



**IEEE TRANSACTIONS ON  
MICROWAVE THEORY  
AND TECHNIQUES**

**DECEMBER 1971**

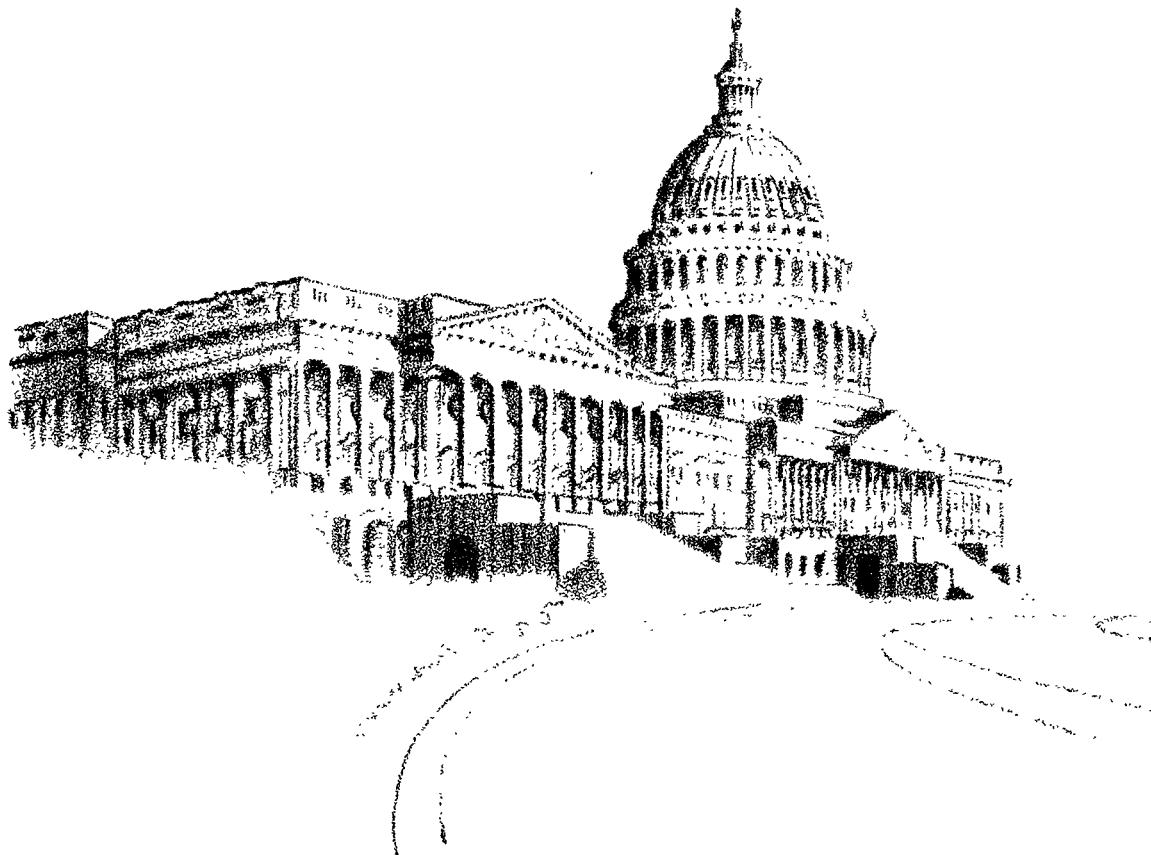
**VOLUME MTT-19**

**NUMBER 12**

Published Monthly



**1971 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 \$6.00. 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

<b>S. OKWIT, Chairman</b>	<b>A. CLAVIN, Vice Chairman</b>	<b>N. LIPETZ, Secretary-Treasurer</b>
F. R. ARAMS	R. V. GARVER	J. B. HORTON
R. W. BEATTY	G. I. HADDAD	M. C. HORTON
J. H. BRYANT*	R. E. HENNING*	D. B. LEESON
H. W. COOPER		J. M. OSEPCHEK

\* *Ex officio (past chairmen)*

### Honorary Life Members

<b>A. C. BECK</b>	<b>A. G. CLAVIER</b>	<b>W. W. MUMFORD</b>	<b>G. C. SOUTHWORTH</b>
-------------------	----------------------	----------------------	-------------------------

### G-MTT Chapters

Atlanta	T. J. LYON	Houston	H. C. BOURNE, JR.	Phoenix	M. D. SIRKIS
Baltimore	B. A. SICHELSTIEL	Huntsville	M. D. FAHEY	St. Louis	W. E. HORD
Boston	H. HOWE, JR.	Long Island	J. GOLDBERG	San Diego	D. G. KILLION
Buffalo		Los Angeles	N. PELNER	San Francisco	
Central N. C.	T. R. SCHILLER	Milwaukee	R. W. LADE	Schenectady	J. B. UNDERWOOD
Chicago	A. W. RUDGE	Montreal	E. F. MORRIS	Seattle	F. P. CARLSON
Columbus	R. T. COMPTON, JR.	N. J. Coast	M. V. SCHNEIDER	S. E. Michigan	C. P. TRESSLT
Connecticut	R. MASTROIANNI	New Hampshire	W. J. WILSON	Syracuse	B. L. BOWLER
Dallas	D. N. BOWYER	New York		Tokyo, Japan	S. OKAMURA
Denver	M. T. DECKER	North Jersey	K. C. O'BRIEN	Toronto	S. DIMITREWSKI
Florida-W. Coast	B. E. SIGMON	Orange Co.	D. K. WAINO	Tucson	E. P. PIERCE
Foothills, Calif.	H. P. JOHNSON	Orlando	J. M. SCHUCHARDT	Washington, D.C.	C. E. EDWARD
		Philadelphia	W. H. SCHAEDELA		

### IEEE TRANSACTIONS® ON MICROWAVE THEORY AND TECHNIQUES

<b>Editor</b>	<b>Associate Editors</b>		
<b>G. I. HADDAD</b> <i>(Institutional Listings)</i>	<b>S. OKWIT</b>	<b>F. G. R. WARREN</b> <i>(Foreign Abstracts)</i>	<b>J. W. BANDLER</b> <i>(Computer Program Descriptions)</i>

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

JAMES H. MULLIGAN, JR., *President*  
ROBERT H. TANNER, *Vice President*  
HAROLD CHESTNUT, *Vice President, Technical Activities*

CLARENCE L. COATES, JR., *Vice President, Publication Activities*  
JOHN R. WHINNERY, *Secretary*  
RAYMOND W. SEARS, *Treasurer*

#### Headquarters Staff

##### DONALD G. FINK, *General Manager*

JOHN L. CALLAHAN, *Staff Consultant*  
ELWOOD K. GANNETT, *Director, Editorial Services*  
WILLIAM J. HILTY, *Director, Convention and Publishing Services*  
WILLIAM J. KEYES, *Director, Administrative Services*  
JOHN M. KINN, *Director, Educational Services*  
LEON PODOLSKY, *Staff Consultant*

CHARLES F. STEWART, JR., *Director, Member Services*  
BETTY J. STILLMAN, *Administrative Assistant to the General Manager*  
RICHARD M. EMBERSON, *Director, Technical Services*  
EDWIN D. MACDONALD, *Conference Services*  
SAVA I. SHERR, *Standards*

#### Editorial Department

##### H. JAMES CARTER, *Managing Editor, Transactions*

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

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 \$2.50 (first copy only) by IEEE members and \$5.00 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 © 1971 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.