IEEE SOCIETY ON MICROWAVE THEORY AND TECHNIQUES

NEWSLETTER

Number 121
Spring 1988

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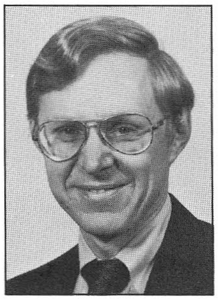
EDITOR'S NOTES



by Peter Staecker

As this issue goes to press, the New York Symposium Steering Committee is preparing for the assault on the Big Apple by over 6000 attendees in late May. From the reports at AdCom, the coverage in this Newsletter, and from personal calls to members of Chuck Buntschuh's gang, the overwhelming sense I get is one of readiness and organization. The advance program is in the mail, and final reports and schedules are in this issue. The Hertz Centennial Exhibit is in good shape and thanks to the efforts of many and the direction of John Bryant. The financial backing behind this enterprise comes from the support of private industry within the microwave community as well as IEEE. See Mario Maury's tribute to these sponsors below.

Gossip: Look for an increased awareness of the Society's fiscal health. As our member services increase, we become increasingly dependent on the income produced by our (very successful) Symposium. To some extent, this dependence parallels that of the US dependence on foreign oil, in that our destiny is linked to one "energy source." An *ad hoc* Budget Committee of AdCom has been established to address the planning expenses. Walt Gelnovatch will provide details in future Newsletters.

On a related issue, Martin Schneider has informed us that the cost of our member services when viewed at the national level reveal that MTT could be accused of *dumping*. He has also compiled an impressive *Speaker Bureau*, for the technical benefit of our membership. See the details in his report below.

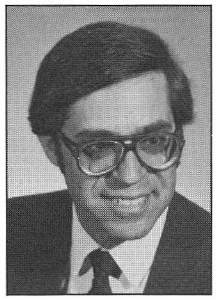
The Winter 1988 issue, somewhat late in shipment, was a big one. In an effort to cut some costs and get back in line with our page budget, the usual *line-up* shots of TPC and AdCom folks have been omitted from this issue. They will appear in the Digest — and probably at the Symposium also. See you in New York!

MTT-S NEWSLETTER
COPY DEADLINE INFORMATION

Issue	Copy Deadline*
Summer/Fall	July 2
Winter	December 1
Spring	February 28

* For special technical articles, submit 8 weeks earlier.

TAB HIGHLIGHTS



by Barry E. Spielman

A Technical Activities Board (TAB) meeting was held in San Antonio, Texas on February 15 and 16, 1988. As this was the first meeting for this year the agenda was rather light. However, there were some substantive items dealt with at this meeting, which was chaired by TAB Chairman, Rex Dixon.

One of these involved an action to approve the formation of an IEEE Robotics and Automation Society. Heretofore, such activity existed through IEEE in the form of a Council, administered through eight cooperative Societies of IEEE. It was brought out that the Journal of Robotics and Automation has over 7,000 individual subscriptions and over 1,000 institutional subscriptions. Also, the Annual Robotics and Automation Conference has had an average paid attendance of over 700 for the past two years. Considering these and other indicators of sustained and independent vitality, the vote of TAB supported the change of status from Council to Society.

Other noteworthy activity at this meeting was more informational. Tom Crystal reported on new technology directions being considered by Dr. Henry Kressel's New Technology Directions Committee. Technologies being discussed included: superconductivity; electronics manufacturing; materials processing; and neural networks. It is noteworthy that the MTT-S is already working to provide information to its membership relating to the first two categories. Finally, based upon discussion at the forum for presidents of Societies and Councils, it was made very clear that effort must be expended to strengthen and provide continuity in the communication between TAB and the Societies/Councils.

Did you know that . . .

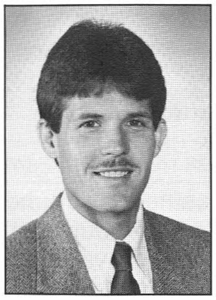
. . . **one working wife in four** earns more money than her husband?

US Census Bureau, quoted in *New Woman,* Box 5252, Boulder, CO 80321. Monthly. $15/yr.

. . . **Tuesday** is the day people do the most work? Wednesday is the next most productive workday. *Friday:* The least amount of work gets done.

Survey of 100 US personnel managers, cited in *Research Recommendations*, 1328 Broadway, New York 10001. Weekly. $48/yr.

MARK A. McDONALD NAMED ROCKWELL ENGINEER OF THE YEAR



EL SEGUNDO, CA, (Feb. 25, 1988) — Rockwell International Corporation has named Mark A. McDonald an Engineer of the Year, the company's highest honor for technical achievement.

McDonald, 30, is an engineer for Rockwell's Lightwave Systems division in Richardson, Texas.

He was selected for the award for his work in the development of advanced capacity lightwave transmission systems. Lightwave systems use hair-thin strands of glass to transmit voice, data and image signals. A single glass fiber can carry as many voice conversations as thousands of copper wires.

McDonald is one of 17 selected for the company's Engineer of the Year award from among the more than 19,000 engineers and scientists employed by Rockwell.

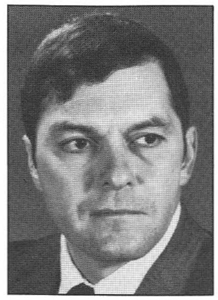
The awards were presented in Los Angeles in conjuction with National Engineers Week, February 21-27.

"Mark McDonald's technical expertise has led to a lightwave transission system that can carry 16,000 phone calls over a single fiber," said Robert L. Cattoi, Rockwell's senior vice president of Research & Engineering. "This is twice the capacity of previous lightwave transmission systems."

A native of Oklahoma City, Okla., McDonald earned a bachelor's degree in electrical engineering from Oklahoma State University in 1980 and a master's degree in electrical engineering from Cornell University in 1981. He joned Rockwell in 1983, and currently resids in Garland, Texas.

McDonald is a member of the Microwave Theory and Techniques Society of IEEE.

AdCom HIGHLIGHTS



by Vladimir G. Gelnovatch

The Winter meeting of the MTT-S AdCom was held in New York City on the 12th and 13th of January 1988. This meeting was held in conjunction with the Technical Program Committee of the 1988 MTT-S International Symposium at which papers were selected and sessions formulated. This year, 393 contributed papers were submitted which was an all time record. Of these, 170 were accepted as full length regular presentations and 50 went into an open forum format. This year at the International Symposium four parallel sessions will be used to accommodate this large number of papers.

Barry Spielman, AdCom President, in his quest to assure long term financial stability to the MTT-S, formed an *ad hoc* standing budget committee to review all long term financial commitments. This committee will be chaired by the Vice President and will be formally changed from *ad hoc* status to permanent as soon as procedural matters allow it. It is hoped that a meaningful and productive long term financial initiative can be developed which will allow the society to maintain meaningful services to its members through varying financial climates.

A motion to help retired but active MTT members who can contribute their services with financial expenses such as travel, telephones, etc., was passed. The motion allows the MTT president, at his discretion, to allow up to $2,500 per person with a $10,000 overall limit to support qualified individuals.

San Diego and San Francisco were designated as candidates for the site for the MTT International Microwave Symposium in 1994. Negotiations will now be conducted to determine the actual site under a priority set by AdCom.

The MTT society health appears to be excellent via the statistics which became available to attendees. Specifically, AdCom MTT had been the fastest growing IEEE Society (13.1% in 1987) and passed the 10,000 member status in November 1987. We are now the 6th largest Society in the IEEE.

A suggestion by the outgoing budget committee was made that the Society adopt a financial position where the cash reserve of the society should equal 100% of one year's operational monies. Additionally 2/3 AdCom vote would be needed to dip into this reserve. No action was taken on this suggestion.

CALL FOR NOMINATIONS

by E.C. Niehenke

The MTT-S holds elections at the annual Fall meeting to elect members to serve on the Administrative Committee (AdCom). The Bylaws state that the Nominations Subcommittee will select a slate of at least two members of the Society for each vacancy in the elected membership, which will occur on the AdCom the following January 1. The Nominations Subcommittee will be guided in its selections by principles of efficiency and geographical and organizational distribution. Members who have served three consecutive terms by the following January 1 shall not be considered eligible for nomination by the Nominations Subcommittee.

The Bylaws provide three means by which one may be nominated for the AdCom. They are:

1) Nomination by the Nominations Subcommittee.
2) Nomination by petition signed by 25 MTT-S members and submitted to the Nominations Chairman (Edward C. Niehenke: (301) 765-4573) prior to September 1, 1988.
3) Informal Chapter nominations.

The informal nomination by Chapters does not guarantee nomination. The Chapter Chairman should convey the informal nominations to the Nominations Chairman by September 1, 1988. Both nominees and potential nominees must be contacted prior to the Fall annual meeting to ascertain that they will accept the nomination.

This year the Nominations Subcommittee members consists of eight Society members, half of whom are not current AdCom members as specified by the Bylaws. They are:

N. W. Cox, Atlanta, GA	(404) 894-2928
K.C. Gupta, Boulder, CO	(303) 492-7498
C. Holmes, Westlake Village, CA	(818) 991-7530
T. Itoh, Austin, TX	(512) 471-1072
R. Kaul, Adelphi, MD	(202) 394-1403
J. Raue, Redondo Beach, CA	(213) 535-7409
S.J. Temple, Bedford, MA	(617) 274-4736
T.Y. Wong, Chicago, IL	(312) 567-5796

The wide geographic distribution of the Nominations subcommittee should give a reasonably fair representation to all Chapters and members. The geographic and affiliation distribution of the current AdCom membership is given below.

Present (1988)				Total = 18
East	7	Industry	15	
Central	4	Government	1	
West	7	University	2	
Holdover Members (1989)				Total = 12
East	6	Industry	10	
Central	3	Government	0	
West	3	University	2	
Term Ends (1988)				Total = 6
East	1	Industry	5	
Central	1	Government	1	
West	4	University	0	

The Nominations Subcommittee needs your help in suggesting potential nominees to serve our membership as AdCom members. Please submit your suggestions to a member of the Nominations Subcommittee and/or your local Chapter Chairman. The schedule for the Nomination Subcommittee calls for providing a slate of candidates by September 1, 1988. Please keep in mind that the potential nominees must be able to commit themselves to at least three meetings a year held across the U.S. Nominate your prospective AdCom member today.

MTT STUDENT PAPER CONTEST

The MTT Student Paper Contest is open to all undergraduate student members of IEEE, and follows the same basic guidelines as the IEEE Student Paper Contest, with the exception that the subject of the paper must fall within the areas normally covered by the Transactions of the MTT. Its objective is to increase awareness of undergraduate students of Microwave subjects, and to enhance their communication skills. Winners from local branch and area contests will be submitted to the national contest and the overall winner will be invited, at MTT expense, to present his or her paper at the MTT International Microwave Symposium. Prizes will be awarded at the local branch and area contests to the winners with $250 being the maximum available individual prize money. Limited travel expense money will be available. Judging of the local and area contests will be on the basis of both oral and written presentation, while the national contest will be judged solely on the basis of the written material. Papers will be due from judging at the area level by December 1, 1987 and from the branch contests be November 14, 1987.

For information contact:

John M. Owens
Electrical Engineering Department
University of Santa Clara
Santa Clara, California 95053
(408)-554-4482

1988 IEEE MTT-S INTERNATIONAL MICROWAVE SYMPOSIUM SCHEDULE OF EVENTS

SUNDAY, MAY 22, 1988 — Registration — Marriott 7th Floor — 3:30 pm - 7:30 pm

MONDAY, MAY 23, 1988 — Registration — Marriott 7th Floor — 7:30 pm - 7:30 pm

WORKSHOPS — MARRIOTT HOTEL

M-1	M-2	M-3	M-4
SUPERCONDUCTIVITY AND MICROWAVES 9th Floor Ballroom 8:30 am - 5:00 pm	MIC AND MMIC FET HIGH-POWER AMPLIFIER DESIGN TECHNIQUES Gramarcy/Herald/Soho 8:30 am - 5:00 pm	DESIGNING MMICS THROUGH FOUNDRIES Astor Ballroom 8:30 am - 5:00 pm	PACKAGING HYBRID AND MONOLITHIC MICROWAVE AND MILLIMETER WAVE COMPONENTS Duffy/Columbia 8:30 am - 5:00 pm

MMWMC SYMPOSIUM RECEPTION — South Broadway Ballroom — 7:00 - 10:00 pm

TUESDAY, MAY 24, 1988 — Registration — Marriott 7th Floor — 7:30 am - 7:30 pm

WORKSHOPS — MARRIOTT HOTEL

T-1	T-2	T-3	T-4
FET STRUCTURES AND THEIR MODELING Gramarcy/Herald/Soho 8:30 am - 5:00 pm	CAD ORIENTED MODELING OF DISCONTINUITIES IN MICROWAVE AND MILLIMETER WAVE TRANSMISSION STRUCTURES 9th Floor Ballroom 8:30 am - 5:00 pm	HIGH VOLUME MICROWAVE APPLICATIONS Empire/Hudson/Chelsea 8:30 am - 5:00 pm	DEVELOPMENTS IN LINEARITIES FOR MICROWAVE POWER AMPLIFIERS Duffy/Columbia 8:30 am - 5:00 pm

MMWMC SYMPOSIUM — Marriott Hotel		ARFTG — New York Penta Hotel
BROADWAY BALLROOM NORTH	ASTOR BALLROOM	7:30 am - 5:00 pm — MANUFACTURERS EXHIBITS Sky Top Room
I. MMIC TECHNOLOGY 8:30 am - 10:20 am		8:00 am - 12:00 — MORNING TECHNICAL SESSION Penn Top South
II. FIBER OPTICS COMMUNICATIONS 10:50 am - 12:00 noon		
III. NON-LINEAR APPLICATIONS OF MMICs 1:30 - 2:50 pm	IV. MILLIMETER WAVE OSCILLATORS 1:30 - 2:50 pm	12:00 - 1:15 pm — LUNCH — Penn Top Center 1:15 - 5:00 pm — AFTERNOON TECHNICAL SESSION — Penn Top South
V. MMIC RECEIVER COMPONENTS 3:10 - 4:30 pm	VI. MILLIMETER WAVE MONOLITHIC CIRCUITS 3:10 - 4:30 pm	6:00 pm - 7:00 pm — COCKTAILS — Penn Top Foyer 7:00 pm - 10:00 pm — ARFTG AWARDS BANQUET Penn Top South

6:00 - 8:00 pm — MICROWAVE JOURNAL RECEPTION — Roseland — 239 W 52nd St.

WEDNESDAY, MAY 25, 1988 — Registration — Jacob Javits Convention Center — 7:30 am - 5:30 pm

ROOM 1	ROOM 2	ROOM 3	ROOM 4
OPENING CERMONY 8:30 - 10:00 am			
A. PRODUCIBILITY AND APPLICATIONS Joint Session 10:30 - 12:00 pm	B. ACOUSTICS & FERRITES 10:30 - 12:00 pm	C. SPECIAL SESSION IN HONOR OF PROF. A.A. OLINER 10:30 - 12:00 pm	D. BIOLOGICAL EFFECTS & MEDICAL APPLICATIONS 10:30 - 12:00 pm
	PANEL SESSION I U.S. COMPETITIVENESS — SOME VIEWS 12:00 - 2:00 pm		
E. POWER AMPLIFIERS Joint Session 2:00 - 3:30 pm	F. HEINRICH HERTZ CENTENNIAL SPECIAL SESSION I 2:00 - 3:30 pm	G. GUIDED WAVE EFFECTS 2:00 - 3:30 pm	H. MEASUREMENTS I 2:00 - 3:30 pm
I. MMIC LOW NOISE AMPLIFIERS Joint Session 4:00 - 5:30 pm	J. HEINRICH HERTZ CENTENNIAL SPECIAL SESSION II 4:00 - 5:30 pm	K. HIGH POWER MICROWAVES (Focused Session) 4:00 - 5:30 pm	L. MEASUREMENTS II 4:00 - 5:30 pm

OPEN FORUM I — 4:00 pm - 6:00 pm

1988 IEEE MTT-S INTERNATIONAL MICROWAVE SYMPOSIUM SCHEDULE OF EVENTS (continued)

THURSDAY, MAY 26, 1988 — Registration — Jacob Javits Convention Center — 7:30 am - 5:30 pm

ROOM 1	ROOM 2	ROOM 3	ROOM 4
M. MONOLITHIC AMPLIFIERS 8:30 - 10:00 am	N. FILTERS & MULTIPLEXERS I 8:30 - 10:00 am	O. HIGH FREQUENCY SUPERCONDUCTIVITY 8:30 - 10:00 am	P. MILLIMETER WAVE INTEGRATED CIRCUITS AND TECHNOLOGY 8:30 - 10:00 am
Q. MONOLITHICS — COMPONENTS 10:30 - 12:00 pm	R. FILTERS & MULTIPLEXERS II 10:30 - 12:00 pm	S. SOLID STATE DEVICES 10:30 - 12:00 pm	T. MICROWAVE INTEGRATED CIRCUITS 10:30 - 12:00 pm
	PANEL SESSION 2 THE BUSINESS OF MICROWAVES 12:00 - 2:00 pm		PANEL SESSION 3 HETEROJUNCTION BIPOLAR TRANSISTORS 12:00 - 2:00 pm
U. MONOLITHICS — SYSTEMS 2:00 - 3:00 pm	V. PASSIVE NETWORKS I 2:30 - 3:30 pm	W. DIELECTRIC RESONATOR OSCILLATORS 2;00 - 3:30 pm	X. NEW METHODS FOR PLANAR CIRCUIT DISCONTINUITIES 2:00 - 3:30 pm
Y. AN OVERVIEW OF EUROPEAN ACTIVITIES 4:00 - 5:30 pm	Z. PASSIVE NETWORKS II 4:00 - 5:30 pm	AA. NEW DEVELOPMENTS IN OSCILLATOR AND MIXER TECHNOLOGY 4:00 - 5:30 pm	BB. MICROSTRIP AND FIN-LINE DISCONTINUITIES 4:00 - 5:30 pm

OPEN FORUM II — 4:00 pm - 6:00 pm

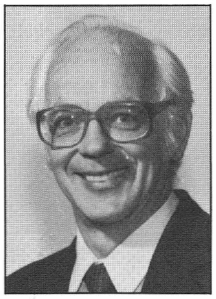
MTT-AWARDS BANQUET — 7:30 pm - 10:30 pm — Marriott Hotel — Broadway Ballroom

FRIDAY, MAY 27, 1988 — Registration — Jacob Javits Convention Center — 7:30 am - 10:00 am

ROOM 1	ROOM 2	ROOM 3	ROOM 4
CC. FIBER OPTIC LINKS AND TRANSMISSION SYSTEMS (Focused Session) 8:30 - 10:00 am	DD. FET POWER AMPLIFIERS 8:30 - 10:00 am	EE. HIGH SPEED DIGITAL TRANSMISSION 8:30 - 10:00 am	FF. MICROWAVE AND MM WAVE FERRITES 8:30 - 10:00 am
GG. FIBER OPTIC LINKS AND TRANSMISSION SYSTEMS II (Focused Session) 10:30 - 12:00 pm	HH. FET AMPLIFIERS 10:30 - 12:00 pm	II. COMMUNICATION SYSTEMS 10:30 - 12:00 pm	JJ. PHASED AND ACTIVE ARRAY TECHNIQUES 10:30 - 12:00 pm
	PANEL SESSION 4 NOISE AND ITS MEASUREMENTS 12:00 - 2:00 pm		PANEL SESSION 5 FERRITES AT MILLIMETER FREQUENCIES 12:00 - 2:00 pm
KK. HIGH SPEED FIBER OPTIC LINKS 2:00 - 3:30 pm	LL. SIGNAL DISTRIBUTION FET APPLICATIONS 2:00 - 3:30 pm	MM. SYSTEM APPLICATIONS 2:00 - 3:30 pm	NN. COMPUTER AIDED DESIGN: LARGE ANALYSIS 2:00 - 3:30 pm
OO. HIGH SPEED OPTICAL TECHNIQUES AND COMPONENTS 4:00 - 5:30 pm	PP. NON-LINEAR FET APPLICATIONS 4:00 - 5:30 pm	QQ. COMPUTER AIDED DESIGN, ANALYSIS AND MODELING 4:00 - 5:30 pm	

On page 7:
LIBERTY'S TORCH: The grand lady of the harbor proudly raises her new torch with gold-leafed flame, a symbol of freedom to people everywhere. The restoration is faithful to sculptor Bartholdi's original design, and the new torch now shines more brightly than ever. *(Credit: N.Y. Convention & Visitor's Bureau)*

MICROWAVES — PAST, PRESENT AND FUTURE: THE 1988 IEEE MTT-S INTERNATIONAL MICROWAVE SYMPOSIUM



by Chuck Buntschuh

The Steering Committee of the 1988 International Microwave Symposium invites you to join us for Microwave Week in New York. We are returning to the Big Apple for the first time since 1964, the year of the first *International* Microwave Symposium. We are sure that this year's technical and social programs, coupled with attractions of the most fascinating city on earth, will make the 25th International Microwave Symposium the most rewarding and memorable of all. Don't miss it!

TECHNICAL ACTIVITIES

The technical program — "Microwaves — Present" — consists of the Microwave Symposium and its associated workshops, the Monolithic Symposium, and the 31st ARFTG conference. The content of these meetings are described elsewhere in this newsletter, and I won't try to summarize them here. However, it will be useful to review the schedule, locations, and other event.

The eight workshops will be on Monday and Tuesday, and the first day of the Monolithic Symposium will be on Tuesday, in the Marriott Marquis, or headquarters hotel, located in Times Square, the veritable core of the Big Apple.

The social program also begins on Monday in the Marriott with the reception for the Monolithic Symposium registrants and their guests. The Microwave Journal Reception is on Tuesday evening in the Roseland Ballroom, a few blocks north of the Marriott on 52nd Street, off 7th Avenue — "where your parents and grandparents danced the Shag, the Peabody, and the Tango."

This year the ARFTG Conference is a one-day affair, including the technical sessions, Exhibition, reception, and banquet. It will be on Tuesday in the N.Y. Penta Hotel located across from Penn Station and Madison Square Garden. This was the old Statler- Hilton Hotel; it has been completely remodeled and has a pleasant European ambiance.

On Wednesday morning the Microwave Symposium officially gets underway in the Jacob Javits Convention Center with the Opening Ceremonies. Following the usual opening remarks by me and our Technical Program Chairman, we will be officially welcomed to New York by Alair Townsend, Deputy Mayor and most sparkling spokeswoman for the City. Russell Drew, IEEE President, and Barry Spielman, MTT-S President, will also address us. Frank Brand, Vice President and Chief Technical Officer of M/A-COM will deliver the keynote address, "Tomorrow's Microave Technology," with some insights into "Mcrowaves — Future."

The Symposium which continues through Friday in the Javits Center, has been expanded to our parallel sessons to accommodate comfortably the record number of papers. The Open Forum continues to grow in popularity; we will have two such sessions, including the traditional refreshments. Lunch time panel sessions have also become quite popular. This year we are expanding the lunch period to two hours to add to the value and enjoyment of the panels.

The longer lunch hour will also give you more time to visit the Microwave Exhibition. You'll need it. There will be approximately 290 exhibitions in 480 booths spread out over almost three acres. Also, for the first time in many years, the Exhibition will be located immediately adjacent to the technical sessions, making it especially convenient to drop in whenever you have a few minutes to spare.

The second day of the Monolithic Symposium, Wednesday, will also be in the Javits Center in joint sessions with the Microwave Symposium.

AWARDS BANQUET

The highlights of the social program are the Industry-Hosted Cocktail Party and the annual Awards Banquet on Thursday evening in the Marriott Marquis. Awards will be presented to a number of outstanding contributors. In particular, Dr. Leo Young will receive the Microwave Career Award for his achievements and contributions to the field of microwave theory and techniques, and Dr. Fred Rosenbaum will receive the Distinguished service Award for his dedicated service to the Society.

We will also be honoring 8 newly elected MTT-S Fellows of the IEEE. Dr. Russell Drew, President of the IEEE will present the awards to Drs. Berthold Bosch, Walter Curtice, Kuldip Gupta, Song- Tsuen Peng, Saul Rosenthal, and Ingo Wolff, and Messrs. James Whelehan and Joseph Calviello. I note, with special pleasure, that four of the new Fellows are members of the NY/LI Chapter and serve on the Symposium Steering Committee.

To cap the festivities, the talented *Curtain Up* troupe will entertain us with a Broadway Revue featuring popular show tunes of yesterday and today.

