IEEE

Electromagnetic Compatibility Society

Newsletter

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1985 IEEE-EMC REGICON IN LOS ANGELES

The Los Angeles Chapter in cooperation with the San Diego and Orange County Chapters of the IEEE-EMC Society will be hosting a Regional Conference. The conference will be a review of the state-of-the-art in EMC in Commercial and Military Electronics and will be held at the Los Angeles Hilton, 5711 West Century Blvd., Los Angeles, on Wednesday, 23 January 1985.

Two comprehensive seminars will be held:

— Commercial and Consumer Products EMC
— Military EMC

Each session will have nationally recognized speakers.

Presentations will be made by invited speakers. Handouts will be available. Topics to be covered are:

— Designing to Meet FCC & VDE Requirements
— The FCC Certification/Verification Process
— The VDE Certification Process
— Shielding for EMC/EMP
— Immunity Design & Requirements
— Cabling Design

An exhibition of RFI, EMC, EMP, ESD and immunity equipment facilities and suppression services will be held to coincide with the seminar. Potential exhibitors should reserve their space early, since space is limited in the Exhibition Hall. For general information contact Ms. Terry Cantine, Eaton Corporation, 5340 Alla Road, Los Angeles, CA 90066. Phone: (213) 822-3061.

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EDUCATION COMMITTEE NEWS

There are still a few copies available of the *Experiments and Demonstrations in EMC* booklet mentioned in the last newsletter. If you would like a copy please contact me.

The following is a partial listing of some of the short courses and seminars on EMC related topics being offered this fall and winter.

R & B Enterprises will offer a course on *Understanding & Applying MIL-STD-461B* in Washington DC on November 19. *Grounding, Bonding and Shielding* will be presented in Washington DC on Nov. 13-14. A one-day seminar on *Printed Circuit Boards* will be given Nov. 8 in Philadelphia. *EMI Susceptibility Guidelines for Computing Equipment* will be offered in Philadelphia on November 7. For more information contact R&B Enterprises at 215-825-1965.

Don White Consultants will be offering *Grounding and Shielding* on December 4-7 in New York, and *EMC Design and Measurement for Control of EMI* on December 3-7 in Dallas. *EMC Design of PCB's and Electronic Modules* is scheduled for presentation in Sunnyvale on November 27-29, and *Interference Control in Computers and Microprocessor-Based Equipment* will be presented in San Diego on December 11-14. For more information contact Don White Consultants at 703-347-0030.

EMXX and CKC will present a course on *Electrostatic Discharge Control* in Sunnyvale on November 16. For more information contact them at 703-451-4619.

If you have any information of an educational nature that you would like to see included in this newsletter, please contact me. To be included in the newsletter information must reach me by March 1 for the spring issue, June 1 for the summer issue, September 1 for the fall issue, and December 1 for the winter issue.

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ANS C63 COMMITTEE NEWS

At its April 27 meeting in San Antonio, TX, the C63 Committee of the American National Standards Committee officially changed its name to the C63 Committee on Electromagnetic Compatibility. The committee also revised its goals to be the

> Development of definitions and methods of measurements of electromagnetic noise and signal strengths (radiated and conducted), determination of levels of signal strength and levels of unwanted sources, limiting ratio of noise and/or unwanted sources, to signal and development of methods of control of, and guidelines for, influence, coupling and immunity.

Current efforts to revise the C63 standards include preparing an amendment to C63.4-1981 on measurement methods to include open area test sites. Other work currently underway is the drafting of a report on medical device EMC. The report will address emissions of medical diathermy and ultrasound therapy equipment and the immunity of pacemakers, EEGs and EMGs. However, a study to develop susceptibility limits for medical devices has been discontinued due to the establishment of higher priorities.

NATIONAL ELECTRIC SAFETY CODE 1984

The National Electrical Safety Code ANSI-C2 is a basic reference source on power and community utilities. The publication is designed for engineers and technicians concerned with overhead and underground lines and supply stations. Information is provided on safe installation and maintenance of electric supply stations, supply and communication lines. The publication is divided into sections, all of which have been recently and extensively revised.

The publication is available from the IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854 for $14.75, plus $2 shipping charge; IEEE members $13.25.

1985 INTERNATIONAL SYMPOSIUM ON EMC

The 1985 IEEE International Symposium on EMC will be held at the Hilton at Colonial, Wakefield, Massachusetts from August 20-22, 1985. The theme "EMC, A UNIVERSAL GOAL", was chosen to stress the need for engineers of all disciplines to be concerned about EMC. The IEEE EMC-Society is seeking original, unpublished papers on all aspects of EMC. Suggested topics include but are not limited to the following categories:

TECHNICAL AREAS

- EMP
- ESD
- Filters
- Instrumentation & Theory
- Lightning
- Magnetics
- Materials
- Microwave Theory & Techniques
- Non-Sinusoidal
- Radiation Hazards
- Regulations
- Signal Processing
- Spectrum Management
- Standards
- Susceptibility
- Vulnerability

APPLICATION AREAS

- Aerospace & Electronic Systems
- Electrical Insulation
- Electron Devices
- Antennas & Propagation
- Biomedical Engineering
- Communications
- Components, Hybrids & Manufacturing
- Computer Aided Design of Integrated Circuits & Systems
- Computers
- Consumer Electronics
- Geoscience & Remote Sensing
- Isolation & Shielding
- Medical Imaging
- Military Applications
- Quantum Electronics
- Solid State Circuits
- Vehicular Technology

Abstracts and summaries (three copies) are due by November 30, 1984. Notifications of acceptance will be issued by February 1, 1985. Camera-ready copy must be submitted by April 5, 1985.

Abstracts and summaries should be sent directly to: Dr. Donald D. Weiner, Department of Electrical and Computer Engineering, 111 Link Hall, Syracuse, NY 13210.

For other information, contact: Dr. Chester L. Smith, General Chairman, P.O. Box 536, Bedford, MA 01730. Tel: (617) 271-7086.

CHAPTER CHATTER

by Charles F.W. Anderson

Not unexpectedly, the Summer doldrums took their usual toll — Chapter reports always seem to reach the ebb at this time of the year.

Central New England

John Clarke reports that the Chapter will have their first meeting on October 25. The subject will be Electrostatic Discharge Testing, with Glen Dash of Dash, Straus & Goodhue as speaker. John and his wife had a fine five-week vacation in Denmark, England and Ireland. He says he's having a little trouble getting back to his normal pace — no wonder!

Chicago

The Chapter's first meeting of the '84-'85 season was on September 20. Mr. V. Necker (Rohde & Schwartz-Stuttgart) presented two talks, one on European EMC Standards and VDE Test Procedures, and the other on Comparison of Receivers & Spectrum Analyzers. A demonstration and "hands-on" operation of Polarad receivers and spectrum analyzers followed.

Israel

More Good News! Just received a copy of a letter from Bob Hofmann to Mr. Rafi Rubenstein in Tel Aviv (affiliation not mentioned) which indicates that we now have a *third* non-USA EMC Chapter. We'll be waiting to hear from the Society's newest affiliate. Good Luck (Mazel Tofs!)

Littleton

Dave Lubar reports that the July quarterly meeting was addressed by Mike Hart (Electromechanics, Austin) who discussed calibration of antennas based on the new ANSI Standard for sites and antennas. EMCO has made comparison measurements using several methods and Mike Hart's presentation reported some of the preliminary results. A lively and interesting discussion on antenna factor determination followed. A videotape on EMC design was also shown.

The September meeting was held at the Englewood sales office of Tektronix. There were two speakers: Dennis Carlton (Denver FCC Engineer-in-Charge) whose topic was "Interference Resolution & EMC"; and,Chuck Higler (Tektronix), who spoke on Spectrum Analyzers.

Los Angeles

On September 20, Steve Jensen (Steve Jensen Consultants, Inc.) spoke on "EMC Problems Related to Broadcast Services." He recounted three interesting actual experiences from his consultant activities which involved interference effects to or from broadcast transmitters.

New Jersey

At the September 18th Chapter Meeting, Mr. V. Necker (Rohde & Schwartz-Stuttgart) presented two talks, one on European EMC Standards and VDE Test Procedures, and one on Comparison of Receivers and Spectrum Analyzers.

Tokyo

Six more fine papers were presented at the June 27 meeting of our Far-East Chapter. Topics included automated measurements of EM fields, with patterns obtained in a building; comparisons of theoretical and experimental determinations of VHF/UHF waves over the range of 3 to 100 meters; and, use of microwave techniques to measure melting rates of snowpacks.

Elsewhere in this issue you'll find a list of the Chapter Chairpeople as Bob Hofmann had them at presstime. Please send him corrections/updates — and please send me activity reports!

SHORT PAPERS, ARTICLES, AND APPLICATION NOTES

by Edwin L. Bronaugh

Response to our new department is very gratifying, with two interesting papers to start out the first issue. These papers, "Hazards to Flammable Atmospheres and to Electroexplosive Devices Due to R.F. Radiation: Recent British Experience and the New Draft British Standards," by Dr. Excell, and, "Digital Models For Use in EMC ISPICE Analysis," by Mr. Gabrielson and Mr. Carlson are good examples of what we wanted for this department. I think you will find these papers interesting and useful. Please keep them coming.

