IEEE

# Electromagnetic Compatibility Society

Newsletter

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## REXFORD DANIELS, JUNE 16, 1898–JANUARY 2, 1987

**Associate Member IRE, 1954; Senior Member IEEE, 1969; Life Senior, 1977; Life Fellow, 1980.**

"There were giants in the land in those days . . ."

Genesis 6:4

The EMC Society has lost one of its own giants with the passing of Rexford Daniels at his home in Concord, MA on January 2, 1987. Rex, as he was known to his friends, was a founding member of the Institute of Radio Engineers Professional Group on Radio Frequency Interference in 1957. The PGRFI was the predecessor of the IEEE Electromagnetic Compatibility Society. In 1954, even before the PGRFI was established, Rex had recognized that the group of engineers contending with interference problems could be served by a newsletter whereby they could exchange information. In 1954 Rex started his own publication, "Quasies and Peaks." It was circulated freely to anyone requesting it at no charge. Rex was its editor and publisher. Consequently, when PGRFI was established, "Quasies and Peaks" became the PGRFI Newsletter with Rex as its editor.

Rex was a Hoosier by birth but spent his adult life in New York and, from 1940 on, in Massachusetts. His early interest in engineering brought him to Yale, where he graduated from the Sheffield Scientific School in 1920 with a PhB degree in Mechanical Engineering. As a member of the U.S. Navy Reserve he was called up in 1940 as a Lt. Commander in the intelligence office. This was followed by a stint at the MIT RadLab, where he organized and managed Group 39 of the Transition

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# EDUCATION COMMITTEE NEWS

### DISTINGUISHED LECTURER PROGRAM

At their January 29, 1987 meeting, the Board of Directors approved the following proposal for the establishment of an EMC Distinguished Lecturer Program:

"It is hereby proposed that the Board of Directors authorize the establishment of an EMC Distinguished Lecturer Program, wherein no more than four lecturers will be selected and engaged to present a maximum of four lectures each per year on subjects relating to EMC. Presentation of lectures at other than EMC-S chapters and functions is encouraged. Lecturers shall solicit funds to offset expenses from their affiliation and/or the inviting organization. Non-reimbursed expenses not to exceed $750 per lecture will be paid by the EMC Society."

"A Program Chairman will be nominated by the Education Committee and approved by the Board of Directors. The Chairman shall have the authority to select lecturers, topics, and approve the expenditure of funds within a budget approved by the Board of Directors. The Chairman must be a member of the EMC-S, will serve a two-year term and cannot also serve as a Distinguished Lecturer. The Chairman shall report annually on the status of the program to the BOD."

"Distinguished Lecturers will be selected by the Program Chairman from written nominations submitted by members of the EMC-S. The Distinguished Lecturer must be a member of the EMC-S. Distinguished lecturers will serve in that capacity for two years, and may not serve two consecutive terms. The lecturers will be selected based on: (1) topic of lectures, (2) lecturer's area of expertise, (3) lecturer's presentation skills and (4) balance of all topics. The topics, abstracts and biographical sketches for each lecturer will be published in the EMC-S Newsletter."

"The lecturers will be responsible for obtaining prior approval for a lecture from the Program Chairman, and for submitting a travel expense statement and receipts to the EMC-S Treasurer for reimbursement. Copies of the expense statement and receipts will also be sent to the Program Chairman."

"The Education Committee will prepare, and the BOD will approve, a set of guidelines to be used by the Program Chairman in administering the program."

Work is presently underway to implement this program, the objective being to have the program operational by the end of the year.

Henry Ott
Chairman, EMC-S
Education Committee

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Department. In 1946, after WWII, he set up a partnership, Henderson and Daniels, to develop new products and techniques resulting from research done at the MIT RadLab.

Rex ventured out on his own in 1952 as The Interference Testing and Research Laboratory with offices in Boston. He offered complete technical supervision and administration of contracts and surveys and development and testing of radio frequency interference instrumentation. This became Interference Consultants, Inc. in 1960, with the emphasis on consulting contracts with DoD, ODDR&E, Western Electric, MIT, and others.

As the importance of spectrum engineering gained recognition, Rex was requested by the Executive Office of the President to act with the Joint Technical Advisory Committee (JTAC) in establishing a group to study the "side effects" caused by electromagnetic energy. During the four-year course of this work Rex made many personal contributions and, as a result, a central data bank was established in the President's Office of Telecommunication Policy and an Electromagnetic Radiation Management Council (ERMAC) was set up to coordinate the study of side effects of EM emissions. As an output of this project, Rex edited a two-volume report on Electromagnetic Side Effects published by the Office of Telecommunication Management, Executive Office of the President, in 1968.

Rex was a veritable encyclopedia of EM side effect knowledge. One of the last of his works was published in the book *Future Science* (1970)* with the intriguing title, "The Possibility of a New Force in Nature."** To quote from it:

> "We found eight different individuals, or groups, who had happened upon an unknown force which penetrated everything; could not usually be measured by conventional electronic instrumentation; did not attenuate according to recognized formulas; and could cause instantaneous reactions at incredible distances. Because of the diversities of use of this force, it appeared that it might even have a spectrum of its own. Each group interested in it had a name descriptive of its use, such as; a second force of gravity (gravitons), hydronics, eloptics, orgone, Backster's phenomenon, dowsing, radionics, and radiesthesia. . . . Probably the most common use of this force is in dowsing, which is a controversial method of finding water, but which is now gradually becoming respectable through its use by the U.S. Marine Corps in Vietnam to locate underground tunnels, buried ammunition, and other materials. . . . A common civilian application of this force is called 'map dowsing' from which it is claimed that it is possible to locate a desired object by dowsing a map of the location by means of a pendulum or other instrument."