HERTZ EXHIBIT

We will pay tribute to "Microwave — Past" by celebrating the centennial of the public recognition of Heinrich Hertz's work demonstrating Maxwell's theory at RF frequencies. Through the efforts of John Bryant of the University of Michigan, the IEEE, and the

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MICROWAVES — PAST, PRESENT AND FUTURE
(continued from page 7)

generous contributions of 28 microwave companies, the IEEE, and the MTT Society, we will have an exhibit of 20 exact replicas of Hertz's experiental apparatus, on loan from the Science Museum of London. A commemorative guide book, "Hertz — The Beginning of Microwaves," by John Bryant, will accompany the exhibition. Also, on Wednesday afternoon there will be two special sessions with five invited papers on Hertz and the history of microwaves.

The Hertz Exhibit will be appropriately complimented by the usual MTT-S Historical Exhibit of the Society's own collection. Of course, most of these artifacts are of more recent vintage. Together, these two exhibits will present the most comprehensive historical view of microwave and RF ever assembled in one place.

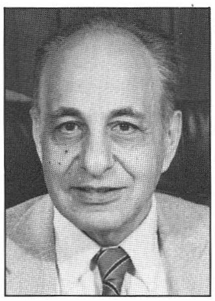
STUDENT PROGRAM

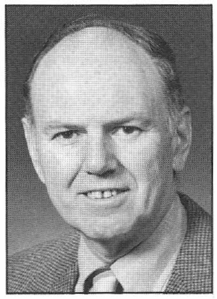
Looking toward "Microwaves - Future" we have instituted a special, new student program, in which a number of the top technology-oriented high school students from the New York area will participate. On Wednesday, in the Javits Center, they will attend the historical session and exhibits, the Industry Exhibition, and a few technical sessions. At lunch they will be welcomed by Barry Spielman, MTT-S President and professor at Washington University, and has a talk about engineering by Tony Cappello of Eaton-AIL. Several college engineering students have volunteered to be their guides for the occasion.

New York is, without a doubt, the most fascinating and exciting city in the world to visit. It would be impossible to try to list even the most well-known and popular attractions here — museums, Broadway theater, restaurants, ethnic districts, etc. etc. To help you get the most out of your visit, and to find the things which most suite your taste, you will receive a *Frommer's Guide to New York* with your registration material. And, of course, there are seven great tours arranged for the Guests' Program which will provide introductory, and behind-the-scenes views of the city. Since the technical program will keep you pretty busy during the week, we recommend spending the Memorial Day weekend in New York, to give you extra time to explore and enjoy this notable city. All of our hotels will continue the convention rate through the weekend or have special pakage deals.

By the time you read this you will have received the Advance Program booklet. If you haven't already done so, fill out and return the conference registration and hotel reservation forms; the hotel convention rates are valid until May 1st and the conference pre-registration rate is good until May 7, 1988. We're looking forward to seeing you at a truly outstanding Microwave Week.

1988 MTT-S INTERNATIONAL MICROWAVE SYMPOSIUM: TECHNICAL PROGRAM





by Jesse Taub and James Whelehan

The 1988 IEEE MTT-S International Microwave Symposium has an exciting and innovative program that will appeal to the broad spectrum of our membership. The technical program held jointly with the Microwave and Millimeter-Wave Monolithic circuits (MMWMC) Symposium, and the ARFTG Conference offers the engineer a full week of all aspects of microwaves. The Technical Program Committee had the formidable task of reviewing 394 contributed papers. This count did not include papers sent directly to the MMWMC Symposium for review. Forty percent of the papers were from outside the Untied States which continues to maintain the strong international flavor of MTT-S Symposia of recent years. The 104 members of the Technical Program Committee, divided into 22 subcommittees, selected 100 regular length, 65 short length, and 49 Open forum papers. In addition, 12 papers were selected by the MMIC Symposium for three joint sessions with MTT-S. Twenty- seven invited papers are also scheduled for presentation. These contributed and invited papers give an excellent picture of recent technical advances in the newly emerging as well as the more established areas of microwaves. This trend is most exemplfied by a session on microwave superconductivity — an exciting topic of major interest because of dramatic advances in high critical temperature materials and their potential use in the microwave field.

FORMAT

The format of the Symposium is similar to thr 1987 Symposium. A plenary session will open the Symposium on Wednesday morning. We have retained features adopted from previous symposia such as Focused Sessions, European Microwave Session, Open Forum Sessions, Panel Sessions, and Workshops. The regular sessions, of which there are four per day, will be of 90 minute duration. The Panel Sessons will be held on Wednesday, Thursday, and Friday. They have been expanded to two hours (from noon

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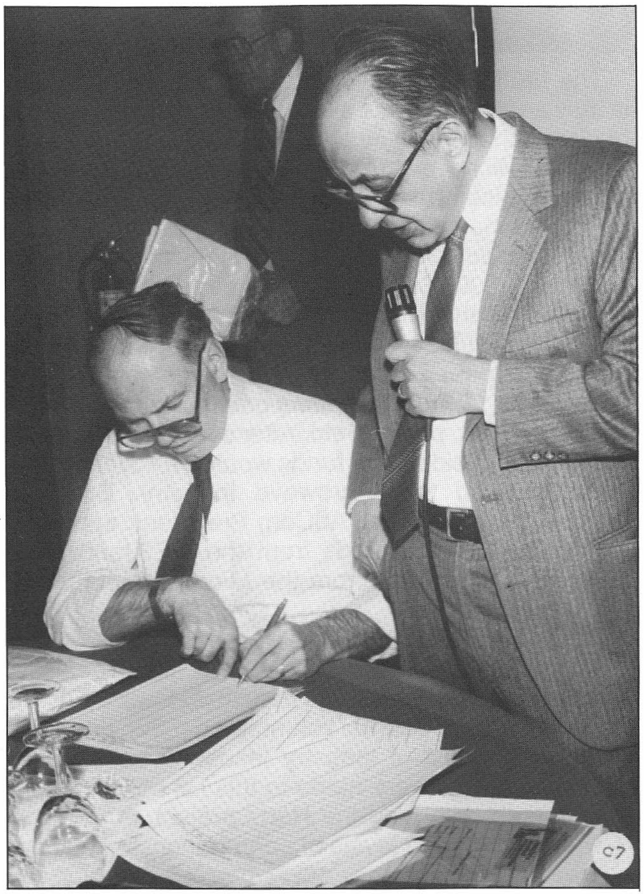
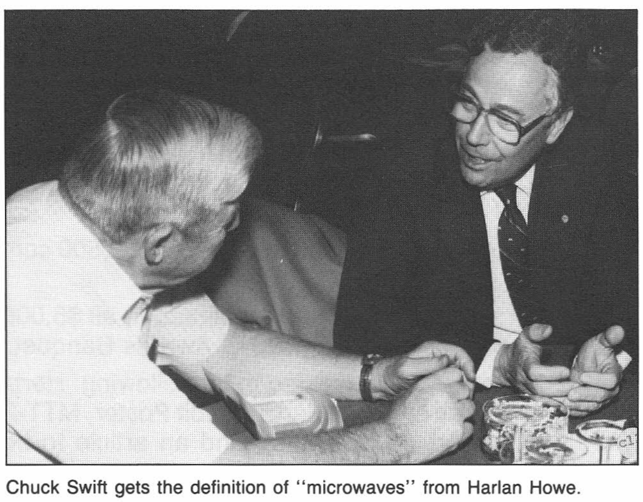
TECHNICAL PROGRAM (continued from page 8)

to 2 p.m.). Other invited sessions commemorate the one hundredth anniversary of Hertz's demonstration of microwaves and a retrospective of the contributions of Professor Arthur Oliner of the Polytechnic University. The Focused Sessions cover exciting areas of interest such as High Power Microwaves and Fiber Optic Links and Transmission systems (two sessions). The Special Session in honor of Profesor A. Oliner for his contributions to Field theory features papers by T. Itoh, F. Schwering, and N.G. Alexopoulos, Two Special Sessions on the Heinrich Hertz Centennial organized by J. Bryant will feature talks by distinguished engineers such as R.S. Eliott, C. Susskind, H. Friedburg, J. D. Krauss, and J.E. Brittain. The European Session which update the technology developments throughout Europe includes papers by W. Baechtold on "GaAs Device Activities in Europe," J. Magershack on "European MMIC Activiites," and H. Meinel on "Millimeter Wave systems in Europe." An invited paper by A.S. deSalles from the University Catolica that will encompass the research activities in Brazil will also be presented.



Jesse Taub double checks Jim Whelehan's arithmetic.



Chuck Swift gets the definition of "microwaves" from Harlan Howe.

SPECIAL SESSIONS

The lunch time panel sessions offer a wide choice of topics including:

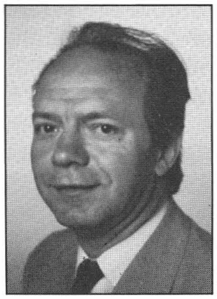
- U.S. Competitiveness in the World Market
- Heterojunction Bipolar Transistor Circuits
- The Business of Microwaves: The Better Mousetrap is No Longer Enough
- Ferrites at Millimeter wave Frequencies
- Noise Measurements

Eight Workshops are planned for Monday and Tuesday. They include:

- MIC and MMIC FET High Power Amplifier Design Techniques
- Superconductivity and Microwaves
- Packaging Hybrid and Monolithic Microwave and Millimeter Wave Components
- CAD-Oriented Modeling of Discontinuities in Microwave/Millimeter Wave Transmission Line Structures
- High Volume Microwave Applications
- Linearizer Techniques

This year MMIC technology is heavily featured in the Symposium. The larger number of papers submitted directly to the MTT-S Symposium covering monolithic technology and circuits clearly shows that this exciting new field is rapidly expanding and becoming more of a mainstream topic for the Symposium. In the MTT-S Symposium, there are three sessions on Thursday in addition to the three Joint Sessions on Wednesday. Four sessions on FETs and FET applications are scheduled for Friday. Two contributed sessions on Fiber Optics Technology (in addition to the Focused Sessions) will be given on Friday. Three sessions on Microwave Systems are indicative of new and expanding applications of microwaves. We have also structured strong sessions on solid state devices and their applications measurements, filters, passive components, MIC, millimeter waves, microwave acoustics, ferrites, phased array techniques, field theory, guided waves, and microwave CAD. This outstanding program demonstrates the vitality and diversity of microwaves. It could only be made possible by contributions of the authors and the dedication of the Technical Program Committee. We are most grateful for the efforts of Special Sessions Chairman John Pierro, Invited Papers Coordinator Donald Neuf, and Open Forum Chairman Joseph Levy, and MMWMC/ARFTG liaison Paul Meier. We look forward to seeing you in New York City in May.

MTT-S/EuMC: EXCHANGE BETWEEN THE U.S. AND EUROPE



by A. Vander Vorst
Microwave Laboratory
Bâtiment Maxwell
1348 Louvain-La-Neuve
Belgium

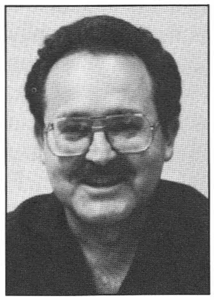
The MTT-Symposium in the U.S. has its counterpart in Europe: the European Microwave Conference is a yearly event which is held with and without exhibition in alternate years. The first EuMC was held in London, in 1969. Since then it has moved around Europe, including Poland in 1980, and Hungary in 1990. The EuMC's are led by a Management Committee comprising representatives from European countries or groups of countries including eastern countries. The Committee yearly appoints a Chairman and a Technical Program Committee, composed by half of local people and by half of more remote experts.

MTT-AdCom was approached in 1985, in St. Louis, by A. Van der Vorst (Univ. Louvain-la-Neuve) and R. Mariott (MEPL) in view of establishing a U.S. session at the EuMC and a European session at MTT-Symposium. Quite rapidly, an agreement was reached on the basis of a reciprocal relationship. The first European session was held in Baltimore, and the first U.S. session in Dublin, Ireland. It is worth noting that the EuMC is also organizing a Japan-session, with the cooperation of well-known Japanese scientists and engineers.

The main goal is to have a session where the authors do not present their own work. They rather have to emphasize "what is going on" in a specific field, either in the U.S. or in Europe. Practically speaking, the TPC of the MTT-Symposium is being offered a list of good European speakers, so that a choice can be made by the TPC. The reverse is true.

At this meeting in New York, last January, the TPC of the next MTT-Symposium has selected three speakers, to have a view on actual European trends on devices, components, and systems: Prof. W. Baechtold (ETH-Zurich, Switzerland) on GaAs Device Activities, Dr. J. Magarshack (Thomson-CSF, France) on MMIC's, and Dr. H. Meinel (AEG-Telefunken, F.R. Germany) on Millimeter- Wave Systems and Applications. At the time of writing this paper, the TPC of the next EuMC (Stockholm, next September) was in the process of making its selection for the U.S. session.

HERTZ FUND RAISING REPORT



by Mario A. Maury, Jr.

The 1988 IEEE/MTT-S Hertz Centennial Celebration is truly an industry-wide event. It has been made possible by funds provided by the IEEE, MTT-S, 1988 International Microwave Symposium and a number of microwave companies.

At the June 1987 AdCom meeting, Dr. John Bryant requested additional funding for the Hertz project since at least $50,000.00 would be required to carry it out. A project of this magnitude requires a considerable amount of funding; costs would be incurred for transporting the Hertz experimental replicas from storage, etc.; also for preparing graphics for the posters and Hertz book, printing, etc. After considerable discussion, it was decided that funds would be solicited from the IEEE and the Microwave Industry. Dr. Dave McQuiddy, then MTT-S AdCom President, appointed Ted Saad to solicit funds from the IEEE and Mario Maury to solicit funds from the Microwave Industry.

INDUSTRY FUND RAISING

A plan was developed to raise $40,000 from industrial companies in the Microwave Industry. Howard Ellowitz of the Microwave Journal volunteered to provide a 267 name mailing list of industry leader to be solicited. Several mailings were made to this list soliciting contributions to help fund the Hertz project.

There were three levels of contributions as outlined below:

$5,000.00 — Honored Contributor
$2,500.00 — Sponsor
$1,000.00 — Donor

As an incentive to the contributors, they would be provided with the following in appreciation for their contribution:

- A certificate of appreciation would be provided to all contributors, along with a letter thanking them on behalf of MTT-S AdCom.
- A small wall plaque will be mailed to all $2,500 contributors prior to the 1988 Symposium.
- A larger wall plaque will be presented to all $5,000 contributors at the 1988 MTT-S Awards Banquet.
- All contributors will be listed in the following: Hertz Commemorative Book, Hertz Exhibit Poster, MTT-S Newsletter Article (this one), and an article to be

continued on page 11

Acknowledgement

The 1988 IEEE/MTT-S Hertz Centennial Celebration, consisting of the exhibition at the 1988 MTT-S International Microwave Symposium and this publication, was made possible by the generous contributions of the following organizations:

• INSTITUTIONAL ORGANIZATIONS •

Institute of Electrical and Electronic Engineers, Life Members Fund
($10,000 Donation)
IEEE/Microwave Theory and Techniques Society ($10,000 Donation)
1988 IEEE/MTT-S International Microwave Symposium Steering Committee
($5,000 Donation)

• INDUSTRIAL ORGANIZATIONS •

Three levels of contributions were made as outlined below:

HONORED CONTRIBUTORS ($5,000 Donation)

Andrew Corporation
Hewlett Packard Company
Maury Microwave Corporation
Texas Instruments Incorporated

SPONSOR ($2,500 Donation)

Sage Laboratories, Inc.
Weinschel Engineering Co., Inc.

DONOR ($1,000 Donation)

Alan Industries, Incorporated
Alpha Industries, Incorporated
Avantek, Incorporated
Communications Techniques, Inc.
Delta Microwave
Diamond Antenna & Microwave Corp.
EEsof Incorporated
EIP Microwave, Inc.
Haverhill Cable & Manufacturing Corp.
Horizon House-Microwave, Inc.
Hughes Aircraft Company
K&L Microwave Incorporated
Krytar, Inc.
Microwave Development Laboratories, Inc.
Microwave Semiconductor Corp.
Miteq Inc.
The Narda Microwave Corporation
Sierra Microwave Technology, Inc.
C. W. Swift & Associates
Watkins-Johnson Company
Wiltron Company

HERTZ (continued from page 10)

published in the May 1988 issue of the Microwave Journal (1988 MTT-S International Microwave Symposium issue).

- All contributors will receive the Hertz Commemorative Book free of charge.

The results of the industry fund raising was extremely encouraging and reflected the active participation of microwave companies in a worthwhile industry wide event. There was a total of 27 industrial contributors who are listed in the "Acknowledgement" plaque following this article. A total of $46,000.00 was contributed which exceeds the original goal of $40,000.00 and is summarized below by levels of contribution:

4 Contributors at $5,000.00 =	$20,000.00
2 Contributors at $2,500.00 =	5,000.00
21 Contributors at $2.000.00 =	22,000.00
TOTAL =	$46,000.00

INSTITUTIONAL FUND RAISING

The Microwave Theory and Techniques Society provided the initial funding support for the project of $10,000.00 at the January 1987 AdCom meeting. Ted Saad obtained a $10,000.00 contribution from the IEEE Life Members Fund in October 1987 to be used toward the preparation and production of the Hertz Commemorative Book. Chuck Buntschuh, on behalf of the 1988 IEEE/MTT-S International Microwave Symposium Steering Committee, has agreed to provide $5,000.00 to cover expenses for the Hertz Exhibition during the symposium. The total amount contributed by institutional organizations is $25,000.00.

The grand total of funds availale to support and carry out the Hertz Centennial Celebration is summarized below:

Industrial Contributions =	$46,000.00
Institutional Contributions =	25,000.00
Grand Total	$71,000.00

YOU TOO CAN PARTICIPATE

All MTT-S members can show their support of the 1988 IEEE/MTT-S Hertz Centennial Celebration by visiting the Hertz Exhibit and attending the Hertz Technical Sessions at the 1988 IEEE/MTT-S International Microwave Symposium in New York. Also, by buying the Hertz Commemorative Book, you will provide funding to further the success of this activity. See the Symposium Advance Program for further details (which you will get in the mail shortly) and below for information on the Hertz book.

HERTZ COMMEMORATIVE BOOK

A book commemorating the Hertz Centennial Celebration entitled, "Hertz - The Beginning of Microwaves," which provides a biography of this brilliant scientist and describes his experiments, will be available for sale, This is a limited edition publication which is sure to become a collectors item.

The price of the book is $5.00 for IEEE Members and $10.00 for Non-IEEE Members. You will be able to buy the book on the Conference Registration Form or at the Symposium. Even if you can't attend the Symposium, you can still show your support of the 1988 IEEE/MTT-S Hertz Centennial Celebration by purchasing this book.

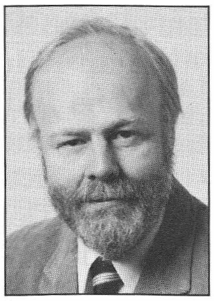
KUDOS TO BRYANT

John Bryant has been the main driving force behind the Hertz Centennial Celebration and it would not have been possible without his dedication, zeal and considerable efforts. He has brought to us a greater appreciation of the major contributions made by one of the first microwave pioneers — **Hertz**!!

SUMMARY

The Hertz Fund Raising activity has been extremely successful in generating funds to produce an activity, that in general, benefits the whole Microwave Industry. Show your support by visting the Hertz Exhibit and attending the Hertz Sessions in New York (if you attend the 1988 Symposium) and by purchasing the Hertz Book (whether or not you attend the 1988 Symposium).

HISTORICAL COLLECTION



by Ted Nelson

The Historical Electronics Museum located at the Westinghouse Corporation, Baltimore, Maryland has graciously agreed to house the MTT Historical Collection. The Museum is under the direction of Robert Dwight, with the assistance of Warren Cooper.

The Baltimore MTT Chapter requested the formation of a committee to be responsible for the Historical Collection and arrange for its exhibition. This committee has been formed and presently consists of:

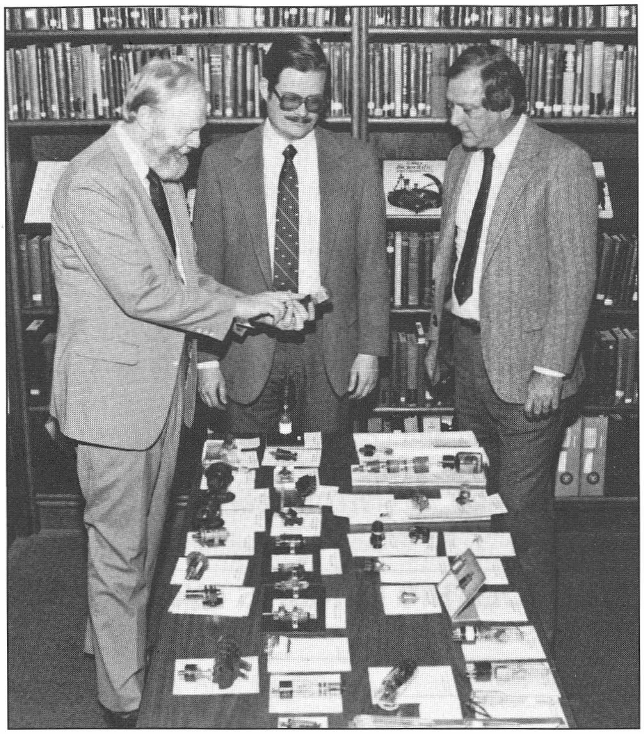
Chairman: Ted Nelson
Westinghouse Electric Corporation
Post Office Box 746
Baltimore, MD 21203
Mail Stop 709
(301) 765-6461

continued on page 13

HISTORICAL COLLECTION (continued from page 10)

Secretary: Steve Stitzer
Westinghouse Electric Corporation
Post Office Box 1521
Baltimore, MD 21203
Mail Stop 3716
(301) 765-7348

Treasurer: John Gipprich
Westinghouse Electric Corporation
Post Office Box 746
Baltimore, MD 21203
Mail Stop 75
(301) 993-7949



Left to right: Ted Nelson, Chairman, Steve Stitzer, Secretary, and John Gipprich, Treasurer, of the MTT-S Historical Collection Committee examine an early klystron from the collection. In the background are additional microwave tubes of historical significance from the collection.

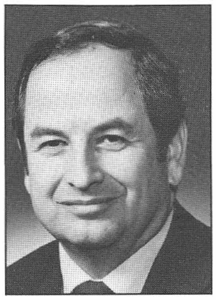
The committee, with the help of Warren Cooper, has obtained the support of Ellen Prucha and Warren Von Uffel of the Westinghouse Display Department to assist in the formation of the historial displays.

The committee will also arrange for the transportation of the Historical Collection to and from the MTT International Symposium each year. The display will be ready for shipment to the 1988 symposium on May 1, 1988.

☐ **Three C's** to conquer stress: *Commitment,* the willingness to involve yourself rather than withdraw from stressful circumstances. . . *control,* the belief that you can influence events. . . *challenge,* the recognition that setbacks can provide learning experiences.

Dr. Suzanne Kobasa, associate professor of psychology, City University of New York.

SPECIAL ARTICLES FOR THE MTT NEWSLETTER



by Zvi Galani

The MTT Newsletter staff is very interested in obtaining feature articles dealing with current topics in the technical and professional areas of interest to MTT members. The idea is to provide the members with a general understanding of the topic and its significance in current and future activities in the microwave field. I would like to emphasize, however, that these special articles will cover topics in a broad, general sense. Specific design techniques and applications will be covered in papers appearing at the MTT Symposium and in the Transactions.

If you know of a topic that is current and/or you are willing to contribute an article to the Newsletter, please contact:

Zvi Galani
Raytheon Company
Mail Stop M1-41
Hartwell Road
Bedford, MA 01730
(617) 274-4184

OR

Peter Staecker
M/A-COM, Inc.
52 South Avenue, Bldg. 7
Burlington, MA 01803
(617) 272-3000, X1602

This issue features the article *Modulation Techniques in Terrestrial Microwave Communication Systems*. The authors, J.P. Moffatt and J.F. Moss, present the various modulation techniques and describe the relationship between system requirements and requirements imposed on microwave components.

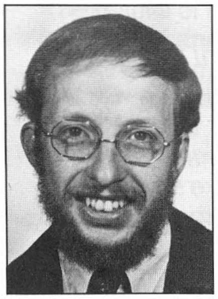
Several interesting feature articles are in the process of preparation for future issues of the Newsletter, on the following topics:

- phased array antennas
- GaAs monolithic microwave integrated circuits
- frequency synthesizers

The editorial staff of the Newsletter hopes that these articles will be informative and useful to the MTT-S community.

Your comments and suggestions are welcome.

