

科技资料

Millimeter Wave and Microwave

MILLIMETER WAVE AND MICROWAVE

*Proceedings of the International Conference on
Millimeter Wave & Microwave
ICOMM-90*

December 19-21, 1990

Defence Electronics Applications Laboratory (DEAL)
P O Box 54, Raipur Road, Dehradun 248001, India

SPONSORS

Defence Research and Development Organisation (DRDO)
Defence Electronics Applications Laboratory (DEAL)
Department of Science and Technology (DST)
Council of Scientific and Industrial Research (CSIR)
Department of Space (DOS)



Tata McGraw-Hill Publishing Company Limited
NEW DELHI

McGraw-Hill Offices

New Delhi New York St Louis San Francisco Auckland Bogotá Guatemala
Hamburg Lisbon London Madrid Mexico Milan Montreal Panama
Paris San Juan São Paulo Singapore Sydney Tokyo Toronto

© 1990, Defence Electronics Applications Laboratory

No part of this publication can be reproduced in any form or by any means without the prior written permission of the publishers

This edition can be exported from India only by the publishers,
Tata McGraw-Hill Publishing Company Limited

Published by Tata McGraw-Hill Publishing Company Limited
4/12 Asaf Ali Road, New Delhi 110 002 and printed at
Rajkamal Electric Press, B 35/9 GT Karnal Road, Delhi 110 033

FOREWORD

The International Conference on Millimeter Wave & Microwave (ICOMM-90) in the Silver Jubilee year of the Defence Electronics Applications Laboratory (DEAL) at Dehradun is the first ever conference in India emphasising on MMW techniques and systems. The conference received an overwhelming response from most of the related organisations from all over the world. The level of enthusiasm is reflected through 212 contributed papers received from India, USA, USSR, UK, Canada, Japan, China, Bulgaria, Brazil, Hungary, Spain, Egypt, Bangladesh and Turkey. In spite of three parallel sessions spread over three full days, we could accommodate only 170 papers for publication in the proceedings and presentation in the conference. I would like to, first, congratulate and, then, thank the referees for accomplishing the review process within the time schedule and, I hope, without any heart burns. I must specially thank the authors, particularly those whose papers are left out, for considering us worthy of their attention.

MMW technology is expected to revolutionise the civil and defence applications in the coming decade. The potential applications such as Portable Radars, Man-pack Satellite Communication Terminals, Missile-head Seekers, Smart Munition, Collision Avoidance, All-weather Imagery, Wide-band Communication Systems are engaging attention of users, developers and planners. While the conference will provide an international level of appreciation and consolidation on the type of work currently being undertaken, it will help us to identify the thrust areas for India.

The conference is covering a very wide range of subjects classified into 24 sessions. The general trend of contemporary work in Millimeter Wave and Microwave is visible through large number of papers in the areas of Antennas, Propagation, Computer Aided Design, MMW Sources, Monolithic Circuits, Solid State Devices, Passive Components and Analytical and Numerical Techniques. Other front-line subjects adequately getting covered are related to Satellite and Radar Systems; Imaging and Radiometry; Short or Sub-Millimeter Waves and Biological Effects.

A pre-conference course on Millimeter Wave and Microwave Systems and Application along with experimental demonstration of automatic testing and Computer Aided Design has also been organised for the benefit of the related Scientists and Engineers.

I would like to record heartfelt appreciations and thanks to the Sponsors, Advisory Committee and Organising Committee members; Co-ordination Committee and its Sub-committee members and my colleagues at DEAL. I must specially thank the Tata McGraw-Hill Publishing Company for publishing the Proceedings at short notice and in record time.

While presenting the proceedings, as a part of the conference kit, let me welcome all authors, chairpersons of sessions, delegates and invitees to ICOMM-90 and wish them fruitful deliberations and pleasant stay at Dehradun.

VP SANDLAS
Chairman, Organising Committee (ICOMM-90)
and Director, DEAL, Dehradun

ADVISORY COMMITTEE

Chairman

Dr VS Arunachalam, Scientific Advisor to the Minister of Defence, Govt of India

Members

Dr APJ Abdul Kalam, Director, DRDL Hyderabad
Mr OPN Calla, President, IETE
Prof. KL Chopra, Director, IIT Kharagpur
Mr Promode Kale, Director, SAC Ahmedabad
Dr VP Kodali, Advisor, Department of Electronics
Prof. NC Mathur, IIT Kanpur
Capt S Prabhala, Chairman & Managing Director, BEL
Mr YS Rajan, Director, TIFAC
Mr UDN Rao, Chairman & Managing Director, ITI
Prof. S Sampath, Chairman, RAC, DRDO
Dr RP Shenoy, Professor Emeritus, IISc Bangalore
Lt Gen Harbhajan Singh, Signal Officer-in-Chief
Air Marshal Lakhmur Singh, CCR&D, DRDO
Mr VP Sandlas, Director, DEAL Dehradun

