### IEEE COMMUNICATIONS SOCIETY

The field of interest of the IEEE Communications Society consists of all telecommunications including telephone, telegraphy, facsimile, and point-to-point television, by electromagnetic propagation including radio; wire; aerial, underground, coaxial, and submarine cables; waveguides, communication satellites, and lasers; in marine, aeronautical, space, and fixed station servies; repeaters, radio relaying, signal storage, and regeneration; telecommunication error detection and correction; multiplexing and carrier techniques; communication switching systems; data communications; and communication theory.

In addition to the above, this JOURNAL or the IEEE TRANSACTIONS ON COMMUNICATIONS contains papers pertaining to analog and digital signal processing and modulation, audio and video encoding techniques, the theory and design of transmitters, receivers, and repeaters for communications via optical and sonic media, the design and analysis of computer communication systems, and the development of communication software. Contributions of theory enhancing the understanding of communication systems and techniques are included, as are discussions of the social implications of the development of communication technology. All members of the IEEE are eligible for membership in the Society upon payment of the annual Society membership fee of \$40.00. Members may receive this JOURNAL upon payment of an additional \$65.00 (\$105.00 total), the IEEE TRANSACTIONS ON COMMUNICATIONS upon payment of an additional \$65.00 (\$105.00 total). For information on joining, write to the IEEE at the address below. *Member copies of Transactions/Journals are for personal use only*.

# IEEE COMMUNICATIONS SOCIETY JOURNAL Editorial Board J-SAC Home Page URL: http://www.argreenhouse.com/society/J-SAC

D. P. TAYLOR, Director of Journals Dept. Elect. & Electron. Eng. Univ. of Canterbury Private Bag 4800 Christchurch New Zealand taylor@elec.canterbury.ac.nz P. COSMAN, Editor-in-Chief Dept. Elect. & Comput. Eng. Univ. of California, San Diego 9500 Gilman Drive La Jolla, CA 92093-0407 USA pcosman@code.ucsd.edu M. SEALEY-FREY, Executive Editor Dept. Elect. & Comput. Eng. Univ. of California, San Diego 9500 Gilman Drive La Jolla, CA 92093-0407 USA msfrey@ece.ucsd.edu

#### **Senior Editors**

A. M. BUSH P.O. Box 15496 Atlanta, GA 30306 USA

A. LEON-GARCIA
Dept. Elect. & Comput. Eng.
Univ. of Toronto
10 King's College Rd.
Toronto, ON M5S 1A4
Canada

D. TOWLSEY COINS Dept. Lederle Graduate Res. Ctr. Amherst, MA 01003 L. J. CIMINI JR. Dept. Elect. & Comput. Eng. Univ. of Delaware 306 Evans Hall Newark, DE 19716

S. Low Dept. Comput. Sci. & Elect. Eng. Caltech MC 256-80 Pasadena, CA 91125

W. H. TRANTER Dept. of Elect. Eng. Virginia Polytechnic Inst. 432 New Engineering Bldg. Blacksburg, VA 24061-0350 G. KARLSSON
Dept. of Signals, Sensors
& Systems
KTH, Royal Inst. of Technology
100 44 Stockholm
Sweden

L. B. MILSTEIN
Dept. Elect. & Comput. Eng.
Mail Code 0407
Univ. of California, San Diego
La Jolla, CA 92093
USA

M. ZUKERMAN ARC, EEE Dept. Univ. of Melbourne Victoria, 3010 Australia C.-T. LEA EEE Dept. Hong Kong Univ. of Science & Technology Clear Water Bay Kowloon, Hong Kong

M. B. PURSLEY Dept. Elect. & Comput. Eng. Clemson Univ. 303 Fluor Daniel EIB Clemson, SC 29634 USA D. LEE Dept. Comput. Sci. & Eng. Ohio State Univ. 2015 Neil Ave., DL597 Columbus, OH 43210 USA

M. STEENSTRUP Stow Research L.L.C. 16 Prides Crossing Flanders, NJ 07836 USA and Clemson Univ.

#### IEEE Officers

MICHAEL R. LIGHTNER, President and CEO
LEAH H. JAMIESON, President-Elect
J. ROBERTO DE MARCA, Secretary
JOSEPH V. LILLIE, Treasurer
W. CLEON ANDERSON, Past President
MOSHE KAM, Vice President, Educational Activities

SAIFUR RAHMAN, Vice President, Publication Services and Products Pedro Ray, Vice President, Regional Activities
DONALD N. HEIRMAN, President, IEEE Standards Association
CELIA L. DESMOND, Vice President, Technical Activities
RALPH W. WYNDRUM, JR., President, IEEE-USA

MARK J. KAROL, Director, Division III—Communications Technology

## **IEEE Executive Staff**

JEFFRY W. RAYNES, CAE, Executive Director & Chief Operating Officer

DONALD CURTIS, Human Resources
ANTHONY DURNIAK, Publications Activities
JUDITH GORMAN, Standards Activities
CECELIA JANKOWSKI, Regional Activities
BARBARA COBURN STOLER, Educational Activities

MATTHEW LOEB, Corporate Strategy & Communications
RICHARD D. SCHWARTZ, Business Administration
CHRIS BRANTLEY, IEEE-USA
MARY WARD-CALLAN, Technical Activities
SALLY A. WASELIK, Information Technology

# IEEE Periodicals Transactions/Journals Department

Staff Director: Fran Zappulla Editorial Director: Dawn Melley Production Director: Robert Smrek

Managing Editor: JEFFREY E. CICHOCKI ASSOCIATE DIRECTOR PATRICIA M. PENA

IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS (ISSN 0733-8716) is published monthly by the Institute of Electrical and Electronics Engineers, Inc. Responsibility for the contents rests upon the authors and not upon the IEEE, the Society/Council, or its members. IEEE Corporate Office: 3 Park Avenue, 17th Floor, New York, NY 10016-5997. IEEE Operations Center: 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331. NJ Telephone: +1 732 981 0060. Price/Publication Information: Individual copies: IEEE Members \$20.00 (first copy only), nonmembers \$63.00 per copy. (Note: Postage and handling charge not included.) Member and nonmember subscription prices available upon request. Available in microfiche and microfilm. Copyright and Reprint Permissions: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy for private use of patrons, provided the per-copy fee indicated in the code at the bottom of the first page is paid through the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923. For all other copying, reprint, or republication permission, write to Copyrights and Permissions Department, IEEE Publications Administration, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331. Copyright © 2006 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 JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, IEEE, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331. GST Registration No. 125634188. Printed in U.S.A.