Hazards to Flammable Atmospheres and to Electroexplosive Devices Due to R.F. Radiation: Recent British Experience and the New Draft British Standards

Peter S. Excell (Member, IEEE and EMC-S)

Abstract — The potentially harmful effects of currents induced by RF radiation in electrical wiring associated with electroexplosive devices, and in industrial structures associated with flammable gas/vapour mixtures, is discussed. The work of the British Standards Institution covering such hazards is reviewed. A large natural gas handling plant is being constructed at the same time at a nearby powerful LF/MF/HF radio transmitter facility. This potentially hazardous situation is discussed in light of the new information produced and two new draft standards that have been written as a result. [Ed]

Close to powerful RF sources it is possible for substantial currents to be induced in metallic structures (acting as unintended receiving antennas or URAs). The firing cable for an electroexplosive device (EED, i.e., electric detonator) could constitute such a structure, and the RF current consequently flowing in the EED could cause an undesired explosion. This hazard has long been recognized in both military and civilian fields and safety guides such as ANSI C95.4 have been published in an attempt to eliminate it.

Such currents may also be induced in the pipework of plants handling fuels and other flammable substances. If the current is sufficiently large, sparks may be generated at make-and-break contacts in the structure which could cause ignition of flammable mixtures. It is, of course, intuitively clear that this is a very remote possibility but nonetheless a desire that it be quantified has been expressed by operators of high-risk installations (notably in the oil and chemical industries and military organizations).

British Standard 4992, covering both of these hazards, was published in 1974. The theoretical basis of this document was not thoroughly developed, and a contract to investigate possible refinements (concentrating on the ignition hazard) was left to the author's research group. This group produced a new draft of the standard in 1976, outlined in [1]. While this was in the process of scrutinization by the competent committee of the British Standards Institution (BSI), a situation arose which put it to an onerous test. This was the discovery that, on the north-east coast of Scotland, a plant (at St. Fergus) handling one-third of Britain's natural gas supply was being erected simultaneously with a large LF/MF/HF Naval radio transmitter (at Crimond) only some 4km distant.

An initial study, based on the draft revision of the standard, suggested that a potential hazard existed at the gas plant. However, it also suggested that many of the simplifying assumptions on which the draft was based would be unsound when such a complex transmitter was involved.

A more detailed theoretical study was then undertaken, under the auspices of the Government's Health & Safety Executive (HSE). This used the general philosophy introduced in the draft revision but it critically examined, and in many cases modified, assumptions made and parameters used in the revision [2]. The conclusion of this study was that there might still be a potential hazard at the gas plant under certain modes of operation of the transmitter, if the lowest published values of the RF power required for spark ignition of gas/air mixtures were used.

In view of the residual uncertainties and the importance of

the installations involved, a number of research projects were funded [3] and a new HSE inquiry convened. This commissioned a large program of on-site tests of the RF power available from gas plant structures (measured while the transmitter was radiating an agreed schedule of test transmissions). These measurements were scaled to correspond to the worst-case operating mode of the transmitter and then compared with bench measurements of RF ignition power. The conclusion of this inquiry [4] was that ignition hazards were 'unlikely' although there was a possibility of hazards with large cranes and certain proposed structures which had not yet been constructed.

The St. Fergus inquiry produced a large amount of new information on RF ignition hazards below 30MHz. A smaller parallel inquiry into the safety of another gas plant [5] generated new information on ignition hazards at higher frequencies, since the proposed plant would be subject to irradiation by ship-borne transmitters, in particular Naval radars.

The amount of information gained in the course of these studies was such that a new draft revision of the standard was required. It has taken some time for this to come to fruition since further research work was required, in particular to bring the part relating to EEDs up to the level of that dealing with ignition. The 'Drafts for Public Comment' of these two parts have recently been published [6, 7]: it is now intended that these will, if approved, be issued simultaneously as separate standards.

Both drafts are based on graphs of the maximum safe field strength (as a function of frequency) for structures or firing circuits of given sizes in combination with common gas mixtures or standard EEDs. The user is instructed to calculate the incident field strength using standard (CCIR) methods, or to measure it directly. The effect of multiple incident fields at different frequencies (one of the most intractable problems that occupied the St. Fergus/Crimond investigations) is dealt with, for the ignition hazard, by assuming that the structure has a worst-case minimum Q of 5 and then considering it to be tuned to each frequency in turn; the effective aggregate power is found in each case and the largest value found is compared with given values for the RF ignition power. For the EED hazard a simpler procedure is used involving only one summation on the assumption that the firing circuit will not have significant selectivity.

If, as seems likely, these drafts are approved, they will become full standards in late 1984 or early 1985. It should be noted that a committee of the German Electrotechnical Commission (DKE) is also working on an ignition hazard draft [8] which will ultimately become a VDE/DIN standard.

References

[1] P.S. Excell, G.H. Butcher, and D.P. Howson, "A Generalised Basis for the Determination of the Hazard of Ignition of Flammable Gas Mixtures by Radiofrequency Radiation," *Proc. Euro. EMC Symp.*, Montreux 1977, pp59-64.

[2] "Report of a Working Group on Radio Ignition Hazards at St. Fergus, Scotland," *Health & Safety Exec.*, 1978 (ISBN 0-7176-0010-6)

[3] *The Radio & Electronic Engineer: Special Issue on Radio Frequency Ignition Hazards,* Vol. 51, No. 4, April 1981.

[4] "Report of the Steering Committee on Radio Frequency Ignition Hazards at St. Fergus, Scotland," *Health & Safety Exec.*, 1979 (ISBN 0-7176-0015-7)

[5] "Assessment of the Hazard from Radio-Frequency Ignition at the Shell and Esso sites at Braefoot Bay and Moss Morran, Fife," *Health & Safety Exec.*, 1978 (ISBN 0-7176-0011-4)

[6] *Draft British Standard Guide to Prevention of Inadvertent Ignition of Explosive Atmospheres by Radio-Frequency Radiation,* BSI Doc. No. 83/23662DC, 1983.

[7] *Draft British Standard Guide to Prevention of Inadvertent Initiation of Electro-Explosive Devices by Radio-Frequency Radiation,* BSI Doc. No. 84/25247DC, 1984.

[8] *Gefaehrdung durch elektromagnetische Felder; Explosionsschutz,* DIN 57848/VDE 0848, Part 3, 1983 (Draft).

[6] and [7] are available from: Sales Administration (Drafts), BSI, Linford Wood, Milton Keynes, MK14 6LE, UK; Prices are £10 (ref.6) and £5 (ref.7).

Peter S. Excell is a lecturer in the Schools of Electrical and Electronic Engineering at the University of Bradford, UK. He has been involved in the development of RF ignition hazard standards since 1974. He serves as the University's representative on BSI committee EEL/23 and served on the HSE inquiries into RF ignition hazards at the St. Fergus natural gas plant. He obtained his PhD on this topic in 1980.

Digital Models For Use In EMC ISPICE Analysis

B. C. Gabrielson and A. B. Carlson

Abstract — When performing EMC noise analysis on circuits containing both digital IC's and discrete or analog devices, considerable computer time is often required to simulate even simple designs. ISPICE is the preferred program used to estimate noise and EMISM values for linear circuits, but becomes extremely inefficient when used to model digital devices. Now there is a ray of hope. It has been determined that it is both easy and very accurate from the viewpoint of susceptibility to model only the last gate in the digital chain in ISPICE. Separate analysis programs can then be used to simulate the digital and linear circuitry for noise susceptibility. Two models have been developed for ISPICE programs which will save significant computer time when evaluating circuits with digital-to-analog interfaces. The models exhibit nearly the same EMC characteristics as actual digital devices. This paper explains their implementation and use.

Introduction

In recent years, mathematical simulation and analysis of electronic circuitry using computers have gained acceptance as viable alternatives to time-consuming standard development practices. As EMC continues to move towards a mainstream design and analysis function, the EMC engineer has found it increasingly important to sharpen his skills in the use of computer modeling and analysis. Noise estimates and Electromagnetic Interference Safety Margins (EMISM) at the circuit level have become extremely difficult to predict as circuits increase in complexity and environmental requirements. EMISM is defined as the margin in dB between the turn on threshold at the input of a device and the noise potential at the same location. The evolution of interactive computer programs such as ISPICE provides the EMC design engineer with a flexible and responsive technique for the investigation of circuit noise performance. However, there are limitations.

From an EMC viewpoint, a large number of problems occur in circuits containing both linear and digital elements. ISPICE effectively evaluates the linear circuitry, and many programs are available which will predict the response of digital circuitry due to external or internal stimulation. The problem is what to do if both circuit-types exist in the same circuit. If ISPICE is used to model even a few simple digital gates, a tremendous amount of computer time and cost will be the result. In addition, the number of nodes required may exceed the number allowed for the program (55) resulting in an aborted run.

