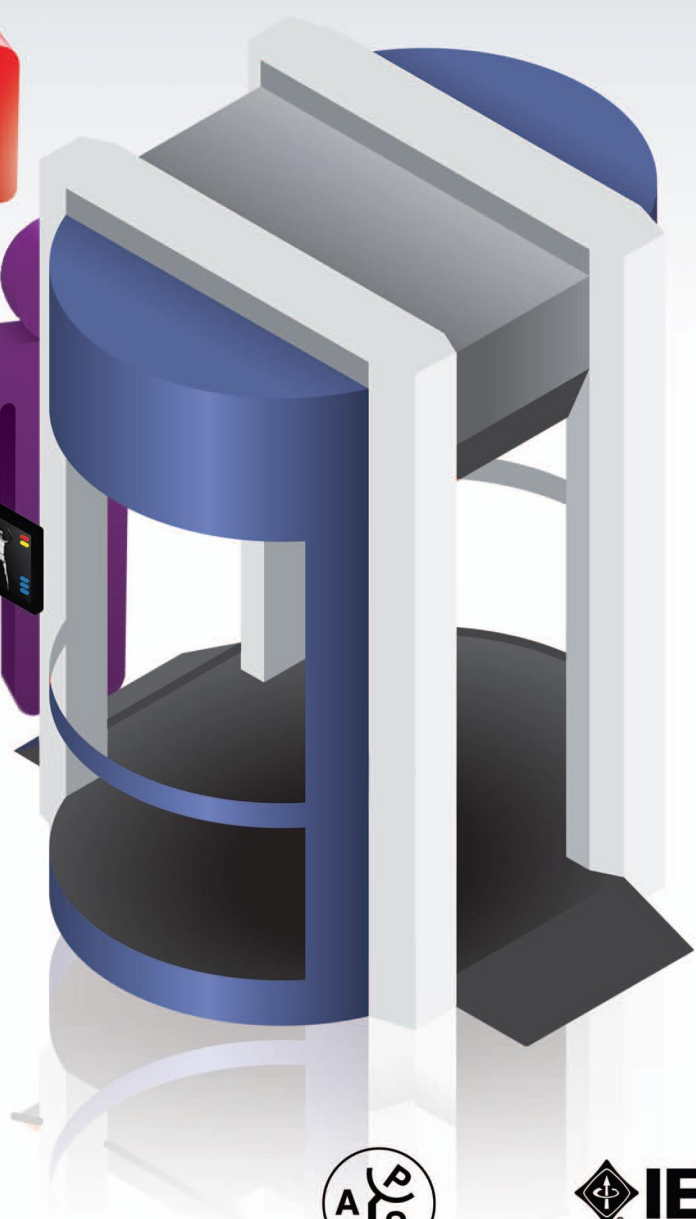


# IEEE **Antennas & PROPAGATION** Magazine



## THE FULL PICTURE

Scanning the World Safely



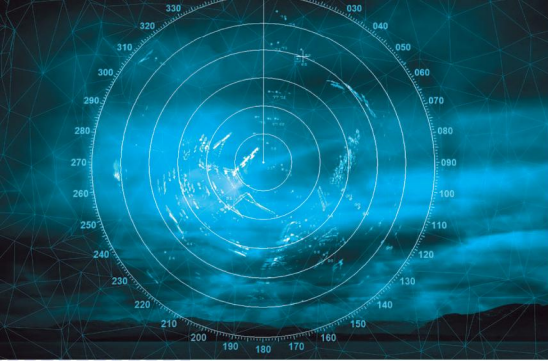


IMAGE LICENSED BY INGRAM PUBLISHING



VOLUME 58 // NUMBER 4 // AUGUST 2016

# IEEE **Antennas &** **PROPAGATION** Magazine

## FEATURES

22 **High-Gain and Wideband Antenna Arrays**  
*Chao Zheng, Huan Yi, and Shi-Wei Qu*

35 **Improving Security Screening**  
*Borja Gonzalez-Valdes, Yuri Álvarez, Spiros Mantzavinos,  
Carey M. Rappaport, Fernando Las-Heras,  
and José Ángel Martínez-Lorenzo*

48 **A Novel Beamforming Technique**  
*Li-Wen Chen, Jian-Sheng Zheng, Ming-Kun Su,  
and Shan Huang*

60 **Ka-Band Circularly Polarized Reflectarray**  
*Abdelhady Mahmoud, Ahmed A. Kishk, Zhangcheng Hao, and Wei Hong*



### ON THE COVER

Building a better scanner—the four feature articles in this issue focus on various concepts that could enhance future imaging scenarios—is it possible to combine all of these ideas into a next-generation advanced imaging system for security and other applications? Read on to decide.

