



IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES

OCTOBER 1993

VOLUME 41

NUMBER 10

IETMAB

(ISSN 0018-9480)

A PUBLICATION OF THE IEEE MICROWAVE THEORY AND TECHNIQUES SOCIETY



SPECIAL ISSUE ON QUASI-OPTICAL TECHNIQUES

Guest Editors' Overview J. W. Mink and D. B. Rutledge 1661

PAPERS

Overview

Focal Plane Imaging Systems for Millimeter Wavelength (*Invited Paper*) P. F. Goldsmith, C.-T. Hsieh, G. R. Huguenin, J. Kapitzky, and E. L. Moore 1664

Gaussian Beams

Long Wave Optics D. H. Martin and J. W. Bowen 1676

Gaussian Beam-Mode Analysis and Phase-Centers of Corrugated Feed Horns R. J. Wylde and D. H. Martin 1691

Mode Conversion at Diffracting Apertures in Millimeter and Submillimeter Wave Optical Systems J. A. Murphy, S. Withington, and A. Egan 1700

Slot-Fed Higher Order Mode Fabry-Perot Filters J. McCleary, M.-Y. Li, and K. Chang 1703

Gaussian-Beam Open Resonator with Highly Reflective Circular-Coupling Regions T. Matsui, K. Araki, and M. Kiyokawa 1710

Quasi-Optical Antennas and Waveguides

Tapered Slotline Antennas at 802 GHz P. R. Acharya, H. Ekstrom, S. S. Gearhart, S. Jacobsson, J. F. Johansson, E. L. Kollberg, and G. M. Rebeiz 1715

A Hybrid Dielectric Slab-Beam Waveguide for the Submillimeter Wave Region J. W. Mink and F. K. Schwing 1720

A Planar Wide-Band 80–200 GHz Subharmonic Receiver B. K. Kormanyos, P. H. Ostdiek, W. L. Bishop, T. W. Crowe, and G. M. Rebeiz 1730

Double Slot Antennas on Extended Hemispherical and Elliptical Silicon Dielectric Lenses D. F. Filipovic, S. S. Gearhart, and G. M. Rebeiz 1738

An Improved Solution for Integrated Array Optics in Quasi-Optical Millimeter and Submillimeter Waves Receivers: The Hybrid Antenna T. H. Buttgenbach 1750

Active Grid Arrays

A 100-Element HBT Grid Amplifier M. Kim, E. A. Sovero, J. B. Hacker, M. P. De Lisio, J.-C. Chiao, S.-J. Li, D. R. Gagnon, J. J. Rosenberg, and D. B. Rutledge 1762

A 6.5 GHz–11.5 GHz Source Using a Grid Amplifier with a Twist Reflector M. Kim, E. A. Sovero, J. B. Hacker, M. P. De Lisio, J. J. Rosenberg, and D. B. Rutledge 1772

Quasi-Optical VCO's T. Mader, S. Bundy, and Z. B. Popovic 1775

A Monolithic Diode Array Millimeter-Wave Beam Transmittance Controller L. B. Sjogren, H.-X. Liu, F. Wang, T. Liu, X.-H. Qin, W. Wu, E. Chung, C. W. Domier, and N. C. Luhmann, Jr. 1782

Quasi-Optical Millimeter-Wave Hybrid and Monolithic PIN Diodes Switches K. D. Stephan, P. H. Spooner, and P. F. Goldsmith 1791

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Continued on back cover)



IEEE MICROWAVE THEORY AND TECHNIQUES SOCIETY

The Microwave Theory and Techniques Society is an organization, within the framework of the IEEE, of members with principal professional interest in the field of microwave theory and techniques. All members of the IEEE are eligible for membership in the Society and will receive this TRANSACTIONS upon payment of the annual Society membership fee of \$20.00. Affiliate membership is available upon payment of the annual affiliate fee of \$33.00, plus the Society fee of \$20.00. For information on joining write to the IEEE at the address below. *Member copies of Transactions/Journals are for personal use only.*