During his 13 years as editor of the PGRFI Newsletter (1957-1969) he set the high standard of excellence which has been maintained to this day. In addition to this he also served on the PGRFI Administrative Committee for two terms, 1960-1962 and 1964-1966. He was Vice Chairman in 1962. When the PGRFI awards program was established in 1962, Rex was the first recipient of the Certificate of Appreciation. In 1968 he received the Certificate of Recognition and in 1970, when the Honorary Life Membership was inaugurated, Rex was the first to be honored with it. In addition to these EMC Society honors, Rex was awarded a Certificate of Recognition for his professional contributions to the NASA EMC Awareness Seminar. The highest IEEE honor came in 1980, when he was elected to Fellow grade with the citation; "for innovative concepts and leadership in the beneficial uses of nonionizing electromagnetic energy and its potential dangers." For over 30 years Rex Daniels was internationally recognized for outstanding contributions to the technical aspects of electromagnetic compatibility, instrumentation and EMC effects. In addition, his outstanding and unselfish contributions to the IRE and the PGRFI over the years, as well as the IEEE and the EMC Society, have made him so well known as to earn the nickname "Mr. EMC."

Rex was never one to back off from anything. An example is his visit to a medical doctor's office as recounted to Chet Smith. Most of us have had the experience of being hustled into an examining room and having to divest ourselves of our clothes. The psychological effect of inhibiting us is intentional and usually quite effective. Not so with Rex. While waiting he did not sit still, but was all over the place examining the electrical and electronic apparatus in the room. When the doctor made his entrance, Rex confronted him with, "Someday you are going to kill your patient with this stuff. You have no common ground and you don't have polarized plugs!" The doctor was startled with this attack and when he recovered his wits he was somewhat peeved. Hopefully he took this advice, but then we have no way of knowing.

Even after his retirement Rex was interested in, and, until failing health intervened, was active in all things EMC-wise. When Rex was no longer able to attend the annual EMC Symposium his many friends always got together to send him a greeting from the symposium. Rex was most unique in many ways and those of us who cherished our friendship with him will sorely miss him.

Many of us knew his wife, Nancy, who survives him. There are also three daughters; Mrs. Edith Tucker, Mrs. Nancy Oliver and Harriet Daniels. We in the EMC Society extend our condolences to them.

*Edited by John White & Stanley Krippner. Paperback edition is from Anchor Books. Doubleday & Co., Garden City, NY, 1977, $4.50.
**Reprinted from the *Proceedings of the 1970 IEEE International Symposium,* Anaheim, CA, July 14-16, pp. 160-168.

# BOARD OF DIRECTORS' MEETING IN WASHINGTON, DC

by Donald N. Heirman

The first Board meeting of 1987 was held on January 29, 1987 at the Washington, DC Hilton, the site for the 1990 EMC Symposium. Eleven of the 18 Board members were present. All of the four Board members newly-elected for 1987 were also present. Four other Society members attended. President Carlson opened the meeting at 10 am. Secretary Haskins reviewed the minutes of the San Diego Board Meeting and the Board approved the minutes with minor changes.

Important items from the meeting are now summarized:

1. Treasurer Ford presented his report which showed that the current net worth of the Society is $282K with $227K of that in long-term investments. The 1986 through 1988 symposium steering committees had loans outstanding totalling $4K. The net income from the 1985 symposium is now final at $22.6K. The cost for printing and distributing copies of the 1986 symposium record to all EMC-S members was $12K, a real bargain. The report was accepted by the Board.

2. Bob Haislmaier, Director for Communications Services, introduced his committee chairmen who presented their brief reports. Dick Schultz, *Transactions* editor, reported that the number of manuscripts received are increasing and that he has had very positive comments on the November issue, which published papers which had mixed reactions from the various reviewers. No report was forwarded from the *Newsletter* editor. Gene Cory presented an in-depth review of symposium activity. The books were closed on the 1982 Santa Clara symposium with the final repayment made in September 1986 to the Society Treasury. The 1986 symposium in San Diego was expecting a surplus of around $15K. 1987 in Atlanta was covered by Hugh Denny, General Chairman. The hotel was purchased by the Radisson chain. Room rates are $62 single; $69 double. A total of 105 abstracts were reviewed and as of the end of January 1987, 55 exhibit booths were sold. The conference records will also be mailed to all Society members. The advance program will be mailed in March. Don Weber reported that the symposium site for 1988 is the Western Hotel in Seattle. We have two sites in 1989: the Radisson in Denver on May 23-25 and in Nagoya, Japan in October. Washington, DC is the 1990 site; Chairman Tom Doeppner passed out the list of Steering Committee members. During the lunch break the staff of the hotel took the Board on a tour of the facilities, which are extensive. The Board appreciated their kind hospitality. The 1991 symposium is scheduled for August 13-15 at the Hyatt in Cherry Hill, NJ (metropolitan Philadelphia area). Next, Bob indicated that Don Williams of Southwest Research Institute was helping Mel Johnson with the EMC Abstracts until Mel fully recovers from his illness. We all wish Mel continued recovery wishes. A brief discussion of Jim Hill's History Committee was held. Of particular interest was a listing of all Board-approved policy statements made since our existence as a Society/Group. Dick Schulz agreed to review past minutes and other resources for such statements with the view of publishing them in total.