Overseas Members

Dr SL Johnstan, Huntsville, Alabama, USA
Dr GB Morgan, University of Wales, UK
Prof. Banmali Rawat, University of Nevada, Reno, USA
Prof. Ingo Wolf, Duisburg University, Germany

ORGANISING COMMITTEE

Chairman

Mr VP Sandlas, Director, DEAL, Dehradun

Members

Dr WS Khokhle, CEERI Pilani
Dr E Bhagiratha Rao, IAT Pune
Prof. Bharathi Bhat, IIT Delhi
Prof. BN Das, IIT Kharagpur
Dr IS Gupta, DTSR, DRDO
Dr SP Kosta, VC, Jabalpur University
Dr KG Narayanan, ADE Bangalore
Mr S Rajendran, LRDE Bangalore
Prof AK Sen, Calcutta University
Dr AK Sreedhar, SPL Delhi
Mr K Swaminathan, DLRL Hyderabad
Dr S Swarup, D of L&I, DRDO

Convener

Dr AS Bains, DEAL, Dehradun

Secretary

Dr RK Tewari, DEAL, Dehradun

COORDINATION COMMITTEE

Dr AS Bains—*Chairman*
Dr CK Chatterjee
Dr RK Tewari
Dr KD Nayak
Dr Deepak Singh
Mr Girja Shanker
Mr RK Agarwal
Mr SK Jindal
Mr Susheel Verma

SUB-COMMITTEES

LOCAL ARRANGEMENTS

Mr Girja Shanker—*Convener*
Mr Ashok Sen
Mr K Shiv Kumar
Mr BS Jassal
Mr RP Dixit

LOGISTICS

Dr KD Nayak—*Convener*
Lt Col SC Sharma
Maj S Dasgupta
Mr MK Pande
Mr Kanhaiya Lal

FINANCE

Dr Deepak Singh—*Convener*
Mr SK Jindal

REGISTRATION

Dr Deepak Singh—*Convener*
Mr RK Agarwal
Dr (Mrs) Sangeeta
Miss Rekha Gandhi
Mr Susheel Verma

CATERING

Dr RK Tewari—*Convener*
Mr DK Dutta
Mr GD Gupta
Mr Dilip Kumar

PUBLIC RELATIONS

Dr CK Chatterjee—*Convener*
Mr PK Gargya
Mr PK Tewari
Mr RS Misra

PUBLICATIONS

Dr RK Tewari—*Convener*
Dr KD Nayak
Mr RK Agarwal
Mr SK Jindal
Mr Susheel Verma

PANEL OF REFEREES

Dr AS Bains
Prof Bharathi Bhat
Dr CK Chatterjee
Prof. BN Das
Dr SP Kosta
Dr KD Nayak
Prof. VM Pandharipande
Prof. Banmali Rawat
Dr MD Raj Narayan
Prof. MN Roy
Prof. BK Sarap
Prof. S Sarkar
Prof. AK Saxena
Prof. AK Sen
Dr RP Shenoy
Dr AK Sreedhar
Prof. GP Srivastava
Dr KK Srivastava
Dr Deepak Singh
Dr RN Singh
Dr S Swarup
Dr RK Tewari

CONTENTS

Foreword	v
Advisory Committee	vi
Organising Committee	vi
Coordination Committee and Sub-committees	vii
Panel of Referees	viii

SESSION S-1 IMAGING

Chairperson: Y.S. Rajan, Dept of Science and Technology, Govt of India

Rapporteur: S.C. Jain, DEAL, Dehradun

S-1.1	Imaging the Compact Range Probe Data Using Music Algorithm <i>Inder J. Gupta</i>	1
S-1.2	Millimeter-Wave Instrumentation High Resolution Imaging Radar System (MIHRIRS) <i>William C. Parnell</i>	5
S-1.3	Active Millimeter Wave Imaging with Linear Detector Arrays <i>S.C. Jain, V.V. Rampal, K.S. Bist, H.S. Malhotra and K.N. Sarebahi</i>	12
S-1.4	Multispectral Video Data Transmission at X-Band <i>S.S. Santara, K.S. Bist, K.N. Sarebahi, H.S. Malhotra and S.C. Jain</i>	16

SESSION S-2 RADIOMETRY

Chairperson: V.P. Kodali, Dept of Electronics, Govt of India

Rapporteur: S.D. Mehta, DEAL, Dehradun

S-2.1	Radiometric Signature of Layer Clouds Observed at 22.235 GHz <i>A.K. Sen, A.K. Devgupta, P.K. Karmakar, R. Bera, M.K. Dasgupta, O.P.N. Calla and S.S. Rana</i>	20
S-2.2	Vertical and Slant Path Attenuation Measurements Due to Precipitation by Microwave Radiometer at 11 GHz <i>M.K. Raina</i>	22
S-2.3	Dual Frequency Radiometric Measurement of Millimeter Wave Attenuation in Clear Air and Rain <i>A.K. Sen, P.K. Karmakar, R. Bera, M.K. Dasgupta, O.P.N. Calla and S.S. Rana</i>	29
S-2.4	Millimeter Wave Radiometer for Detecting Metallic Objects <i>V.B. Mathur</i>	31