AIRPORT SCANNER IMAGE ©ISTOCKPHOTO.COM/ZERNIEW,  
FIGURES IMAGE ©ISTOCKPHOTO.COM/MISTAY

### MISSION STATEMENT:

IEEE *Antennas and Propagation Magazine* publishes feature articles and columns that describe engineering activities within its scope, taking place in industry, government, and universities. All feature articles are subject to peer review. Emphasis is placed on providing the reader with a general understanding of either a particular subject or of the technical challenges being addressed by various organizations, as well as their capabilities to cope with these challenges. Review, tutorial, and historical articles are welcome.

Digital Object Identifier 10.1109/MAP.2016.2585999





# DEPARTMENTS

## IEEE ANTENNAS AND PROPAGATION MAGAZINE EDITORIAL BOARD

### Editor-in-Chief

**Mahta Moghaddam**  
University of Southern California, USA  
apm-eic@ieee.org

### Editorial Assistant

**Christina Tang-Bernas**  
University of Southern California, USA  
tangbern@usc.edu

### Associate Editors for Feature Articles

**Aria Abubakar**  
Schlumberger, Texas, USA  
aabubakar@slb.com

**Yahia Antar**  
Royal Military College of Canada  
Antar-Y@mc.ca

**Ahmed Kishk**  
Concordia University, Canada  
kishk@encs.concordia.ca

**Marta Martinez-Vasquez**  
IMST GmbH, Kamp-Lintfort, Germany  
martinez@imst.de

**Hisamatsu Nakano**  
Hosei University, Tokyo  
hymat@hosei.ac.jp

**Matteo Pastorino**  
University of Genoa  
matteo.pastorino@unige.it

**Meisong Tong**  
Tongji University, China  
mstong@tongji.edu.cn

**Chenming Zhou**  
National Institute for Occupational Safety and Health, Pennsylvania, USA  
czhou@cdc.gov

### Columns and Departments

**Antenna Applications Corner**  
**Sudhakar Rao**  
Northrop Grumman Aerospace Systems, California, USA  
skraoks@yahoo.com

### Antenna Designer's Notebook

**Tom Milligan**  
Milligan & Associates, Inc., Colorado, USA  
tmilligan@ieee.org

### AP-S Turnstile

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

### Book Reviews

**Levent Gürel**  
ABAKUS Computing Technologies, Turkey  
University of Illinois at Urbana-Champaign, USA  
lgurel@gmail.com