3. Ed Bronaugh, Director for Technical Services, introduced his committee chairmen who presented their reports. Don Heirman, Standards Committee Chairman, indicated that several ballots for updates to standards under the cognizance of the Society are being circulated. A new project for establishing techniques for measuring E and H in the near field was established and the request for approval sent to the IEEE Standards Board. Mike Hart stepped down as Secretary and was replaced by Steve Berger of EMCO, Austin, TX. Don described the new standards submittal procedures and the requirements for coverage by the Institute to indemnify those working on standards. For those interested in more information on the indemnification policy, contact Paul Lange of the IEEE Standards Office on (212) 705-7960. The next meeting will be on 7 May in Seattle immediately preceding the next Board meeting. Ed Bronaugh reviewed a report from Wil Lauber, Chairman of the Technical Advisory Committee. Wil reported that our EMC-S Technical Committees reviewed 105 abstracts for the Atlanta Symposium. The category of measurements had the most abstracts (34) followed by 21 on EMI control. He also suggested that a new technical committee on FCC/MIL SPEC measurements be formed. No action was taken. Hank Ott, Education Chairman, reported that the EMC Experiments Manual was being updated and that a basic bibliography of books and articles on EMC was being prepared by his committee. He also prepared a proposal for Board approval of guidelines for an EMC-S "Distinguished Lecturer Program." This program will identify EMC-S members who are available to present up to four lectures a year. The lecturers will be available to local chapters as well as for non-EMC organizations. A non-reimbursed stipend is included. The Board approved the

program. For more information, call Hank on (201) 386-6660.

4. Member Services were next discussed. Bob Hofmann, Chapter Activities Chairman, reported that as yet he has heard of no chapter availing themselves of their "angels" who were identified in this column in the last Newsletter. The angels can help with guest lecturers and provide up to $500 reimbursement for chapter special projects. There was no report on membership and awards. Bill Duff reported a very successful election of EMC-S members to Fellow grade for 1987. The new Fellows are:

Bob Haislmaier
Don Heirman
Clayton Paul

Congratulations to them for their many contributions to our technology and Society. It was also noted that Carl Baum was awarded the 1987 Harry Diamond Memorial Award, a prestigious IEEE Field Award.

5. A limited discussion was held on Professional Services. Walt McKerchar indicated that he was coming up to speed on preparing a scope for the Public Relations Committee, which he chairs. A proposal for guidelines for conducting the annual employment survey at our yearly symposia was passed out to the Board. No action was taken at this time. For more information, contact Walt McKerchar on (206) 779-7069.

6. Under Old Business, the Board approved a policy on EMC-S participation in non-IEEE events. For a copy, contact Gilda Haskins on (215) 752-4749. A reminder that IEEE banners are available, paid by the Society, for chapters requesting them. Contact Bob Hofmann on (312) 979-3627.

7. Finally, the election of Officers and Technical Directors for 1987 was held. Gene Knowles presented the voting procedures and a secret ballot was held. The results are as follows:

| | |
|---|---|
| President: | Len Carlson |
| Vice President: | Don Clark |
| Secretary: | Gilda Haskins |
| Treasurer: | Dick Ford |

Technical Directors:

| | |
|---|---|
| Communications Services: | Bob Haislmaier |
| Member Services: | Bob Hofmann |
| Technical Services: | Ed Bronaugh |
| Professional Services: | Walt McKerchar |

Congratulations to our 1987 Officers and Directors!

8. President Carlson adjourned the meeting at 4:15 pm. The next Board meeting will be at 10 am on May 7th at the Western Hotel in Seattle, the site of our 1988 symposium. For more information contact Gilda Haskins on (215) 752-4749 or Len Carlson on (206) 773-6297.

Respectfully submitted,
Donald N. Heirman
Associate Editor
Board of Director Activities

# *POINT AND COUNTERPOINT*

by Anthony G. Zimbalatti

I am planning a column for the Summer 1987 issue of the Newsletter. The subject will cover the "Department of Defense Specification Streamline" effort. I have some thoughts on this effort derived from my participation on the past related effort called "tailoring" which was conducted for the DoD by the Electronics Industry Association. I served on the MIL-E-6051 panel. If you would like to contribute to the column, please contact me as soon as possible. Written or typed inputs are due to me, no later than 1 May 87.