1988 MICROWAVE AND MILLIMETER-WAVE MONOLITHIC CIRCUITS SYMPOSIUM



by Derry Hornbuckle

The seventh annual IEEE Microwave and Millimeter-wave Monolithic Circuits Symposium will be held Tuesday and Wednesday, May 24 and 25, 1988. The Tuesday sessions will be held at the Marriott Marquis Hotel, Times Square, New York. On Wednesday, the Symposium will be held jointly with the IEEE Microwave Theory and Technique International Microwave Symposium at the Jacob Javits Convention Center.

The Technical Program Committee, under the chairmanship of Dr. Reynold Kagiwada, has selected thirty-two contributed papers, representing the state-of-the-art in monolithic microwave and millimeter-wave IC technology. In addition, three invited papers will cover present and future technology directions:

- The MIMIC Program by Eliot Cohen of the Department of Defense
- Commercial Applications of GaAs IC's by Jerry Gladstone of Hewlett-Packard
- Microwaves versus Fiber Optics by Joseph Campanella of COMSAT.

This is the largest MMWMC Symposium ever, describing a truly impressive group of accomplishments. The program is divided into nine sessions, covering MMIC Technology, Fiber Optic Communication, Wave Oscillators, MMIC Receiver Components, Millimeter-wave Monolithic Circuits, Producibility and Applications, Power Amplifiers and MMIC Low-Nose Amplifiers. In addition to the technical program, Symposium attendees and their guests are invited to a reception on Monday evening, May 23rd from 7 to 10 PM, to meet with colleagues in an informal setting. This year's social program will also include the traditional continental breakfast for attendees, beverage service during breaks, and a hospitality suite for guests.

The Technical Program Committee and Steering Committee, with the help of the MTT Symposium Committee, are to be commended for assembling an outstanding program. On behalf of the Steering Committee, I encourage you to plan now to attend the 1988 Microwave and Millimeter-wave Monolithic Circuits Symposium in New York; I belive you will find it an informative and rewarding experience. If you did not receive registration material by mail, contact:

Charlie Huang
Registration and Local Arrangements Chairman
c/o LRW Associates
1218 Balfour Drive
Arnold, MD 21012

1988 IEEE MICROWAVE AND MILLIMETER-WAVE MONOLITHIC CIRCUITS SYMPOSIUM SCHEDULE OF EVENTS

MONDAY, MAY 23, 1988 — Marriott Marquis			
	7:00 - 10:00 pm Broadway Ballroom South MMWMC Symposium Reception		
TUESDAY, MAY 24, 1988 — Marriott Marquis			
	8:30 - 8:50 am Broadway Ballroom North Introduction by General Chairman and Technical Chairman		
I.	8:50 - 10:20 am MMIC Technology		
II.	10:50 - 12:00 noon Fiber Optics and Communications		
	Broadway Ballroom North		Astor Ballroom
III.	1:30 - 2:50 pm Nonlinear Applications of MMICs	IV.	1:30 - 2:50 pm Millimeter-Wave Oscillators
V.	3:10 - 4:30 pm MMIC Receiver Components	VI.	3:10 - 4:30 pm Millimeter-Wave Monolithic Circuits
WEDNESDAY, MAY 25, 1988 — Jacob Javits Convention Center — Room I			
A.	10:30 - 12:00 noon Producibility and Applications		
E.	2:00 - 3:30 pm Power Amplifiers		
I.	4:00 - 5:30 pm Low Noise Amplifiers		

REPORT OF THE MTT-S TRANSACTIONS EDITOR

by Ralph Levy

PAPER STATISTICS

1987 saw a record number of 340 papers submitted for publication, a figure which is exclusive of special issues, e.g. the December issue. A complete report of activity for 1987 is given in Table 1. The rejection ratio was 26.7%, this percentage including papers recommened for transfer to another journal after the review process had been completed. You will notice that the total of dispositions is larger than the number of submitted papers, due simply to the fact that papers recommended for revision undergo a second disposition after resubmission. Also the sets of papers received and for which dispositions are made, while overlapping, are not identical, dispositions having been made for papers received in the previous year.

TABLE 1.
1987 ACTIVITY

Papers Submitted	340
Dispositions:	
Published or Accepted	217
Rejected	66
Transfer After Review	13
Transfer Without Review	19
Revise and Resubmit	77
Total Disposition	392

Table 2 is a snapshot of the contents of my files at the end of 1987, indicating the status of the manuscripts in process. This is another indicator of increased activity, since the total of 192 is up from 133 at the end of 1986. Although the rejection rate in 1987 was lower than the previous year I am confident that standards remain high. I have conjectured that possibly authors become more aware of the expectations of a new editor as his term progresses, but then we may be seeing only a statistical quirk. Results for 1988 should be interesting in this regard.

NEW REVIEW FORM

Reviewers and authors will have noticed a radical change in the manuscript review form, which is no more incisive and direct. One of the reviewers had written to me pointing out that the old form was deficient in the sense that it was possible to answer most of the questions affirmatively, i.e. favoring acceptance, yet to conclude in recommending rejection! Following this Tatsuo Itoh wrote to Editors of other Transactions for copies of the forms which they use, receiving an excellent response. We analysed these forms and distilled them down to give a revised form which we hope combines their best features. The most significant addition is the first question — "Does the paper represent an original contribution to the field of Microwave Theory and Techniques?" — a request which was only alluded to vaguely on the old form.

TABLE 2.
STATUS OF MANUSCRIPTS AS OF 12/31/87

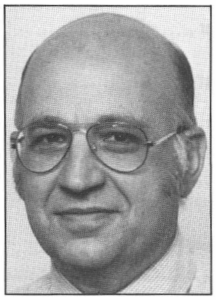
Papers Requiring Editorial Action	
Original submitted manuscripts under review	90
New papers received to be processed	3
Revised manuscripts under review	10
Decisions pending	0
Total manuscripts under review	103
Papers Requiring Author Action	
Awaiting a revised version from author	47
Papers accepted but awaiting a final version from the author	42
Total manuscripts requiring author action	89
Total manuscripts in process	192

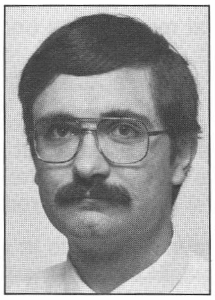
HERTZ CENTENNIAL SPECIAL ISSUE

A most noteworthy special issue is for May 1988 commemorating the Heinrich Hertz Centennial. I am very grateful to John Bryant for organizing the papers for this issue, which will, I hope, prove to be a most useful and appropriate adjunct to our special Historical Issue of September 1984. Reading the accounts of Hertz's experiments took me back to undergraduate lectures at the Cavendish Lab. in 1952, where his experiments demonstrating diffraction of e.m. waves by dielectric prisms and by wire gratings were repeated, to the delight of the audience.

It is perhaps valid to debate whether historical papers should find a place in an archival journal such as the MTT Transactions. They are in a similar category to survey papers, which surely perform a useful function. In addition, knowledge of the History of Science is useful in acquiring and developing a proper perspective relating to research and development. It is just as important to be aware of the thought processes and professional attitudes of our predecessors as it is to carry out a thorough search of the literature when embarking on a new venture. Surely these two activities are closely related, and History provides a wealth of case examples to inspire our own endeavours.

MODULATION TECHNIQUES AND DEVICE REQUIREMENTS IN TERRESTRIAL MICROWAVE RADIO SYSTEMS





by James P. Moffatt and James F. Moss

1. Introduction

This article traces the evolution of modulation techniques in terrestrial microwave radio systems and highlights the microwave device requirements stemming from each technique. The article is organized into two main parts. Part I presents the system design view of the various modulation techniques and indicates how microwave device requirements are obtained from the basic systems requirements. Part II presents the device design viewpoint and relates the design features of typical microwave devices to the various systems requirements.

The modulation techniques are divided into two categories, analog techniques and digital techniques. Typical analog techniques include frequency modulation (FM) and single sideband (SSB) amplitude modulation. Digital techniques include digital FM which is sometimes termed frequency shift keying (FSK), and quadrature amplitude modulation (QAM). Phase shift keying (PSK) techniques are primarily used in satellite systems and are not discussed in detail.

Analog FM systems have the longest history and generally require microwave devices to have good transmission characteristics, reasonable phase noise, and relatively low levels of AM/PM conversion. Analog SSB systems add additional requirements on phase noise and the expansive/compressive behavior of amplifiers and modulators. Digital modulation techniques generally require device performance comparable to or better than analog systems. FSK and PSK requirements generally parallel those of analog FM systems. The QAM systems, being linear, have requirements similar to SSB systems.

2. Definitions

In order to facilitate easy reading and a common understanding of some of the terms used in the text that follows, the following brief definitions are provided.

- Amplitude Dispersion — A device property in which the gain or loss of the device is a non-constant function of frequency.
- Phase Dispersion — A device property in which the transfer phase of the device is a non-linear function of frequency.
- AM/AM Conversion — A device nonlinearity in which the gain of the device is a function of input power.
- AM/PM Conversion — A device nonlinearity in which the transfer phase of the device is a function of input power.
- 1 dB Compression Point (P_{1dB}) — For amplifiers and up-converters, the *output* power level at which the device gain or loss is reduced by 1 dB from its small-signal value. For down-converters, the *input* power level at which the device gain or loss is reduced by 1 dB from its small-signal value.

PART I — SYSTEM DESIGN

3. Analog FM Systems and Requirements

Analog FM microwave radio systems began widespread commercial service in 1950 with the introduction of the 4-GHz TD-2 system [1] by AT&T. Throughout their thirty-seven year history, the analog FM systems have generally employed low-index modulation such that the information is carried primarily in the first-order FM sidebands. This low-index feature also allows the modulation to be analyzed, in many instances, as quasi-linear. These systems are currently used primarily to transmit ordinary telephone voice circuits and television signals. The frequency modulated carrier can be represented by [1]:

$$F(t) = A \cos(\omega_C t + \Phi(t)) \qquad (1)$$

where the phase function $\Phi(t)$ is related to the information or baseband signal waveform s(t) by the relation

$$\Phi(t) = m_f \int_{-\infty}^{t} s(\tau)\, d\tau \qquad (2)$$

Here m_f is the frequency modulation index or peak frequency deviation when $|s(t)| \leqslant 1$. The instantaneous frequency of the resulting modulated carrier is linearly proportional to s(t).

The calculation of the power spectrum of the frequency modulated carrier has been the subject of numerous papers. Abramson [2] and others have shown that the power spectral density of the first order sidebands in low-index systems can be approximately described by:

$$S_{FM}(f') = \frac{f^2_{rms}\, S(f')}{s\, f'^2\, P_S} \qquad (3)$$

where: f′ represents frequency offset from the carrier, $S_{FM}(f')$ is the power spectral density of the FM sideband relative to the carrier power, P_S and S(f) are the power and power spectral density of the base-

continued on page 17

MODULATION TECHNIQUES
(continued from page 16)

band signal, and f_{rms} is the rms frequency deviation of the carrier in Hz. the f'^2 factor in the denominator results from the integral relation in (2).

Figure 1 shows an example of the baseband and resulting frequency modulated spectra for a low-index analog FM system. The baseband spectrum approximates that of a 1200 circuit frequency-division-multiplexed telephone baseband signal s(t). The modulation index corresponds to an rms frequency deviation of 100 kHz.

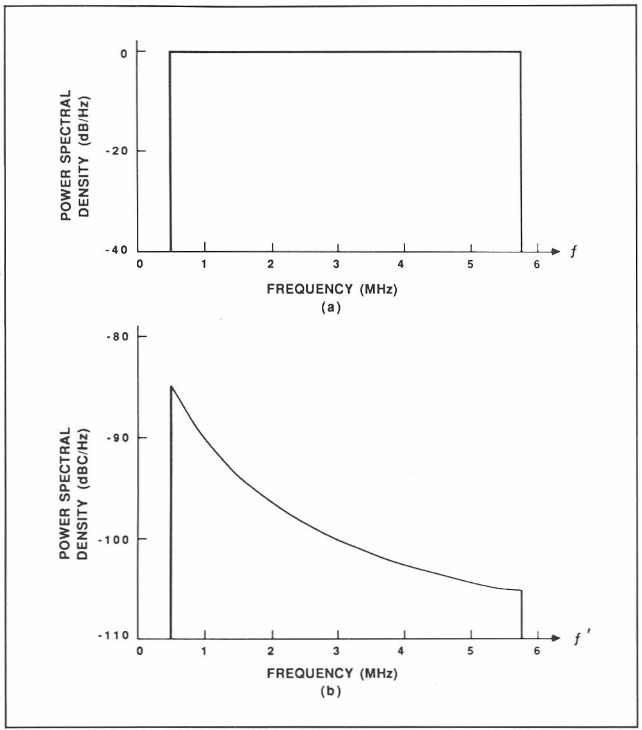


FIGURE 1. Baseband (a), and RF (b) spectra for a 1200 voice-circuit FM system

Typical microwave component characteristics that influence the transmission of analog FM signals include amplitude and phase dispersion, AM/PM conversion, and phase noise.

Amplitude and Phase Dispersion

Amplitude dispersion can affect an FM system by producing both intermodulation noise and amplitude shapes in the output baseband signal. The predominant effect depends on the type of the dispersion as illustrated below.

Amplitude dispersion that is even about the carrier frequency produces equivalent amplitude shape in the baseband amplitude characteristic is identical to that resulting from translating the bandpass dispersion characteristic of DC. The FM system designer can thus specify the even portion of the amplitude dispersion of microwave components and subsystems based directly on the baseband signal amplitude requirements. Although the even portion can produce intermodulation noise the predominant consideration in most system designs is the baseband amplitude response.

Amplitude dispersion that is odd about the FM carrier frequency can be generally classified as linear, cubic, fifth-order, and so on. Linear amplitude dispersion is unique in that it introduces no significant signal degradation. Its only effect on the output baseband signal is a time shift which can occur only if it is followed by a source of AM/PM conversion. As a result, FM systems are generally very tolerant of this type of dispersion.

The cubic and higher-order odd amplitude dispersion introduces both intermodulation noise and spurious AM in the FM signal. The intermodulation noise can be evaluated using approximate techniques [1], [3] based on Taylor series expansions of the amplitude dispersion and the modulation process. These techniques yield signal-to-intermodulation-noise ratios which can be directly related to telephone circuit noise. For television transmission, subjective evaluation of the noise may be required. The spurious AM introduced by the cubic and higher-order odd amplitude dispersion can cause signal degradation only if it reaches a source of AM/PM conversion, such as a high-power amplifier.

Phase disperson in analog FM system devices is usually specified by the equivalent envelope-delay characteristics which is the first derivative of the phase-versus-frequency function. The envelope delay characteristic can be conveniently plotted and interpreted. A constant envelope-delay (linear phase) versus frequency characteristic introduces no distortion in FM systems since it corresponds simply to a time shift of the signal.

Linear envelope-delay (parabolic phase) dispersion introduces intermodulation noise and spurious AM into the FM signal. Direct baseband amplitude effects are usually minimal. The intermodulation noise can be evaluated with the approximate techniques described above and a signal-to-noise ratio can be obtained. The spurious AM can be converted to addditional intermodulation noise and baseband amplitude shape only if it is followed by a source of AM/PM conversion. Higher order delay characteristics produce similar effects.

AM/PM Conversion

AM/PM conversion becomes a source of signal degradation in FM systems only if it is preceded by amplitude or phase dispersion. The dispersion effectively converts a portion of the signal frequency modulation to amplitude modulation. This resulting AM corresponds to either a replica or a distorted replica of the system input signal. When the AM reaches a device having AM/PM conversion it is converted into PM which also corresponds to a distorted version of the signal. The spurious PM is then demodulated in the FM receiver and becomes a signal distortion at baseband.

If the PM corresponds to a linear distortion of the signal, the output baseband signal will have undesirable amplitude and phase shapes. If the PM

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corresponds to a nonlinear distortion of the signal, the output baseband signal will contain intermodulation noise. Both the linear and nonlinear effects can be evaluated by the approximate techniques discussed above.

FM system design thus generally includes an evaluation of the interaction of microwave device dispersion with sources of AM/PM conversion. In a typical system design, the dispersion and AM/PM conversion of each device in the system are characterized and an overall assessment of the baseband response and intermodulation noise is made. Device performance specifications are then chosen to meet the overall system requirements.

Phase Noise

In analog FM systems, the radio local oscillators used for frequency translation of the signal between IF and RF are usually the predominant source of phase noise. The phase noise represents an additive phase modulation of the otherwise ideal oscillator signals. Since this modulation is identical in type to that of the FM signal, the signal-to-phase-noise ratio resulting at the baseband output of the FM system at any given frequency is easily calculated. If α is the ratio of the FM signal sideband to the FM carrier and β is the ratio of the phase noise sideband to the oscillator signal, then the system output signal-to-noise ratio is α/β. Simple spectrum analyzer measurements can be used to evaluate the signal-to-noise ratio. Oscillators chosen for use in FM systems should thus have phase noise performance adequate to meet overall system signal-to-noise objectives.

4. Analog Single-Sideband Systems and Requirements

Analog SSB microwave radio systems began commercial service in January, 1981 with the introduction of the 6-GHz AR6A system [4]. The SSB amplitude modulation technique allowed the telephone circuit capacity of a microwave radio repeater to increase by a factor of 2.5. The highest capacity FM systems in 1981 could transmit 2400 voice circuits and the AR6A repeater capacity is 6000 voice circuits. The increased spectral efficiency of the SSB modulation technique also allows the AR6A system to transmit these circuits in the same microwave bandwidth as the 2400-circuit FM systems. An AR6A radio repeater bay containing a transmitter and receiver is shown in Figure 2.

The primary technological advancement that allowed the successful realization of a SSB system was the development of a predistorter [5] which compensates for the nonlinearities in the microwave repeater output power amplifier. The predistorter generates third-order intermodulation distortion which cancels the distortion generated by the AM/AM and AM/PM conversion of the amplifier. A SSB repeater with properly adjusted predistorter performs as a linear transmission system.

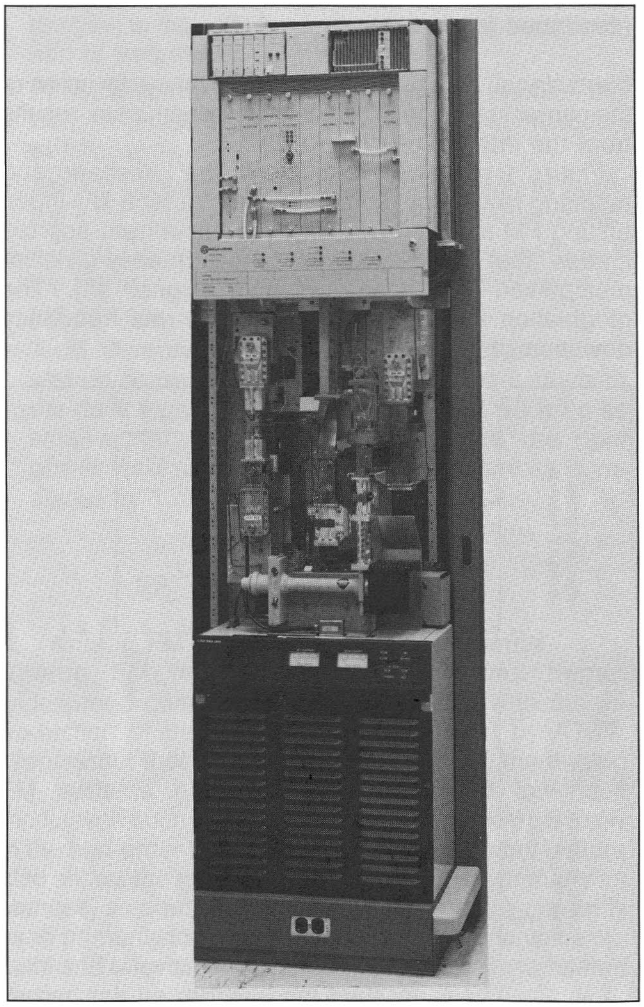

FIGURE 2. AR6A SSB radio repeater bay.

If a baseband signal s(t) is applied to the input of a SSB modulator which utilizes upper-sideband conversion, the resulting modulated signal can be represented by [1]:

$$m(t) = \tfrac{1}{2}\, s(t) \cos(\omega_c t) - \tfrac{1}{2}\, \hat{s}(t) \sin(\omega_c t) \qquad \textbf{(4)}$$

where $\hat{s}(t)$ is the Hilbert transform of s(t) given by:

$$\hat{s}(t) = \frac{1}{\pi} \int_{-\infty}^{\infty} \frac{s(\tau)}{t - \tau}\, d\tau$$

and ω_c is the local oscillator radian frequency. The effect of the modulation process on the power spectrum of s(t) is a simple frequency translation equal to the local oscillator frequency. The IF or RF power spectral density of a SSB microwave radio system is thus a frequency-translated replica of the input baseband spectrum. The IF spectrum of the AR6A system is illustrated in Figure 3 [6]. The figure shows the ten 600-circuit mastergroups and the pilot tones required for system operation.

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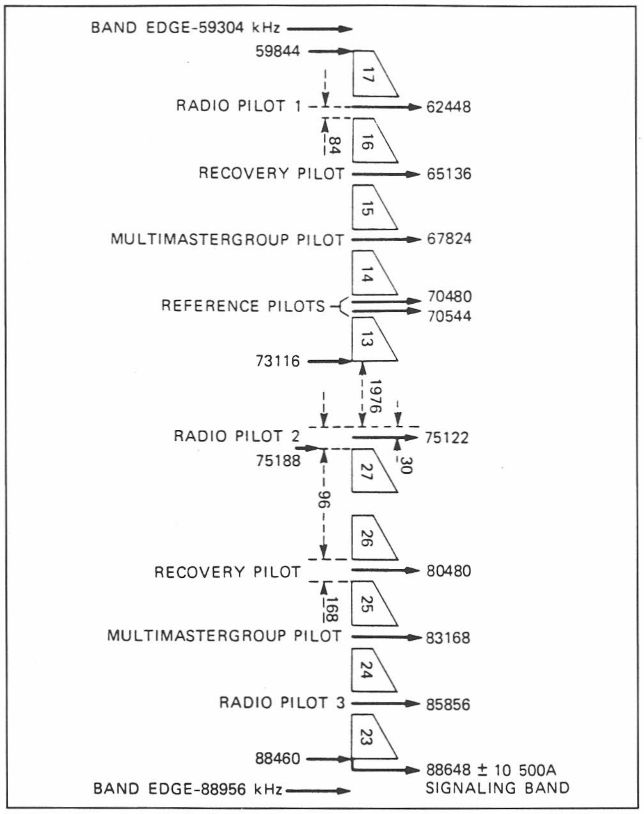

FIGURE 3. AR6A SSB IF spectrum.

Amplitude and Phase Dispersion

Since SSB is a linear modulation technique, the specification of microwave device and subsystem requirements is somewhat simplified relative to FM systems. The absence of intermodulation noise resulting from amplitude and phase dispersion allows these specifications to be chosen based directly on the requirements of the baseband signal. An additional simplification results since the system carries only narrow-band voice circuits. The narrow-band nature of these signals relative to the bandwidths of the microwave devices results in very relaxed requirements on the phase dispersion of the devices. The phase requirements are derived by insuring that the phase shape in any voice circuit meets standard requirements for voice and data-set use.

The amplitude dispersion requirements for SSB systems are generally somewhat more stringent than in FM systems since the double-sideband nature of the FM signal results in a partial immunity to odd amplitude dispersion shapes. The SSB amplitude shapes in the IF or RF passband translate directly to baseband shape when the system uses upper-sideband conversion. For lower-sideband conversion the RF shapes are frequency-reversed at baseband. The amplitude dispersion requirement of a microwave device or subsystem is usually specified by allocating the allowable baseband shapes to the various components of the system.

AM/FM and AM/PM Conversion

In contrast to the FM systems which are sensitive only to AM/PM nonlinearities, SSB systems require good AM/AM and AM/PM performance. The specification of the linearity of the components in a SSB system is usually based on an overall allocation for the system signal-to-intermodulation-noise ratio. Since the system signal is composed of a very large number of independent voice circuits, the composite signal is very accurately modeled by Gaussian noise.

The signal-to-intermodulation-noise ratio resulting from a device in a SSB system can be calculated [7] from three-tone or similar measurements [8] on the device. The signal-to-intermodulation-noise ratios from the various system devices are then added according to a two-dimensional vector law of addition. The two vector dimensions correspond to the AM/AM and AM/PM components of the device nonlinearity. The overall law-of-addition for the individual devices in a system is generally greater than power-law or random-phase addition but less than voltage-law or in-phase addition. When the signal-to-intermodulation-noise ratios are summed, the result can be compared to the overall system signal-to-noise requirements. Device specifications can then be chosen so that requirements are met.