The "Last Gate" Method

In studying the modeling problem, it can be determined for the vast majority of cases that only the last digital gate in the signal chain is required for an effective EMISM estimate. Using ISPICE, a good estimate is to assume the EMISM of the last gate is about the same as all other gates in the signal chain, and then only include these last interface gates in the computer susceptibility analysis.

The "Last Gate" method requires the inclusion of only two additional model types in the ISPICE analysis program. ISPICE analysis employs dynamic memory allocation methods, adding regions as required and releasing unused ones as processing requirements vary; therefore, the size of the circuit which ISPICE can simulate is dependent only on the core size of the computer facility used. If a large integrated circuit were to be used, it's possible to exceed the available computer memory before the first element on circuit card is evaluated.

To circumvent this problem, consider that for an EMISM analysis the worst case noise condition is preferred. Regardless of the IC type, the maximum noise generated or the worst case sensitivity will exist during a transition; therefore, a reasonable number of gate transitions can be modeled (assuming a digital/analog card) using either an inverter or a NAND gate. In addition, using a source resistance to ground at the input to a gate will provide sufficient information for calculating the EMISM of an IC. The one remaining problem is developing an adequate, but simple model for the ISPICE program.

The "Last Gate" Models

The two models developed for "Last Gate" ISPICE analysis simulate a low-power Schottky (LS) inverter and NAND gate. Each model exhibits EMI characteristics very similar to those of an actual gate. The simple discrete subcircuits can be used in systems operating below 25 MHz, and are both sensitive to generated noise and generate noise themselves during transitions. To use these models with ISPICE simulations, they must first be incorporated into your ISPICE library.

The two models are each of filetype SUBCKT. Being so, the description of the devices found in each subcircuit need be entered in only one location: The SUBCKT model files. The models can then be referenced as needed in any ISPICE circuit simulation. Listings of the Inverter and NAND gate subcircuits are shown in Figure 1.

To reference the Inverter model in a CKT file or in another SUBCKT file, use the following format in the referencing file:

```
Xname    N1    N2    N3    N4    INVRT
```

Where:

Xname is the keyletter for "Subcircuit" coupled with a unique name designation;

N1 - N4 are the nodes of the referencing file listed in the sequence

N1	Ground Node,
N2	Input Node,
N3	Output Node, and
N4	+V Node; and

INVRT is the subcircuit model file.

Reference to the NAND gate model follows the same scheme with the exception of the NODES specification.

Xname N1 N2 N3 N4 N5 NAND

The NODE sequence for this model is:

N1	Ground Node,
N2	Input Node,
N3	Input Node,
N4	Output Node, and
N5	+V Node.

An example of referencing these two models in a CKT file might be:

```
XINV6    0  10  11  12  INVRT
XNAND3   0  21  22  23  24  NANDGATE
```

When using these models, it is necessary to attach the National Semiconductor Library with the command "ATTACH NSLIB" or an equivalent library with similar transistors immediately after signing on to ISPICE.

```
NANDGATE
NODES (0,11,12,7,1)
R1 1 2 40K TOL=.01
D1 2 11 DCL OFF
D2 2 12 DCL OFF
D5 8 3 DCL OFF
D6 7 3 DCL OFF
D7 6 5 DCL OFF
D9 0 2 DZ1 OFF
R2 1 9 8K TOL=.01
R3 1 10 120 TOL=.1
R4 8 7 4K TOL=.01
R5 4 5 1.5K TOL=.01
R6 4 6 3K TOL=.01
Q1 3 2 4 NSL21N
Q2 6 5 0 NSL21N
Q3 7 4 0 NSL21N
Q4 10 9 8 NSL21N
Q5 10 8 7 NSL21N
MODEL DCL D(PB=1.0 IK=10M IS=10N)
MODEL DZ1 D(BV=2.5)
R10 11 0 1ME
R20 12 0 1ME
```

```
HEXINVRT
NODES (0,11,7,1)
VIN 1 0 AC 1
R12 11 0 600
R1 1 2 40K TOL=.01
D1 2 11 DCL OFF
D5 8 3 DCL OFF
D6 7 3 DCL OFF
D7 6 5 DCL OFF
D9 0 2 DZ1 OFF
R2 1 9 8K TOL=.01
R3 1 10 120 TOL=.1
R4 8 7 4K TOL=.01
R5 4 5 1.5K TOL=.01
R6 4 6 3K TOL=.01
Q1 3 2 4 NSL21N
Q2 6 5 0 NSL21N
Q3 7 4 0 NSL21N
Q4 10 9 8 NSL21N
Q5 10 8 7 NSL21N
MODEL DCL D(PB=1.0 IK=10M IS=10N)
MODEL DZ1 D(BV=2.5)
R10 11 0 1ME
```

Figure 1. ISPICE Program Models

Editor's Remarks

SPICE stands for Simulation Program with Integrated Circuit Emphasis and ISPICE is Interactive SPICE. SPICE is an analog circuit simulation program using a lattice network approach. It was developed at the University of California, Berkeley. ISPICE is interactive allowing the user to insert information during run-time. It is proprietary to National CSS, Inc.

Two references for SPICE and ISPICE are:

1. L.M. Nagel and D.O. Pederson, "SPICE (Simulation Program with Integrated Circuit Emphasis),-- *Memorandum No. ERL-M382,* Electronics Research Laboratory, University of California, Berkeley, 12 April 1973, p6.

2. *ISPICE Reference Guide*, National CSS, Inc., Norwalk, Conn., May 1977.

Bruce C. Gabrielson is the TEMPEST and EMC Program Manager for Comsearch Applied Technology, with 14 years of TEMPEST and EMC design, analysis, and test experience. Mr. Gabrielson attended California State University at Long Beach, has BSEE, MSEE degrees, and is working on an MBA. He has authored 11 technical papers and is preparing to publish a book on lightning.

Al B. Carlson is an Engineering Aid at Aerojet Electrosystems in Azura, California. He specializes in computer aided analysis and he evaluated various circuits used on DSP Surveillance Satellites.

BOOK REVIEWS

by Jim Hill, EMXX Corporation.

In this issue we will get back to the serious business of book reviewing. There are two reviews that have come our way. One, prepared by Herman Garlan, is a review of the proceedings of the Seventh International Symposium on EMC recently held in Wroclaw, Poland. This symposium is held biennually on even numbered years. The output is a two-volume set in 17 by 24 cm. format with a total of 1069 pages, part in English and part in the Russian Cyrillic. Through the exchange program between the EMC Society and the Polish EMC group we have copies available for sale here in the USA.

The second book review was borrowed from the IEEE Antenna and Propagation Society Newsletter of August 1984. It is one of the IEEE Press books, a compilation of papers taken from IEEE Transactions, Symposium Records, and various IEEE sources over a period of years. This collection of papers on "Biological Effects of Electromagnetic Radiation" is of current concern now that the old exposure limits are undergoing an adjustment based on a limited research data base. The credentials of the reviewers are impressive and their review comments and additional bibliography are worthwhile.

PROCEEDINGS OF THE SEVENTH INTERNATIONAL WROCLAW SYMPOSIUM ON EMC, JUNE 1984

Organized by Wroclaw Technical Institute, Wroclaw, Poland. Copies available from the EMC Proceedings Editor, Technical University of Wroclaw, Wybrzeze Wyspainskego 27, 50-370 Wroclaw, Poland. In the USA, copies are available from EMXX Corp., 6706 Deland Drive, Springfield, VA. 22152, telephone (703) 451-4619 at a cost of $30.00 for the two volumes.

The papers of the Wroclaw Symposium (EMC 84) are contained in two volumes. A total of 101 are presented: 56 in English, 45 in Russian. A feature of the presentation is the abstract that follows each paper. The abstract is in Russian if the paper is in English and in English if the paper is in Russian. In most cases, the abstract is very short (5-10 lines) although in a few cases it runs to a full page. It is to be regretted that so many papers are in Russian, since many of the abstracts indicate that the subject matter of the paper would be of interest to engineers in the Western World very few of whom can read Russian. To list just a few:

— One paper deals with forecasting reception quality in the mobile radio services.
— One paper deals with the design of cellular mobile radio systems.
— One paper deals with the use of spread spectrum techniques by mobile radio communication systems.
— One paper sets out parameters for digital transmission of TV systems.

Two keynote addresses were presented. Professor Stumpers of Netherlands discussed the work of URSI (International Union of Radio Science) in the EMC field and then spoke briefly about lightning in EMC and in particular about discharges to towers and buildings. Professor Seidler of the Polish Academy of Science presented an interesting paper describing a system for improving compatibility by incorporating subsystems to evaluate the state of the EM environment which he defines as getting current information about other users of the environment. The paper presents the fundamental relationships between the quality of performance of the communication system and the size of the state identification subsystem and cautions that the cost of subsystem rises rapidly with the sophistication thereof.

(Continued. . . .)