Anthony Zimbalatti
Grumman Aerospace Corporation
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## EIGHT EMC-S MEMBERS ELECTED IEEE FELLOWS

In honor of their valuable contributions to electronics and electrical engineering, the following eight members of the Electromagnetic Compatibility Society have been awarded by their elevation to IEEE Fellow:

- Mr. Edward J. Glenner
  GTE Communication Systems
  For contributions to the digitization of the United States public telephone network.
- Dr. Robert J. Haislmaier
  U.S. Navy Space and Naval Warfare
  Systems Command
  For contributions to the development of engineering practices and standards for hardening ships against nuclear-generated elctromagnetic pulses.
- Mr. Donald N. Heirman
  AT&T Information Systems
  For leadership in establishing techniques and standards for accurate electromagnetic emission measurements.
- Mr. William R. Kruesi
  General Electric Company
  For leadership in coordinating electrical and electronic standardization programs.
- Professor Goro Matsumoto
  Hokkaido University
  For contributions and leadership in the field of electrical components as applied to biomedical engineering.
- Professor Clayton R. Paul
  University of Kentucky
  For contributions to the understanding and solution of crosstalk problems in cable assemblies.
- Professor Adolf J. Schwab
  University of Karlsruhe
  For contributions to the analysis and design of high-voltage and high-current measuring devices.
- Professor Donald R. Wilton
  University of Houston
  For contributions to numerical techniques for solving electromagnetic scattering, radiation and penetration problems.

An interesting sidelight to the contributions of these Fellows to the field over their careers is that five of them were elected following favorable evaluation of their work by Societies other than the EMC Society: Mr. Glenner by Communications, Mr. Kruesi by Industry Applications, Professor Matsumoto by Components, Hybrids and Manufacturing, Professor Schwab by Power Engineering and Professor Wilton by Antennas and Propagation. This is a good indication of the multiple talents of some of our members. Congratulations to them all.

## SHOULD IEEE STANDARD 263 BE ABANDONED?

The November, 1986 issue of the IEEE Vehicular Technology Society Newsletter reprinted IEEE Standard 263 and published an appeal to VTS members for input as to whether or not this standard should be revised or abandoned.

Standard 263 measures ignition interference in mobile communication receivers, but provides a near field intensity measurement, in contrast to the SAE Standard, which provides a far field measurement. Standard 263 gives more consistent results, not being subject to variations in propagation conditions.

Prepared by a joint VTS and EMC Society committee in 1965, it is long overdue for updating and revision. Efforts to organize a revision committee have been unsuccessful in the past. A proposed revision was rejected by the EMC Society and SAE a few years ago and a recommendation is about to be made to the Institute Standards Board that it be officially abandoned.

Anyone with any comments on this issue or who is interested in working on a committee to revise and update IEEE Standard 263 should contact J.R. Neubauer, P.E., P.O. Box 125, Collingswood, NJ 08108. (Note: Copies of IEEE Standard 263 are available for $4.50 (member's price) from Publication Sales, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854-4150 or by calling (201) 981-0060. Orders must include a $5.00 charge for all standards publications as well as a $2.00 billing charge for orders under $100.00 unless a check or money order is included with the order. A membership number is required to get the member's price and there is an additional handling charge for telephone orders.)

## PROPOSED EXPOSURE STANDARD

In a Notice of Proposed Recommendations on Federal Radiation Protection Guidance, the Environmental Protection Agency has introduced a new approach to limit the public's exposure to non-ionizing radiation in the range 10 kHz to 100 GHz. (For details on the EPA proposal, see the *Federal Register,* July 30, 1986, Vol. 51, No. 146, pp. 27318-27339.)

The proposed standards are based on a specific absorption rate (SAR) in watts per kilogram, as contrasted to the ANSI (American National Standards Institute) voluntary standards, which are based on incident power per unit area. IEEE's Committees on Man and Radiation (COMAR) and Communications and Information Policy (CCIP) filed a statement with EPA on December 2, 1986, to support the SAR approach, saying they favor the proposed limit of 0.08 watts per kilogram for frequencies above 3 MHz.

# PCs FOR EMC

by Edmund K. Miller

This is the second of two trial appearances of Professor Miller's column on the application of personal computers to the solution of problems in electromagnetics. This column, which usually appears in the IEEE Antennas and Propagation Society Newsletter, first appeared in our Winter 1987 issue. Your comments and suggestions on the usefulness of this kind of column for the EMC Newsletter will determine whether it (or a related column) will continue in the future. Please send your comments and suggestions directly to your Newsletter Editor or to Professor Miller at Nichols Hall, The University of Kansas, Lawrence, KS 66045.

PCs for AP
April, 1987
E. K. MILLER

As you can surmise, I've finally gotten my hands on a Laser printer, in this case the LaserWriter from Apple. The quality and speed of such pieces of hardware continually amaze me, especially as I think back a few years over the evolution of such devices. When I got my first PC, the Commodore PET, I was able to accomplish useful work (to me) without benefit of a printer at all. My mode then was to copy by hand the screenfuls of data that were produced by some monte-carlo experiments being conducted with Prony's Method(!). Because the computer wasn't all that fast and had only 8K of memory besides, that approach wasn't particularly burdensome. When I subsequently obtained an Apple II and added a printer as well, even though this was only a thermal printer, the improvement was almost spectacular, especially since I could also dump screen graphics. Then along came the Macintosh and my first excursion into word processing using the dot-matrix ImageWriter printer. To say that this has greatly changed my work style would be an understatement, as I am able to produce all of my correspondence and technical documents, besides doing numerical analysis and graphics. But the laser printer represents still another generation of evolution, bringing near-typeset quality to desktop publishing. One next logical step would be color hardcopy output, and beyond that sound, movies, simulated three-dimensional imagery, . . . !