SESSION S-3 BIOLOGICAL EFFECTS

Chairperson: Air Marshal Lakhmir Singh, Defence R&D Organisation, New Delhi, India

Rapporteur: C.L. Arora, DEAL, Dehradun

S-3.1	A New Approach for the Evaluation of Electromagnetic Dose in Man and Animals <i>Vivianne K. Hanna</i>	35
-------	--	----

S-3.2	Intense Microwave Radiation from REB-Plasma Interaction from EMI Simulation <i>A.S. Paithankar, G. Venugopala Rao and S.K. Iyyengar</i>	41
S-3.3	Microwave Biological Effects <i>K. Sri Nageswari, K.R. Sarma, R. Saran, V.S. Rajvanshi, Manju Sharma, Vinita Barthwal and Vinod Singh</i>	46
S-3.4	Magic Tee and Variable Short for Measuring the Dielectric Constant of Semi-Infinite Materials including Biological Samples <i>S.P. Singh and R.K. Jha</i>	52

SESSION S-4 MILLIMETER WAVE SOURCES

Chairperson: S. Rajendran, Electronics and Radar
Development Establishment, Bangalore, India
Rapporteur: G.S. Kalsey, DEAL, Dehradun

S-4.1	Analysis of Wideband Microstrip Varactor Controlled Gunn Oscillator for EHF Satellite and Electronic Warfare Millimeter Applications <i>Nizar Sultan</i>	56
S-4.2	Planar Integration of Gunn Oscillator and Short Slot Hybrid at W-Band <i>S.S. Sarin, R.P. Dixit and Deepak Singh</i>	61
S-4.3	50 Watt, W-Band IMPATT Transmitter for a Noncoherent Radar <i>A.K. Shukla, R.S. Misra and Satish Kumar</i>	66
S-4.4	Modulation and Spectral Characteristics of a 94 GHz PLO-ILO Combination <i>A.K. Sen, R. Bera, A. Mitra and C.K. Sarkar</i>	71
S-4.5	Development Studies on a Ka-Band Pulsed Miniature Packaged Magnetron <i>Sharda Prasad, H.K. Dwivedi, S.K. Dey, P. Dutta and S.C. Kaushik</i>	73
S-4.6	Design and Optimisation of Two Diode Pulsed IMPATT Resonant Cavity Combiner at Ka-Band <i>R.P. Dixit and Deepak Singh</i>	77
S-4.7	Four Diode Pulsed Impatt Hybrid Combiner at Ka-Band <i>Dilip Kumar, R.P. Dixit, V. Nautiyal and Deepak Singh</i>	82
S-4.8	Theory and Design of Programmable Microwave Synthesized Signal Generator <i>S.K. Sen, P.K. Gupta and K.S. Patel</i>	86
S-4.9	An Efficient Technique of Second Harmonic Generation <i>B.N. Biswas, P. Pal and D. Mondal</i>	90

SESSION S-5 MONOLITHIC CIRCUITS

Chairperson: A.K. Sreedhar, Solid State Physics Laboratory, Delhi, India
Rapporteur: K.D. Nayak, DEAL, Dehradun

S-5.1	Modelling of General Microstrip Gap Discontinuities on Layered Medium for Hybrid and Monolithic Microwave and Millimeter Wave Circuits <i>Animesh Biswas and Vijai K. Tripathi</i>	94
S-5.2	A Predistorter Linearizer Suitable for MMIC Implementation <i>Surinder Kumar</i>	98
S-5.3	Multiconductor and Multilayer Transmission Line Structures with Trapezoidal Conductor Cross Sections for MMIC's <i>Ravindranath T. Kollipara and Vijai K. Tripathi</i>	105

S-5.4	GaAs Monolithic Microwave Switches <i>L.G. Gassanov, K.S. Sunduchkov, A.V. Tumenok and E.A. Melnik</i>	109
S-5.5	Single and Dual-Gate FET Monolithic Switches for Microwave Switch Matrix Applications <i>Ramesh K. Gupta</i>	111
S-5.6	Design and Development of SPST Switches at Ka-Band <i>K.P. Chandra Mohan, Ashok Mittal and S.K. Koul</i>	115