ADMINISTRATIVE COMMITTEE

P. W. STAECKER, <i>President</i>	E. J. CRESCENZI, JR., <i>Vice President</i>	M. J. SCHINDLER, <i>Secretary</i>	R. E. BRYAN, <i>Treasurer</i>
R. E. BRYAN	R. H. JANSEN	B. S. PERLMAN	P. W. STAECKER
E. D. COHEN	S. A. MAAS	R. POLLARD	R. SUDBURY
E. J. CRESCENZI, JR.	M. A. MAURY, JR.	J. E. RAUE	D. G. SWANSON
D. HORNBuckle	R. A. MOORE	E. REZAK	G. THOREN

Honorary Life Members

A. C. BECK	T. S. SAAD
S. B. COHN	K. TOMIYASU
A. A. OLINER	L. YOUNG

Distinguished Lecturers

W. CURTICE
P. GOLDSMITH
F. IVANEK
V. RIZZOLI
J. R. WHINNERY

Past Presidents

R. KAGIWADA (1992)
F. IVANEK (1991)
T. ITOH (1990)

S-MTT Chapter Chairmen

Albuquerque: M. A. DINALLO	Israel: E. LEVINE	Schenectady: R. J. GUTMANN
Atlanta: A. J. GASIEWSKI	Ithaca: L. PALMATEER	Seattle: D. T. HARVEY
Baltimore: S. L. ANTHONISEN	Kitchner-Waterloo: C. R. SELVAKUMAR	Seoul: J. S. MYUNG
Beijing: Y.-R. ZHONG	Y. L. CHOW	Singapore: L. M. SENG
Benelux: K. VAN T. KLOOSTER	Los Angeles: H. J. DE LOS SANTOS	South Africa: A. J. BOOYSEN
Buffalo: M. R. GILLETTE	Milwaukee: J. RICHIE	South Australia: B. D. BATES
Central Iowa/Cedar Rapids: D. OLIVER	Montreal: G. L. YIP	South Brazil: D. CONSONI
Central & South Italy: P. LAMPARIELLO	New Hampshire: T. O. PERKINS	Southeastern Michigan: E. J. ROTHWELL
Central New England/Boston: R. T. WEBSTER	New Jersey Coast: T. FITCH	Spain: M. P. SIERRA
Chicago: T. G. JURGENS	New South Wales: C. D. WILSON	Springfield: K. M. LAU
Cleveland: D. A. FORCE	New York/Long Island: F. J. WINTER	St. Louis: R. INDECK
Columbus: T.-H. LEE	North Italy: C. N. NALDI	Sweden: P. T. LEWIN
Dallas: G. A. TRUITT	North Jersey: R. V. SNYDER	Switzerland: L. PROST
Dayton: G. R. SIMPSON	Oregon: K. SHENAI	Syracuse: D. W. FERGUSON
Denver-Boulder: R. VIDANO	Orlando: D. L. DUNN	Taipei: C. C. TZUANG
Egypt: O. L. EL-SAYED	Ottawa: D. H. REEKIE	Tokyo: T. YONEYAMA
Finland: E. T. KEMPPINEN	Philadelphia: A. S. DARYOUSH	Tucson: H. C. KOHLBACHER
Florida West Coast: R. HENNING	Phoenix: G. MARACAS	Turkey: A. BUYUKAKSOY
France: V. F. HANNA	Poland: J. W. MODELSKI	Twin Cities: A. GOPINATH
Germany: F. ARNDT	Portland: D. SHENAI	United Kingdom/Ireland: T. H. OXLEY
Greece: N. K. UZUNOGLU	Princeton: A. KATZ	Utah/Salt Lake City: M. F. ISKANDER
Houston: J. T. WILLIAMS	Rio de Janeiro: J. R. BERGMANN	Venezuela: A. N. BIANCHI
Hungary: I. FRIGYES	San Diego: A. CLAVIN	Virginia Mountain: I. J. BAHL
Huntsville: H. L. BENNETT	San Fernando Valley: A. M. MADNI	Washington/Northern Virginia: G. TAIT
India: S. K. KOUL	Santa Clara Valley/San Francisco: W. OU	Winnipeg: G. BRIDGES
Indonesia: S. NATANAGARA		Yugoslavia: B. JOCANOVIC