Two columns ago, I "mini-reviewed" several books dealing with numerical analysis, PC applications, etc. As one source of the book *Numerical Recipes,* I mentioned the Library of Computer and Information Sciences (LCIS) but neglected to provide their address, an omission that several readers pointed out. Advertisements for this *book club* can be found in various magazines, or you can write to P.O.Box 1010, Riverside, NJ 08370-1010. I should emphasize that because this is a book club, you must be a member to purchase books at their (usually) special prices. As an alternative for *Numerical Recipes,* you might contact Cambridge University Press, 32 East 57th Street, New York, NY 10022, or call (800) 431-1580 (outside New York State and Canada), where you can use a Visa or MasterCard for payment. Please note that although I belong to LCIS, I am not making a particular recommendation for it or any book club. I mention it only because it represents one source of discounted scientific/technical books that might be of potential interest to you.

I must also express my thanks to Ray Rosich of Littleton, CO for sending me information concerning several interesting books, including a full-page ad for Cambridge U. Press on page 112 of the June 1986 issue of *Physics Today* in which *Numerical Recipes* was described. If any of you have come across similar books that you think readers of this column might enjoy, I'd appreciate your sending me your comments and suggestions.

In this connection, I'll list here a number of books that are computationally or modeling oriented that I have seen advertised, listed and/or reviewed in various sources such as *Science* magazine, *Byte, Physics Today,* IEEE *Spectrum,* etc. I realize that not all are devoted to AP-S and EMC-S topics, but the general topics sound interesting to me and might have some relevance to the overall theme of com-

puter modeling. Asterisks* denote books I already have and will review in future columns, while the others might also be reviewed or summarized as seems appropriate. For now, I'll just provide names, authors and publishers:

*Computer Simulation Methods in Theoretical Physics,* by D.W. Heermann, Springer-Verlag, New York, 1986, $29.00.

*Computational Heat Transfer,* by Y. Jaluria and K.E. Torrance, Hemisphere, NY, 1986, $49.00.

*The Recursive Universe,* by W. Poundstone, William Morrow, 1985, $19.95.

*Computer Modeling of Complex Biological Systems,* edited by S.S. Iyengar, CRC Press, Boca Raton, FL, $59.00.

*The Computer Modeling of Mathematical Reasoning,* by A. Bundy, Academic Press, Orlando, FL, 1985, $35.00.

*Computers in Mathematics,* edited by D.H. Ahl, Creative Computing Press, $15.95.

*Numerical Methods in Engineering Practice* and *Computerized Numerical Analysis,* by A.W. Al-Khafaji and J.R. Tooley, Holt, Rinehart and Winston, New York.

**Differential and Difference Equations Through Computer Experiments,* by H. Kocak, Springer-Verlag, New York, 1986, $44.00 including disk.

*Numerical Methods in Fluid Dynamics,* edited by F. Brezzi, Springer-Verlag, New York, 1985, $20.50.

**Optimization Using Personal Computers,* by T.R. Cuthbert, John Wiley and Sons, New York, 1987.

*Computational Methods for Kinetic Models of Magnetically Confined Plasmas,* by J. Killeen, G.D. Kerbel, M.G. McCoy, and A.A. Mirlin, Springer-Verlag, New York, 1986, $38.00.

As an update on another topic touched on in a recent column, that of producing the equations needed in scientific/technical word processing, I'll briefly summarize my initial impressions of MathWriter for the Macintosh. This is a product available from Cooke Publications, P.O. Box 4448, Ithaca, NY 14852 for $49.95. This is a WYSIWYG (what you see is what you get) editor for writing equations whose design philosophy of point-and-click is well suited to someone like me who might use such a tool infrequently enough to have difficulty memorizing and remembering a large collection of embedded commands.

MathWriter interfaces with other Macintosh word-processing software so that importing equations into a text document is straightforward. It provides a variety of options, including the stretching or shrinking of an equation to fit available space while maintaining the width-to-height ratio even after pasting the equation into a document. An overlay screen is also available to manually handle superpostion of multiple characters. Some special characters are always on screen, such as integral, summation and product signs, while others are available either from a pull-down menu or a user-defined, on-screen palette. Automatic alignment of fractions and matrices is possible, and the program also automatically and retroactively adjusts in size the parenthesis, bracket or brace which preceeds and follows a fraction.

As a demonstration of the kinds of equations MathWriter produces, I include two examples below:

$$V = \sum_{m=1}^{m=\infty} \sum_{n=1}^{n=\infty} A_{m,n} \sqrt{\frac{\sinh \pi (c - z) \sqrt{\frac{m^2}{a^2} + \frac{n^2}{b^2}}}{\sinh \pi c \sqrt{\frac{m^2}{a^2} + \frac{n^2}{b^2}}}} \sin \frac{m\pi x}{a} \sin \frac{n\pi y}{b}$$

$$J_\nu(z) = \left(\frac{z}{2}\right)^\nu \sum_{\kappa=0}^{\infty} \frac{\left(-z^2/4\right)^\kappa}{\kappa!\ \Gamma(\nu + \kappa + 1)}$$

An interesting feature of MathWriter is that a library of equations can be created and stored in a data base for later access and use in document preparation. Switcher™ is also provided with the program to permit convenient "real-time" operation. While I have just received this program and don't have much experience using it so far, I expect to be a real asset in creating future, equation-laden, documents.