The papers are divided into 20 sections (chapters) covering the entire gamut of EMC technology. In addition to covering subjects such as measurement, spectrum management, EM environment, antennas, etc., the Wroclaw Symposium presented subjects seldom highlighted in the EMC Symposia in the Western World. The subject of EMC in wire line communications is treated at some length in sessions sponsored by Study Group V of the CCITT. After a brief review of CCITT studies in this field, subsequent papers discuss the behaviour of voltage limiting components, the suppression of magnetically induced interfering voltages in four-wire and three-wire circuits, etc.

Another unusual section was devoted to EMC and the Radio Amateur Service which included a paper from New Zealand describing the procedures used in that country. Of particular interest were the two appendices: "A Code of Practice for Broadcast and Television Interference" — a pamphlet distributed by the New Zealand radio amateurs; and, "Radio Interference to Audio Devices" — a pamphlet published by the New Zealand Post Office.

It is not possible to discuss or even mention each paper individually and only a few of the English language papers are highlighted below.

Under measurements, a German paper addresses the difficulties being experienced when meaningful EMI tests are to be performed. This is of particular concern when testing equipment that can be operated in differing combinations, such as large computing systems.

An Italian paper describes a system for frequency assignments in broadcast networks using computers.

Some highly specialized studies are presented by Russian and Polish authors (papers in English) on the effect of RF energy on seedlings, the differences of biological effects of simple and combined fields, etc. This chapter also included a paper from Taiwan on the use of RF energy to treat bone fractures. The EMC problems in mobile communications are treated basically in Russian papers, three of which have already been mentioned.

A number of papers are presented dealing with immunity. One paper describes the West German regulations and their method of measuring immunity. A paper in Russian discusses the basic principles of immunity control in domestic frequency equipment in the band 20 Hz to 30 MHz. An Italian paper (in the last section — Late Papers) discusses the generation of EM fields for immunity testing and the associated problems.

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BIOLOGICAL EFFECTS OF ELECTROMAGNETIC RADIATION

Edited by John M. Osepchuk
Published by the IEEE Press
The IEEE Service Center
445 Hoes Lane, Piscataway, NJ 08854
608 pages, Copyright 1983
Member price $47.95

INTRODUCTION

This IEEE Press book is a collection of about 100 papers on the physical, biological, medical, health, and safety-standards aspects of RF/microwave biological effects. It consists of reprints of papers written by engineers, physicists, and medical and biological professionals. There are seven sections, each compiled by an associate editor who has written a short overview, with its own list of references covering significant papers not reprinted in the book. The book was prepared by some members of the IEEE Committee on Man and Radiation (COMAR). All of the associate editors were on the committee. While the title uses the term "electromagnetic radiation," this book only considers the RF portion of the EM spectrum.

A critical point that is made in the foreword of the book is the fact that while the book has a publication date of 1983, almost all materials were incorporated in the text in 1979, so the articles in the book are somewhat dated. In this rapidly-changing field, a delay of five years can seriously affect the relevance of this kind of a book. An attempt was made to solve this problem by breaking the book into sections, and having each section's associate editor incorporate an updated summary/bibliography of the literature on that section's subtopic, emphasizing more recent developments. This was only partially effective, as will be mentioned later.

Section I: QUANTITATION OF ELECTROMAGNETIC FIELDS IN BIOLOGICAL SYSTEMS by A. W. Guy

This section provides a good but somewhat incomplete coverage of RF/microwave dosimetry (measurement and theoretical prediction of fields inside biological bodies) via several "overview" papers, and several original works on theoretical and experimental dosimetry. The lack of authoritative overview papers on the important experimental tools for modern dosimetry weakens this section. These tools are the non-perturbing temperature probe, electric and magnetic field survey instruments, and the implantable E-field probe. While one short paper by Bowman is presented on the design of one particular temperature probe, the state of the art, as it now exists, is not covered adequately for any of these tools. Well-written overview papers such as those on thermometry (Cetas, Med. Phys. 5, 1978), on survey instruments (Aslan, IEEE MTT-21, 1972) and on implantable E-field probes (Bassen, Radio Science (6S) 1979), should have been included or at least cited in the section's summary/bibliography.

Persons interested in the state of the art of EM biological-effects measurements should read the comprehensive book from the National Council on Radiation Protection (NCRP Report 67, Washington, DC, 1981) on radiofrequency electromagnetic fields, properties, quantities and units, and biophysical interaction and measurements. This NCRP book can provide important contemporary material on the state of the art of EM bioeffects dosimetry.

Section II: BIOPHYSICAL CHEMICAL BASIS OF RF FIELD INTERACTIONS by J. W. Frazer

This section covers the complex and interdisciplinary area of the biophysical interaction of RF energy with molecular, cellular, and biological micro-systems. Frazer concludes that most effects of RF and microwave radiation in biological systems seem adequately explained as a direct response to a temperature rise. This is a questionable conclusion in light of many recent findings and theories. In situations where the temperature dependence is carefully controlled, nonthermal, quantum-mechanical explanations are necessary, as in the work by Olcerst, quoted by Frazer. Persons interested in this subject should read the publication by Olcerst, et al. (Radiation Research 82, 2, 1980). Also, the excellent collection of papers on mechanisms of interaction entitled "Biological Effects of Nonionizing Radiation," edited by K. H. Illinger (American Chemical Society symposium series No. 157, Washington, DC, 1981) should be read by anyone delving into this subject. It is surprising that in the review paper by Frazer, no mention is made of the Frohlich theory, nor is any of K. H. Illinger's work quoted. An interesting inclusion in this section is a collection of papers entitled "Summaries of Selected Papers from USSR Academy of Sciences." It represents a school of thought on RF bioeffects that believes effects are induced by levels of RF radiation that are considered insignificant by a majority of Western scientists in this field.

One important new area of RF biophysical interaction was not included in this section. Research on the basis of interactions of pulsed, extremely low frequency (ELF) magnetic fields and pulse-modulated RF fields with biological tissues has become a very active area in the past five years. Of key importance in this area is the concept of electro-chemical information transfer and the interference of electromagnetic fields with this process. Actually, the basic papers on this subject of Basset et al., Chiabrera et al., Pilla et al., span the period from late sixties to the present, and as such should have been cited. Those interested in this subject should read some or all of the following:

Pilla A. A., J. Biol. Physics 11, 51, 1983
Pilla A. A., Advances in Chemistry Series 188, 126, 1980
Pilla A. A., in *Mechanism of Growth Control*, R. D. Becher ed., C. C. Thomas, Springfield
Beltrame et al., Alta Frequenza 49, 101, 1980
Bassett, C. A. et al., Annals of the N.Y. Academy of Sciences 238, (1974) (242-262).

Section III: EFFECTS OF RADIO FIELDS ON THE CENTRAL NERVOUS SYSTEM AND BEHAVIOR by D. R. Justesen

The associate editor's overview of radiofrequency effects on the central nervous system and behavior is a well-written, concise presentation of most of the available information. Despite some obvious oversights, such as the lack of mention of microwave-drug interactions on behavior, this section's summary/bibliography covers most of the important topic areas and can serve as a starting point for those who wish to pursue specific areas more thoroughly.

The eight papers following this overview do not serve to fully represent the present state of the art on the central nervous system (CNS) and behavioral effects of RF. For example, two of the eight papers deal with the subject of the "microwave hearing effect." It should be noted that recently this

phenomenon has been shown to be associated with thermoelastic pressure waves generated in the ear, and thus appears to represent a purely mechanical effect, rather than a direct CNS interaction, as was previously assumed. Another paper deals with dosimetric considerations in two RF exposure systems. While these latter three papers are interesting, one must question the wisdom of including many marginally-related papers in a section on central nervous system and behavioral effects. Because of the delay in the publication of this book, a significant portion of the CNS/behavioral papers presented in it were published in the early 1970's. Although such material may have served as a basis for subsequent work, today it is primarily of historical interest. It does not adequately represent the most current information in this critical area of research, nor does it reflect the current state of knowledge of the central nervous system and behavioral effects of RF.

Section IV: PATHOPHYSIOLOGIC ASPECTS OF MICROWAVE/RADIOFREQUENCY ENERGY EXPOSURE by S. M. Michaelson

This section deals with the harmful whole-body effects of RF energy. This is a vast area, so it is almost impossible to select a few papers and obtain an adequate collection. The brief introduction by S. M. Michaelson consists almost exclusively of caveats concerning the proper design and execution of experiments, and would apply to any area of biomedical research. One is left with the impression that very few, if any solid data on RF/MW bioeffects are available. This associate editor even states that in the appended bibliography, papers were included which "do not meet the criteria of sound scientific publications." It would be desirable for the associate editor to substantiate his opinion that "most of the experimental data support the concept that the effects of microwave exposure are primarily if not only, a response to hyperthermia or altered thermal gradients in the body." We noted that the conclusion of one of the reprints (Imig et al.) in this book is that in experiments on testicular degeneration "damage may result in part from factors other than heat." The important aspect of thermoregulatory responses is represented by a paper of peripheral vasodilation in the squirrel monkey by Adair, while the paper by Ely et al. has only historical interest. Recent papers by Way et al. (Bioelectromagnetics 2, 341, 1981) and Spiegel et al. (Bioelectromagnetics 1, 253, 1980) should be read for a more complete coverage of this area. To fully appreciate the subject, the papers on cataracts in this section should be supplemented by reading the excellent review of microwave cataractogenesis by Cleary (Proc, IEEE, 68, 49, 1980). In conclusion, this section contains a collection of papers of mixed quality and relevance, which do not provide a coherent representation of the present state of knowledge on the pathophysiologic aspects of RF energy.