Phase Noise

Phase noise associated with local-oscillators used for frequency translation between IF and RF in SSB systems produces a noise-like impairment in the system. The noise can be evaluated by convolving the phase-noise spectral density with the spectral density of the system signal [9]. From the convolution, an effective noise power spectrum is obtained. This spectrum is then integrated to obtain a signal-to-noise ratio which can be compared to overall system requirements.

In addition to the noise-like impairment introduced by the phase noise, the low frequency portion of the phase noise spectrum introduces phase jitter into data-set signals transmitted over the voice circuits. Data-set phase jitter requirements can then be used to place additional requirements on the close-in phase noise of the local-oscillators.

5. Digital FM Systems and Requirements

The earliest digital FM microwave radio system was developed around 1971 [10]. This system utilized the TD-2 microwave radio system equipment to transmit a 20.2 Mb/s four-level PAM baseband signal. The digital signal replaced the normal telephone message circuit input to the radio system FM transmitter and was recovered from the output of the radio system FM receiver. In this system, the digital signal could be transmitted up to 400 miles or approximately 16 hops without regeneration. Due to the relatively low spectral efficiency of this type of transmission, however, subsequent long-haul digital radio systems have used QAM rather than FM modulation. Digital FM radio systems

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have evolved primarily as local distribution systems operating in the 2, 18 and 23 GHz common carrier bands. These systems typically are used in a single-hop configuration and transmit data rates between 1.5 Mb/s and 6.7 Mb/s.

The mathematical representation of digital FM signals generally follows equations (1) and (2) given previously. The baseband signal s(t), however, can be expressed as [11]:

$$s(t) = A \sum_{n=-\infty}^{\infty} a_n \, g(t - nT) \qquad \textbf{(6)}$$

where A is an amplitude scaling factor, a_n is the symbol level chosen from the set ±1, ±3, ±5, etc., T is the baud or symbol period, and g(t) represents the transmitted pulse shape. The number of transmitted levels is usually an integer power of two. Four-level transmission, for example, uses levels ±1 and ±3. Most current systems use either two-level or four-level transmission.

Calculation of the power spectral denstiy of digital FM signals has been the subject of numerous papers [12] [13] [14]. The spectrum is typically calculated by first numerically obtaining the autocorrelation function of the baseband signal given in (6). The autocorrelation function of the digital FM signal is then obtained from a power series involving the baseband autocorrelation function. A numerical Fourier transform is then performed on the FM signal autocorrelation function to obtain the power spectrum.

An example of a digital FM power spectrum is shown in Figure 4. The spectrum analyzer photograph was obtained at a center frequency of 70 MHz and has a frequency span of 50 MHz. The vertical scale is 10 dB per division. The spectrum is from a four-level system that transmits 23.4 Mb/s, employs raised-cosine spectral shaping with 80% excess bandwidth, and has 50% of the Nyquist filtering preceding the transmitter. The rms frequency deviation of the FM signal is 2.39 MHz. The spectral shape is typical of those illustrated in the references.

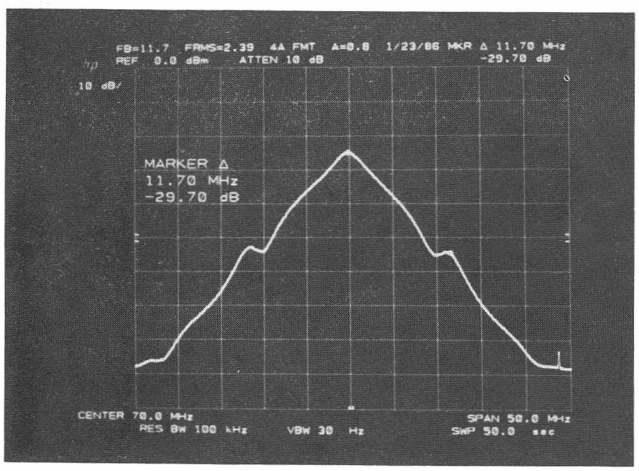

FIGURE 4. A four-level digital FM spectrum.

The digital FM system requirements for amplitude and phase dispersion, and AM/PM conversion are generally analogous to those for analog FM systems. The baseband frequency response effects are identical and the analysis methods described previously can be used. It is then necessary to relate these effects to the performance of the digital system. This is usually accomplished by a computer simulation of the baseband portion of the digital system. The simulation allows the frequency response impairments to be qualified in terms of equivalent signal-to-noise ratios which degrade the system error rate.

In order to quantify the effects of the FM system intermodulation noise, a simulation of the FM portion of the system may be required. Since the intermodulation noise is a result of the signal s(t) given in (6), a simulation based on this equation can be developed. The end result of the simulation is a determination of the effect of the intermodulation noise on the bit error rate of the system.

Phase noise in the microwave oscillators used in a digital FM system produces ordinary thermal-like noise in the output signal as discussed in the phase noise section for analog FM. The effect of this noise on the bit error rate performance of the system can be calculated with standard Gaussian noise analysis techniques.

6. Digital QAM Systems and Requirements

The earliest digital radio systems employing QAM modulation were developed in the late 1970s [15] [16]. The current DR6-30-135 system [17] [18] employs 64-QAM and provides a transmission efficiency of approximately 4.5 bits-per-Hz. The radio repeater bay for the DR6-30-135 system is shown in Figure 5.

The QAM signal can be represented by the relation:

$$s(t) = i(t) \cos(\omega_c t) + q(t) \sin(\omega_c t) \qquad \textbf{(7)}$$

where ω_c is the carrier frequency and i(t) and q(t) are the in-phase and quadrature baseband signals. Each baseband signal can be represented as in equation (6). The signals thus become:

$$i(t) = A \sum_{n=-\infty}^{\infty} a_n \, g(t - nT) \qquad \textbf{(8)}$$

and

$$q(t) = A \sum_{n=-\infty}^{\infty} b_n \, g(t - nT) \qquad \textbf{(9)}$$

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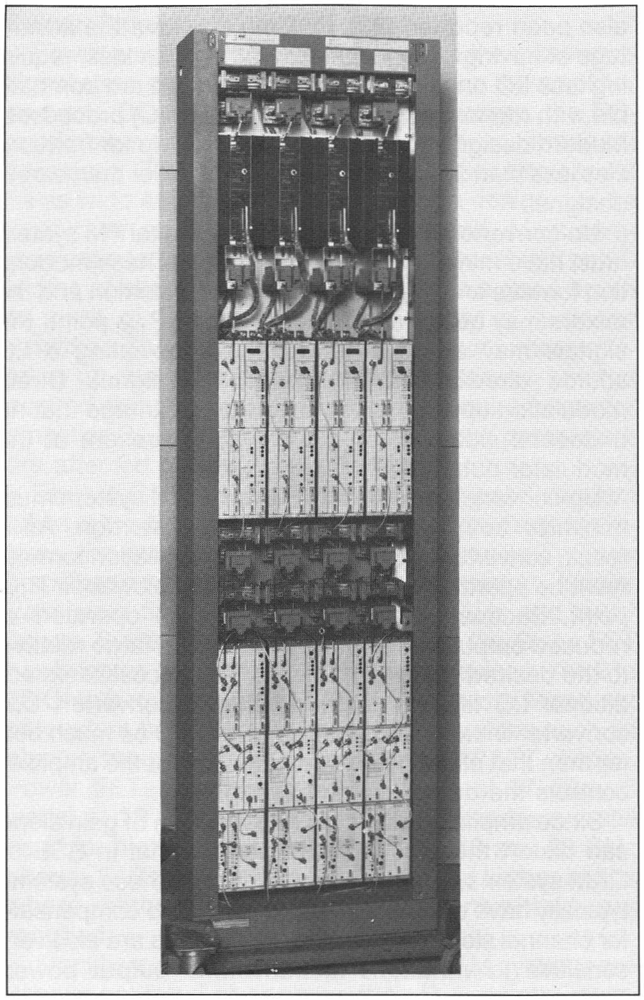

FIGURE 5. DR-6 digital radio bay with four transmitter-receiver pairs.

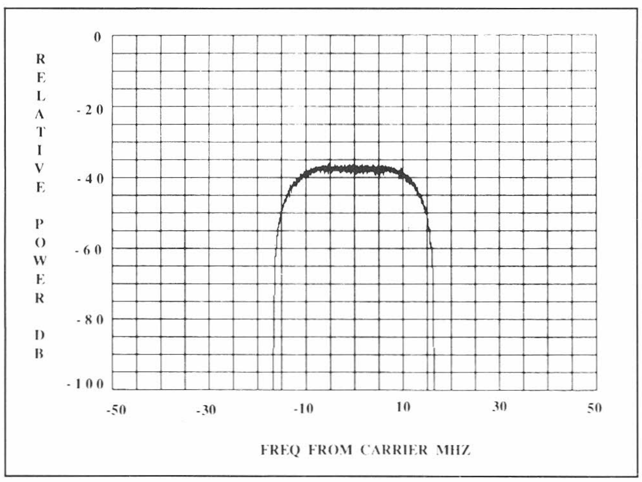

FIGURE 6. RF spectrum for a typical digital QAM radio system.

where a_n and b_n represent the in-phase and quadrature data values to be transmitted. Since each baseband signal amplitude modulates its respective carrier, the modulation is a linear process. Typically the two baseband signals have identical power spectral densities and the power spectrum of the QAM signal is simply a frequency-translated replica of the baseband spectrum. Figure 6 shows the RF power spectral denisty of a typical QAM signal as it exists in the radio portion of a microwave transmission system [19]. The 64-QAM signal is derived from a raised-cosine Nyquist spectral characteristic with 45% excess bandwidth. As in typical radio practice, half of the Nyquist filtering precedes the radio equipment and half follows it. The spectral characteristic thus represents a square-root Nyquist or "half-Nyquist" shape.

Amplitude and phase dispersion in microwave QAM transmission systems introduce inter-symbol interference since they produce a departure from the ideal Nyquist pulse shape. Since the QAM modulation process is linear, the dispersion shapes are directly translated to baseband shapes. The distorted baseband pulses then create inter-symbol interference. In order to evaluate the effects of the shapes on the bit error rate of the digital transmission system, a time domain computer simulation is usually employed [19]. The amplitude and phase shapes are then converted to equivalent impulse responses by a numerical inverse Fourier transform.

AM/AM and AM/PM nonlinearities in the microwave portions of QAM radio system produce nonlinear inter-symbol interference and crosstalk between the two baseband signals. Even though the nonlinearities can usually be classed as zero-memory, the receive Nyquist filters introduce memory as a result of their reactive elements. As a result of this complication, the effect of nonlinearities on the bit-error-rate performance of digital systems usually requires a computer simulation for accurate evaluation. As an alternative, many systems have been designed with an empirical evaluation of the nonlinearities.

Phase noise generated by local oscillators in the microwave equipment introduces phase jitter in the QAM carrier through the up-conversion and down-conversion process. Since any phase error in the recovered QAM carrier produces crosstalk between the two baseband signals, the jitter represents a potential source of crosstalk. The carrier recovery circuits in the digital receiver can usually track the low-frequency portions of the phase noise but the high-frequency portions remain and can degrade the system bit-error-rate performance. The analysis of phase jitter in QAM systems is treated in many texts on digital data transmission.

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PART II — DEVICE DESIGN

7. Microwave Devices

A typical microwave radio system repeater, depicted in Figure 7, consists of the following devices: an up-converter, power amplifier, low-noise amplifier, filters, down-converter, and microwave sources. The requirements for each of these devices are governed by the modulation technique used. Part II of this paper relates typical microwave device requirements to the system modulation techniques described in Part I.

Up-converters

Up-converters translate the information carrying signal to the microwave or RF frequency. If the information carrying signal is at IF, this translation is usually accomplished by using a mixer. The mixer is usually driven with a local oscillator (LO) source and the IF signal. The output is a double-sideband signal and some LO leakage. The LO leakage is determined by the isolation between the ports of the mixer. The LO leakage must be controlled to reduce the filtering requirements following the up-converter. A channel filter selects the desired sideband and rejects the undesired sideband and LO signals. A variable gain stage in the up-converter, controlled by an ALC loop, as shown in Figure 7, may be used to compensate for transmitter gain variations due to temperature and aging.

Up- and down-converters used in earlier systems employed diodes mounted in relatively bulky waveguide structures. The early designs used both Schottky-barrier and varactor diodes. Varactor diode mixers are advantageous because they can be designed to have conversion gain. However, varactors are prone to parametric oscillations and other instabilities [22]. More recent designs use double-balanced beam-lead Schottky-barrier diodes. These mixers are popular because of their low cost, good LO to RF port isolation (typically 30 dB), and low VSWR on all ports (typically 2.5:1). The diode mixer 1 dB compression point (P_{1dB}) may be adjusted by choice of the diode barrier height. In general, (P_{1dB}) is 5 to 10 dB lower than the LO input power. Mixers are available with required LO drive levels between 0 and 27 dBm. Mixers using FETs have also been reported [23]. FET mixers have the advantage of having conversion gain rather than loss, requiring less LO drive than diode mixers, and are compatible with monolithic integrated circuit (MIC) processes. Modern designs are realized on microstrip for frequencies less than 30 GHz and are much smaller than earlier designs.

Up-converters used with analog or digital FM system must have minimum AM/PM distortion. These modulation formats are insensitive to AM/AM distortion and the mixers may be driven at or above their P_{1dB} point. FM signals may also be generated by deviating a LO source directly with the baseband signal. Direct modulation up-converters have the advantage that no undesired sideband or LO energy is present at the modulator output.

Up-converters used with SSB and QAM system must minimize both AM/AM and AM/PM distortion. As a result, converter mixers using these modulation formats must be operated at output levels well below their P_{1dB} point. Because these mixers must be operated at reduced output levels, the LO leakage is large relative to the desired sideband energy. This necessitates additional LO filtering following the up-converter. Up-converter linearity is typically designed to be much better than that of the power amplifier so that the amplifier controls the overall transmitter linearity.

Since amplitude dispersion in the form of gain slope can distort the received baseband signal in SSB or QAM systems, up-converters used with these systems typically have a slope adjustment circuit to compensate for channel slope. SSB and QAM systems are also very sensitive to variations in transmitter output power. Typically a variable gain stage in the up-converter controls overall transmitter gain variation due to aging and temperature. This stage is controlled via a voltage generated by a detector circuit at the transmitter output. The control of transmitter output power, channel slope, and linearity are particularly important if predistortion is used [24].

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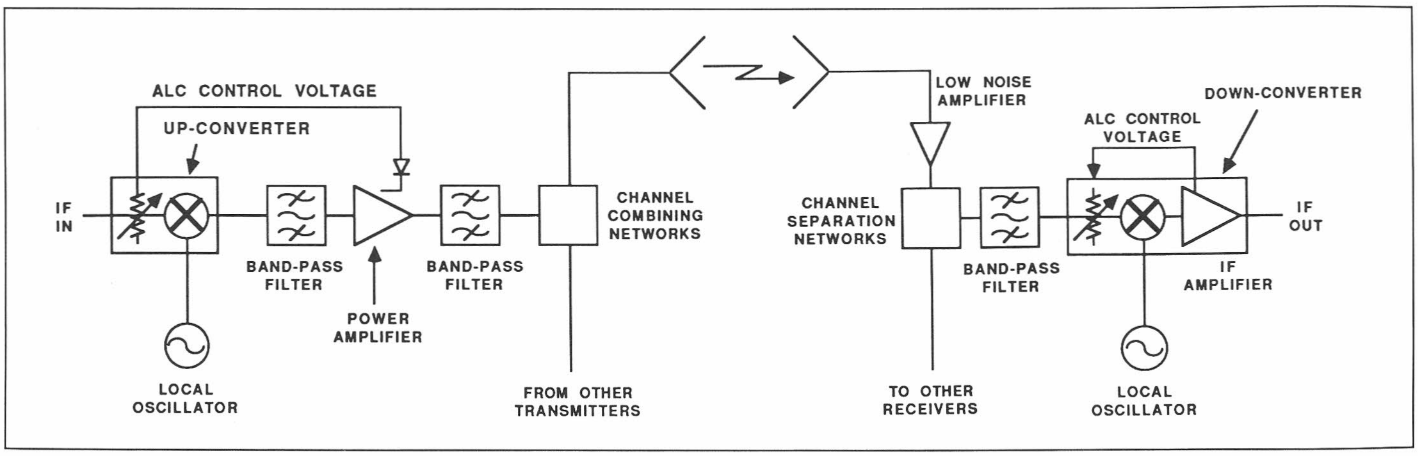

FIGURE 7. Typical multi-channel microwave radio system block diagram.

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Power Amplifiers

Power amplifiers are used to increase the microwave signal strength before transmission. Since the amplifier converts DC energy into microwave energy, the DC-to-microwave conversion efficiency is an important parameter. The bandwidth of the amplifier also should be as wide as practical so that a single design can be used over an entire band or half band. Most communications band amplifiers have percentage bandwidths of about 10%. The P_{1dB} point is a good figure of merit of the power-handling ability of a power amplifier. The amplifier gain requirement is determined by up-converter output power, filter losses, and the desired transmitter output power. Requirements for amplifier P_{1dB}, efficiency, gain, and other parameters are affected by the modulation used.

Early 4 GHz systems such as TD-2 used vacuum tubes in the output power amplifier. In more modern systems, the vacuum tube has been replaced by TWTs or amplifiers employing FETs or bipolar transistors. Bipolar transistors find applications in the 4 GHz and lower bands. Since the mid 1970s, however, the GaAs FET has become the dominant solid-state device in the 2 to 26 GHz frequency range. The FET has displaced not only tubes but also other solid-state devices such as bipolar transistors, and Gunn and IMPATT diodes. Power FETs now achieve P_{1dB} levels of 37 dBm (5 watts) at 12 GHz. Gunn and IMPATT diodes are still used for high power amplifiers in the 18 and 23 GHz bands. TWTs are used in the 6 GHz and higher bands where highly-linear high-power transmitters are required.

Amplifiers used in analog and digital FM systems are usually operated at or above their P_{1dB} point. Operating above P_{1dB} maximizes the amplifier efficiency. For example, a solid-state amplifier operating in the 4 GHz band at $P_{1dB} = 37$ dBm (5 watts) with a DC power consumption of 35 watts would have an efficiency of 14%. Since the FM signals carry the information in the frequency or phase of the carrier, the large amount of compression caused by an amplifier operating at its P_{1dB} point will not be a source of distortion. However, if there is any residual AM of the desired FM signal, the AM/PM distortion of the amplifier will cause FM intermodulation noise. This type of distortion may be reduced by proper equalization or by using limiters before the AM/PM source. The AM/PM coefficient of a power amplifier is an important parameter which allows the engineer to estimate the total distortion within the radio system. There are several methods of measuring AM/PM distortion in microawve devices [25] [26] [27] [28]. A plot of AM/PM versus output power for an 8 GHz GaAs FET amplifier is shown in Figure 8. Note how the AM/PM changes with output level. Thus it is important to measure the AM/PM at the level the amplifier will be operated at. Almost all FM systems now use GaAs FET rather than TWT amplifiers because they can achieve the required 5 to 10 watt output levels with high reliability and simpler low-voltage power supplies.

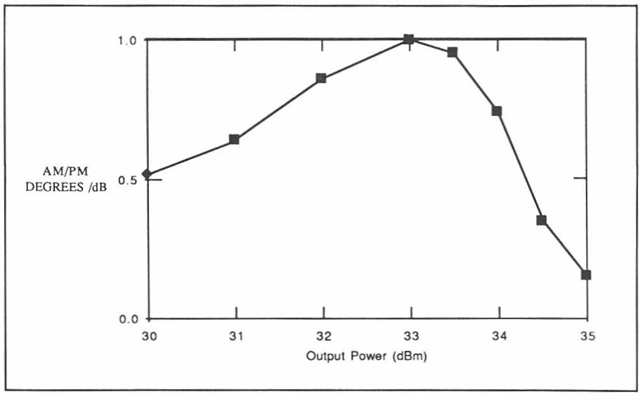

FIGURE 8. AM/PM for a typical GaAs FET amplifier.

Because information is carried in the envelope of signals using SSB or QAM modulation, amplifier linearity is of primary importance. Both AM/AM and AM/PM nonlinearities cause distortion. To reduce the effects of nonlinearities, power amplifiers are operated at levels well below their P_{1dB} point. To reduce the amount of power reduction required, various forms of linearization are employed. These linearization methods include predistortion [5] [29] and feed-forward [30] [31]. The power reduction required for an amplifier used in a 64-QAM radio system is 10 to 13 dB without linearization and between 7 and 8 dB with linearization. Two and three tone intermodulation measurements are used to measure the nonlinear distortion. The subject of linearization is very active currently and will become more important as higher level digital formats come into increasing use.

Since the SSB or QAM amplifier operates at power levels well below saturation, the DC-to-microwave conversion efficiency is poor when compared to FM systems. If the amplifier used in the earlier FM example is used in a 64-QAM system with a power reduction of 7 dB it would have an efficiency of less than 3%.

Replacement of TWTs by GaAs FET amplifiers has been slower with high linearity systems employing SSB and QAM modulation. Predistorted TWTs are used in 64-QAM systems to achieve operating levels greater than 5 watts. Linearized solid-state amplifiers, used in similar systems, run at approximately 2 watts. The nonlinearity of FETs is not as well understood or behaved as that of TWTs. TWTs generally exhibit well behaved third-order AM/AM and AM/PM conversion. FETs may have significant fifth-order AM/AM conversion and AM/PM conversion that is a non-monotonic function of output power as shown in Figure 8. The complex behavior of FETs reduces the dynamic range over which they may be linearized. FETs also have significant gain and nonlinearity variations with temperature.

TWTs will remain an important component of radio systems for years to come. However, there have been great strides in recent years to improve the P_{1dB} point and linearity of FETs. As better devices become

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available GaAs FETs will enjoy a wider range of applications in linear radio systems.

A 6-GHz GaAs FET linear power amplifier is shown in Figure 9. This amplifier is used in the DR6-30-135 system and operates at an output power of 31 dBm.

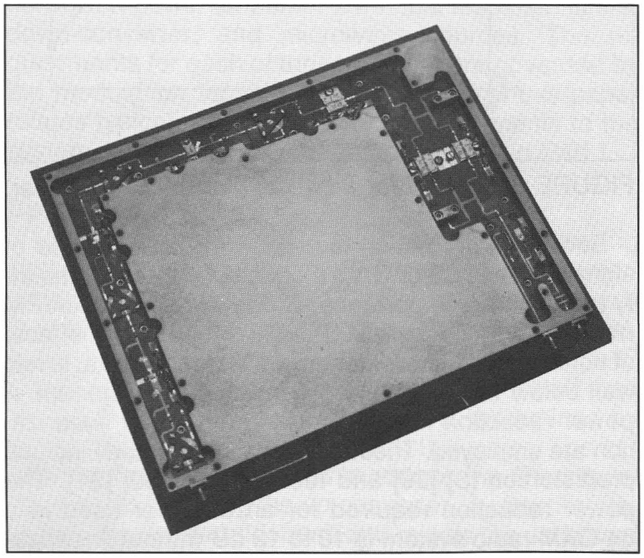

FIGURE 9. 6-GHz GaAs FET power amplifier used in the 64-QAM DR-6 system.

Low Noise Amplifiers

Low noise amplifiers are used in microwave radio systems to improve the overall receiver noise figure. GaAs FET devices can now achieve a noise figure of 1 dB with a gain of 10 dB at 12 GHz. A common amplifier may be used to amplify a group of radio channels if it is placed between the antenna and the channel filters, or separate amplifiers can be used for each channel if they are placed after the channel filters. A common amplifier has the advantages of economy and a location preceding the loss of the channel filters. However, if a common amplifier fails, all incoming channels will be lost or seriously degraded. This problem is eliminated by designing amplifiers with a failsafe mode [32] as shown in Figure 10. If the transistor fails or DC power is lost, the signal is by-passed through the circulators. The amplifier gain then typically goes from +10 dB to −8 dB.

Signal distortion caused by receiver amplifiers is much reduced over that of transmitter amplifiers because of the low power levels involved. However, for SSB and QAM modulation, low noise amplifiers must be linear enough to prevent AM/AM and AM/PM distortion during up-fades as high as 15 dB. Common channel amplifier linearity must be sufficient to prevent intermodulation "crosstalk" between channels for all modulation schemes.