SESSION S-6 SOLID STATE DEVICES

Chairperson: Jun-Ichi Nishizawa, Semiconductor Research
Institute, Sendai, Japan

Rapporteur: A.S. Bains, DEAL, Dehradun

S-6.1	THz Semiconductor Devices <i>Jun-Ichi Nishizawa</i>	119
S-6.2	Modelling of Si Pulsed Double Drift IMPATT Diode at W-Band <i>S.R. Shukla and M.N. Sen</i>	120
S-6.3	Temperature Distribution in Millimetre-Wave IMPATT Diodes CW Case <i>J. Akhtar and S. Ahmad</i>	129
S-6.4	Effect of Avalanche Expansion in Silicon DDRs for Operation in F, D and G Bands <i>S.P. Pati, G.N. Dash, J.P. Banerjee and S.K. Roy</i>	131
S-6.5	A Study on the Role of Reverse Saturation Current on the High Frequency Performance of Millimeter Wave Double Drift Silicon IMPATT Diode <i>N. Mazumdar and S.K. Roy</i>	135
S-6.6	Studies of Low-High-Low and High-Low IMPATTs Based on GaAs and InP for MM Wave Frequencies <i>J.P. Banerjee and S.K. Roy</i>	138
S-6.7	An Analytical Model for I-V Characteristics of MISFETs Incorporating Deep Level Trap Effects <i>M.B. Dutt, Meena Sharma and B.L. Sharma</i>	139
S-6.8	Extraction of Intrinsic Parameters of a GaAs MESFET <i>Sushil Kumar, G.P. Sharma and Ishwar Chandra</i>	143

SESSION S-7 RADAR SYSTEM/MMW SYSTEM

Chairperson: R.P. Shenoy, Indian Institute of Science, Bangalore, India

Rapporteur: S. Haldar, DEAL, Dehradun

S-7.1	Implementation of Wide Band Millimeter Wave Systems <i>Chandra Gupta</i>	147
S-7.2	Broadband Direction Finding and ESM System 18 GHz to 110 GHz and 0.1 GHz to 18 GHz <i>Frank Liu, Weimin Sun, Mike Chen Charles Chandler, Karen Liu, Shanley Min, Albert Chen and Sunny Chien</i>	155
S-7.3	Design of Waveform Agile Radar Systems <i>Y.S.N. Murty and A. Bhagavathi Rao</i>	157
S-7.4	An 8 Millimeter-Wave Transmitter-Receiver System for Pulsed Measurements <i>A.C. Saxena and S.K. Iyyengar</i>	161

S-7.5	Dynamic Testing of Radio Proximity Fuze for a Missile System <i>C.L. Patel, E. Malliah, C.G. Balaji and K. Rama Sharma</i>	165
S-7.6	Polarimetric Radar Cross-Section Measurements at X-Band <i>Y.M.M. Antar and S.R. Mishra</i>	172
S-7.7	The Study of Radar Clutter at Millimetric Wave <i>C. Govindaswamy, M.S. Virk and D.P. Roy</i>	176
S-7.8	Design of 35 GHz Multichannel Video Transmission System <i>V.B. Mathur, N.S. Chhabra, Gyanesh, V.S. Negi, Sheo Prasad and S.S. Bist</i>	183

SESSION S-8 PLANAR TRANSMISSION LINES

Chairperson: Bharathi Bhat, Indian Institute of Technology, New Delhi, India
Rapporteur: Girja Shanker, DEAL, Dehradun

S-8.1	Properties and Applications of Asymmetric and Multiple coupled Fin Lines <i>Vijai K. Tripathi and Animesh Biswas</i>	188
S-8.2	Series Reactance due to Thin Transverse Slot in the Microstrip Line <i>K. Srinivas Rao and V.M. Pandharipande</i>	192
S-8.3	Spectral Domain Analysis of a Microstrip Line with Two-Layer Substrate <i>Huang Jingxi and Fan Zhibo</i>	198
S-8.4	Analysis of Millimeter Wave Broadside Coupled Cylindrical Suspended Microstrip Lines <i>C. Jagadeswara Reddy</i>	202
S-8.5	Dispersion Analysis of Modified Suspended Coupled Strips for High Directivity Directional Couplers <i>F. Masot, F. Medina and M. Horno</i>	206
S-8.6	Quasi-TEM and Full Wave Approaches for Coplanar Multistrip Lines in Semiconductor and Magnetic Media <i>F. Mesa and M. Horno</i>	210
S-8.7	A Simple and General Method for Analysis of Microwave, Millimeter and Optic Wave Transmission Lines <i>Ming-Quan Bao and Yu-Kun Zhang</i>	214
S-8.8	Shielded Suspended Coupled Dielectric Guide <i>A.K. Tiwari, A.K. Rastogi and S.C. Shrivastava</i>	216

SESSION S-9 MATERIALS/DIELECTRIC RESONATORS

Chairperson: G.B. Morgan, University of Wales, UK
Rapporteur: Deepak Singh, DEAL, Dehradun