Section V: MEDICAL APPLICATIONS OF ELECTROMAGNETIC FIELDS by O. P. Gandhi

This section includes papers on the classical medical application of RF fields — diathermy (the therapeutic heating of the musculature, tendons, etc. for physical therapy), and papers on most of the new, important areas such as Nuclear Magnetic Resonance (NMR) imaging (which may soon challenge the most sophisticated, computerized X-ray imaging modalities such as Computerized Tomography (CT), and RF hyperthermia for the treatment of cancer. Most of the areas of medical applications of RF are discussed adequately, but the coverage of the rapidly changing field of cancer hyperthermia does not present a comprehensive overview of the state of the art of hyperthermia applicators. Those interested in the subject should read Kantor (J. Microwave Power 16 (2) 1981).

One significant flaw in this section is the lack of almost any mention of the subject of bone and wound healing that is induced through the application of strong, pulsed magnetic fields or pulse-modulated RF carrier signals. Recently a new technical society was formed (Biological Repair and Growth Society) to cover this area. Also, the book gives no indication that there has been a steady history of clinical practice in which Basset and others have been active for over 20 years. Many thousands of patients suffering from bone fractures that would not heal normally have been successfully treated by physicians with long-term, pulsed magnetic fields. In light of this, the Food and Drug Administration has recently approved one bone-healing device as being clinically safe and effective. Therefore, the lack of any mention of such interactions of EM fields with biological systems is a significant oversight in this and the other sections of the book. A reference to the papers by Basset et al. and Becker et al. (see section II) should have been made, and at least one reprint included in this section.

Section VI: SAFETY STANDARDS by J. M. Osepchuk

This section contains papers dealing with personnel exposure standards and guidelines, and the physical basis for such standards. A paper that covers the prevalent personnel exposure and product-emission standards in 1980 by S. Michaelson was included. It is brief and somewhat incomplete. We assume that this paper was included as an up-to-the-minute summary of the status of RF safety standards at the time of publication of the book (since it was reproduced directly from a typed and photocopied, rather than typeset, manuscript). Because of its "timeliness" it has a rough physical appearance and is difficult to read, with the tops of virtually each character clipped off. Papers on the occupational exposure of personnel, and standards for control of such exposures were not included in this book. A paper, such as one by Conover (Proc. IEEE 68(1), 1980) or other knowledgeable regulatory agency professionals should have been included in this section's summary/bibliography.

Section VII: INTERFERENCE EFFECTS: ELECTROMAGNETIC COMPATIBILITY OF CARDIAC PACEMAKERS by J. C. Mitchell

Electronic cardiac pacemakers are the only medical devices covered in this section on interference effects. Mr. Mitchell and his group at the U.S. Air Force School of Aerospace Medicine are world experts in the area of pacemaker interference. Although this paper represented the state of the art at the time of its publication, effects on the new generation of "programmable" pacemakers were not mentioned. These new devices actually contain radiofrequency receivers or other means to obtain instructions for their operational adjustment after implantation in the patient, and can be susceptible to certain kinds of RF interference. A shortcoming of this section on RF interference in biomedical systems is the lack of any attempt to cover any other medical-device EM-interference problems, such as interference with critical, life-support and monitoring devices. The FDA's Bureau of Medical Devices (now part of CDRH) published a proposed final draft standard on electromagnetic compatibility for medical devices several years ago. This document (Medical Device Standard MDS 201 0004, 1979) should be read by anyone who is concerned with RF interference effects on medical electronics.

CONCLUSIONS

This book and its collection of papers provides relatively good, but somewhat outdated, coverage of the engineering and physical aspects of RF fields and their interaction with biological systems, plus the biomedical applications of electromagnetic fields. The coverage of the "biological" areas of this subject (the biophysical, pathological, and behavioral/central nervous system effects of EM fields) lacks a discussion of some of the most important scientific information on this subject, including the important area of pulsed-magnetic and RF field biological effects, their biophysical basis, and medical application to bone and wound healing. An overall view of this book is that it provides an extensive but incomplete set of references for this complex, controversial, and rapidly-changing field. Due to the changes that have occurred since this book went to press, it does not provide a complete overview of the present state of knowledge in this area.

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1985 BOD ELECTION RESULTS

The Board of Directors Election ballot of the IEEE EMC-S was held August 3, 1984. The following candidates were elected for a three-year term beginning January 1, 1985: B. Leonard Carlson, Donald E. Clark, Robert L. Haislmaier, George Kunkel, Chester L. Smith, and Charlotte R. Tyson. Congratulations to the newly elected members and a special thank you to all nominees for their willingness to serve and for permitting their names to be included on the ballot.

EMCABS

MELVIN J. JOHNSON

In this issue, we are publishing 30 abstracts. These are abstracts on various EMC topics. We plan to continue publishing abstracts of papers from previous EMC Symposia and from other conferences. The EMCABS committee is composed of the members listed below. By way of introduction to the community, they are listed with their company affiliations.

L.F. Babcock, Bell Aerospace Textron
E.L. Bronaugh, Electro-Metrics/Penril Corp.
R.N. Hokkanen, Naval Training Equipment Center
R. Jacobson, Sperry Flight System
D.R. Kerns, Southwest Research Institute
S. Kuniyoshi, Naval Sea Systems Command
R.B. Schulz, Xerox Corp. Off. Prod. Div.
R.M. Showers, University of Pennsylvania

"HOW CAN I GET A COPY OF AN ABSTRACTED ARTICLE?" The answer to this frequently asked question follows.

Most large public libraries, some small public libraries, all engineering school libraries, and most other college or university libraries have copies of publications in which articles appear. If they happen not to have the desired publication, such libraries usually can obtain it or a copy of the article from other libraries or sources. Many company libraries, both large and small, also have such arrangements. Many articles also are available from the National Technical Information Service (NTIS) and/or the Defense Technical Information Center (DTIC). To retrieve an article or publication containing an article abstracted in EMCABS, it is suggested that you contact your company library, a nearby engineering school library, a university library, or your municipal public library. If the library does not have the publication, go to the librarian, explain what you need and he or she will help you get the publication on loan, perhaps, from another library, or for a nominal charge, from NTIS. If you have a Department of Defense contract, the contracting officer, or your company librarian, can help you get publications from DTIC. The information needed is contained in the EMC abstract heading.

EMCABS: 1-9-84

Bistatic Interference Between Neighboring Radars
J. E. Smerczynski
Raytheon Company
IEEE Transactions on Aerospace and Electronic Systems
Vol. AES-18, No. 4, July 1982, pp 410-15

ABSTRACT: Radar transmitters characteristically generate broadband noise sidebands over the entire tunable frequency band of the system for the duration of the transmitted pulse. The noise will be backscattered over a substantial range interval. In certain circumstances, this bistatic reflection of ground clutter emerges as the predominant mode of interference between adjacent radars operating in common bands. Closed-form mathematical expressions are derived which relate this mutual interference to the system noise temperature. These results in turn are applied to a typical S-band radar.

INDEX TERMS: radar, interference, backscatter, S-band

EMCABS: 2-9-84

A Novel Feedforward Input
Filter-Regulator Compensation Canceling Interaction
S. S. Kelkar and F. C. Lee
Virginia Polytechnic Institute and State University
IEEE Transactions on Aerospace and Electronic Systems
Vol. AES-19, No. 2 March 1983, pp 258-268

ABSTRACT: The interaction between the input filter and the control loop of switching regulators often results in detrimental effects, such as loop instability, degradation of transient response, and audiosusceptibility, etc. The concept of pole-zero cancellation is employed to mitigate some of these detrimental effects and is implemented using a novel feedforward loop, in addition to existing feedback loops of a buck regulator. Experimental results are presented which show excellent correlation with theory.

INDEX TERMS: filters, feedforward, pole-zero cancellation

EMCABS: 3-9-84

Computation of the Magnetic Polarizability of Conducting Disks and the Electric Polarizability of Apertures
Ercument Arvas and Roger F. Harrington
Syracuse University, Syracuse, NY
IEEE Transactions on Antennas and Propagation
Vol. AP-31, No. 5, September 1983, pp 719-725

ABSTRACT: The electric polarizability of a small aperture of arbitrary shape is computed by solving the dual magnetostatic problem of a conducting disk. The method of moments is used to solve the integral equation for the current density induced on the disk. Charge-free expansion functions for the current density are introduced. The electric polarizability of the aperture is obtained from the magnetic polarizability of a complementary disk through the use of the duality principle. Results for five typical aperture shapes including the circle and ellipse are computed. The results of the computations are compared with available exact or measured data, and they show good agreement.