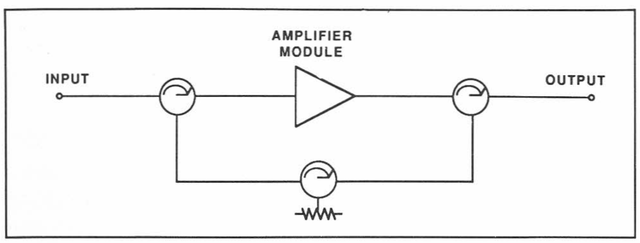

FIGURE 10. Single-ended amplifier with provision for unpowered transmission.

Down-converters

Down-converters translate the information carrying signal from the microwave RF frequency to IF or baseband. As with up-converters, this is usually accomplished with a mixer. Other devices and circuit elements are similar to those used in up-converters.

If the mixer is preceded by a low-noise amplifier, thermal noise at the mixer image frequency can degrade the receiver noise figure. To prevent this, the image frequency noise can be filtered prior to the mixer or a single-sideband down-converter can be used.

Down-converters used with analog or digital FM systems must have minimum AM/PM type distortion. Since these modulation formats are insensitive to AM/AM, mixers for these type systems may be driven at or greater than their P_{1dB} point provided AM/PM distortion is low.

Down-converters used with SSB and QAM systems must minimize both AM/AM and AM/PM distortion. Thus, converter mixers for these modulation formats must be operated at power levels well below from their P_{1dB} points. These mixers must also be protected from being overdriven during up-fades. A variable gain stage may be used to keep the power going into the mixer below a critical level. This gain stage is usually controlled by a voltage generated by an IF detector as shown in Figure 7.

Microwave Sources

Microwave sources are used as LOs for mixers or may be modulated directly as previously discussed. Frequency stability and phase noise are two important parameters of LO sources. Frequency stability is the variation in signal frequency that occurs over relatively long periods of time. Phase noise is the random fluctuation of signal phase over short periods of time typically less than one second.

Early systems used low frequency crystal oscillators and multiplier chains to generate microwave frequencies. Today, dielectric-resonator-oscillators (DROs) in temperature controlled ovens and phase-locked oscillators approach the stability of crystal oscillators but are far less costly or bulky. DROs are used in many modern radio designs. They generate moderate drive levels (about 15 dBm), have low phase noise, and are stable with respect to time and temperature. Varian [33] has reported results for DROs using FETs in the 4, 6, and 11 GHz bands. Plourde [34] has reported results of DROs using bipolar devices.

A modern down-converter plug-in unit with integral DRO is shown in Figure 11. This unit is part of the

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DR6-30-135 radio system. The use of microstrip and dielectric resonator technology has allowed this compact physical design.

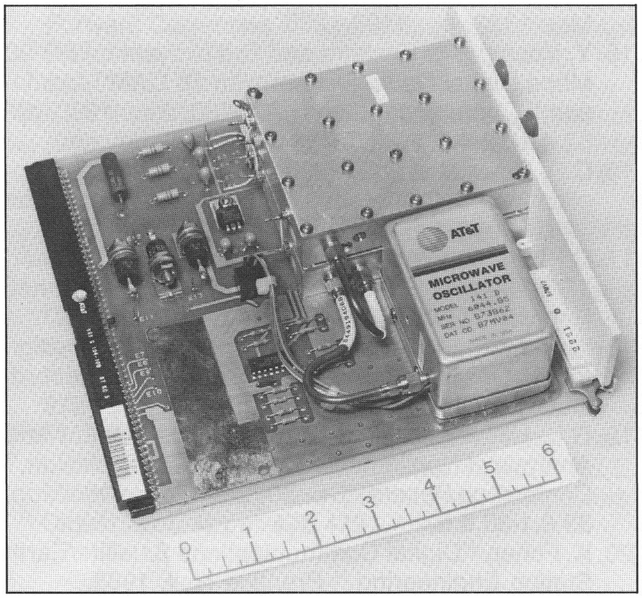

FIGURE 11. Down-converter plug-in with DRO as used in the DR-6 system.

Microwave sources used in analog FM systems using IF repeaters must be stable. Any shift in the receiver LO frequency will result in an IF error. For long-haul FM systems, this frequency error can build up at each hop. The TD-2 system avoided this problem by referencing both the receive and transmitter LOs to one microwave oscillator as depicted in Figure 12. To obtain the receiver LO frequency, the frequency of the transmitter LO is shifted using a stable low-frequency 40-MHz oscillator. The 4 GHz transmitter LO in the TD-2 system was obtained by multiplying up from a 125 MHz crystal oscillator. This system required a frequency stability of ± 1 part per million.

Because the demodulation process of an FM discriminator de-emphasizes noise close to the carrier, FM modulation is relatively immune to low frequency phase noise of the LO. Thus, noise less than about 1 MHz from the carrier is unimportant in analog FM systems.

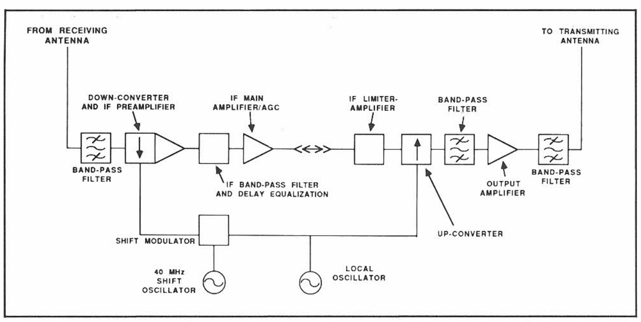

FIGURE 12. Typical non-remodulating FM microwave repeater.

The frequency stability requirement for the AR6A SSB system is about ± 0.2 parts per million per year. This requirement insures that the system pilot tones are located accurately with respect to their narrow-band pick-off filters. To meet this requirement, the microwave carriers are phase locked to an external reference frequency. A 125 MHz crystal oscillator which is phase locked to a central low frequency reference signal is used to drive a string of active and passive multipliers to generate a 6 GHz LO signal. The AR6A system generates the receiver LO by shifting the frequency of the transmitter LO similar to the TD-2 system. The system phase noise requirements were derived as discussed in Section 4.

For digital FM and QAM sytsem, the baseband digital signal is usually regenerated at each hop. As a result of the regeneration, frequency errors and phase noise of the LO signals do not build up from hop to hop as they do in analog FM or SSB systems. Thus, the frequency stability required for digital FM and QAM systems may be relaxed over that for SSB systems. The controlling requirement then becomes the FCC requirement for transmitter frequency stability. The FCC permits a frequency tolerance of ± 25 parts per million. The IF frequency error must also be within the capture range of the demodulator carrier recovery circuits which is typically about ± 500 kHz.

In QAM systems, the digital demodulator tracks phase noise which is closer to the carrier than the bandwidth of the carrier recovery circuit. This bandwidth is typically 10-20 kHz. Phase noise at frequencies above this bandwidth will cause jitter of the recovered carrier. The jitter then causes degraded bit-error-rate performance. Digital modulation is also sensitive to sudden frequency or phase jumps of the LO signal. These phase jumps or "phase-hits" are caused by microphonic effects or mechanical instability of the oscillator with temperature. These phenomena will cause bursts of errors to occur in the digital bit stream [35]. Care must be taken in the oscillator mechanical design to prevent this. Phase-hits are usually not a problem with analog systems because they are too fast to be audible.

8. Conclusion

Modulation techniques and microwave device requirements continue to have an interesting and varied interaction in terrestrial microwave radio systems. As the improved performance of new device designs becomes available, this performance is utilized in new system designs that provide improved transmission quality and higher information capacity.

Future digital microwave radio systems may evolve with higher spectral efficiency in terms of bits transmitter per unit of bandwidth. Each new digital system will also provide higher levels of transmission quality and availability. Solid-state microwave power amplifiers with

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higher power capability and greater linearity will be needed for these systems. Receiver front-ends with even lower noise figures will also be desirable. The new digital systems will provide high-quality information transmission throughout the 1990s and into the twenty-first century.

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BIOGRAPHIES

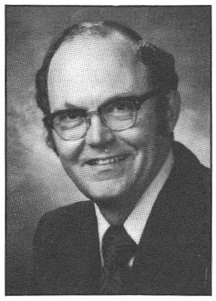
James P. Moffatt received a B.S. degree in Electrical Engineering from Princeton University in 1963 and M.E.E. and Ph.D. degrees in Electrical Engineering from North Carolina State University in 1965 and 1968 respectively. After serving two years in the U.S. Army, he joined AT&T Bell Laboratories in 1970 where he has contributed to the development of long-haul microwave radio systems. He has authored several papers and holds a patent (co-inventor) for distortion compensation in microwave amplifiers. His current work is in the area of digital radio systems. He is a member of the IEEE and Phi Kappa Phi.

James F. Moss received the B.S. and M.S. degrees in Electrical Engineering from the University of Wisconsin, Madison, in 1979 and 1980 respectively. He joined AT&T Bell Laboratories in North Andover, MA in 1981 and has worked on the design of circuits used in 6 and 11 GHz microwave radio systems. He has authored several papers related to microwave device development. His current work includes characterizing nonlinearities of microwave power amplifiers. Mr. Moss is a member of the IEEE Communications and MTT Societies.

☐ **Natural salt substitute:** Lemon juice. Low-salt tomato juice with lemon added tastes the same as regular tomato juice, and it's better for you. *Other interesting salt substitutes:* Ginger. . . pepper. . . curry. . . mustard powder. . . garlic. . . onion. . . vinegar.

Longevity, 1965 Broadway, New York 10023. Monthly. $48/yr.

PCs for MTT



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This month I am pleased to present a guest column by Dan Higgins of Santa Barbara, CA on a topic that should not be at all controversial (!), that of choosing a microcomputer language for scientific computing. While the writeup below was received sometime ago from Dan, the topic is an essentially timeless one and so Dan's remarks remain relevant.

Before presenting Dan's discussion, I would like to repeat a request made frequently in this column. If any of you would like to share your experiences concerning software, hardware, or other computer-related issues with other readers of this column, I would welcome your input. Although I can generally find enough material that is of interest to me to meet each Newsletter deadline, the value of the column will be increased substantially by including a broader variety of experiences and opinions. Please send your communications to the address above or call me.

Along these lines, I want to acknowledge letters recently from, Mel Creusere of ESL, Sunnyvale, CA and Scott Ray of Lawrence Livermore National Laboratory. Mel had originally contacted me concerning difficulty he encountered in obtaining a copy of MathWriter, an equation-writing package for the Macintosh which I reviewed in the April 1987 column. Unable to get MathWriter through a local computer store, he eventually succeeded by writing directly to Cooke Publications, and reports that "the program does all that I hoped for, given some learning curve in getting used to its eccentricities". (I know that standard usage is to put the concluding quotation mark outside the period concluding a sentence, but I prefer to end with a period since the sentence is not all in quotes). In case anyone else is experiencing similar trouble, here is the address again and phone numbers too (which weren't given in the April column): Cooke Publications, PO Box 4448, Ithaca, NY 14852; telephone (607)272- 2708 ext. 15, or US except NY (800)482-4438 ext. 15; in NY (800) 435-4438 ext. 15. Mel also sent me a list of other Cooke software, which includes MacPoisson, a finite-element program for electrostatics which is also avilble fo rthe IBM PC. The program comes in two versions, one for students limited to 300 unknowns ($39.95) and the "professional" ($495.00) which can handle up to 1500 unknowns in extended precision on the Mac+ with 1 megabyte of RAM. Maybe I'll be able to report on one

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or the other of three programs in a future column.

Scott goes on to say that he also agrees with the need for a better system of software distribution. He has used netlib a lot, and says that working on LLNL's unclassified Vax network, he finds it "quicker and more reliable to get the codes from netlib at Argonne than to pull things off the Octopus system (LLNL's mainframe network) via mag tape or floppy."

Continuing to quote from Scott, he adds that "One problem with a software exchange facility is ongoing support. I think that some one person needs to be designated as the librarian. This person would then either keep and distribute the actual codes and/or would keep a list of what is available and where to get it. They would also need to actively solicit submissions to the code collection, keep potential users abreast of what's available, and respond to requests. It would probably be best if they would also write a regular column for the Newsletter. This is beginning to sound like a tough job. The difficult thing would be keeping things going after the initial startup enthusiasm and keeping the code collection growing and useful to the entire community... The problem with public-domain software is that it is often worth about what you paid for it. Maintaining the quality of the software in the public domain EM code collection would be a challenge.

I mentioned in the December 1987 column that I had been informed by a reader of a column, "The PC in Electrical Engineering," being written for the IEEE Circuits and Devices Magazine beginning with the November 1986 issue by Dr. Miles A. Copeland, Department of Electronics, Carleton University, Ottawa, Ontario, Canada K1S-5B6, telephone (613)564-4388. At the time that column was written, I had been unsuccessful in contacting Dr. Copeland to learn more about his column and to see whether he might permit me to use excerpts from it in these columns. I am happy to report that he has sent me all of his back columns with permission to make full use of them, and he will send me his future columns as well. You can expect to see excerpts from Dr.Copeland's column on a regular basis. Now on to Dan's review of FORTRAN alternatives.

ALTERNATIVES TO FORTRAN FOR SCIENTIFIC COMPUTING ON MICROCOMPUTERS

by Daniel F. Higgins —
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Most scientists and engineers are well acquainted with the idea of using the computer as a tool to help their work. To most of these scientists and engineers, FORTRAN is the language used to control that tool. FORTRAN was one of the first high-level computer languages. It was designed to be used by those familiar with equations and mathematical expressions. Very efficient compilers have been developed which make FORTRAN source code capable of generaing efficient and very fast machine code. Also, because of its (relatively) long history, a great deal of powerful FORTRAN code exists, creating useful program libraries. It is thus not surprising that FORTRAN is often the language of choice for developing programs designed to carry out detailed numerical calculations (so-called "number-crunching" programs).

Much has changed in the computer world, however, since FORTRAN was first introduced. Many newer computer languages, such as BASIC, PASCAL, C, LISP, MODULA2, ADA, and FORTH have been invented, and personal desktop computers with remarkable computing power are becoming quite commonplace. Yet much of the scientific and engineering community still seems tied to the large mainframe computers and the FORTRAN language. This is hardly surprising — computer technology has been changing rapidly and scientists or engineers not directly involved in that technology seldom have the time to try to keep up with all the developments. It seems appropriate, however, that a periodic review of new and perhaps better methods should be carried out.

But why consider alternatives to FORTRAN? Have not numerous extremely complicated numerical simulations been successfully coded in FORTRAN? What can be gained by considering an alternative?

For one possible answer, consider the analogy of the typewriter keyboard. The so-called "QWERTY" keyboard arrangement was originally created solely to reduce the mechanical jamming of early typewriters. This arrangement has become a "standard" even though no longer required for modern typewriters and despite the fact that other arrangements of the keys (such as the DVORAK keyboard) have been shown to result in faster typing speeds. However, one can certainly type any English text using a "QWERTY" keyboard, even though there may be better and more efficient ways of typing.

One can thus contend that FORTRAN is the "QWERTY" keyboard of scientific computing. It was created first, and most scientists are familiar with it. Learning a new language and onverting existing code libraries would take considerable effort.

It is also sometimes claimed that FORTRAN is a "natural" language for scientific work. Many formulas are easily translated into FORTRAN, but statements like "X=X+1" are hardly "natural" after high school algebra teaches one that such an equation implies "0=1"! Similarly, long FORTRAN codes can become very difficult to read and debut. (Following the logic of such codes can resemble the feat of tracing a single strand of spaghetti in a large plate of the pasta!)

BASIC

But what are the alternatives to FORTRAN? BASIC is one alternative. BASIC is very much like FORTRAN and easy to learn if you already know FORTRAN. It is also available on almost any microcomputer. One of the big advantages of BASIC is that it is usually an interpreted language. That means that it is interactve. One can test commands by simply typing then on the keyboard. Unfortunately, interpreted languages are usually quite slow compared to a compiled language

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like FORTRAN. Interpreted BASIC is thus not a good number cruncher. Compilers do exist for some BASICs, however, giving one the ability to write and debug a code interactively and then compile the source code for maximum speed once the code is working. Unfortunately, very long BASIC programs often resemble the 'spaghetti' code previously referred to.

PASCAL, MODULA2, ADA

PASCAL is probably the language of choice being taught at universities today. This language was designed to help create readable, well-structured programs. Modularity is encouraged and a variety of commands and data structures are available. The language is usually compiled (although some PASCAL interpreters are now available). MODULA2 is a new descendent of PASCAL, designed by the inventor of PASCAL (N. Wirth) to take care of some of its limitations. ADA, a new language being pushed ("dictated?") by the Department of Defense, is also apparently close to PASCAL in many ways (although designed to handle longer and more complex programs).

C

On the other hand, C is a language very popular with system programmers. It was originally developed at Bell Labs and most of the UNIX operating system is written in C. The C language combines the ability to work at low levels and manipulate individual bits and machine addresses (capabilities often not really achieved in higher level languages) with structured programming techniques and high-level control structures. C is a compiled language.

With a good compiler, a compiled language can be used to create very fast and highly efficient code. The cost for this efficiency is the need for several steps in the process of turning high level source code into an operational program. The user must thus write the source code, compile it, link it to various existing libraries, and then run the object code to see if it works. Due to all these steps, the process is seldom interactive (especially on desktop microcomputer). It is thus difficult to repidly see results and correct errors.

FORTH

A little known computer language with some very interesting characteristics is FORTH. The language was orginally devised for controlling a radio telescope and it is widely used in robotics and other applications. FORTH is a language which is compact, interactive, relatively fast, highly modular, extendable and extremely powerful. It is also substantially different from most other languages in a number of ways. It has attracted a small but dedicated group of proponents, but it also has a number of vocal opponents.

A simple description of FORTH is difficult, but one way of describing it is to say that FORTH is a language made up of nothing but subroutines (small independent modules). In most other languages, it is desirable to build a program out of a number of modularized subroutines but often not convenient or efficient to do so. In FORTH, however, the entire language has been designed to be broken into small modules called "words." The action of each word is defined in a "definition" made up of previously defined words. As each definition is compiled, the word naming it is added to the FORTH "dictionary" and can be used in further definitions. FORTH is thus interactive because it is incrementally compiled. Each word is usually only a few lines long, and once the definition of a word has been loaded, the word can be executed by simply typing its name. And once a word has been compiled and added to the dictionary it has the same status as any other word; thus, FORTH can be expanded to have hundreds of words (as opposed to the few dozen key words in BASIC or most other languages).

This extreme modularity and interactive capability make FORTH very easy to debut and to modify. In fact, that ease is one of its major advantages. FORTH is also relatively fast. It is typically 10-100 times faster than BASIC, but perhaps 2-4 times slower than the code generated by a good computer. [And FORTH code is often speeded up by re-writing only one or two words in assembler after the overall code structure is put together.]

FORTH is fast because its internals are very simple. Parameters are usually passed from one word to another by putting the parameters on a stack. Reverse Polish notation (RPN) is also used (like HP calculators). The use of a stack and RPN help keep the basic FORTH nucleus uncomplicated. Some people find the use of a stack for parameter passing and RPN objectionable, but others find it just takes some getting used to (and most scientists and engineers do not find RPN calculators particularly troublesome). The simplicity of the basic FORTH system is also appealing because its details can be understood with a little effort, while it is virtually impossible for anyone but an expert to understand the internals of a FORTRAN compiler.

The fact that FORTH can be extended also means that if you do not like some feature of the language, then you can change it. For example, one can write an algebraic paper so that algebraic, rather than RPN expressions can be typed from the keyboard. One can also incrementally extend the compiler so that matrices or complex numbers can easily be created and manipulated. This extensibility also means that all FORTH systems tend to be slightly different even though there is an attempt to standardize the language. It is just too easy to customize it to the user's specific desires. FORTH systems are generally quite similar, however, and do exist for virtually every computer. They also tend to be one of the first languages available when a new microcomputer is built.

When a FORTH system is first turned on, the interpreter is simply waiting for input from the keyboard. One enters either FORTH words or numbers separated by spaces. The interpreter simply takes each "word" (as defined by the intervening spaces) and tries to find it in the FORTH dictionary. If the word is found, it is

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executed (i.e. whatever action it was defined to have is carried out). If the word is not found, then the interpreter assumes the characters represent a number and tries to convert them to a number. If conversion is successful the number is placed on the stack. If not, the interpreter informs the user that it does not recognize the character string.

Certain FORTH words change this process. One example is the word ":" which is used to begin a 'colon definition'. [Note that any character other than a space can be used in a FORTH word— thus ":" is a perfectly acceptable word.] Such defining words are used to create new FORTH definitions. The colon thus 'turns on' the FORTH compiler and creates a series of bytes in the computer's memory describing the actions to be taken later when the word being compiled is executed. The word immediately following the colon is the name of the new definition. All words after the name until a semicolon ";" is reached (making the end of the definition) are the words to be executed when the word's name is later invoked. The semicolon returns the interpreter to normal action and shuts off the compiler. The long compiling and linking process to other languages can thus be done incrementally with FORTH and the results checked interactively by simply typing the word on the keyboard.

Unlike most compilers, the FORTH colon compiler does not convert the words in the definition to machine code instructions for the specific computer processor being used. Instead, a series of addresses of the words in the definition are stored. Thus pointers to other words are saved and FORTH is therefore said to be a "threaded" language (because the words are linked or threaded by these pointers). Much of the power of FORTH comes from the ability to efficiently follow all of these threads and execute the words in a definition very rapidly.

Another unusual feature of FORTH is the ability to change and modify the compiler itself. New "defining words" can be created to compile special classes of words. It is thus easy to add such concepts as complex numbers or matrices to a FORTH system which previously did not contain such structures. The ability to easily change the compiling proces is a feature absent from traditional computer languages.

What are the limitations of FORTH? Some claim that FORTH programs are very difficult to read, especially for anyone but the original programmer. Difficulties in reading FORTH come from several sources, one of which is the poor choice of names. A programmer can name a word to draw a plot "DRAW-PLOT", but he could also name the word "#$-??". The second choice would obviously be somewhat hard to read. The use of reverse Polish notation is also sometimes blamed for making progams cryptic. Perhaps the biggest reason, however, is the fact that FORTH programs are seldom sequential. Programs are designed from the top down, but have to be written from the bottom up. Thus, low- level words which take care of the details are compiled first, while the overall program control words are not entered until last. In fact, reading a FORTH program is usually easier if one starts at the last words compiled and works backward! It is thus the authors's contention that a well-written FORTH program is not particularly difficult to understand and read (once one is familiar with FORTH), but it must be admitted that a poorly written one can be virtually impossible to understand.

It is also claimed that it is difficult to learn FORTH. Such claims may be related to the fact that FORTH is significantly different than most other computer languages, and using it effectively may require "unlearning" certain techniques which have been previously learned. Learning FORTH can also be quite frustrating because the language has relatively little error checking and it is easy to make errors which can wipe out an operating system. Yet many people have learned FORTH, most without any format training. FORTH may not be the language for everyone, but most who have bothered to learn just how powerful it can be continued to use it even when familiar with other possibilities.

We at JAYCOR (note: this column was written while Dan worked at JAYCOR) have used FORTH for several microcomputer programming projects. One of these is the M.A.C.E. code, an aide for EMP coupling analysis, which is being commercially marketed by JAYCOR. Another code, being used for in-house studies, is called GRAPHIT. GRAPHIT is really a set of FORTH words designed to make it very easy to graphically display and compare mathematical functions. One only has to define a function such as "F1(X) = SIN(X)/X END" and then one can plot the function using the command "PLOT F1". Plot types and scale values are easily changed and various types of overlays are easily generated. Functions can also be entered as data points (instead of algebraic expressions). Complex numbers are also supported as are Fourier transforms. The interesting point is that all these capabilities have simply been added to the FORTH language. They can be used in programs or just typed in from the keyboard. We have thus been able to build a customized language particularly for aiding various scientific and engineering studies. Building such an interactive system within the framework of FORTRAN would have been very difficult.

In summary, we have described various computer languages which might be used instead of FORTRAN for scientific and technical work on microcomputer. The emphasis has been on FORTH which is a particular favorite of the author. The real goal, however, has been to encourage others to consider any of the number of languages now available for microcomputers. It is the author's observation that the language used in a program affects the way a programming problem is solved. New languages will thus encourage new ways of thinking and new approaches. Microcomputers are very personal tools and you may find a language which meets your personal needs—but you will have to look at what is available.

Dan also provided other contributions that I plan to include in furture columns. One concern benchmarks for the Mac II. The other is a Macintosh program he is developing called Math Plot, which he is currently willing to provide free to those interested, although he may eventually develop it into a commercial product.

