



**IEEE TRANSACTIONS ON
MICROWAVE THEORY
AND TECHNIQUES**

DECEMBER 1972

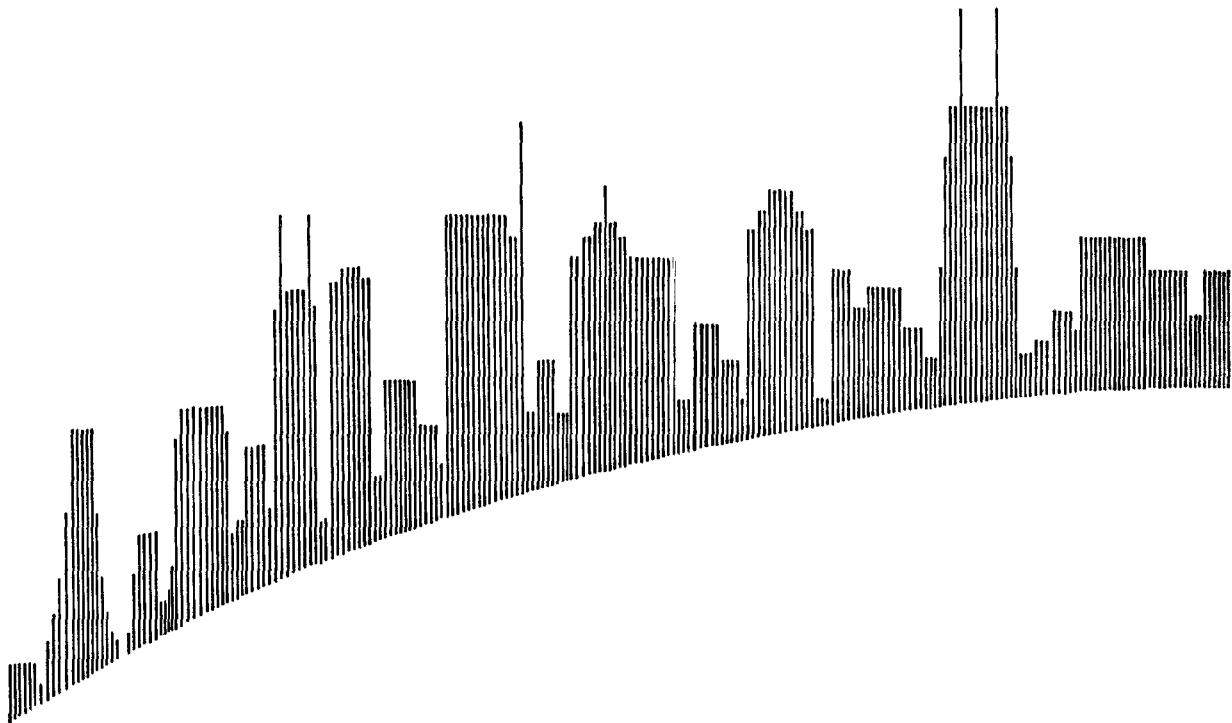
VOLUME MTT-20

NUMBER 12

A PUBLICATION OF THE IEEE MICROWAVE THEORY AND TECHNIQUES GROUP



1972 Symposium Issue





IEEE MICROWAVE THEORY AND TECHNIQUES GROUP

The Microwave Theory and Techniques Group 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 Group and will receive this TRANSACTIONS upon payment of the annual Group membership fee of \$7.00. Affiliate membership is available upon payment of the annual affiliate fee of \$16.00. For information on joining write to the IEEE at the address below.