INDEX TERMS: polarizability, disks, apertures, methods of moments

EMCABS: 4-9-84

A Hybrid Moment Method/Finite-Difference Time-Domain Approach to Electromagnetic Coupling and Aperture Penetration into Complex Geometries
Allen Taflove and Korada Umashankar
ITT Research Institute
IEEE Transactions on Antennas and Propagation
Vol. AP-30, No. 4, July 1982, pp 617-627

ABSTRACT: An approach is presented for the direct modeling of electromagnetic penetration problems which involves a hybrid technique combining the frequency-domain method of moments (MM) and the finite-difference time-domain (FD-TD) methods. The hybriding is based upon a novel use of a field equivalence theorem due to Schelkunoff, which permits a field penetration problem to be analyzed in steps by treating the relatively simple external region and the relatively complex internal region separately. The method involves first, determination of an equivalent short-circuit current excitation in the aperture regions of the structure using MM for a given external illumination. This equivalent current excitation over the aperture is next used to excite the complex loaded interior region and the penetrating fields, and induced currents are computed by the FD-TD method.

INDEX TERMS: aperture penetration, method of moments, finite difference time domain, electromagnetic coupling

EMCABS: 5-9-84

Simple Formulas for Transmission through Periodic Metal Grids or Plates
Shung-Wu Lee, Gino Zarrillo, and Chak-Lam Law
University of Illinois, Urbana, IL
IEEE Transactions on Antennas and Propagation
Vol. AP-30, No. 5, September 1982, pp 904-909

ABSTRACT: A simple, closed-form, approximate solution is given for the transmission coefficient of a normally incident electromagnetic plane wave through a screen made of periodic metal grids (inductive screen), or made of metal plates (the complementary capacitive screen). Explicit formulas are also presented for cascading screens and dielectric slabs. When compared with the exact solution, our approximate simple formulas show good numerical accuracy.

INDEX TERMS: transmission, grids, plates, approximate solutions

EMCABS: 6-9-84

Electromagnetic Transmission through Apertures in a Cavity in a Thick Conductor
Yehuda Leviatan, Roger F. Harrington, and Joseph R. Mautz
Syracuse University, Syracuse, NY
IEEE Transactions on Antennas and Propagation
Vol. AP-30, No. 6, November 1982, pp 1153-1165

ABSTRACT: The problem of electromagnetic coupling from one region to another through an aperture-to-cavity-to-aperture system is specialized to the case of electrically small circular apertures on the axis of a cylindrical cavity of circular cross-section for the transverse electromagnetic (TEM) and transverse electric (TE) cases. A simple equivalent circuit for the coupling system is developed. It is found that for certain cavity depths an exceptionally large amount of electromagnetic energy can be transmitted, and that for identical apertures the transmission cross-section of the system is independent of the common radius of the apertures as well as the radius of the cavity.

INDEX TERMS: apertures, coupling, cavities, transverse electromagnetic, transverse electric

STUART LAWRENCE BAILEY, 1905 to 1984

Stuart L. Bailey, a founding member of the EMC Societies' predecessor, the Professional Group on Radio Interference, died August 11 at the Montgomery General Hospital, Bethesda, Maryland of pneumonia and deratomyositis. He was a past national president of the Institute of Radio Engineers and treasurer of that organization and the Institute of Electrical and Electronics Engineers during the period of negotiation and consolidation. Stuart Bailey was the dean of Washington-area businessmen when he retired in 1970. He cofounded Jansky and Bailey with C. M. Jansky, Jr. in 1930 and was president of that firm from 1953 to 1959 when it was acquired by Atlantic Research Corp. He retired from that firm in 1970 as vice president and general manager of its electronics and communications division.

The Jansky & Bailey firm pioneered many advances in radio technology over the years. They did early work on directional antennas for radio broadcast stations and helped map the UHF educational TV networks for 21 states. Between 1938 and 1946 they built and then operated the nation's third FM radio station, W3XO. That station is now WINX-FM in Washington, DC.

Mr. Bailey, along with C. M. Jansky, Jr., was a founding member of the Association of Federal Communications Consulting Engineers. Founded to foster engineering understanding between the desires of the broadcasting industry and the FCC, this organization, dating from 1948, continues to flourish in its 36th year.

Mr. Bailey was a native of Minnesota. He was a 1927 graduate of the University of Minnesota and earned a master's degree in electrical engineering there a year later. He spent the next two years with the Department of Commerce Lighthouse Service before forming the partnership with C. M. Jansky, Jr. in 1930.

He was the recipient of the University of Minnesota's outstanding achievement award in 1958, and the IEEE Centennial Medal in 1984. He was a member of the National Academy of Engineering, the Broadcast Pioneers and the Cosmos Club of Washington.

EMCABS: 7-9-84

Millimeter Wave Electromagnetic Measurement Techniques
E. E. Donaldson, J. C. Mantovani, G. B. Melson, and D. W. Acree
Georgia Inst. of Tech., Atlanta, GA, Engineering Experiment Station
AD-A116 369/0, PC A07/MF A01, Final rept., 1 Sep 80-30 Apr 82.
May 82, 148p, GIT-A-2746-F, CECOM-80-0569-F, Contract DAAK80-80-C-0569

ABSTRACT: This report presents the results of studies to develop the rationale for EM measurement techniques for use in the EMC evaluation of millimeter wave (MMW) communication-electric equipment and systems. In the development of this rationale, seven basic tasks were performed. Under the first task, the EMC/EMI data requirements for MMW equipments and systems were established to provide a clear definition of the type of data needed. The second task was the definition of appropriate measurement philosophy and techniques for obtaining the required data. Third task, the state-of-the-art in EMC/EMI measurement instrumentation and components for the 10-300 GHz frequency band was reviewed to identify the available instrumentation for the measurement techniques defined in the previous tasks. Fourth task was an evaluation of the advantages and disadvantages of manual, semi-automated, and fully-automated measurement techniques to determine both the feasibility and cost-effectiveness of these three approaches to data collection and analysis. Fifth task, the likely errors associated with EMC/EMI measurements at MMW frequencies were identified. The sixth task involved selected experimental measurements to investigate the possible impact of surface wave phenomena on EMI coupling at MMW frequencies.

INDEX TERMS: EM measurement, millimeter wave

EMCABS: 8-9-84

High-Resistance Grounding
Baldwin Bridger, Jr.
Powell Industries, Inc., P.O. Box 12818, Houston, TX 77217
IEEE Transactions on Industry Applications
Vol. IA-19, No. 1, Jan./Feb. 1983, pp 15-21

ABSTRACT: High-resistance grounding of electrical power systems offers many advantages of both solidly grounded systems and ungrounded systems, including practical suppression of transient overvoltages, practical reduction of equipment damage due to ground fault, and the ability to continue to operate a system in the presence of a ground fault on one phase. The design, application packaging, and field testing of high resistance grounding systems, including a practical method of fault location, are described.

INDEX TERMS: high-resistance grounding, electrical power system, fault location

EMCABS: 9-9-84

Shielding Effectiveness Measurements Using a Dual-TEM Cell Fixture
Richard D. Scheps
TEC KNIT, Inc., Cranford, New Jersey 07016
EMC Technology
Vol. 2, No. 3, July-Sept. 1983, pp 61-65

ABSTRACT: Methods for evaluating the shielding effectiveness of EMI shielding materials traditionally require the use of room size shielding enclosures. Tests of this type are typically based upon a modified version of MIL-STD-285. In order to eliminate the cumbersome nature and to improve the reliability and repeatability of shielded room testing, a new and radically different approach was used. This article describes the use of transverse electromagnetic (TEM) cells for shielding effectiveness measurement. The test system operates on the principle of aperture-coupled coaxial transmission lines. Significant advantages of this system are presented along with the actual test results.

INDEX TERMS: EMI shielding, shielding effectiveness, transverse electromagnetic (TEM) cells

EMCABS: 10-9-84

Power Line Monitoring
Stephen J. Tharp
Dranetz Engineering Laboratories, Edison, New Jersey 08817
EMC Technology
Vol. 2, No. 3, July-Sept. 1983, pp 27-38

ABSTRACT: This article defines several types of power line disturbances, shows methods of monitoring them, and presents a simple means of interpreting the data. Computers and other sensitive electronic devices are effected by ac power anomalities. Many EMI malfunctions are due to these anomalities. Power line disturbance analyzers are simple to install and operate. They provide printed records of disturbance occurrence time, its severity and duration. These printouts must be interpreted in terms of what the computer or other devices in question will actually tolerate.