SECRETS OF THE GREAT COMMUNICATORS

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The Great Communicators — we have all seen or heard a few. A Great Communicator is one who writes something you just have to read, even though the subject is not your favorite. He is the speaker who holds you under a spell when he is on the podium and makes you like him immediately when you are talking one-to-one.

Over the past few years, I have been studying Great Communicators. These people have turned many of my ideas about communication upside down. They have taught me some truths that I think are essential for anyone who wants to communicate well. In the next few columns, I will be sharing these discoveries with you.

PASSIVE INTERACTION

Recently, I attended a lecture by Patricia St. John, an educator and advanced open-water diver, on communication with dolphins. She told us that dolphins in training would sometimes balk at the trainers' requests for no apparent reason. The more the trainer tried to get them to perform, the stronger their refusal became and the greater the distance they would place between themselves and the trainer.

St. John tried just "hanging around" the dolphins when they were feeling recalcitrant. She did not try to control them; she was just there, waiting passively to see what they wanted to do.

Sooner or later, as she showed us on video clips, the dolphins came to her. They would circle around her and encourage her to join them. Her nondemanding "passive interaction" with them won their trust. For once, here was a human being who was not trying to manage them but simply existing in harmony with them.

In a mind-boggling leap of the imagination, she decided to apply this passive interaction to work with autistic children. Her observations of three children led her to believe that they were suffering from a perceptual overload; their senses simply could not process all the input bombarding them from the world around them. So they "shut down."

St. John just sat quietly with a child, not asking anything of him, not even attempting to engage him in nonverbal communication; she did not intrude in any way. Slowly, she saw the children turn to her. They began to engage her in some interactions. Then she responded — on their terms.

Now this, of course, is exactly what every communcator wants! We want people to turn to us, focus on us, engage with us. But how many of us really listen to understand?

SKILL VS. ATTITUDE

Before we go any further, here is a warning. This passive interaction is *not* a subtle "listening skill that you perform to get the other person's attention. If you use it as such, you will fail. In fact, I have come to believe that "skills" is a bad word in matters of human interaction. It suggests that you can manipulate the other person by using your well-honed skills efficiently and effectively. That implies that people are things. And you don't communicate with things; you use them.

What we are really talking about is an *attitude* of deep, fundamental and absolute respect for the other. St. John respected the dolphins. To her. they were not puppets to be jerked into place by a trainer's verbal string. They were independent, complex, worthy beings who had the right to be as they were. By not asking anything of them but simply being there with them, waiting for them to initate contact, she signified her respect for them as living creatures no less important then herself. Similarly with the autistic children, St. John's silent, passive presence expressed respect, a willingness to meet *on their terms*, and to engage in active communication when *they* were ready.

The first step toward becoming a Great Communicator is to acknowledge that everyone else is as important, as complex, and as feeling as you are. If you reflect on just this fact, "He is as important as I am," before you write or speak to anyone, you will not need listening skills. You will naturally give the other person the time and attention he needs. You will listen to understand him, not to react to him. If he is disturbed, you will just be there, ready to listen, but not to push. You will let the conversation go his way.

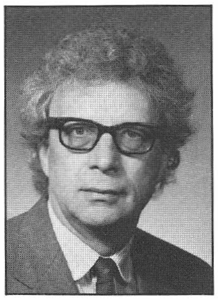
As a nation, we spend a great deal of money and time on personal therapy and various forms of psychoanalysis. Ask most people why they go, what they get out of it, and the answer is usually a variant of, "For a whole hour, he *listens* to me." People are crying out to be heard. They value those who listen.

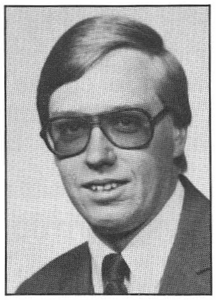
When you have finished reading this, try really listening to the next person you meet. Do not listen to react, listen to understand him. Remind yourself that he is every bit as important and complex as you are and that his thoughts and ideas are as worthy as yours. And then just *listen*.

☐ **Confectioner's sugar substitute:** Combine one cup granulated sugar with one tablespoon cornstarch. Process in a blender at high speed for several minutes, until powdery.

McCall's, 230 Park Ave., New York 10169. Monthly. $13.95/yr.

MEMBERSHIP SERVICES





by Martin V. Schneider, Chairman and Steven J. Temple, Co-Chairman

MTT-S FIRST (AGAIN!) IN GROWTH

At the end of 1987 MTT-S was the sixth largest IEEE Society with a total membership of 10,687. One year earlier we held the ninth position in terms of size. Typical membership growth rates among the top ranked 33 IEEE Societies for the year 1987 were:

	Increase in %
1. Microwave Theory and Techniques	13.1
2. Electromagnetic Compatibility	8.3
3. Acoustics, Speech and Signal Processing	7.4
4. Communications	6.3
5. Antennas and Propagation	6.0

A summary of the overall MTT growth statistics is shown in Table I. A more detailed study indicates that Region 8 (Europe, Middle East, Africa) continues to be the most active area of the Society in overall performance (number of chapter meetings, new chapter formation and membership growth).

IEEE-MTT LECTURES

With a total of four Distinguished Lecturers for 1988, our chapters have a wide choice in offering talks on timely topics to their members. The current titles and speakers are listed in Table II.

TABLE I.
Membership and Chapter Growth Statistics

Year	Membership Year End	Change from Previous Year	Number of Chapters
1980	6429	8.36%	38
1981	6635	3.20%	39
1982	6968	5.02%	38
1983	7435	6.70%	42
1984	8064	8.46%	43
1985	8715	8.07%	46
1986	9445	8.38%	53
1987	10687	13.15%	58

In addition to providing the Distinguished Lecture to our chapters, we are in the process of expanding our speaker's bureau (IEEE-MTT Lecturers) to satisfy the growing need of MTT members to remain informed on a large number of technical subjects related to microwave devices, circuits and systems. Our new IEEE-MTT Speakers (Microwave Lecturers) will give about six talks during the year and will accept your invitations if you can convince them that they wll meet a lively and sizable audience. A list of the current Microwave Lecturers with the titles and contact infomraiton appears in this Newsletter.

COST OF MEMBERSHIP SERVICES

The current cost of services which are received by each member in 1988 are listed in the Table III. Since the membership dues are only $8.00 per year and the cost of all services is $47.47. the annual deficit per member amounts to $39.47. The services provided below cost to Regions will 8 to 10 result in a projected MTT-S overseas trade deficit of $98.675.00 as shown in Table IV. If you have any suggestions on how to reduce our deficit please feel free to discuss your recommendations with the AdCom liaison officer assigned to your chapter.

TABLE II. Distinguished Lecturers and Topics 1987 to 1989

Year	Distinguished Lecturer	Topic	Talks Given	Declined Invitations
87/88	David Barton	Technology Trends in Microwave Radar	31	3
87/88	Rolf Jansen	CAD of Hybrid and Monolithic MICs and MMICs	36	2
88/89	Reinhard Knerr	Lightwave Communications	10	1
88/89	Arnold Silver	Microwave & GB Superconductive Electronics	3	1

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MEMBERSHIP SERVICES (continued from page 32)

TABLE III.
Cost of Membership Services
Average of 10,000 Members in 1988

Type of Service	Cost Per Member In Dollars	Cost Per Additional Member
IEEE Transactions on MTT, 12 issues	36.00	13.08
MTT Newsletter, 3 Issues and Directory	6.82	3.78
Distinguished Lecturers, 50% paid by MTT-S	2.40	0
Chapter Support for Technical Meetings	1.25	0
Support for Chairpersons attending MTT Symposium	1.00	0

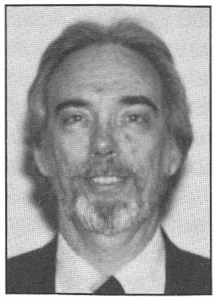
TABLE IV.
Overseas Trade Deficit 1988
Caused by Services provided below cost
for Regions 8 to 10

Cost of Services per Member	$ 47.47
Membership Dues	$ 8.00
Deficit per Member	$ 39.47
MTT-S Membership Regions 8 to 10	2,500
MTT-S TRADE DEFICIT	$ 98,675.00

CHAPTER CHAIRPERSON'S MEETING

A reception, dinner and meeting will beheld for Chapter Chairpersons and Vice-Chairpersons at the forthcoming International Micowave Symposium in New York City. The meeting is scheduled for Wednesday, May 25, 1988 at the Marriott Marquis Hotel in the Schubert/Uris room. The reception and dinner are an excellent opportunity to interact with other chapter officers and AdCpom members and to exchange information on improving services to the MTT-S membership. Invitations to attend the meeting have been mailed to the Chapter Chairpersons and Vice-Chairpersons.

MEMBERSHIP DEVELOPMENT



by Alton L. Estes

1987 IN REVIEW

Summary

- 1987 Marks Ten Successive Years of Membership Growth
- 13.1 Percent Membership Growth Rate
- Fastest Growing IEEE Society In 1987
- 6th Largest IEEE Society, Was 9th At End of 1986

Membership Reaches New Record High

The Society Membership has continued to increase steadily this year through December when compared on a month-by-month basis to the 1986 Membership results. The MTT-S membership growth rate (compared to the other 32 IEEE Societies) varied between second and third place for the first six months of 1987. The MTT-S became the fastest growing IEEE Society in July 1987 and held that distinguishing positon each month therefter. At the end of December, the MTT-S continued to be the fastest growing IEEE Society with a 13.1% Membership growth compares favorably to the Institute Membership growth rate of 3.7% and to the Institute Society Membership growth rate of 4.1% for the same period. In addition, at the end of 1987 the MTT-S was the 6th largest IEEE Society with 10,867 active Members. The MTT-S ws the 9th largest Society at the end of 1986 with 9,445 active Members.

July 1987 marked the month that ended with the MTT-S Membership growing for the tenth successive year. A special thanks to all the past and present Chapter officers and members who were instrumental in achieving these impressive results over the past 10 years.

Keep your membership growing by continuing to hold many excellent technical meetings and adding a Membership Committee to your Chapter's organization! Baltimore, India Council, Schenectady, and West Germany Chapters received $200 and a plaque at the 1987 International Microwave Symposium Chapter Chairman's Meeting in recognition of their outstanding efforts in promoting membership in 1986. Congratulations Again!

Putting 1987 In Perspective

Congratulations to the Dallas, Portland, South Africa, and West Germany Chapters for their outstanding

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MEMBERSHIP DEVELOPMENT (cont'd. from page 33)

efforts in promoting MTT-S membership in 1987. Each representative from the four Chapters shall receive membership recognition awards, $200 plus a plaque, at the 1988 International Microwave Symposium Chapter Chairman's dinner. A special thank you goes to the West Germany Chapter which has won this membership recognition for three years in a row!

The IEEE/MTT-S membership booth set up at the 1987 IEEE MTT-S IMS was a tremendous success. A total of 167 new members enrolled with the Society. Of this total, 129 members joined the IEEE in addition to the MTT-S, and 38 current IEEE members took advantage of the free Membership offer by the MTT-S. Also, adding to the booth success was the receiving and servicing of many inquiries concerning current IEEE or MTT-S members. In addition, three MTT-S members paid their dues which were in arrears. Thanks to all who participated in making this year's booth a success.

Twelve Chapters achieved membership growth for each of the past five years. This result is two more Chapters than the ten Chapters reported to have achieved the same significant membrship result at the end of 1986. Keep up the good work so your Chapter can continue to be listed as achieving a positive membership growth rate for each of the previous five years. The twelve Chapters are Central Illinois, Chicago, Dallas, Denver, Milwaukee, Ottawa, Philadelphia, Princeton, San Diego, Santa Clara Valley/San Francisco, Sweden, and Syracuse. Congratualtions!!!

Two more Chapters, Columbus and Tokyo can join this list next year if they continue to increase membership in 1988. Paying attention to quantity and quality of Chapter technical meetings and adding a Membership Committee to each Chapter's organization will help retain and increase membership. Good luck to all Chapters attempting to be added to the list of Chapters with membership growth for each of the prevous five years.

Ten years of Society growth was achieved only one month into the second half of 1987. This was a significant achievement that ocurred over the past ten years. The growth may continue for over ten years of the Chapters work to retain and add members. One of the best methods to retain membership is for the Chapters to encourage maximum involvement of the Membership in Society activities. Certainly, one of the best methods to add membership is to... Support the Membership Drive!!!

1988 MEMBERSHIP DEVELOPMENT

Objectives

The major 1988 goals of Membership Development are:

1) To achieve a 10% MTT-S membershp growth rate.
2) To promote retaining existing MTT-S Membership by taking appropriate actions to retain members.
3) To promote elevation in IEEE grade so that all MTT-S Members hold the highest grade for wich they are qualified.

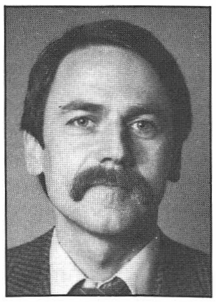
A new membership drive is underway. The Institute is promoting elevation in grade and in particular the elevation to Senior Member by those who qualify. A member should always seek to hold the highest member grade he or she is qualified for in his or her professional society. If you have been working in the profession for ten years or more and have demonstrated significant performance for at least five of those years, you may be qualified to be elected to the grade of Senior Member. Check with your Chapter or Section officer for further information and applications to elevate your grade.

FEBRUARY PROGRESS REPORT

The MTT-S membership increased 8.0% to 8,891 as compared to 8,234 members at the end of February 1986. The MTT-S was the fastest growing IEEE Society for both January and February even though the number of members whose dues are in arrears was 2,305 compared to 1,810 at the end of February 1987.

There will be a Membership booth at the 1988 International Microwave Symposium. Please drop by and visit with the Membership Development person, Al Estes, and the AdCom members who will be contributing their time to increase membership and service Member's questions at the booth. The booth is located in the Registration area.

CAD OF HYBRID AND MONOLITHIC MICROWAVE & MILLIMETER-WAVE MICs



by Rolf H. Jansen
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Ratingen 1 West Germany
49-2102-83095

DISTINGUISHED MICROWAVE LECTURER (1987/1988)

My 1988 lecturing activities started with a well-prepared one- week trip to Japan from which I have just returned. This lecturing tour included another five presentations to different groups in Tokyo, Osaka and Kyoto with audiences up to about 60 people and led me to such high technology companies as Toshiba,

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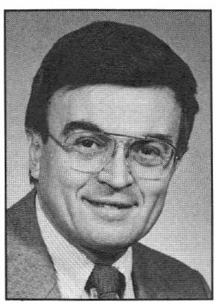
DISTINGUISHED MICROWAVE LECTURER —
R. Jansen (continued from page 34)

NEC, ATR and Murata. Due to the excellent coordination of my visit and schedule by Mr. S. Hori, the Secretary of the Tokyo MTT-Chapter, the relatively short time of my lecturing tour was efficiently used for information, lectures, discussions and exchange of ideas on CAD-related fields of interest. It was really impressive to see the success of our Japanese MTT- colleagues in device and circuit development.

For March 1988, a series of lectures is scheduled for presentation to the recently established Finland MTT-Chapter and other MTT related groups in Finland and Sweden. From Scandinavia I shall directly go to the second workshop of our Germany MTT/AP- Chapter on CAD of Microwave Circuits and Antennas which will be held in Munich March 24/25, 1988. We shall have guests and contributors there from all over Europe; I shall participate with a presentation specifically on CAD techniques for the mm-wave region. The Munich workshop will offer a very good opportunity for our Germany chapter to coordinate efforts with the attending representatives of the chapters of our European neighbors.

In April 1988 I shall have my second extensive lecturing tour through the United States with a total of seven to eight presentations. I am sure that this will again be a fascinating experience and I look forward to meeting people which are particularly involved in MMIC design and development.

LIGHTWAVE COMMUNICATIONS



by Reinhard H. Knerr
AT&T Bell Laboratories
555 Union Boulevard
Allentown, PA 18103
(215) 439-7505

DISTINGUISHED MICROWAVE LECTURER 1988/89

ABSTRACT

Lightwave communications technology has now reached a fairly sophisticated level of maturity. Applications range from multi-mode short wave length LED systems, which can trasmit at kilobits per second and are used primarily for short range applications, to long-haul single-mode laser systems, which can transmit at the rate of gigabits per second.

This talk will touch on the full range of lightwave communications applications. A short introduction to basic fiber technology will be given. Applications to optical data links, and interfaces for point-to-point data networks will be discussed, as well as the extension of such technologies to lightwave local area networks (LANs). Different network architectures for lightwave LANs will be discussed, including the fiber distributed data interface (FDDI), and the manufacturing automatic protocol (MAP). Long haul digital systems will be mentioned, with special emphasis on the microwave aspects of gigabit systems, such as stripline and low noise GaAs preamplifier technology.

Coherent lightwave systems will be reviewed with emphasis on the equivalence between such systems and the older microwave technology. We will detail problems which have been addressed in microwave systems and which are now being encountered in coherent lightwave systems and being solved by analogy to the older microwave technology. These include techniques such as isolation, internal and external modulation schemes, low noise amplification, and phase lock techniques. Emphasis will be placed on heterodyne rather than homodyne systems.

Because of the wide range of topics covered the talk will be more in the nature of a review than an in-depth presentation of any given topic. Some theoretical discussion will be included, but hardware will be emphasized. We will conclude with a short look into the future, and discussion of the fundamental problems that have yet to be solved in order to make certain exploratory systems practical.

BIOGRAPHY

Reinhard H. Knerr is a native of Pirmasens, Germany. He received a PhD and a MS in EE from Lehigh University, Bethlehem, PA and Dipl. Ing. degree from the Ecole Nationale Superieure d'Electrotechnique, d'Electronique et d'Hydraulique in Toulouse, France and a BS degree from the Technical University of Aachen, Germany.

He joined AT&T Bell Laboratories as a Member of the Technical Staff in 1968. He was involved in R&D on circulators, IMPATT power amplifiers, low noise and power GaAs FET amplifiers and satellite receivers. He has published extensively in the field and holds six patents.

Knerr has supervised work in lightwave passive components, integrated optics, lightwave local ara networks and lightwave data interfaces. He is a Fellow of the IEEE and was editor of the Transactions on MTT from 1980 to 1982. He served as president of the MTT society in 1986.

☐ **Safer bacon:** Cook it in a microwave at the highest setting for 45-60 seconds. There will not be enough time for nitrates to be converted to cancer-causing nitrosamines.
Self, 350 Madison Ave., New York 10017. Monthly. $15/yr.

MICROWAVE AND GIGABIT SUPERCONDUCTIVE ELECTRONICS

by Arnold H. Silver
TRW Space and Technology Group
One Space Park MS R1//2170
Redondo Beach, CA 90278
(213) 812-0115

DISTINGUISHED MICROWAVE LECTURER 1988/89

Superconductive electronics is an integrated circuit technology which can provide the highest performance detection and signal processing circuits from dc to the submillimeter-wave region and the fastest digital logic and memory. This performance is achieved by combining the fundamental properties of superconductors, the superconducting Josephson tunneling diode, and the cryogenic environment required for superconductivity.

This lecture will review the fundamental and historical development of superconductive electronics. Its inception traces from the successive discoveries of flux quantization, the Josephson effect and the SQUID (Superconducting Quantum Interference Device) in the early 1960's; its application is a direct consequence of the development of a thin film integrated circuit technology for computer applications. From a lead alloy technology in the 1970's, we now have a highly developed niobium circuit technology which is capable of operating at picosecond speeds and into the submillimeter-wave region.

We will discuss the performance and application of such components as quantum-noise limited microwave and millimeter-wave amplifiers, mixers, and video detectors, voltage-controlled oscillators, analog correlators and convolvers, and analog-to- digital converters. The recent discovery of superconductivity at temperatures as high as 95 kelvin may be herald the widespread use of superconductive circuits. Prospects for development and application of high temperature superconductive electonics, and its possible impact on semiconductor devices will be explored.

Biography

Arnold H. Silver joined TRW Space and Technology Group in 1981 after serving as Director of the Electronics Research Laboratory at the Aerospace Corporation for 10 years. Prior to that, he was with the Scientific Laboratory of the Ford Motor Company at Dearborn, MI for 12 years. He is a member of the IEEE, a Fellow of the APS, and has been active in the superconductive electronics community including service at Technical Program Chairman of the 1976 Applied Superconductivity Conference and a member of the Organizing Committees of the Workshop on superconductive Electronics and the US - Japan Workshop on Josephson Electronics.

Silver has been active in the development and application of superconductive electronics since his invention of the SQUID at Ford in the early 1960's. At Aerospace, his laboratory pioneered the development of low noise millimeter wave mixers and detectors, including the super conducting-Schottky diode and the quantum theory of superconductive Electronics Research at TRW, his group has pioneered the development of low noise microwave amplifiers and oscillators, analog-to-digital converters, a niobium-based itegrated circuit technology and now the development of a high temperature superconductive technology.

Silver received the BS, MS, and PhD degrees in Physics from Rensselaer Polytechnic Institute. His dissertation was on the application of nuclear magnetic and quadrupole resonance effects in the study of the structure of solids. He continued that research at Ford until his work on superconductive devices. He has authored more than 50 publications and holds numerous patents.

MTT SPEAKER BUREAU

THE IMPACT OF COHERENT DETECTION TECHNIQUES ON TERRESTRIAL AND PLANETARY ATMOSPHERIC RESEARCH, AND ON THE DISCOVERY OF INTERSTELLAR MOLECULES

by Pierre Encrenaz
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92190 Meudon, France
Phone: 33-14-5347530

ABSTRACT

Coherent detection techniques of millimeter and submillimeter waves have dramatically improved in the last two decades. the cooling of Schottky receivers, the use of both homo- and pseudomorphic HEMTs, and the technology of superconducting (SIS) junctions have increased the receiver sensitivities by two orders of magnitude. Interstellar molecules which could barely be detected in the seventies are now being observed with radiotelescopes in a few seconds. The detections

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SPEAKER BUREAU (continued from page 36)

of deuterated species, of acetone, sodium and potassium chloride show that the interstellar medium is far more complicated than previously assumed.

While the astronomical observations need to be done from high altitude sites (high platforms, ballons, airplanes, satellites), the telluric lines (molecular oxygen, water vapour, ozone) can be observed from both the ground and from space. The data obtained from the atmospheric studies will permit more accurate short and long range weather predictions. The same technques are applicable and are being used for investigating the atmosphere of the planets like Venus, Mars, Jupiter and their satellites.

BIOGRAPHY

Pierre Encrenaz is a graduate of one of France's most prestigious *grandes ecoles*, the Ecole Normale Superieure, where he is also presently on the faculty. He extended his studies at the Astrophysics Department of Princeton University and has performed radioastronomical observatons on high velocity hydrogen clouds with Arno Penzias and Robert Wilson at Bell Laboratories.

Pierre is currently Head of the Millimeter Wave Divisions at both the Ecole Normale and the Observatory of Paris. With a professional staff of fifty people, his activities include research on radioastronomical and meteorological projects and the development of sensitive receivers with advanced two and three terminal junction devices.

Pierre has published over sixty papers in the fields of astronomy and microwave detection techniques, and has authored two books. He has been instrumental in using the most advanced heterodyning detection techniques for scientific research and technical applications.

GaAs FET AND HEMT MODELING, CIRCUIT AND SYSTEM SIMULATION

STATE OF THE ART AND BEYOND

by Charles Holmes, Peter Parrish and Octavius Pitzalis
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Westlake Village, CA 91362
(818) 991-7530

ABSTRACT

A number of significant simulation tools have emerged in the past several years that permit the microwave engineer to realistically simulate most all aspects of microwave circuit design: device modeling, circuit simulation. Although linear (small signal) frequency-domain circuit simulation has been widely available since the mid 70s, many other tools are required: non-linear device models and circuit simulation, thermal analysis, reliability analysis and system-level simulation.

The continuing advancements in MMIC manufacturing have also exposed the need for an *integrated* suite of tools — including circuit layout and yield/cost analysis — operating in a heterogeneous, networked computer environment.

Recent developments in GaAs FET and HEMT modeling have resulted in a single device model that can be used in nonlinear time-domain and linear/nonlinear frequency-domain circuit simulators. The model also supports a statistical description reflecting the manufacturing process. Future extensions should include temperature as a parameter, and as a dynamic variable in conjunction with device/circuit thermal analysis. Extensive measurement data will be presented to demonstrate model validity.

Recent advances in nonlinear time domain and hybrid (e.g., harmonic balance) circuit simulation will be presented. Special attention will be paid to circuit performance as a function of power and quiescent bias.

Field-based simulation — both spectral and spatial techniques will be discussed as a tool to analyze complex geometries and coupling between components that arise in MMIC development. A critical comparison of MMIC simulation requirements and present capabilities will be made.