John Murray of John Murray Associates, 1823 Folsom Street, Suite 201, Boulder, CO 80302, telephone (303) 444-4874, has informed me of a family of radio-system

design tools he's developed for IBM PCs and compatibles. These are available in two packages, *Radio Design Utilities* (RDU) and *Radio Systems Planning Techniques* (RSPT). In the former is included a set of tools that provides many of the formulas and constants needed for routine radio-design calculations. For example, conversion among the various popular units for field strength, power density, received power, noise, levels, etc. are included. Among the calculations/formulas are contained free-space path loss and range, Gaussian and Rayleigh statistics, satellite links, great-circle range-bearing and channel loading. The user interface includes default data, screen graphic displays and fully buffered and error-checked input. Extensive prompts and help messages also assist in interpreting input data requirements and results.

RSPT embodies an integrated set of planning and design capabilities for VHF and UHF frequencies. Included in its set of tools is path analysis for both descrete- and nominal/statistical-terrain models, where the former contains digital topographic data files for the coterminous United States. Other options in RSPT are coverage analysis, cosite analysis and frequency assignment. The program evaluates the RF path between transmitter output and receiver input, with median received signal level and signal variability determined by considering transmitter and receiver characteristics, siting information and intervening terrain and atmospheric factors. Transmission loss is computed using a series of propagation models chosen to best serve specific applications, with the primary one being the Irregular Terrain Model developed at the Institute for Telecommunications Sciences. For prices and further information, contact John Murray. Computer requirements are an IBM PC/XT/AT compatible, color-graphics adapter with single-color monitor, 512K minimum memory, with a 20M hard disk and math coprocessor (8087 or 80287) recommended. John has indicated his willingness to make special arrangements for using these programs in educational applications.

Another program that I thought would be worth mentioning, this time for IBM PCs and compatibles, is *Drafix 1,* a computer-aided 2D design and drafting (CAD) program that has drawn rave reviews from *PC Magazine* (September 16, 1986). This program is available for $295 from Foresight Resources Corp., 932 Massachusetts, Lawrence, KS 66044-2868, telephone (913) 841-1121. I was first made aware of *Drafix 1* by a student in my graphics class who works part time for Foresight and arranged a class demonstration. It requires 512K RAM (640K preferred), mouse or digitizer, and DOS 2.1 or later, and works with CGA, EGA, Hercules, Sigma 400, Conographics 40, Techmar Graphics Master and AT&T PC graphics cards, with the 8087/80287 being optional.

The user interface is claimed by the reviewer Glenn Hart, from whose PC review this summary is excerpted, to be "perhaps the best on *any* CAD" package. It features a sort of Macintosh-mutant approach using a hierarchial menu structure where the lower levels are always visible in a thin strip below the higher levels. Image manipulation includes features such as zoom, pan, redraw, and up to eight numbered views of an image can be saved and recalled instantly. Besides drawing lines, arcs, circles and such, *Drafix 1* draws parallel lines having variable width and offset, perpendiculars and parallels to existing lines and tangents to one or two circles. Boxes and polygons can be drawn, filled with color and exploded into segments. Hart concludes his review by observing "all serious CAD users will find that *Drafix 1* offers incredible performance for the price." Foresight Resources does provide an interface to other engineering modeling programs so that preparation of the input data needed for the latter might be accomplished using *Drafix 1.* A program such as this might have possibilities for inputting EM models as well.

If you give demonstrations using a computer to audiences of more than a few people and don't have a projection TV or multiple monitors, you might want to consider *Kodak Datashow* or similar products. The unit consists of a liquid-crystal display (LCD) panel which generates projectable dark-blue-on-light-grey-background images when linked by one cable to the color graphics adapter RGB port or CGA-compatible RGB port of a host IBM PC or compatible. A hand-held wireless remote controller enables walk-around operation so that graphics or other screen images can be selected and displayed as desired. Other features are also provided, such as split-screen images, image reversal, highlighting, adjustable screen contrast and an electronic pointer. In operation, the LCD projection pad is placed on an overhead projector in the manner as a transparency, which the LCD image resembles.

Using either presentation images prepared beforehand or images which demonstrate the real-time operation of demonstration software, the *Datashow* system represents the first phase of the electronic transparency. If true color eventually follows and the resolution increases beyond the $640 \times 200$ now offered, these units may also offer competition to projection TVs for various purposes. The base price of a single unit is $1270 and educational discounts are available through Pacific Crest Software, Inc., 887 N.W. Grant Avenue, Corvallis, OR 97330, telephone (503) 754-1067. I've seen a *Datashow* demonstrated, and agree with Jerry Pournell of *Inforworld* that "this product is going to have one mighty effect on education, starting with science and engineering, and then everywhere else."