ADMINISTRATIVE COMMITTEE

A. CLAVIN, President	J. B. HORTON, Vice President	D. PARKER, Secretary-Treasurer
F. R. ARAMS	H. W. COOPER	N. LIPETZ
R. W. BEATTY	R. V. GARVER	S. OKWIT*
J. H. BRYANT*	G. I. HADDAD	J. M. OSEPCHEK
	D. B. LEESON	R. A. RIVERS
<i>* Ex officio (past chairmen)</i>		
<i>Honorary Life Members</i>		
A. C. BECK W. W. MUMFORD		

G-MTT Chapter Chairmen

Atlanta	T. G. HICKMAN	Houston	T. K. GAYLORD	Philadelphia	E. G. SCHWARZ
Baltimore	G. I. KLEIN	Huntsville	W. G. BRISCOE	Phoenix	P. D. KENNEDY
Boston	R. E. GRABOWSKI	Long Island	P. MEIER	St. Louis	G. A. LINDAUER
Buffalo		Los Angeles Council	R. M. HAUTZIK	San Diego	J. H. PROVENCHER
Chicago	T. M. P. SMITH	Milwaukee	R. W. LADE	San Francisco	D. A. GRAY
Columbus	D. B. HODGE	Montreal		Schenectady	J. M. BORREGO
Connecticut	M. GILDEN	N. J. Coast	R. W. BENJAMIN	Seattle	R. J. COE
Dallas	R. M. LIVINGSTON	New Hampshire	W. J. WILSON	S. E. Michigan	W. R. CURTICE
Denver	S. W. MALEY	New York		Syracuse	D. H. KUHN
Florida-W. Coast	B. E. SIGMON	North Jersey	B. D. DEMARINIS	Tokyo, Japan	S. OKAMURA
Foothills, Calif.		Orange County	R. A. DELL-IMAGINE	Tucson	E. P. PIERCE
Fort Worth	S. D. COLEMAN	Orlando	D. E. WUNSCH	Washington, D. C.	W. F. WORKMAN
		Ottawa	D. H. REEKIE		

IEEE TRANSACTIONS* ON MICROWAVE THEORY AND TECHNIQUES

Editor

F. J. ROSENBAUM

N. LIPETZ
(*Institutional Listings*)

Associate Editors

F. G. R. WARREN
(*Foreign Abstracts*)

J. W. BANDLER
(*Computer Program Descriptions*)

M. CAULTON

Address all manuscripts to the Editor, F. J. Rosenbaum, Dep. Elec. Eng., Washington Univ., St. Louis, Mo. 63130. Submission of three copies of manuscripts, including figures, will expedite the review.

THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

Officers

ROBERT H. TANNER, President

HAROLD CHESTNUT, Vice President

JOSEPH K. DILLARD, Vice President, Technical Activities

CLARENCE L. COATES, Jr., Vice President, Publication Activities
ARTHUR P. STERN, Secretary
RAYMOND W. SEARS, Treasurer

Headquarters Staff

DONALD G. FINK, Executive Director

ELWOOD K. GANNETT, Director, Publishing Services
WILLIAM J. KEYES, Director, Administrative Services
JOHN M. KINN, Director, Educational Services
CHARLES F. STEWART, Jr., Director, Member Services

BETTY J. STILLMAN, Executive Assistant to the Executive Director
RICHARD M. EMBERSON, Director, Technical Services
EDWIN D. MACDONALD, Conference Services
SAVA I. SHERR, Standards

Editorial Department

H. JAMES CARTER, Manager, Editorial Services

Senior Editors: ANDRÉE ABRAMOFF, ANN H. BURGMAYER, CAROLYN ELENOWITZ, GAIL S. FERENC
Associate Editors: NANCY B. BUDDE, HELEN S. GOLDMAN, MARY M. HALL, RUTH MELNICK, NELA RYBOWICZ

IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES is published monthly by The Institute of Electrical and Electronics Engineers, Inc., 345 East 47 Street, New York, N. Y. 10017. Responsibility for the contents rests upon the authors and not upon the IEEE, the Group, or its members. This journal is available in either microfiche or printed form. Individual copies may be purchased at \$3.00 (first copy only) by IEEE members and \$6.00 per copy by nonmembers. Annual subscription price: IEEE members, dues plus Group fee. Price for nonmembers available on request. Abstracting is permitted with mention of source. All rights, including translation, are reserved by the IEEE. Requests for republication permission should be addressed to the IEEE Editorial Department, 345 East 47 Street, New York, N. Y. 10017. Copyright © 1972 by The Institute of Electrical and Electronics Engineers, Inc. Printed in U.S.A. Second-class postage paid at New York, N. Y. and at additional mailing offices.