S-9.1	Regarding the Scattering of Electromagnetic Waves in a Chiral Medium by a Perfectly Conducting Sphere <i>Akhlesh Lakhtakia</i>	223
S-9.2	The Calculation of Equivalent Circuit Parameters of Partially Dielectric-Filled Rectangular Wave-Guide Junctions <i>Zhang Yu-Sheng and Fu Jun-Mei</i>	227
S-9.3	Measurement of Dielectric Properties using Dielectric-Slab-Loaded Rectangular Guides <i>Feng Enxin Pen Yuhua and Fu Jun-Mei</i>	231

S-9.4	Transverse T Dielectric Waveguide <i>R.P. Singh and A.K. Tiwari</i>	235
S-9.5	Analysis of Dielectric Slabs in Rectangular Waveguides <i>Subrata Gupta and B.N. Das</i>	240
S-9.6	Quality Factor Measurement of a Higher Mode Square Dielectric Resonator Coupled to a Microstrip Line at X-Band <i>Deepak Singh and G.B. Morgan</i>	244
S-9.7	6-GHz DRO Based Phase-Locked Oscillator <i>G.K. Yogeshwar</i>	248
S-9.8	High Temperature Superconductors at Microwave/Millimetric Waves <i>M.S.V. Gopala Rao, B. Lakshminarayana, UMS Murthy and A. Gangadhara Rao</i>	252

SESSION S-10 SATELLITE SYSTEMS

Chairperson: Pramode Kale, Space Application Centre, Ahmedabad, India

Rapporteur: Surendra Pal, DEAL, Dehradun

S-10.1	Satellite Communications Expansion <i>Klaus G. Johannsen</i>	257
S-10.2	Mobile Communications Satellite System for Voice and Data Transmission <i>Klaus G. Johannsen</i>	265
S-10.3	Communications Technology Challenges for NASA's Space Exploration Initiative <i>D. Bell, W. Rafferty, R. Markley, R. Riley and J. Lesh</i>	274
S-10.4	Secure and Reliable Satellite Communications <i>Vijay K. Bhargava and M. Jamil Ahmed</i>	279
S-10.5	Design of S-Band Range and Range-Rate Transponder (SRRT) <i>S. Satyanarayana, J. Girija and R.N. Singh</i>	283
S-10.6	Wide Band Satellite Borne C&S Band Feed for INSAT II <i>Arun Kumar, Vipin Ghai and K.N. Shankara</i>	290

SESSION S-11 TRANSMISSION IN WAVEGUIDES

Chairperson: Banmali Rawat, University of Nevada, Reno, USA

Rapporteur: R.M. Jain, DEAL, Dehradun

S-11.1	Some Characteristics of the Circular Waveguide with Remanent Ferrite Toroid <i>K.P. Ivanov, G.N. Georgiev and M.N. Georgieva</i>	294
S-11.2	A Simplified Variational Formulation of a Vertical Post in a Rectangular Waveguide <i>Amlan Datta and B.N. Das</i>	298
S-11.3	Exact Equivalent Network of a Thick Diaphragm in a Rectangular Waveguide <i>B.N. Das and P.V.D. Somasekhar Rao</i>	302
S-11.4	On the Admittance Characteristics of Narrow Wall Inclined Slot with Moderate Width to Length Ratios <i>P.H. Rao</i>	306
S-11.5	Analysis of Longitudinal Striations on the Broad Face of Rectangular Waveguides <i>S. Gupta and B.N. Das</i>	312
S-11.6	Effect of Energy Storage in the Primary Guide of E-H Plane T-Junction <i>G.S.N. Raju, K.R. Gottumukkala, Ajoy Chakraborty and B.N. Das</i>	316

S-11.7	Radiation from an Open Ended Partially Dielectric Loaded Circular Waveguide Mounted on an Infinite Ground Plane <i>Reena Sharma and Bharathi Bhat</i>	320
--------	--	-----

SESSION S-12 SUB-MILLIMETER WAVES

Chairperson: D.J. Harris, University of Wales College of Cardiff, Wales, U.K.