INDEX TERMS: power line monitoring, power line disturbance, power line disturbance analyzer

EMCABS: 11-9-84

Occurrence of Local Oscillator Interference on Cable Television Systems
Fernand Bouchard
Department of Communication, Ottawa, Ontario
IEEE Transaction on Cable Television
Vol. 5, No. 3, July 1980, pp 90-103

ABSTRACT: In cable systems, with augmented channel capacity, the local oscillators of TV receivers can cause an interference between neighboring subscribers. To avoid the interference, channel off-setting techniques are in effect in cable systems and standards for maximum receiver local oscillator leakage are being implemented. A study, based on a two-subscriber model and on the removal of channel off-setting, has been undertaken to evaluate the maximum overall probability of occurrence of local oscillator interference.

INDEX TERMS: cable television systems, local oscillator interference, channel off-setting technique

EMCABS: 12-9-84

A Tutorial Review of the New EMI (Electromagnetic Interference) Models and Their Effects on Receiver Performance
David Middleton
Contract COM-OT-0124 May 80, 73p, NTIA-CR-80-7

ABSTRACT: New models of electromagnetic interference (EMI) have been developed by the author over the last five years (1974-1979), which for the first time have provided a canonical, analytically tractable, and experimentally well-established quantitative descriptions of nearly all EMI environments. These models are physically derived; canonical in the sense that they are invariant of the nature and waveform of the source and details of preparation, as far as their formal analytical structure is concerned; highly nongaussian; and, analytically and computationally manageable. Their principal quantitative and most widely applied form is embodied in the first-order probability distributions of the (instantaneous) amplitude and envelope, of the received waveform following the linear front-end states of a typical receiver. Three basic EMI models are distinguished: Class A, B, and C, respectively, involving sets of three, six and eight physically derived parameters, which are measureable from observed EMI amplitude (or envelope) data. These three basic classes are defined in terms of receiver bandwidth vis-a-vis that of the EMI.

INDEX TERMS: models, electromagnetic interference, quantitative, descriptions, receiver bandwidth

SURVEY DATA
1984 EMC SYMPOSIUM
ATTENDEES

A survey of the attendees at the 1984 EMC Symposium in San Antonio was accomplished with the cooperation of one of the exhibitors who provided an incentive by raffling off a set of EMC handbooks to those completing the form. This resulted in a much larger response than received in the past. Of those attending, 247 submitted profiles. The following results were tabulated by Ernest R. Freeman, President, Sachs/Freeman Associates.

1. IEEE Membership Grade	
Associate	3.3%
Member	41.3%
Senior Member	8.7%
Fellow	1.7%
Not Member	45.0%
2. Age	
20-25	5.3%
26-30	13.0%
31-35	13.4%
36-40	11.4%
41-45	18.3%
46-50	13.0%
51-55	13.0%
56-60	7.3%
Over 60	5.3%
3. Highest Earned Degree	
None	4.5%
Associate	13.4%
Bachelor	49.4%
Professional Degree	2.0%
Master	22.7%
Doctorate	8.1%
4. Employment Status (select one)	
Employed full-time in EMC area	60.6%
Employed full-time in other than EMC area	19.1%
Employed part-time in EMC area	18.3%
Unemployed involuntarily	0%
Unemployed voluntarily	0%
Retired - not available for employment	0%
Retired - available for employment in EMC area	0%
Self employed	2.0%

(Continued. . . .)

EMCABS: 13-9-84

Composite Material Aircraft Electromagnetic Properties and Design Guidelines
J. A. Birken, W. G. Duff, D. R. Pffug, and R. A. Wallenberg
Atlantic Research Corp., Alexandria, VA
Contract N00019-79-C-0634

ABSTRACT: This document collects and primarily summarizes aircraft advanced composite material electromagnetic properties, and secondarily, summarizes composite material mechanical, thermal, environmental, fabrication properties noting their ramifications on electromagnetic performance. It, then, overviews the electromagnetic sub-disciplines of threats, external to internal aircraft coupling, component and subsystems susceptibility protective methods as well as test and evaluation of small sample to total aircraft composite material electromagnetic performance. The sub-disciplines constitute a partioned set of independent variables which allow the reader to locate his area of interest in one section of the book. The sub-discipline are then combined to perform total aircraft electromagnetic system performance noting the protective methods, advantages and penalties. (Author)

INDEX TERMS: aircraft, composite material, electromagnetic properties

EMCABS: 14-9-84

Basic EMC Technology Advancement for C(3) Systems
Robert T. Abraham, and Clayton R. Paul
Southeastern Center for Electrical Engineering Education, Inc., St. Cloud, FL.
Vol. IV A., Coupling of Electromagnetic Fields onto Transmission Lines: A Comparison of the Transmission Line Model and the Method of Moments
Phase report Jun-Dec 81; Nov 82, 175p RADC-TR-82-286-VOL-4A See also Vol. 4b, AD-A124 862

ABSTRACT: The coupling of electromagnetic fields onto transmission lines is investigated. The transmission line model which with distributed sources is employed as a computationally efficient method of predicting currents induced on transmission wires by an incident field. Results obtained from the transmission line model solution are compared with predictions made by the more rigorous, but much less efficient, method of moments technique. Two user-oriented computer codes, using different expansion and testing functions, have been selected to provide the method of moments solution. Both the prediction accuracy and limitations of the transmission line model are explored in depth using a carefully selected transmission line structure. The structure is modified slightly to illustrate several important characteristics of the transmission line model solution. Low frequency limitations of the method of moments solution are investigated. In addition, the differences between the two method moments formulations are found to have a significant effect on the integrity of their individual solutions. These differences are illustrated.

INDEX TERMS: coupling, electromagnetic field, transmission line

EMCABS: 15-9-84

Basic EMC Technology Advancement for C(3) Systems & Shield
Vlayton R. Paul
Southeastern Center for Electrical Engineering Educations, Inc., St. Cloud, FL

ABSTRACT: This report contains the description and verification of a digital computer program, SHIELD, to be used in the prediction of crosstalk in transmission lines consisting of unshielded wires and/or shielded cables. The line may be above a ground plane (Type 1) or within an overall, circular, cylindrical shield which may be solid or braided and a wire (the shielded wire) located concentrically on the axis of the shield. All wires may be stranded and all conductors are treated as imperfect conductors; that is, their per-unit-length impedances are nonzero. Through-braid coupling for braided shields as well as diffusion for both types are included in the model. The shielded cables may have exposed sections at either end (pigtail sections) in which the shielded wire is not covered by the shield. Over these pigtail sections, a pigtail wire, parallel to the shielded wire, connects the shield to the reference conductor at that end via either a short circuit or an open circuit. These pigtail sections are included in the representation to simulate the common practice of terminating a shielded cable in a connector via these pigtail wires. The pigtail sections may be of different lengths.

INDEX TERMS: digital computer program, SHIELD, prediction of crosstalk, transmission lines

EMCABS: 16-9-84

Band Pass Filters
National Technical Information Service, Springfield, Va.
September 1981-October 1982 (Citations from the NTIS Data Base).
Feb 83, 66p Supersedes PB82-800160 and PB809676

ABSTRACT: The design, fabrication, characterization, and application of bandpass filters are investigated in the cited federally-sponsored research reports. Radiofrequency, digital, acoustic surface wave, and x-ray filters are included. Optical filters are excluded. (This updated bibliography contains 59 citations, all of which are new entries to the previous edition.)

INDEX TERMS: design, fabrication, characterization, application, band pass filters, bibliography

EMCABS: 17-9-84

High Pass Filters: Design and Theory
National Technical Information Service, Springfield, VA.
1975-February, 1983 (Citations from the International Information Service for the Physics and Engineering Communities Data Base).
Report for 1975-Feb 83. Feb 83, 97p

ABSTRACT: This hibliography contains citations concerning the theory, design and synthesis of high pass filters. Included are computer-aided design, filter network optimization and filter evaluation. Both active and passive filter designs are discussed, and a few applications are referenced to demonstrate design advantages. (Contains 91 citations fully indexed and including a title list.)

INDEX TERMS: hibliography, theory, design, synthesis, high pass filters

EMCABS: 18-9-84

Filter Characterization
C. P. Stanton
Sandia National Lab., Albuquerque, NM
Contract AC04-76DP00789, Jul 82, 41p SAND-81-2489

ABSTRACT: Some insight into the characteristic response of filters versus frequency and loading is presented. A computer program is provided which will allow the user to vary the filter model in order to assess the effect of specific conditions. (ERA citation 07:057830)

INDEX TERMS: response, filters versus frequency and loading

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(Continued. . . .)