System simulation can be viewed as the top of a hierarchical design suite, with device modeling feeding circuit simulation, which in turn feeds system simulation.

Finally, design automation will be discussed both from the point of view of integrating discrete products, and from the perspective of radically different approaches: physical device modeling as a basis for process modeling and circuit yield estimation/optimization, circuit topology generation, and layout-driven simulation.

BIOGRAPHY

Charles H. Holmes, was born in LaFayette, Alabama in 1930. He received his bachelor's and master's degrees in Electrical Engineering from Auburn University and the Polytechnic University of New York, respectively, and the Ph.D. degree from Stanford University where he conducted research in the Ginzton Laboratory. In addition, he has an MS in Operation Research from Stanford University.

Holmes is currently Vice President, Advanced Development and Chief Scientist of EEsof, Incorporated. He first joint EEsof in March 1984. Prior to that, he was at Compact Software, Inc. (and predecessors Compact General Integrated Systems and Compact Engineering), Farinon Electric, the Hewlett-Packard Company and Auburn University where he held

continued on page 38

LECTURE BUREAU (continued from page 37)

teaching and administrative positions in the School of Engineering. He is a Senior Member of the IEEE and currently serves as Chairman of the Santa Clara Valley Chapter of the MTT Society.

Holmes has contributed to the development of computer aids for microwave circuit design since 1972 when he first joined the Hewlett-Packard Company. There he helped organize an intensive design seminar and developed a computer program used for instructional purposes in that seminar which was available on a world-wide time-sharing service to the microwave community.

At Compact, he was chief architect and principal author of *Supercompact™*. At EEsof, he collaborated with Dr. William H. Childs in the development of the engineering and scientific portions of the first release of Touchstone™, primarily responsible for models, optimization, noise analysis and statistical analysis. More recently, he has shared responsibility for development of EEsof's harmonic balance simulator and has also been involved with electromagnetic simulation.

BIOGRAPHY

Peter Parrish was born in Oakland, California in 1945. He received the A.B. degree from the University of Colorado at Boulder and the Ph.D. degree in physics in 1974 from the University of California at Berkeley.

In 1974 he joined the Physics Department of Berkeley as a postdoctoral research assistant studying superconducting junctions for applications to microwave low noise amplification. While at Berkeley he developed Josephson junction parametric amplifiers at 10 and 33 GHz.

From 1976 to 1981 he was Assistant Professor at the University of Massachusetts, Amherst holding appointments in the Physics and Astronomy, Electrical Engineering and Computer Science Departments, and the Five College Radio Astronomy Observatory. His research interests there focussed on millimeter-wave component development including cryogenic mixers, high efficiency multipliers and planar antenna arrays. He also was an active consultant to industry and government laboratories, including Alpha Industries, M/A-COM and MIT Lincoln Laboratory.

From 1981 to 1984 he was with RCA Advanced Technology Laboratories and from 1984 to 1987 he was with the Advanced Technology Division of Alpha Industries, Woburn, Massachusetts. He became involved with MMIC development including MMIC design, computer-aided test and process specification. He also held Adjunct Professorships at Northeastern University and Drexel University.

At present, Parrish is Vice President for Business Development at EEsof, Incorporated. His major responsibilities include management of EEsof's MMIC Design Workstation product, GaAs foundary libraries and MIMIC Program development.

He is a member of the IEEE, American Institute of Physics, Sigma Xi and Phi Beta Kappa; and is the author of over thirty-three technical publications.

BIOGRAPHY

Octavius Pitzalis, Jr., born in Ridgewood, New Jersey, in 1934. He received a BSEE from the University of Missouri in 1959. From 1963 to 1966 he did graduate study towards the MSEE degree at New york University. From 1959 to 1978, Mr. Pitzalis was a civilian electronics engineer at the U.S. Army Research and Development laboratories (presently called LABCOM) at Ft. Monmouth, N.J. Until 1966, he was involved in advanced analog and digital circuit design for the newly emerging silicon integrated circuit technology. During this time, he was a principal contributor in the first design studies for micropower digital and analog circuits.

In 1967, Mr. Pitzalis pioneered an engineering methodology for broad bandwidth, high efficiency, RF and microwave transistor power amplifiers using transmission lines and ferrite impedance transformers and power combining hybrids. In 1970, Pitzalis and Russell Gilson pioneered the now widely accepted approach of using gain compensating lossless reactive input matching networks to produce level gain over octave bandwidths in power transistor stages. In 1971, they collaborated in developing a design methodology for the synthesis and design of broad bandwidth output matching networks for transistor power amplifier stages. In recognition of this work, Pitzalis and Gilson were presented the 1974 Outstanding R and D Achievement Award by the Department of the Army.

In 1978, Mr. Pitzalis joined the Hughes Research Laboratories, Malibu, CA. From 1978 to 1981, he led the development of power-combining circuits for microwave diodes in transistors. From 1981 to 1987, he held principal responsibility for the design of MMICs (microwave and millimeter-wave) and transistor modeling and characterization at the Hughes Research labs.

Since 1987, Mr Pitzalis has been Senior Staff Scientist at EEsof, Incorporated where his responsibilities include microwave-circuit design, and advanced product development. He also serves as a technical spokesman and as a technical advisor to the MIMIC program.

Mr. Pitzalis, a member of the IEEE, is the author of over thirty-five technical publications and has five patents.

☐ **Top US business schools,** in rank order: Stanford University. . . Harvard University. . . University of Pennsylvania's Wharton School . . . MIT's Alfred P. Sloan School of Management. . . University of Chicago. . . Northwestern University's J.L. Kellogg Graduate School of Management.

Survey of 232 business school deans by *U.S. News & World Report,* 2400 N St. NW, Washington, DC 20037. Weekly. $41/yr.

. . .**only 10% of the MBAs** about to graduate from New York University have a job lined up. Last year at this time the figure was 80%.

Forbes, 60 Fifth Ave., New York 10011. 26 Issues. $42/yr.

MICROSTRIP CIRCUIT ANALYSIS: THE INTEGRAL APPROACH

by Fred E. Gardiol
Ecole Polytechnique, Dept. D'Electricite
El-Ecublens, CH-1015 Lausanne, Switzerland
Phone: 41-2-472669
FAX: 41-21-474660

For abstract and biography, please see Winter 1988 issue of the MTT-S Newsletter.

REMOTE SENSING WITH MICROWAVES AND MILLIMETER-WAVES

by Erwin Schanda
Institute of Applied Physics
University of Bern, Sidlerstrasse 5
CH-3012 Bern, Switzerland
Phone: 41-31-658910

For abstract and biography, please see Winter 1988 issue of the MTT-S Newsletter.

QUANTUM NOISE IN MICROWAVE AND MILLIMETER-WAVE ELECTRONICS

by Bernard Yurke
AT&T Bell Laboratories
600 Mountain Avenue
Murray Hill, NJ 07974
(301) 582-4961

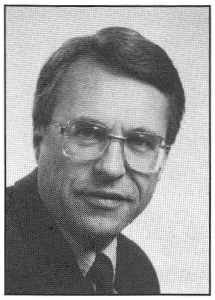
For abstract and biography, please see Winter 1988 issue of the MTT-S Newsletter.

MICROWAVE AND MILLIMETER-WAVE HEMT DEVICES AND CIRCUITS

by Heinrich Daembkes
AEG Research Center
Sedanstrasse 10
D-7900 Ulm
West Germany
Phone: 49-731-392-4274

For abstract and biography, please see Winter 1988 issue of the MTT-S Newsletter.

EDUCATIONAL AWARDS



by Jorg E. Raue

Both the graduate fellowship and grant-in-aid programs were launched last year, with two fellowships and one grant-in-aid awarded. For this year, the number of graduate fellowships awarded was increased to four. The 1988/1989 awards, approved by AdCom at its January Meeting, are summarized below:

1. Fellowship Award, $5,000 each

Recipient	Institution
Patrick L. Heron	North Carolina State University
Mark A. Sletten	University of Wisconsin
Leonard Hayden	Oregon State University
William P. Shillue	University of Mass. at Amherst

2. Grant-in-Aid

A $10,000 Grant-in-Aid was awarded to Dr. Donald P. Butler, who is an Assistant Professor in the Electrical Engineering Deparmtent at Southern Methodist University. The grant is to enchance the CAD facilities of the EE Department by providing additional computer systems and software tools, the latter specifically for the design of microwave and millimeter wave devices and circuits.

For 1989/90, the closing date for graduate fellowship applications is October 24, 1988, the closing date for grant-in- aid applications is November 7. Requests for information must be made no later than September 12, 1988. (See separate announcement on page 45 for additional details.)

"One vital conclusion reached by thinking about thinking is that creativity is associated with failure. The mind that creates a significantly new, orderly relationship of thoughts has usually wandered down seemingly unprofitable bypaths . . . However, the actions taken that lead to these frustrations are essential parts of creativity. Thus, thinking about thinking encourages tolerance of one's inevitable human limitations and enables the individual to be more creative by recognizing that his failures are often usable building blocks to gain intellectual power in a new situation." [from remarks made in a 1969 college address by William Shockley, inventor of the transistor.]

TECHNICAL COMMITTEES

by Reynold S. Kagiwada

This is the third of a series of reports by the Technical Committees of MTT-S. The purpose is to give the membership a better understanding of the role of the various committees and their activities.

Articles which have appeared so far include:

Committee	Author	Issue
MTT-3	Lee	119
MTT-6	Niehenke	119
MTT-15	Itoh	119
MTT-8	Williams	120
MTT-13	Hord	120

This issue will feature a description of the recently-organized committee on RF Packaging, MTT-12, and MTT-1, Computer-Aided Design.

MTT-1: COMPUTER-AIDED DESIGN

by Barry S. Perlman

The Technical Committee on Computer-Aided Design is involved with coordinating activities for timely exchange of ideas concerning the development and application of computer-aided design tools for microwave and millimeter-wave engineering. This is accomplished by the promotion of discussions at organized forums, workshops and panel sessions, special transactions, issues and focused sessions, including activities held in conjunction with other technical committees and interested organizations.

Areas of interest include:

1) Modeling of active and passive devices, lumped and distributed components, hybrid and monolithic circuits.
2) Analytical techniques for linear and nonlinear modeling and simulation in time and/or frequency domains;
3) Algorithms for optimization, sensitivity and tolerance analysis;
4) Electromagnetic analysis for parameter extraction of arbitrary shaped transmission structures and characterization of discontinuities and coupling structures.

With the evolution and advancement of tools for microwave CAD new issues arise where a committee such as MTT-1 can play a key role. Some of these issues are time versus frequency domain simulation, empirical versus analytical modeling, schematic versus physical circuit/geometry description, the use of a common descriptive language for representing circuit designs, design for test concepts, and cooperation with other organizations in evolving CAD software standards such as: EDIF and VHDL as they might apply to analog/microwave circuits.

Because of the general applicability of device modeling and circuit design, measurements, and field theory to CAD, MTT-1 is closely related to the activities of other subcommitees such as:

Microwave and Millimeter Wave Integrated Circuits (MTT-6), Microwave Millimeter Wave Solid State Devices (MTT-7), Microwave Measurements (MTT-15), and Microwave Field Theory (MTT-15). Over the past few years, these committees have sponsored a number of joint groups such as ARFTG. In conjunction with the 1986 MTT-S meeting in Baltimore, MTT-1 sponsored a well-attended workshop on Trends in Microwave CAD, which was organized by K. C. Gupta. This highly successful meeting was followed by a workshop on Nonlinear CAD and Device Modeling, held in conjunction with the 1987 MTT-S Symposium in Las Vegas. This workshop was also well attended (>200) and highly successful.

An opportunity to capture much of the past two years of CAD workshop activity occured in the form of a special issue of the **Transactions**. This was accomplished in January of 1988 with the publication of a special issue on Computer-Aided Design with guest editorials by K. C. Gupta (MTT-1) and T. Itoh (MTT-15). Topics included CAD for MMIC's, modeling of active devices, modeling of transmission structures, modeling of passive components, nonlinear analysis, passive circut analysis and optimization methods.

With all this activity, momentum, and interest on the part of the MTT community, a third in the series of CAD-oriented workshops is planned for this year's meeting in New York City in May. The theme will be CAD-Oriented Modeling of Discontinuities in Microwave/MM Wave Transmission Structures. This workshop is being jointly organized by K. C. Gupta (MTT-1) and T. Itoh (MTT- 5). Plans are to have a few (4-6) state-of-the-art tutorial presentations of various techniques and results for discontinuity characterization. Discussion of discontinuity characterizations for transmission line structures, other than microstrip lines will be included. A panel session is planned to focus on the still unresolved issues, modeling difficulties, radiative losses and circuit interactions. This format should allow for a useful exchange of ideas and, again, a highly successful workshop.

MTT-1 continues to plan for future activities and encourages your participation. The area of CAD is pervasive and should be an area of substantial interest in years to come. Feel free to contact me or any other member of this committee with your suggestions.

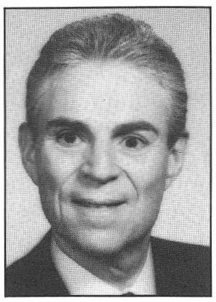
continued on page 41

MTT-1: COMPUTER-AIDED DESIGN
(continued from page 40)

The committee members are as follows:

B. Perlman, Chairman	David Sarnoff Research Center SRI International Princeton, NJ 08543-5300 (609) 734-2661
S. March, Co-Chairman	Tracor Aerospace 6500 Tracor Lane Austin, TX 78725-2070 (512) 929-4356
K. Gupta	University of Colorado Campus Box 425 Boulder, CO 80309 (303) 492-7327
R. Pucel	Raytheon Co. Research Division 131 Spring Street Lexington, MA 02173 (617) 860-3092
I. Wolff	University of Duisburg Dept. Electronics Engineering Bismarckstrasse 81 D-4100 Duisburg 1 West Germany 49 (02 03) 379-3213
R. Jansen	Industrial Microwave & RF Techniques Neanderstrase 5 D-4030 Ratingen 1 West Germany 49 (2102) 83095
F. Gardiol	Ecole Polytechnique Dept. D'Electricit'e EL-Ecublens CH-1015 Lausanne Switzerland 41-21-47-2629

MTT-12: MICROWAVE AND MILLIMETER WAVE PACKAGING COMMITTEE



by Bert Berson

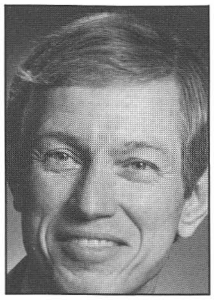
Packaging is the key to the success of the new thrusts in microwave and millimeter wave electronics. Without properly designed, reliable, cost effective packaging at the chip, component and system level it will not be possible to take full advantage of the performance contributions of new Gallium Arsenide and Silicon discrete and integrated circuit devices.

With this in mind we have formed a new technical committee MTT-12 Microwave and Millimeter Wave Packaging. The co-chairs of the committee are Bert Berson, Berson & Associates, Doug Maki, Tachonics, and Fred Rosenbaum, Washington University. The initial membership of the committee is Sarjit Barj, Anadigics, Richard Decker, Lehigh University, Tom Moravic, Honeywell, and Ray Pengally, Tachonics.

The first activity of the committee is a workshop planned for Monday, May 23, just before the MTT Symposium. The morning session will be concerned with technology and be chaired by Frank Bachner of Ceramic Process Systems. The afternoon sesson will be on applications and will be chaired by Sarjit Barj of Anadigics.

We invited anyone interested in microwave and millimeter wave packaging to participate in the workshop.

MTT-S INTERNATIONAL MICROWAVE SYMPOSIUM SITE SELECTION



by N.W. Cox

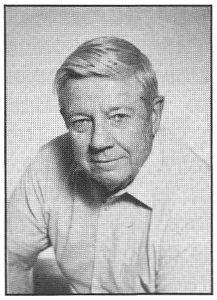
At the January 1988 AdCom meeting, San Francisco and San Diego competed for the site of the 1994 International Microwave Symposium. In a very close vote, AdCom members selected San Diego as the first choice with San Francisco as backup in the event appropriate agreements are not reached with the San Diego hotels and Convention Center. George Oltman and his Site Negotiating Committee will visit San Diego in the near future to negotiate agreements.

Site selection for the 1995 Symposium will be held at the June 1988 AdCom meeting in New York. Thus far, the only proposal received for the 1995 symposium is from Orlando, Florida. Chapters wishing to host either the 1995 or 1996 Symposium should contact Walter Cox, Chairman of the Meetings and Symposia Committee, at (404) 894-2928.

Sites selected for future International Microwave Symposia are listed below along with the Symposia Chairmen.

1988	New York City	C. Buntschuh
1989	Long Beach	C.W. Swift
1990	Dallas	J.W. Wassell
1991	Boston	P.W. Staecker
1992	Albuquerque	J. Hausner
1993	Atlanta	N.W. Cox
1994	San Diego (Tentative)	D. Parker

1989 MTT-S SYMPOSIUM



by Chuck Swift

I'm trying to prepare myself to serve in the capacity of Chairman for the 1989 MTT Symposium to be held in Long Beach June 13-15. I know I will have to have a lot of information at my finger tips if the Symposium is to be a success, and I am schooling myself to answer questions such as, "How long a drive is Long Beach from LAX?" (25 minutes) to "Where's a good spot for dinner?" (555 East or Simon & Seafort's). But what if Mike Wallace wants to feature me on 60 Minutes and they do one of those "tight" shots where every pore on your face is visible, your lips quiver, and his first question is, "What's a microwave?" Well, I don't know, but I know how to find out. I'll look it up in the dictionary.

I have one of those 20 pound, Webster's unabridged editions. No use looking up "hernia," I got one when I picked it up. One of those big suckers you leave on the coffee table to impress your neighbors. Unabridged means they didn't leave anything out: Noah didn't skip much, but he sure isn't very definitive when one finds microwave - "*Designating or of that part of the electromagnetic spectrum between the far infrared and some lower frequency limit: commonly regarded as extending from 300,000 to 300 megahertz.*" "Some lower frequency" isn't going to satisfy a blood-hound like Mike Wallace, and he'll have convinced the audience I am a pretender two minutes into the interview. I turn for help to Random House. "*An electromagnetic wave of extremely high frequency, usually one having a wavelength of from 1 mm to 5 cm.*" A lot better than Webster, but Bennett Cerf, Publisher of Random House, is beter remembered as host of "What's My Line" than as an engineer, so I'm leery of using this definition too.

So I printed up a form as follows, and took it with me to an MTT meeting. Get it right from the experts. Well, these guys could have been Jimmy The Greek picking the Super Bowl, for all the useful information I got.

I want to help Chuck Swift define "microwave", this is my definition:

____________ to ____________ length

____________ to ____________ frequency

So here's your chance. Send your answers to me at 15216 Burbank Blvd., Van Nuys, CA 91411. Incidentally, the most innovative answer to date was provided by an engineer from General Dynamics/Pomona; "The wave one gets when a microstone is thrown in a micropuddle." Once I get my problem with microwave solved, then I'm going to start on nanosecond, which someone explained to me as 11.8 inches. That only applies if you are travelling at the speed of light, which is not the speed I used to calculate the time it takes from the airport to Long Beach. Between the hours of 3-6PM, the speed of light (tail) on the freeways approaches zero!

1992 MTT-S SYMPOSIUM

by Jerry Hausner

Get ready for an uplifting and delightful experience when you attend the 1992 Symposium in Albuquerque, New Mexico. A visit to the Southwest will be a new eye-opener for most members who have never been to this part of the country. But first let's clear up a few common questions.

1. No, if you are an American citizen you don't need a passport, or to exchange your money to come here.
2. Yes, you can drink the water.

With that out of the way, we, of course, are planning a valuable conference to further your technical skills. It is impossible to predict just what the hottest technical item and buzz words will be four years from now. However, we can talk about the general interest items.

To begin with, you will be exposed to a culture that is unique to this locale. This is accompanied by a climate which is one of the best in the country. (I hope some volcanic eruption doesn't make a liar out of me.) And to top it off you will get a taste in one of the richest kitchens of scientific research. Albuquerque is in the center of the Rio Grande Research Corridor. This is a State-sponsored project to develop five centers of excellence, each in a different science. Advanced research is continuously being conducted by Sandia National Laboratories, Los Alamos National Laboratories, the Air Force Weapons Lab on Kirtland Air Force Base and at the University of New Mexico. We are planning tours of unclassified areas of both National Labs for the attendees of the 1992 Symposium.

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1992 SYMPOSIUM (continued from page 42)

Tours of this type, which are of interest to our members, are planned for the day after the Symposium so as not to compete with the technical sessions.

We will be encouraging you to spend a little extra time to vacation here. You will want to when you see how affordable it is to do so. The restaurants, especially for NEW Mexican food, are unmatched for taste and atmosphere anywhere else. Albuquerque has no shortage of fine dining of every taste. There are museums, art galleries and sightseeing which can only be found in New Mexico. The art galleries of Santa Fe and Taos boast a world wide clientele. Santa Fe is just a 1 hour drive north of Albuquerque. Only 10 miles separate state-of-the-art scientific development labs at Los Alamos from the ancient cliff dwellings of Bandelier National Monument. If you take the aerial tram up to Sandia Crest, (the longest tram in the world) you will be able to view a change in terrain from desert to rich forest by walking only 20 feet. You will also witness the world's most spectacular sunsets. Native American culture abounds everywhere. Silver and turquoise jewelry is readily available. The towns of Madrid and Cerrillos provide a time warp into the 19th century. It is also a short drive to inhabited pueblos, the very large array (VLA) radio telescope at Socorro, old narrow gauge scenic railroad rides and white water rafting (which will be in season in early June). Finally, Albuquerque is the hot air ballon capital of the world. June is not the peak of the ballooning season but rides can be easily arranged.

SYMPOSIUM FACILITIES

The Symposium will be held in the newly expanded Albuquerque Convention Center. The expansion is scheduled to be completed July 1, 1990. Work to move a roadway to make room for the expansion has already begun. The expanded center will provide an exhibit hall of 110,000 square feet which is uninterrupted by pillars. With the current 62,000 square feet, we will have 178,000 square feet of exhibit space. This year's Symposium is using 110,000 square feet so we will have plenty of room for growth. Meeting rooms are currently adequate for our technical sessions but will be increased in the expansion. The existing Kiva auditorium will be used for our plenary session and largest technical sessions. The Kiva is a breathtakingly beautiful auditorium with 2500 lush seats. The present multilevel atrium will be used for the poster sessions. The cocktail party is planned to be held oudoors around the fountains at Civic Plaza. The awards banquet will be held in the 30,000 square foot ballroom.

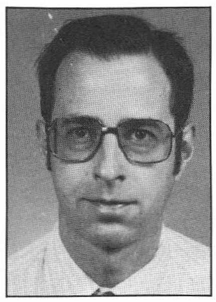
HOUSING

A new hotel complex across the street from the Convention Center is also scheduled for completion on July 1, 1990. Demolition of the building currently on that site has also begun. This will provide four and perhaps even five hotels within walking distance of the Convention Center. Most of the hotels offer a romantic, Southwestern flavor. One of them is the first hotel built by Conrad Hlton. It has been very well maintained and renovated to offer old world atmosphere with all the modern comforts.

The Albuquerque International Airport is presently under reconstruction. At this time it is a mess but is scheduled for completion in September 1989. I have witnessed construction projects here and believe that all of the schedule dates given are realistic. The rebuilt airport will be ultra modern in conveniences but will retain the heritage and flavor of these parts.

The Steering Committee for this Symposium is composed completely of local volunteers from many different companies, the National Labs and our Universities. The local MTT chapter is part of a joint chapter with the Antennas and Propagation Society and the Electromagnetic Compatiblity group. Everyone here is awaiting 1992 with enthusiasm and excitement. We are anxious to welcome you to our town and show off our New Mexican hospitality. Plan to be here the first week of June 1992.

ARFTG HIGHLIGHTS



by R.W. Tucker, Jr.

The Automatic RF Techniques Group (ARFTG) is an independent professional society that is affiliated with MTT-S as a conference committee. ARFTG's primary interests are in computer-aided microwave analysis, design and measurement. ARFTG holds two conferences each year, one in conjunction with the MTT-S International Microwave Symposium, and a second in the late Fall.

31st ARFTG CONFERENCE ANNOUNCEMENT

The Automatic Radio Frequency Techniques Group will hold its 31st technical conference on Tuesday, May 24, 1988 in conjuction with the International Microwave Symposium in New York City. Technical sessions, manufacturers exhibits and the Awards Banquet will be held in the Penn Top and Sky Top areas of the 18th floor at the New York Penta Hotel. The Penta is located at 401 Seventh Ave at 33rd Street, overlooking Madison Square Garden and Penn Station. The Hotel, formerly the Statler has been recently renovated and has excellent facilities for our meetings and exhibits.