Rapporteur: VV Rampal, DEAL, Dehradun

S-12.1	Laser Beam Carried Microwave Interferometer for Rapid Pavement Profiling <i>Dwight D. Egbert and M. Sami Fadali</i>	325
S-12.2	Double-Capacity Subcarrier-Multiplexed Lightwave System Using Electrooptic Interferometers <i>Taraprasad Chattopadhyay</i>	329
S-12.3	Submillimeter Wave Generation Through Optical Difference Frequency Mixing <i>R.K. Tyagi and V.V. Rampal</i>	333
S-12.4	Submillimeter Wave Monolithic Distributed Parameter Power Rectifier Design <i>T. Koryu Ishii</i>	337
S-12.5	Equivalent Transmission Line Circuits for Step Index Multimode Optical Fibers <i>T.K. Bandopadhyay and P.K. Mishra</i>	341

SESSION S-13 MICROSTRIP ANTENNAS

Chairperson: K.G. Narayanan, Aeronautical Development Establishment, Bangalore, India

Rapporteur: P.K. Tewari, DEAL, Dehradun

S-13.1	Flying Decibels—Extremely Lightweight Microstrip Antennas <i>Ferenc Völgyi</i>	345
S-13.2	Analysis of Microstrip Antennas with Dielectric Superstrates <i>Shun-Shi Zhong and Ke-Qing Ding</i>	349
S-13.3	High Efficiency Suspended Microstrip Antenna on GaAs <i>A.K. Verma, Zargham Rostamy, Sushil Kumar and G.P. Srivastava</i>	353
S-13.4	Resonant Frequency of Ferrite Based Equilateral Triangular Microstrip Antenna <i>S.S. Pattnaik, R.K. Mishra and N. Das</i>	356
S-13.5	A Study of the Effect of Post Loading on the Resonant Frequency of a Microstrip Patch Radiator <i>Santokh Singh, G.P. Srivastava and G.S. Chilana</i>	360
S-13.6	A Comparative Study of Microstrip Antennas in Plasma Medium <i>S.S. Pattnaik, R.K. Mishra and N. Das</i>	363
S-13.7	An Experimental Study of Triangular Patch Microstrip Antenna in Simulated Plasma Medium <i>P.K.S. Pourush, V.K. Saxena and Raj Kumar Gupta</i>	367
S-13.8	Measured Mutual Coupling between Triangular Microstrip Antennas <i>P.S. Bhatnagar, C. Terret, J.P. Daniai and K. Mohdjoubi</i>	371
S-13.9	A Simple Approach to Calculate Resonant Frequency of Hexagonal Microstrip Patch Antenna <i>Ranjit Singh, Asok De, P.S. Negi and R.S. Yadava</i>	374

S-13.10	Frequency Scanning Microstrip Array Antenna <i>Rajendra P. Sharma, Mitra Torabipour and Babau R. Vishvakarma</i>	378
S-13.11	Stripline Components for Airborne IFF Antenna System <i>K.M. Balakrishnan, S. Christopher and K.U. Limaye</i>	383
S-13.12	Ku-Band Large Aperture Microstrip Antennas for Satellite Applications <i>Alakananda Paul</i>	389
S-13.13	Planar Antenna Array for Airborne Radiometer Applications <i>F. Memeyi and F. Völgyi</i>	393
S-13.14	Fresnel Ring Antenna Opens a New Window to Microwaves <i>Prämód Kale and S.B. Sharma</i>	397

SESSION-14 PASSIVE COMPONENTS

Chairperson: W.S. Khokhle, Central Electronic Engineering Research Institute, Pilani, India
Rapporteur: K. Shivkumar, DEAL, Dehradun

S-14.1	Simplified Design of Interdigital Microstrip Bandpass Filter <i>Peter F. Mastin and Banmali S. Rawat</i>	407
S-14.2	The Design of Microstrip Hairpin-Line Band Pass Filters for D Band <i>D.N. Kedia and G.B. Morgan</i>	411
S-14.3	Fin Line, Band-pass Filters at Ka-Band <i>R.K. Mongia</i>	415
S-14.4	Band Stop Filters at Ka Band Using Dielectric Gratings <i>R.K. Mongia</i>	420
S-14.5	Design and Development of Finline Directional Couplers at 35 GHz <i>Reena Sharma, Naresh Chander and Bharathi Bhat</i>	424
S-14.6	Ferrite Phase Shifters with Variable Polarization <i>C.R. Boyd, Jr.</i>	429
S-14.7	Twin Toroid Ferrite Phase Shifter Characteristics <i>R. Chaitanya Babu, G.R. Rewankar and S.K. Koul</i>	433
S-14.8	A Wideband K-Band Faraday Rotation Isolator <i>I.M.H. Williamson</i>	438
S-14.9	Analysis of Couplers with Multi-Slot in the Common Broad Wall of Rectangular Waveguides <i>Shen Zhongxiang, Lou Xiaoming, Li Sifan and Hua Rongxi</i>	442
S-14.10	Coupling Coefficient Computation for the Suspended Substrate, Microstrip Interdigital and Hairpin Line Resonators <i>Surinder Kumar and Yongyu Liang</i>	446
S-14.11	A Symmetric Quintoplexer using Planar Microstrip Coupled Combines <i>Saiful Islam and J.E. Carroll</i>	453

SESSION S-15 COMPUTER AIDED DESIGN

Chairperson: K.C. Gupta, University of Colorado, USA
Rapporteur: Ashok Sen, DEAL, Dehradun