## BANGALORE, INDIA EMC CONFERENCE UPDATE

The International Conference & Workshop on Electromagnetic Interference & Compatibility (INCEMIC) will be held on September 10 and 11, 1987, in Bangalore, India at the Hotel Taj Residency. The conference will be preceded by a three-day workshop on September 7, 8 and 9. The workshop/tutorials will cover EMC in digital circuits, EM coupling problems and transient suppression techniques.

The theme of the confrence is "EMC Design of Computer Systems." However, the Call for Papers issued by the Committee requested papers dealing with original work in the following and related fields: a) EMC analysis, b) EMC design and case histories, c) spectrum management, d) EMI coupling in cables and interconnects, e) EMI in communication systems, f) EMI measurements and measuring systems, g) EMP and related topics and h) transient/electrostatic discharge.

The revised schedule for the final Call for Papers is now: submission of 300-word summary/abstract by February 1, notification of acceptance by March 15, Author's Kit mailed March 30, last date of submission of camera-ready manuscripts is now June 15 and last date for advanced registration is August 20, 1987.

Abstracts and papers should be mailed to Dr. G.K. Deb, Convener, INCEMIC, LRDE, DRDO Complex, Byrasandra Village, Jeevan Bima Nagar; Bangalore—560 075 India or phone 562873.

English will be the official language for both the conference and workshops. A Spouse's Program and post-conference tours will be organized if there is sufficient interest. Non-Indian nationals must pay registration fees in U.S. dollars. There will be a ten percent rebate for members of IETE, IEEE AND IE(I). For more information on regular and student registration fees and hotel and hostel accommodations, please contact Dr. G.R. Nagabhushana, Convener, INCEMIC, Department of High Voltage Engineering, Indian Institute of Science, Bangalore—560 012, India, or telephone 364411, ext. 376, Telex 0845-8349 ISSc IN or telegraph Nagabhushana, High Voltage Science, Bangalore India.

## INTERFERENCE MEASUREMENTS

*Electromagnetic Compatibility and Interference Metrology* (TN 1099) includes the text material for a short course in EMC/EMI measurements presented by NBS. It sets out basic EMC measurements, and includes chapters on measurements made using transverse electromagnetic (TEM) cells, anechoic chambers, open fields, reverberating chambers and EM probes. Other chapters deal with measurement of the shielding effectiveness of materials, out-of-band EMC problems, conducted EMI and complicated electromagnetic environments. The publication is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, for $8.50 prepaid. (Order by stock no. 003-003-02760-0).

## SECTION 1706 OF THE TAX REFORM ACT OF 1986: AN IEEE POSITION STATEMENT

The Institute of Electrical and Electronics Engineers, Inc. opposes any legislation which singles out engineers, scientists and computer professionals for unfair or discriminatory treatment.

Section 1706 of the Tax Reform Act of 1986 specifically singles out, discriminates against and adversely and inequitably affects a specific segment of the nation's scientific, technical and engineering workforce by depriving them of rights to which they have been entitled under prior law and which continue to apply to taxpayers in other professions and occupations. More specifically, Section 1706 substitutes common law tests for past industry practice as the criteria to be used determining whether engineers, designers, drafters, computer programmers and systems analysts who provide services to clients of technical services firms are to be treated as employees or as independent contractors for the purpose of establishing liability for the payment of income, Social Security and unemployment taxes.

The short-term result of this legislation has been to create confusion and uncertainty about the employment status and attendant tax liability of thousands of engineers and computer specialists, many of whom are independent businessmen. The dislocation that Section 1706 will create will have a chilling effect on innovation and productivity throughout the nation's research and development community.

The ability of the United States to grow and prosper in an increasingly complex and competitive economy depends in no small part on our national strength in technical and scientific development. Instead of discriminating against and thereby preventing our innovators, engineers and scientists from becoming entrepreneurs, the American people must demand that our Federal tax policies support and encourage the efforts of such individuals to engage in private enterprise.

Section 1706 should be immediately repealed or amended so that it will apply fairly and equitably to all occupations.

The IEEE encourages all members to inform themselves about this new law and to communicate about it with their Senators and Representatives.

United States Activities Board
2/18/87

# EMC PERSONALITY PROFILE

by William G. Duff

## CLAYTON PAUL

Clayton joined the faculty of the Electrical Engineering Department at the University of Kentucky in 1971 after receiving the Ph.D. degree in Electrical Engineering from Purdue University in 1970. He is currently a Professor of Electrical Engineering there. He received the Bachelor of Science degree from The Citadel in 1963 and the Master of Science degree from Georgia Institute of Technology in 1964, all in Electrical Engineering.

Clayton says that his career is an example of how events shape one's career: a comment he has heard from others when he has asked "How did you get involved in EMC?" He enrolled at The Citadel in 1959 intending to make the U.S. Air Force a career and to "fly jets." He remembers that the day he enrolled, the person filling out his enrollment papers asked what specific discipline he wanted to enroll in. He replied that he "didn't care but just wanted to fly jets in the Air Force." Although he doesn't remember the exact statement, the person filling out his enrollment papers said something to the effect that "Son, you have to do something a bit more responsible than that. Do you want to be a doctor, lawyer or engineer?" At that moment he recalled having constructed a small transistor radio from plans that appeared in *Popular Electronics*. So he reasoned that selecting Electrical Engineering would "get that person off his back" and would be as good as any other choice until he was allowed to "fly jets." He made the Dean's List all semesters of his undergraduate career and began to think, "I might begin to like this." He turned down the offer of a pilot's commission in order to go to Georgia Tech for a Master's degree and that represented the "fork in the road" in his life.