The main topic for this conference is *Innovations In Microwave Time-Domain Measurements*. Appropriate papers will describe automated techniques for both

continued on page 44

ARFTG HIGHLIGHTS (continued from page 43)

direct (e.g., time-domain reflectometer) or transform (e.g., FFT, Chirp-Z, etc.) measurement of the time-domain response of microwave devices or the application and interpretation of such measurements.

Two invited papers will be presented. The first will be a paper by Harold E. Stinehelfer, Sr., on the history of time-domain measurements. The second will be a tutorial on time-domain measurements by Hewlett-Packard. A panel discussion on time-domain measurement is also planned.

First consideration will be given to papers on the conference topic, papers on other automated measurement and design techniques will be considered if time permits. A post-conference digest will be published. The deadline for submission of abstracts is March 15, 1988. Authors wishing to have their paper considered are requested to obtain an "ARFTG Instructions-to-Autors Kit" by contacting the Technical Program Chairman:

Dr. James C. Rautio
(Syracuse University)
4397 Luna Course
Liverpool, NY 13090
(315) 622-3641

Manufacturers are encouraged to exhibit and present technical information related to new products applicable to these areas. Submit technical papers to the above address. Manufacturers interested in exhibiting their products, contact the Exhibits chairman:

Mr. Gary R. Simpson
Maury Microwave Corporation
8610 Helms Avenue
Cucamonga, CA 91730
(714) 987-4715

For additional information, please contact the Conference Chairman:

Mr. Raymond W. Tucker, Jr.
Rome Air Development Center
Measurements Branch, RADC/RBCM-M
Griffiss AFB, NY 13441-5700
(315) 330-2841

31st ARFTG CONFERENCE SCHEDULE

Monday, May 23, 1988
5:00 pm - 11:00pm Executive Committee Meeting — Town Room

Tuesday, May 24, 1988
7:30 am - 5:00 pm Registration — Penn Top Foyer
7:30 am - 8:15 am Speaker's Breakfast — Hudson/Sutton Room
7:30 am - 5:00 pm ARFTG Exhibits — Sky Top Room
7:30 am - 8:15 am Continental Breakfast — Sky Top
8:30 am - 12 noon Technical Session — Penn Top South
12 noon - 1:15 pm Lunch — Penn Top North
1:15 pm - 5:00 pm Technical Session — Penn Top South
6:00 pm - 7:00 om Cocktail Party (Cash Bar) — Foyer
7:00 pm - 10:00 pm ARFTG Awards Banquet — Penn Top

Wednesday, May 25, 1988
5:00 pm - 11:00 pm Executive Committee Meeting

31st ARFTG CONFERENCE REGISTRATION

Attendees are encouraged to pre-register using the MTT-S International Microwave Symposium registration material. ARFTG attendees should request the Penta Hotel when completing the Housing Bureau request form. Bus transportation to the Javits convention Center and the Mariott will be available for the MTT-S Exhibits and Technical Sessions which start on Wednesday. The main registration area will be at the Marriott. Those who need to pick up their registration material should do so by Monday evening. A satellite registration area will be established at the Penta for ARFTG attendees. We will attempt to have all remaining ARFTG attendees material at the Penta for Tuesday registration and pick-up.

GENERAL INFORMATION

The Conference fee includes a continental breakfast, lunch and the ARFTG Awards Banquet. Sources of preregistered ARFTG attendees are invited to the ARFTG Banquet at no additional cost. A post-conference digest is also included in the fee. The digest is mailed approximately 90 days after the Conference.

This ARFTG Conference promises to be outstanding, with an excellent Technical Program, Exhibits and Awards Banquet — plan to attend!!

JOIN ARFTG

ARFTG brings you the latest techniques in RF, Microwave and Millimeter wave Analysis, Design and Measurement. State-of-the-Art papers are presented twice a year. If you are involved in automated technique, come and join your peers and keep current with our ever-evolving technology. For more information on ARFTG, write: ARFTG, Sly Hill Road, Ava, NY 13303.

The Top 10 Calorie Burners

Activity	Calories*	Activity	Calories*
☐ Running at 10 mph	1,035	☐ Jogging at 5.5 mph	748
☐ Rowing (racing crew)	943	☐ Playing handball	690
☐ Bicycling at 13 mph	840	☐ Playing racquet ball	690
☐ Jumping rope	805	☐ Skiing downhill	690
☐ Swimming at 50 yd./min	768	☐ Playing squash	690

*Calories burned by a 180-pound man in one hour of exercise.

⋆*not listed: MTT AdCom meetings-ed.*

Hippocrates, 475 Gate Five Rd., Sausalito, CA 94965. Six issues. $18/yr.

TWELFTH INTERNATIONAL CONFERENCE ON INFRARED AND MILLIMETER WAVES

by M.N. Afsar

The twelfth IEEE MTT-S International Conference on Infrared and Millimeter Waves was held at the Grosvenor Resort Hotel, Walt Disney World Village Hotel Plaza, Lake Buena Vista, Florida, during December 14 — 18, 1987. Over the years this conference has changed its focus of interest from submillimeter waves and far infrared spectral region to almost all millimeter waves. There were four parallel sessions each half day for four and a half days (a total of 35 sessions) concentrating mainly on four areas: 1) Millimeter Waves 2) Material Measurement and Techniques 3) Millimeter and Submillimeter Waves and 4) Free Electron Laser and Gyrotron. For the first time there was an official full two day millimeter wave exhibit. Nineteen leading millimeter wave companies displayed thier components and instruments in an area adjacent to the lecture halls.

There were a significant number of invited keynote papers in each area. The total attendence was 328 with representation from 22 countries (USA-244, Canada-8, U.K.-9, France-14, Fed. Rep. Germany-16, Italy-3, Switzerland-2, Netherlands-2, Finland-1, Belgium-1, Sweden-1, Ireland-1, Japan-10, China, PRC-9, Tawain, ROC-3, Hong Kong-1, India-1, Egypt-1, and Israel-1). The average attendance in Millimeter wave, Free Electron Laser and Gyroton and Material Measurement and Techniques sessions were about 80 each and Millimeter and Submillimeter Wave sessions was about 60. The high temperature superconductor session drew 130 attendees. The Millimeter and Submillimeter Wave Sessions included two sessions on Microwave-Optical Interactions in additions to sessions like Millimeter Wave Physics and Astronomy, submillimeter Wave Detectors, Spectroscopy and Applications, and Lasers. There was one session on Plasma Diagnostics.

The conference was organized by a team of International Scientists headed by Kenneth J. Button with assistance mainly from Professor Mohammed N. Afsar (General Management, Registration, Exhibit and Materials Measurement and Techniques sessions), Dr. Richard Temkin (Mailing, Digest and FEL and Gyrotron sessions) and Dr. James C. Wiltse (sessions on Millimeter Waves). Professor Mohammed N. Afsar organized Material Measurement and Techniques sessions together with Dr. George J. Simonis and Dr. Ulrich Strom. Professor Tatsuo Itoh and Professor Chi H. Lee organized two sessions on Mirowave- Optical Interactions.

The 13th International Conference on Infrared and Millimeter Waves will be held at Pacific Beach Hotel on Waikiki Beach, Honolulu, Hawaii, December 5-9, 1988.

IEEE MICROWAVE THEORY & TECHNIQUES SOCIETY 1988-1989 SCHOLARSHIPS, FELLOWSHIPS AND GRANTS-IN-AID

UNDERGRADUATE MERIT SCHOLARSHIPS — for children of MTT-S member (not limited to engineering), $1,000-$2,500 each, renewable for 4 years, given to meritorious students based on PSAT/SAT test scores, academic record, GPA, class rank, leadership, career goals, significant extracurricular and community activity, etc. Applications must be received by December 10, 1988.

GRADUATE FELLOWSHIPS — several $5,000 fellowship awards each year for graduate research studies in microwave engineering on a full-time basis. Applicants must have attained high academic level in engineering or physics. Faculty Research Supervisor must be MTT-S member. Applications must be received by October 24, 1988.

EDUCATIONAL GRANTS-IN-AID — for individual members of MTT-S and for non-profit institutions, number and amount to be based on proposals submitted, proposed activity and financial justification. Applicant must be MTT-S member of 5 years standing. Applications must be received by November 7, 1988.

For further information on the Merit Scholarships, contact:

Dr. Krishna K. Agarwal
Chairman, MTT-S Education Committee
3928 Wilshire Drive
Plano, TX 75023
(214) 867-3947

For further information on the Fellowships and Grants-in-Aid, contact:

Dr. Jorg E. Raue
Chairman, MTT-S Educational Awards Committee
TRW ESG, R8/2757
One Space Park
Redondo Beach, CA 90278
(213) 535-7414

Requests for applications and information on these awards must be made no later than September 12, 1988.

THE THIRD BIENNIAL IEEE CONFERENCE IN ELECTROMAGNETIC FIELD COMPUTATION

IEEE

Washington, D.C. National Capital Area at
Bethesda Hyatt Regency Hotel, Bethesda, MD
December 12 - 14, 1988

ANNOUNCEMENT AND CALL FOR PAPERS

A three-day conference in Electromagnetic Field Computation is being sponsored by the IEEE National Capital Area Council within easy reach of downtown Washington, D.C. in cooperation with the IEEE Magnetics, Antennas and Propagation, Microwave Theory and Techniques, and Computer Societies. The conference will provide a forum for Engineers and Numerical Analysts to discuss and exchange views on the following topics.

- Methods of 2D and 3D Electromagnetic Field Computation for Low- and High-Frequency Applications;
- Modeling and Field Analysis related to:
  - Motors, Generators, Transformers
  - Induction Heating, Non-Destructive Evaluation
  - Magnets, Magnetic Recording
  - Antennas, Radiation and Scattering
  - Microwave Devices, Guided Waves
  - Semiconductor Devices
  - Other Electromagnetic Devices and Technology;
- Automatic Mesh Generation and Computer-Aided Engineering;
- Parallel Computing in Electromagnetic Field Analysis

This conference is the outgrowth of meetings in Schenectady, NY ('86) and Pittsburgh, PA ('84). While preserving the continuity with previous programs, the 1988 conference will emphasize the role of parallel computing in electromagnetic field analysis as a new topic. The conference proceedings will be published in the IEEE Transactions on Magnetics.

English will be the official language of the conference.

Prospective authors are requested to submit a one-page (8-1/2" x 11") abstract of their presentation by May 15, 1988 to

Professor K. Webb
Electrical Engineering Department
University of Maryland
College Park, MD 20742 USA

Complete names, affiliation, addresses and telephone numbers of all authors and co-authors must accompany the abstract.

IMPORTANT DATES

Abstract due:	May 15, 1988
Abstract acceptance sent:	July 15, 1988
Full papers due:	Dec. 12, 1988

PLEASE FILL OUT AND RETURN THE QUESTIONNAIRE ON THE ATTACHED PAGE

GENERAL CHAIRMAN:
Edward Della Torre
George Washington Univ.

SECRETARY:
Wasyl Wasylkiwskyj
George Washington Univ.

TREASURER:
Walter K. Kahn
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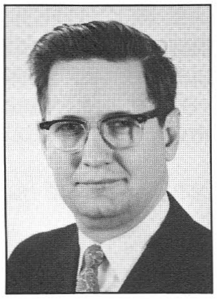
PACE REPORT



by R.A. Moore

TECHNOLOGY TRANSFER II

For the past two issues we have discussed several broad questions of U.S. competitiveness. Some of the questions such as tax policy relative to encouraging investment into research and plant modernization and some social and educational issues will be the topic of the PACE Panel Session at the Microwave Symposium May 25. Through its panel of nationally and internationally-recognized speakers, this session will provide significant insight into key competitiveness issues.

In the Fall Newsletter, we discussed several issues, both in relation to U.S. competitiveness and engineering professional interests in relation to what appears to be a growing tendency of DoD to increasingly restrict categories of nonclassified data. Recognizing the clear security necessity for restricting distribution of *classified* data, the IEEE position is that release of *nonclassified* data should be as free as possible. The article develops the case for security advantages to relatively fee release of nonclassified data. A relatively nonrestrictive environment encourages the more spontaneous commercial growth of technology. Note, for example, the rapid-growth of the computer industry and the advantages to the military of our country's dominant technology positon in that area.

HARDWARE EXPORT RESTRICTIONS

With this issue we would like to come back to technology transfer from the point of view of hardware export restrictions and their its effect both on our military security and trade balance. Without question, the unrestricted export of high technology hardware could provide the Soviets with major advantage both in time and cost of duplicating areas of Western military technology leadership. Yet such restrictions inhibit commercial exploitation of these same technological advantages and consequently our trade balance abd economic health. To the extent that minimization of these controls results in a stronger economy and industrial base, the strengthened technology provides a stronger base for maintaining a strong military posture.

It is frequently pointed out that 80% of U.S. export is carried out by approximately 250 companies. This illustrates the natural barrier to export by other than the very largest companies with capabilities for world wide marketing activities. In the U.S. proper, however, the majority of new jobs come from relatively small companies. For export, the economic viability is already sufficiently limited that any additonal restriction against export activities, such as by present difficult licensing procedures, by all but the largest companies tilts the balance further from more export rather than toward it. Only the most open encouraging environment for export will result in significantly greater interest in companies to enter international merchandising.

Throughout is early history with developing technology the U.S. provided new entrepreneurs with perhaps, the then largest unified market in the world for new products. From the beginning until most recently, scientific information was distributed largely unrestricted except for the proprietary interests of the participants. The U.S. was known for its innovation and by the post World War II period had become an industrial phenomenon. Now that the U.S. is truly a participant in a world-rather than merely a national economy, a strong U.S. economy requires a U.S. industrial base which is competitive on a world wide basis.

BLUE-RIBBON STUDY RESULTS

A "Panel on the Impact of National Security Controls on International Technology Transfer" has spent three years studying the effect of militarily-imposed trade restrictions on both our industrial strength trade balance and military security. The panel was sponsored by U.S. Government Executive Branch Departments of Defense. Energy and State an NASA and NSF. Its sponsors also included many private organizations such as IEEE and industrial concerns. The chairman, Lew Allen Vice President, California Institute of Technology, Director of JPL and formerly Chief of Staff of the U.S. Air Force and member of the Joint Chiefs of Staff, was clearly knowledgeable of many sides of the issues. Members of the Panel came from organizations representing interests a broad as the sponsors.

In carrying out its charge the Panel studied evidence from all facets of our military and industrial communities and those of our Western Allies. In this brief column I can only quote a few ideas from their book length report, "Balancing the National Interest — U.S. National Security Export Controls and Global Economic Competition." The Executive Summary points out that, "There is both anecdotal and statistical evidence that the relative stringency of US. controls is, with increasing frequency, causing Free World customers to turn to non-U.S. suppliers or to begin to explore alternative sources including internal development. Respondents to a panel survey of U.S. companies, [1] reflecting on their experience during the 12 months prior to May 1986, perceived the control system as frequently having significant adverse effects on their business:

- 52% reported lost sales primarily as a consequence of export controles;
- 26% had business deals turned down (in more than 212 separate instances) by Free World customers because of controls;

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PACE REPORT (continued from page 47)

- 38% had existing customers actually express a preference to shift to non-U.S. sources of supply to avoid entanglement in U.S. controls; and
- more than half expected the number of such occurrences to increase over the next 2 years.

Skipping on "There are also indications that the licensing process discriminates against small-to medium-sized firms. With regard to license denials, processing delays, inaction, and conditional approvals-all factors contributing to uncertainty — there is pronounced firm-size differential in the administration of national security export controls. Relative to those of large-volume exporters, small firm applications to Free World destinations take 25% longer on average.

The Panel report could have added that small companies do not have the resources to deal with licensing costs and delays that large companies can stand. Continuing, "An indicator of the efficiency of the administrative control effort-and a perennial concern of Congress, the business community, and the responsible agencies — is the time it takes to process export licenses. Shipping delays impose direct costs on the exporter and an indirect cost in consumer confidence. Both the Commerce Department and DoD have expended substantial effort and resources to speed up the licensing process, and both have made progress in reducing average processing times. What averages in this instance obscure, however, is the highly skewed distribution of processing times. This distribution has an extended "tail," and it is these cases that both *absorb a large proportion* of the corporate *resources* devoted to working the system and *create uncertainty in the market*." (emphasis—author)

Further on the report points out, "One of the principal outcomes of the continuing interagency disagreement on export control policies and procedures has been the virtual breakdown of the technology decontrol process based on positive foreign availability findings, a process originally mandated by Congress in 1979. This breakdown is largely attributable to the fact that no time constraints are specified in the legislation for government completion of investigations of foreign availability. A related problem has been the substantive disagreements between the Departments of Commerce and Defense over importance of particular items. The resulting defacto veto authority exercised by DoD thwarts the intent of Congress, which designated the Department of Commerce as lead agency in determining foreign availability."

The attempt has been to provide just a little of the flavor of the report. Any substantive summary would far exceed the space available in this column. It is, perhaps, worth mentioning a few thoughts:

(1) The Control List of Militarily Critical Technologies continues to grow because there is no effective way of removing items from it, to wit:
   a. Items no longer of strategic importance;
   b. Items so widely available that control, for practical purposes, is impractical;

(2) Though many of our Allies are in general sympathy with our trade restriction goals, our attempts to project our controls though them on items such as (1) above discourages cooperation.

The Panel makes two basic recommendations, which are very briefly summarized with selected quotes as follows:

(1) Strengthen the multilateral control regime. This means: [2]
   a. "Developing a list of items on which we and our key Allies can agree and enforce;"
   b. "Remove items for which control is no longer feasible;"
   c. "Maintain unilateral controls only on a temporary basis or unique national security circumstances;"
   d. "Eliminate reexport authorization requirements in countries participating in a community of common export controls;" and
   e. "Maintain a clear separation between national security and foreign policy export controls."

(2) "Accord greater importance in U.S. national security export control decisions to maintaining U.S. technological strength, economic vitality, and Allied unity."

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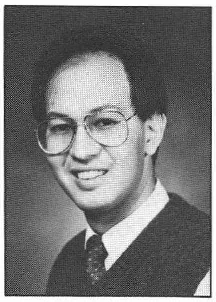
[1] "Balancing The National Interest," Executive Summary, National Academy Press, Washington, DC 1987; pp. 11-13 and 23-26 (selected segments).

[2] Reworded from reference [1] to avoid use of unusual terminologies from report not explained in this summary.

MEETINGS OF INTEREST



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GENERAL INTEREST

SOUTHEASTERN ELECTRIC SHOW & CONVENTION (SOUTHEASTCON '88)
Apr. 10-13, Hyatt Regency Hotel, Knoxville, TN. Contact: Prof. Reece Roth, Dept. Of Electrical Eng, University of Tennessee, Knoxville, TN 37996-2100. (615) 974-4446

ELECTRO '88 / MINI/MICRO NORTHEAST
May 17-19, Bayside Exposition Center, Boston, MA. Contact: Ms. Alexes Razevich, Electronic Convention Mgmt., 8110 Airport Blvd., Los Angeles, CA 90045. (800) 421-6816

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MEETINGS OF INTEREST (continued from page 48

NORTHCON '88
October 4-6, Seattle Convention Coliseum, Seattle, WA. Contact: Ms. Alexes Razevich, Electronic Convention Mgmt., 8110 Airport Blvd., Los Angeles, CA 90045. (800) 421-6816.

WESCON '88
November 15-17, Anaheim Convention Center, Anaheim, CA. Contact: Ms. Alexes Razevich, Electronic Convention Mgmt., 8110 Airport Blvd., Los Angeles, CA 90045. (800) 421-6816.

AEROSPACE MILITARY

1988 IEEE NATIONAL RADAR CONFERENCE
Apr. 20-21, University of Michigan, Ann Arbor, MI. Contact: Dr. Jack L. Walker, Environmental Research Inst. of Michigan, PO Box 8618, Ann Arbor, MI 48107. (313) 994-1200

NATIONAL AEROSPACE & ELECTRONICS CONFERENCE (NAECON '88)
May 23-27, Dayton Convention Center, Dayton, Ohio. Contact: Maj. Larry Nicholas, Chairperson, 1626 Etta Kable Drive, Beavercreek, Ohio 45432. (513) 257-3112/6738

COMMUNICATIONS

TACTICAL COMMUNICATIONS CONFERENCE
May 3-5, Fort Wayne, IN. Contact: Tactical Communications Conference, c/o Eagle Technology Inc., 320 West Street Rd. Warminster, PA 18974. (215) 672-6250

INTERNATIONAL CONFERENCE ON COMMUNICATIONS
June 12-15, 1988, Philadelphia, PA. Contact: IEEE Office, Moore School of EE, Room 209, University of Pennsylvania, Philadelphia, PA 19104. (215) 898-8106.

FOURTH INTERNATIONAL CONFERENCE ON SATELLITE SYSTEMS FOR MOBILE COMMUNICATIONS AND NAVIGATION
October 17-19, Institution of Electrical Engineers, Savoy Place, London WC2R 0BL. Contact: Conference Services, IEEE, Savoy Place, London WC2R 0BL, U.K. 01-240 1871

1988 MILITARY COMMUNICATIONS CONFERENCE — MILCOM '88
October 23-26, Irvine Marriott, Irvine, CA. Contact: Robert Walquist, TRW Electronic Systems Group, One Space Park, Redondo Beach, CA 90278. (213) 536-3478.

COMPUTERS

INFOCOM '88
Mar. 27-Apr. 1, Sheraton, New Orleans, LA. Contact: Ron Rutledge, Martin Marietta, MS 271, PO Box X, Oakridge, TN 37381. (615) 576-7643

1988 COMPUTER NETWORKING SYMPOSIUM - '88 CNS
Apr. 11-13, Sheraton National Hotel, Washington DC. Contact: Mr. George K. Chang, Chairman, Bell Communications Research, 6 Corporate Pl., Piscataway, NJ 08854. (201) 526-2398

INSTRUMENTATION

IEEE INSTRUMENTATION/MEASUREMENT TECHNOLOGY CONF.
Apr. 19-22, San Diego Princess Hotel, San Diego, CA. Contact: Robert Myers, 1700 Westwood Blvd, Suite 101, Los Angeles, CA 90024 (213) 475-4571

CPEM '88 (CONFERENCE ON PRECISION ELECTROMAGNETIC MEASUREMENTS)
June 7-10, Tsukuba Science City, Japan. Contact: Dr. Toshio Nemeto, c/o Business Center for Academic Societies Japan, Conference Dept., Yamazaki Bldg. 4-F, 2-40-14 Hongo, Bunkyo-ku, Tokyo 113, Japan.

MICROWAVES

FOURTH ANNUAL REVIEW OF PROGRESS IN APPLIED COMPUTATIONAL ELECTROMAGNETICS
March 22-24, Naval Postgraduate School, Monterey, CA. Contact: Dr. R.W. Adler, NPS, Code 62AB, Monterey, CA 93943.

1988 MICROWAVE POWER TUBE CONFERENCE
May 16-18, Naval Postgraduate School, Monterey CA. Contact: Mark Goldfarb, Conference Coordinator, Palisades Institute, 2011 Crystal Dr., Crystal Park One, Arlington, VA 22202. (703) 769-5588

31ST AUTOMATIC RF TECHNIQUES GROUP CONFERENCE
May 24, 1988. New York, NY. Contact: Raymond W. Tucker, Jr., Rome Air Development, RADC/RBCM-M, Griffis AFB, NY 13441. (315) 330-2841.

1988 IEEE MICROWAVE & MILLIMETER- WAVE MONOLITHIC CIRCUITS SYMPOSIUM
May 24-25, New York, NY. Contact: Reynold S. Kagiwada, LRW Associates, Arnold, MD, 21012 (707) 577-3658

1988 IEEE MTT-S INTERNATIONAL MICROWAVE SYMPOSIUM
May 25-27, Marriott Marquis Convention Center, New York, NY. Contact: Mr. Charles Buntschuh, Narda Microwave Corp., 435 Moreland Rd., Hauppage, NY 11788. (516) 231-1700

42nd ANNUAL FREQUENCY CONTROL SYMPOSIUM
June 1-3, Stouffer Harborplace Hotel, Baltimore, MD. Contact: T.R. Meeker, 2956 Lindberg Ave., Allentown, PA 18103.

MILITARY MICROWAVES '88
July 5-7, Wembley Conference Centre, London, England. Contact: P.J.B. Clarricoats, Conference Chairman, Dept. of Electrical & Electronic Engineering, Queen Mary College, University of London, Mile End Road, London, England E14NS. Ph: 01-980-4811.

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