S-15.1	Faster Computation of Z-Matrices for Circular Segments in Planar Microstrip Circuits and Antennas <i>Abdelaziz Benalla and K.C. Gupta</i>	458
--------	--	-----

S-15.2	Mathematics and Software for Microwave Circuits Design <i>B.N. Shelkovnikov, G.A. Golovko, G.V. Serdjuk, V.L. Lomaka and A.A. Mikrukov</i>	462
S-15.3	A CAD/CAM of an Optimum and Wideband Triplate Six-Port Junction <i>Fadhel M. Ghannouchi, Renato G. Bosisio and Sining Wang</i>	466
S-15.4	Computer-Aided Design of Waveguide E-Plane Multiplexers <i>Jia-Sheng Hong and Jun-Ming Shi</i>	471
S-15.5	Computer-Aided Design of Millimeter-Wave Large Gap Bilateral Fin-Line Filters <i>S. Raghu Kumar, K.R. Ramesh Kumar and S.K. Koul</i>	475

SESSION S-16 SLOT ANTENNAS

Chairperson: G.S. Sanyal, STEP, Indian Institute of Technology, Kharagpur, India

Rapporteur: Mahakar Singh, DEAL, Dehradun

S-16.1	Radiation Characteristic Calculation of Tapered Slot Antennas <i>Fan Zhibo and Huang Jingxi</i>	479
S-16.2	Spatial Power Combining by Slotted Waveguide Antennas <i>B.V.R. Reddy, M.P. Kale, B. Sinha and S. Sarkar</i>	483
S-16.3	Longitudinal Slot Radiators : Effect of Slot Offset <i>S. Gupta, A. Chakraborty and B.N. Das</i>	487
S-16.4	Design and Fabrication of a Long Slotted Waveguide Antenna with Flared Horn for High Resolution Radar <i>C.J. Reddy, R. Roy and B.K. Sarkar</i>	491
S-16.5	High Performance Wideband Corrugated Horn for Satcom Earth Station Antenna <i>Raghubir Singh and A.H. Patel</i>	495
S-16.6	EHF Horn Radiators of Curved Configuration <i>I.I. Shumljansky</i>	500

SESSION S-17 COMMUNICATION SYSTEMS

Chairperson: V.K. Bhargava, University of Victoria, Canada

Rapporteur: Harbhajan Singh, DEAL, Dehradun

S-17.1	Effect of Radio Noise in 1-2 GHz Band Emitted from Road Traffic on the Functioning of Microcell Type Mobile Radio System <i>Ashok Chandra</i>	501
S-17.2	35 GHz Communication System for Urban Areas <i>V.B. Mathur, Gyanesh, V.S. Negi, N.S. Chhabra, Hari Singh and R.B. Singh</i>	506
S-17.3	Effect of Path Inclination of Multipath Fading in Microwave LOS Links <i>M.V.S.N. Prasad, S.K. Sarkar, H.N. Dutta and B.M. Reddy</i>	510
S-17.4	New Implementation Scheme for Remote Area Communication Using Small Satellite Terminals <i>C.K. Chatterjee and V.P. Singh</i>	514
S-17.5	Performance of Direct Sequence Spread Spectrum System Operating over Fading Channel <i>Y.S.N. Murty, B.V. Rao and Rameshwar Rao</i>	519
S-17.6	EMI Potential of the Rising Layer in Microwave Communication Links <i>H.N. Dutta, M.V.S.N. Prasad and S.K. Sarkar</i>	523

SESSION S-18 MEASUREMENT TECHNIQUES

Chairperson: J.C. Wiltse, Georgia Institute of Technology, U.S.A.

Rapporteur: R.S. Misra, DEAL, Dehradun

S-18.1	Measurement of the Complex Permittivity of Materials at Microwave Frequencies using an <i>In Situ</i> Electric Probe <i>Michael Noffke, Dennis Stank and Devendra Misra</i>	527
S-18.2	P.C. Based System for Characterisation of Antennas in the Microwave Region <i>R. Sen, D.V. Gadre, K.K. Gupta and G.P. Srivastava</i>	531
S-18.3	Measurement of RF Characteristics of a Helix Slow-Wave Structure <i>S. Kapoor, V. Srivastava and S.N. Joshi</i>	535
S-18.4	A Segmented SCS Grating for Elimination of Specular Reflections <i>L. Wilson Gomez, V. Ajaikumar, K.A. Jose, P. Mohanan and K.G. Nair</i>	539
S-18.5	Dielectric and Permiability measurements at mm-Wave Frequencies Using an Exact Solution Technique <i>N.S. Hanumantha Rao</i>	543
S-18.6	Doppler Frequency Tracking by Pisarenko Harmonic Decomposition <i>S. Sadasivan, M. Gurubasavaraj and S. Ravi Sekar</i>	548
S-18.7	EMI Results from Pulse Excited Antennas <i>Archana Sharma, D.C. Pande and P.H. Ron</i>	552