EMCABS: 19-9-84

Band Pass Filters
National Technical Information Service, Springfield, VA
February 1977-August 1981 (Citations from the NTIS Data Base).
Feb 83, 301p
ABSTRACT: The design, fabrication, characterization, and application of band pass filters are investigated in the cited federally-sponsored research reports. Radiofrequency, digital, acoustic surface wave, and x-ray filters are included. Optical filters are excluded. (This updated bibliography contains 293 citations, none of which are new entries to the previous edition.)
INDEX TERMS: design, fabrication, characterization, application, band pass filters, bibliography

EMCABS: 20-9-84

Band Pass Filters
National Technical Information Service, Springfield, VA
March 1980-November 1982 (Citations from the Engineering Index Data Base).
Feb 83, 291p; Supersedes PB82-800186 and PB80-809684
ABSTRACT: The bibliography cites worldwide research on the design, fabrication, characterization, and application of band pass filters. Radiofrequency, electric, digital, and acoustic surface wave filters are included. Optical filters are excluded. (This updated bibliography contains 285 citations, 120 of which are new entries to the previous edition.)
INDEX TERMS: design, fabrication, characterization, application, band pass filters

EMCABS: 21-9-84

Protection of Integrated Circuits from Electrical Transients
Rajan Raghaven, and Henry Domingos
Clarkson Coll. of Technology, Potsdam, NY
Contract F30602-78-C-0281. Sponsored in part by Naval Sea Systems Command, Washington, DC
ABSTRACT: The report summarizes the nature of the threat to integrated circuits from electrical transients in an operational environment. Sources of transients are described, and their effects on integrated circuits are discussed. Some observations on different approaches to protect circuits are made.
INDEX TERMS: threat, integrated circuits, electrical transients

EMCABS: 22-9-84

ESD Failure Analysis Procedures
Owen J. McAteer, and Ronald E. Twist
Westinghouse Electric Corp., Baltimore, MD
Sponsored in part hy Naval Sea Systems Command, Washington, DC. Portions of this document are not fully legible. Contract F30602-78-C-0281
Report for Jun-Oct 81, Oct 81, 68p
ABSTRACT: This report discusses procedures to assist a failure analyst in analyzing parts that have failed due to electrostatic discharge. Basic failure analysis procedures are first presented in detail along with useful analysis techniques. These failure analysis procedures are general procedures that also apply to the analysis of other types of failure mechanisms although ESD peculiarities are emphasized. The second part of this report discusses case histories that illustrate the ESD failure analysis procedures, techniques and subtleties.
INDEX TERMS: electrostatic discharge, failure analysis

EMCABS: 23-9-84

Static Electricity Phenomena in the Manufacture and Handling of Solid Propellants
Ralph Kent
Societe Nationale des Poudres et Explosifs, Saint-Medard-en-Jalles (France)
This article is from "Minutes of the Explosives Safety Seminar (20) Hels" at OMNI International Hotel, Norfolk, VA on 24-26 Aug. 1982.
Volume 1, ADA124 400.
ABSTRACT: The studies described herein show that capacitive discharges and constant potentials may ignite the combustion of composite propellants. The results analysis allowed SNPE to point out criteria based upon percolation phenomena and specific laws of volumic resistivity as a function of temperature. The above criteria should be able to predict, with a rather good approximation, the behavior of some propellants in regard to static electricity. (Author)
INDEX TERMS: behavior, propellants, static electricity

EMCABS: 24-9-84

Band Pass Filters
National Technical Information Service, Springfield, Va.
1979-February, 1983 (Citations from the International Information Service for the Physics and Engineering Communities Data Base).
Report for 1979-Feb 83. Feb 83, 190p
ABSTRACT: This bibliography contains citations concerning the theory, design and synthesis of band pass filters. Included are design evaluations and optimization techniques. Some citations pertain to noise and parasitics and effective design considerations to bring performance up to design requirements. A few examples are included of applications of advance signal processing using band pass filters. (Contains 177 citations fully indexed and including a title list.)
INDEX TERMS: theory, design, synthesis, band pass filters

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EMCABS: 25-9-84

Transient Detector Apparatus
Malcolm Lapeyrolerie
Department of the Air Force, Washington, DC
Patent Application. Filed 23 Dec 82, 10p AD-D010 046/1
Availability: This Government-owned invention available for U.S. licensing and, possibly, for foreign licensing. Copy of application available NTIS.
ABSTRACT: A transient detector apparatus utilizing peak and slope detectors to determine the presence of transient signal in a logic signal. Individual slope measurements of the input signal are compared with a logic criteria to establish the occurrence of a transient. The peak voltage and pulse width of a transient are digitized in order to time tag or isolate a transient to a particular signal. (Author)
INDEX TERMS: transient detector apparatus, logic signal

EMCABS: 26-9-84

VARISTORS
National Technical Information Service, Springfield, VA
1975-January, 1983 (Citations from the International Information Service for the Physics and Engineering Communities Data Base)
Report for 1975-Jan 83. Jan 83, 199p.; Supersedes PB82-868597
ABSTRACT: This bibliography contains citations concerning application technology, research, and modeling of varistors. Overvoltage protection of electric circuits and electronic devices is considered. Effects of temperature, pressure, doping, and manufacturing procedures on varistors are considered. Also discussed are degradation, noise, current instability, aging characteristics, and reliability of varistors. (This updated bibliography contains 196 citations, 20 of which are new entries to the previous edition.)
INDEX TERMS: bibliography, application technology, research, modeling, varistors

EMCABS: 27-9-84

Coaxial Cable Design
James P. O'Loughlin
Department of the Air Force, Washington, DC
Patent, Filed 5 Nov 81, patented 21 Dec 82. 4p AD-D009 988/7, PAT-APPL-6-318 653; Supersedes PAT-APPL-6-318 653, AD D009 216
Availability: This government-owned invention available for U.S. licensing and possibly for foreign licensing. Copy of patent available Commissioner of Patents, Wash. D.C. 20231 $1.00
ABSTRACT: It has been discovered that the transient voltage which develops on the outer sheath of a coaxial cable under pulse voltage excitation is a result of the inequality between the self inductance of the sheath and the mutual inductance between the sheath and the center conductor. The self inductance of the sheath is always less than the mutual inductance by a small amount because of the finite thickness of the sheath. An equality between the sheath self inductance and the sheath to inner conductor mutual inductance can be achieved which results in a cancellation of the transient voltage on the sheath when the cable is pulsed. (Author)
INDEX TERMS: transient voltage, outer sheath, coaxial cable, cancellation

EMCABS: 28-9-84

Basic EMC Technology Advancement for C(3) Systems.
Marty B. Jolly and Clayton R. Paul
Southeastern Center for Electrical Engineering Education, Inc., St. Cloud, PL.
Volume IV C. Crosstalk in Twisted-Wire Circuits
Phase rept. Jun-Dec 81. RADC-TR-82-286-VOL-4C. Contract F30602-81-C-0062
See Also Vol. 4B, AD-A124 862
ABSTRACT: An investigation of wire-to-wire crosstalk is presented in an attempt to accurately predict the magnitude of the voltage coupled to a twisted wire pair. A sensitivity analysis of the twisted wire pair is conducted to determine the effect line twist has on the coupled differential mode voltage when the twisted pair is connected in an unbalanced configuration. An improved computer model is developed to aid in the prediction of the voltage coupled to the twisted wire pair when it is terminated in low impedance loads. Another circuit configuration which is investigated consists of a differential line driver connected to a differential line receiver by a twisted wire pair. Predictions of the common mode voltage coupled to the twisted pair are computed with a single wire model and a comparison is made with experimental results. (Author)
INDEX TERMS: wire-to-wire crosstalk, twisted wire pair, sensitivity analysis

EMCABS: 29-9-84

Intraquad Far-End Crosstalk in Local Cables
Deutsche Bundespost, Darmstadt (Germany, F.R.), Fermmeldetechnisches Zentralamt
K. Sakowski
June 82, 47p FL-44-TBR-89; in German; English Summary
ABSTRACT: Based on the quasi-transversal crosstalk theory, the process of origin of far end crosstalk in twisted line systems is explained using a theoretical line model. As far as intraquad far end crosstalk is concerned, formulas making possible numerical calculation from the geometric cable dimensions are derived from this model. It is calculated that the intraquad far end crosstalk is entirely real and proportional to the cable length, the coupling period, and the square of the frequency. It is mainly caused by double near end crosstalk via third lines. The factors determining crosstalk, such as line parameters, operating conditions (closed, open, short) as well as coupling functions between the lines are separately examined. Furthermore, methods are presented for determining these important parameters either by calculation or by measurement. The crosstalk portions of all third lines as calculated on the basis of the theory, are analyzed and show the strong influence of the unsymmetrical lines.
INDEX TERMS: far end crosstalk, twisted line systems, theoretical line model

EMCABS: 30-9-84

Electromagnetic Shielding Plastics
National Technical Information Service, Springfield, VA.
1978-December, 1982 (Citations from the Rubber and Plastics Research Association Data Base).
Report for 1978-Dec 82; Dec 82, 83p; Supersedes PB82-861295.
ABSTRACT: This bibliography contains citations concerning electromagnetic shielding by means of electrically conducted plastics. Emphasis is placed on composite materials, vacuum metallizing, graphite-epoxy laminates, metal-filled urethanes, and sprayable shielded coatings. Applications include shielding of electronic assemblies, cabinets for business machines and televisions, as well as domestic appliances. (This updated bibliography contains 78 citations, 23 of which are new entries to the previous edition.)
INDEX TERMS: bibliography, electromagnetic shielding, electrically conducting plastics

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