IEEE TRANSACTIONS® ON MICROWAVE THEORY AND TECHNIQUES

Editor	Associate Editors
D. MASSÉ	R. SORRENTINO (Tutorial/Review Papers)
	J. B. HORTON (Systems and Applications)
	P. W. STAECKER (Index Issues)

THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

Officers

MARTHA SLOAN, <i>President</i>	CHARLES K. ALEXANDER, <i>Vice President, Professional Activities</i>
H. TROY NAGLE, <i>President-Elect</i>	HELEN M. WOOD, <i>Vice President, Publication Activities</i>
SOUGUIL J. M. ANN, <i>Secretary</i>	LUIS T. GANDIA, <i>Vice President, Regional Activities</i>
THEODORE W. HISSEY, JR., <i>Treasurer</i>	WALLACE S. READ, <i>Vice President, Standards Activities</i>
EDWARD A. PARRISH, <i>Vice President, Educational Activities</i>	DONALD M. BOLLE, <i>Vice President, Technical Activities</i>

W. KENNETH DAWSON, *Director, Division IV—Electromagnetics and Radiation*

Headquarters Staff

JOHN H. POWERS, *Executive Director and General Manager*

PHYLLIS HALL, *Staff Executive, Publications*

FRANK R. MOORE, *Staff Executive, Volunteer Activities*

RICHARD D. SCHWARTZ, *Staff Executive, Business Administration*

IRVING ENGELSON, *Staff Director, Corporate Activities*

W. R. HABINGREITHER, *Staff Director, Customer Service Center*

PETER A. LEWIS, *Staff Director, Educational Activities*

MELVIN I. OLKEN, *Staff Director, Regional Activities*

EDWARD ROSENBERG, *Controller*

ANDREW G. SALEM, *Staff Director, Standards Activities*

W. THOMAS SUTTLE, *Staff Director, Professional Activities*

ROBERT T. WANGEMANN, *Staff Director, Technical Activities*

Publications Department

Director, Transactions/Journals: PATRICIA WALKER

Publications Manager: GAIL S. FERENC

Electronic Production Manager: JERI L. UZZO

Managing Editor: VALERIE CAMMARATA

Associate Editor: JOSEPH PAGNOTTA

IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES 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 Headquarters:** 345 East 47 Street, New York, NY 10017-2394. **NY Telephone:** 212-705 + extension: Information-7900; General Manager-7910; Public Information-7867; Spectrum-7556. **Telecopiers:** NY (Headquarters) 212-752-4929, NY (Publications) 212-705-7682. **IEEE Service Center** (for orders, subscriptions, address changes, Educational Activities, Publishing Services, Region/Section/Student Services, Standards): 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331. **NJ Telephone:** Information: 908-981-0060; 908-562 + extension: Controller -5365; Technical Activities -3900. **IEEE Washington Office** (for U.S. professional activities): 1828 L Street, NW, Suite 1202, Washington, DC 20036-5104. **Washington Telephone:** 202-785-0017. **Price/Publication Information:** Individual copies: IEEE members \$10.00 (first copy only), nonmembers \$20.00 per copy. (Note: Add \$4.00 postage and handling charge to any order from \$1.00 to \$50.00, including prepaid orders.) Member and nonmember subscription prices available on request. Available in microfiche and microfilm. **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, 29 Congress Street, Salem, MA 01970; 2) pre-1978 articles without fee. For all other copying, reprint, or republication permission, write to Copyrights and Permissions Department, IEEE Publishing Services, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331. Copyright © 1993 by The Institute of Electrical and Electronics Engineers, Inc. All rights reserved. Second-class postage paid at New York, NY, and at additional mailing offices. **Postmaster:** Send address changes to IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, IEEE, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331. GST Registration No. 125634188. Printed in U.S.A.