SESSION S-19 MIXERS/AMPLIFIERS

Chairperson: K. Swaminathan, Director, Defence Electronics

Research Laboratory, Hyderabad, India

Rapporteur: R.K. Agarwal, DEAL, Dehradun

S-19.1	Design of Monolithic Microwave and Millimeter Wave Low-Noise Amplifiers <i>Madhu S. Gupta</i>	557
S-19.2	Development of Wideband GaAs FET Low Noise Amplifier at C-Band for Space Applications <i>R.V. Singh and S.C. Agrawal</i>	561
S-19.3	Design and Development of a Crossbar Mixer at Ka-Band <i>Thomas Varghese and S.K. Koul</i>	566
S-19.4	MM Wave Balanced Mixer in Planar Configuration for Ka Band Down Converter <i>Girija Shankar, R. Thiru Navukkarasu and Deepak Singh</i>	570
S-19.5	Balanced Mixer in Planar Circuit at W Band <i>Virpal Singh, Girija Shankar and K.D. Nayak</i>	574
S-19.6	Millimetric Frequency Balanced Resistive Doublers Design Using Spectral Balance Algorithms <i>H. Abdalla Jr., P. Legaud and G. Michaud</i>	579
S-19.7	High Power MM-Wave Frequency Multipliers <i>I.M.H. Williamson</i>	582
S-19.8	A Study of the Effect of Resonant-Cap Geometry on the Performance Characteristics of Reflection-Type IMPATT Amplifiers <i>S. Kar and S.K. Roy</i>	586

SESSION S-20 PROPAGATION-I

Chairperson: A.K. Sen, Institute of Radio Physics and Electronics, University of Calcutta, India
Rapporteur: R.K. Tewari, DEAL, Dehradun

S-20.1	Effect of Rain on Millimeter Wave Amplitude Scintillation Spectra <i>A.D. Sarma, R.J. Hill and R.J. Latatis</i>	587
S-20.2	An Estimate of Clear Air Attenuation at the Windows and Absorption Bands of Millimeter Wave from Radiosonde Measurements <i>P.K. Karmakar, A. Mitra, R. Bera and A.K. Sen</i>	591
S-20.3	Rain Attenuation at Millimeter Wavelength for the Earth-Space Path as Obtained from a Simple Model and Radiometric Observation <i>A. Maitra, A.K. Devgupta, R. Bera, S.K. Datta, M.K. Dasgupta, A.K. Sen</i>	594
S-20.4	Rain Attenuation Measurements at 94 GHz <i>K. Sivakumar, P.L. Sehgal and R.K. Tewari</i>	598
S-20.5	Rain Rate Characterization over New Delhi for Microwave and Millimeter Wave Applications <i>S.K. Sarkar, M.V.S.N. Prasad, H.N. Dutta and B.M. Reddy</i>	602
S-20.6	Effect of Sand Storms on Millimeter Electromagnetic Wave Propagation <i>H.T. Al Hafid, S.C. Gupta, N.K. Agarwal and A. Srinivasan</i>	606
S-20.7	MMW Propagation in Sand and Dust Storm <i>Babau R. Vishvakarma and C.S. Rai</i>	611

SESSION S-21 ANALYTICAL & NUMERICAL TECHNIQUES-I

Chairperson: B.N. Das, Indian Institute of Technology, Kharagpur, India
Rapporteur: K.K. Jha, DEAL, Dehradun

S-21.1	The Modelling of Third Order Intermodulation Distortion in RF Power Transistors for Narrow Band Communication Channels <i>B.P. Johnson, Junsheng Wang and Fuchang Li</i>	616
S-21.2	Matrix Analysis of Coupled Cavity Structures <i>O. Shanker</i>	620
S-21.3	Synthesis of Parallel Flow Pierce Electron Gun <i>T. Tewari and R.K. Jha</i>	624
S-21.4	A Partial Adaptive Array Algorithm-Usefulness, Effectiveness and Limitations <i>S. Ravi and G.S. Mani</i>	629
S-21.5	Mueller Matrix and Its Resolution for the Asymmetric Scattering Matrix Case <i>Yang Jian and Lin Shi-Ming</i>	633
S-21.6	Multiple Diffraction of Plane Waves by a Metallic Strip Located at the Interface of Two Dielectric Media <i>Alinur Büyükkaksoy and Gökhan Uzgören</i>	637
S-21.7	An Efficient Solution to Sequential GPS Navigation Problem <i>N.L.M. Murukutla and G. Raghava Rao</i>	641
S-21.8	Optimal Orientation Angle and a Kind of the Power Ratio for the Monostatic Case-1 <i>Yang Jian and Su Chao-Wei</i>	646