### Chapter News

**Ajay Poddar**  
Synergy Microwave Corp., New Jersey, USA  
akpoddar@synergymw.com

### Distinguished Lecturers

**Danilo Erricolo**  
The University of Illinois at Chicago, USA  
derric1@uic.edu

### Education Corner

**Karl Warrick**  
Brigham Young University, Utah, USA  
warrick@ee.byu.edu

### EM Programmer's Notebook

**David Davidson**  
Stellenbosch University, South Africa  
davidson@sun.ac.za

### From the Screen of Stone

**Ross Stone**  
Stoneware Limited, California, USA  
r.stone@ieee.org

### Hidden Word

**Fred Gardiol**  
fred.gardioli@hispeed.ch

### Historical Corner

**Giuseppe Pelosi**  
University of Florence, Italy  
g.pelosi@ieee.org

### Measurements Corner

**Brian Fischer**  
Integrity Applications Inc., Michigan, USA  
bfischer@integrity-apps.com

### Meetings, Symposia, and Short Courses

**Raymond Wasky**  
John Hopkins University, Maryland, USA  
raymond.wasky@jhuapl.edu

### Open Problems in Computational EM

**Ozgur Ergul**  
Middle East Technical University, Turkey  
ozgur.ergul@eee.metu.edu.tr

### Stand on Standards

**Vikass Monebhurrin**  
Centralesupelec, France  
vikass.monebhurrin@centralesupelec.fr

### Testing Ourselves

**Levent Sevgi**  
Okan University, Turkey  
levent.sevgi@ieee.org

### Wireless Corner

**Eva Rajo-Iglesias**  
University Carlos III of Madrid, Spain  
eva@tsc.u3m.es

### Young Professionals

**Sai Ananthanarayanan**  
University of Utah, USA  
saianantha21@gmail.com

### IEEE Periodicals Magazines Department

445 Hoes Lane, Piscataway, NJ 08854 USA  
Jessica Barragüé  
Managing Editor  
Geraldine Krolin-Taylor,  
Senior Managing Editor  
Janet Dudar, Senior Art Director  
Gail A. Schnitzer, Mark Morrissey  
Associate Art Directors  
Theresa L. Smith,  
Production Coordinator  
Mark David, Senior Manager Advertising & Business Development  
Tel: +1 732 465 6473  
Fax: +1 732 981 1855  
m.david@ieee.org  
Felicia Spagnoli, Advertising  
Production Manager  
Peter M. Tuohy, Production  
Director  
Dawn M. Melley, Editorial Director  
Fran Zappulla, Staff Director,  
Publishing Operations

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

Address editorial correspondence to the Editor-in-Chief Mahta Moghaddam, Dept. Electrical Engineering, University of Southern California, 3737 Watt Way, PHE 634, Los Angeles, CA 90089 USA; +1 213 740 4712; e-mail: apm-eic@ieee.org.

**General information for contributors:** Contributions to *IEEE Antennas and Propagation Magazine* are accepted through ScholarOne Manuscripts at <https://mc.manuscriptcentral.com/apm-ieee>. Contributors are encouraged to contact the magazine editor-in-chief before submitting their articles to inquire whether their prospective submission is within the scope of the magazine. Article formatting requirements vary based on the type of article. The authors are asked to consult [http://www.ieee.org/publications\\_standards/publications/authors/author\\_submission.html](http://www.ieee.org/publications_standards/publications/authors/author_submission.html) and [http://www.ieee.org/publications\\_standards/publications/authors/authors\\_journals.html](http://www.ieee.org/publications_standards/publications/authors/authors_journals.html) for general instructions. Manuscripts should be in English. The editor-in-chief reserves the right to accept, reject, and/or edit any and all material submitted. Submission of material will be interpreted as assignment and release of copyright and any and all other rights as if the standard IEEE copyright and US Export Control Compliance Forms had been signed by the copyright owner. All material associated with contributions may be discarded after the issue containing the contribution goes to press, unless otherwise requested. The nominal deadline for material not requiring peer review or extensive editing is 120 days prior to the start of the month of publication. Contact the editor-in-chief if you have timely material that cannot make this deadline. All feature articles are subject to full peer review per IEEE policy. A limit of ten printed pages will be imposed on feature

articles starting with the August 2016 issue. All contributions to departments are reviewed by the associate editor(s) for that department, with additional peer review as deemed necessary by the associate editor. Conference reports should be no more than two pages and contain no more than five figures.

*IEEE Antennas and Propagation Magazine* (ISSN1045 9243) is published bimonthly by The Institute of Electrical and Electronics Engineers, Inc. Headquarters: 3 Park Avenue, 17th Floor, New York, NY 10016-5997, U.S.A. +1 212 419 7900. Responsibility for the contents rests upon the authors and not upon the IEEE, the Society, or its members. The magazine is a membership benefit of the IEEE Antennas and Propagation Society, and subscriptions are US\$6.00 per member per year (included in Society fee). Replacement copies for members are available for US\$20 (one copy only). Nonmembers can purchase individual copies for US\$115.00. Nonmember subscription prices are available on request. Copyright and Reprint Permissions: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limits of the U.S. Copyright law for private use of patrons: 1) those post-1977 articles that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01970, U.S.A.; and 2) pre-1978 articles without fee. For other copying, reprint, or republication permission, write to: Copyrights and Permissions Department, IEEE Service Center, 445 Hoes Lane, Piscataway NJ 08854 U.S.A. Copyright © 2016 by The Institute of Electrical and Electronics Engineers, Inc. All rights reserved. Periodicals postage paid at New York, NY and at additional mailing offices. Postmaster: Send address changes to IEEE Antennas and Propagation Magazine, IEEE, 445 Hoes Lane, Piscataway, NJ 08854 U.S.A. Canadian GST #125634188. Printed in U.S.A.

Digital Object Identifier 10.1109/MAP.2016.2586000