His Ph.D. dissertation topic concerned automatic controls and linear systems. He had little interest in electromagnetic fields. In fact, he says that, like most of his colleagues, he despised the subject. However he was convinced that if he couldn't "fly jets," teaching in a university would be the next best thing. (At the time, he also thought that a university job would be better than "having to work for a living.") Unfortunately, 1970 was a bad year for entering the teaching profession. One day his major professor met him in the hall and asked if he wanted a post-doctoral fellowship for one year until the university job market improved. He immediately said yes. The professor inquired, "Don't you want to know what it concerns?" He replied, "No, I'm desperate." It turns out that the post-doctoral fellow work was in something called Electromagnetic Compatibility at an Air Force base. Despite his deep apprehension (since his old nemesis, electromagnetics, was in the title) he accepted the offer. As with other fairy tales, Clayton and EMC learned to live together happily ever after (or at least so far).

Clayton says that the moral to this story should be that no matter how well you think your life is planned, you can't be sure where events will lead you. So the best thing you can do is to prepare yourself with a solid understanding of basics in your education (even electromagnetic fields) in order to be prepared for wherever life's events lead you.

Clayton was recently elected a Fellow of the IEEE for "contributions to the understanding and solution of crosstalk problems in cable assemblies." He is active in the EMC Society and the Education Committee. He is Associate Editor for cables and grounding for the IEEE Transactions on EMC and has published over 100 papers, most of which concern EMC. He is also the author of three textbooks (two of which are in electromagnetic fields) and has two textbooks in preparation.

His family consists of a wife, who holds a Ph.D. in Finance and a law degree and is the Director of the Division of Securities for the state of Kentucky, and 17 children (six dogs and 11 cats). His nonprofessional interests consist of bass fishing (moderate success), playing bluegrass music (adequate but not outstanding talent) and flying (no bad landings yet). Yes, he actually did learn to fly. But he hasn't been able to find a jet in his price range.

# CHAPTER CHATTER

by Charles F. W. Anderson

First, my apologies to some of you. In the course of the recent move from Orlando to Maryland, part of the files got lost or mislaid. If those whose reports do not appear below will send me copies of the info, I'll get it into the next issue.

**NEW JERSEY COAST**

The November meeting featured a presentation by H.W. (Pete) Arnold (Bell Communications Research). His topic was "Radio Propagation in the Portable Communications Environment." The accompanying photo shows, right to left, the speaker and the Chapter officers: Chairman John Mumbauer (Honeywell), Vice-Chairman Tony Noerpel (Bell Communications Research) and Treasurer Mike Sligh (Honeywell). Thanks to Seymour Krevsky for the report.

The announcement of the Chapter's annual Christmas party arrived just a little too late for inclusion in the Winter 1987 issue. Later advice is that there were about twenty celebrants, and that Seymour Krevsky won the HP-15C calculator door prize! Thanks to EMC/VT/A&P Chapter Newsletter Editor Bob Davis (AEL) and to Seymour Krevsky for the inputs.

**TOKYO**

Our Far East colleagues' November meeting had an attendance of 65, of which 42 were guests. Among the papers presented was one on reduction of interference to TV reception caused by duct and sporadic-E propagation. The cancelling technique (developed by a team of NHK engineers) achieved reduction of beat-frequency interference of about 40dB. In another paper, use of silicon-avalanche diodes for ESD protection of IC cards was described. Of particular interest to EMCers in the Rocky Mountain and other snow-catch areas was a paper discussing propagation measurements on roads with high-snow sidewalls.

The January meeting included a paper on measurement of HF radio noise caused by the well-known "bullet" trains, and one on comparisons of calculated and measured field strengths of half-wave antennas installed on a metal ground plane. The measured and calculated values were within 2dB for vertical polarization and within 1dB for horizontal. Our thanks to Professor Echigo for the inputs.

**WASHINGTON/NORTHERN VIRGINIA**

The Chapter announced a meeting on March 12 at which the speaker was Gerome Reeve (NBS Boulder), who discussed developments in measurement of EM fields at the NBS laboratories. (Your Column Editor planned to attend, and should have a first-hand report for the next Newsletter).

Ballots for election of the '87/'88 officers have been distributed, as was the announcement of the Washington area Awards Dinner Dance to be held in April. Thanks to Jack Kelleher for the preceding.

# EMC STANDARDS ACTIVITIES

by Herbert K. Mertel

## ARE THERE IMMUNITY (SUSCEPTIBILITY) STANDARDS FOR CONSUMER & COMMERCIAL EQUIPMENTS?

### 1. Introduction

Microprocessor and digital circuitry is replacing the conventional electro-mechanical control and timing circuitry in nearly all equipments which use such circuitry. The older equipment performed these control functions at circuit voltages of 24 to 115 VRMS and was therefore relatively immune to the electromagnetic environment. The new circuitry often works at noise margins of 1 to 2 V peak. Consequently, a change in state from a "0" to a "1" may occur when low levels of additional noise are induced into the equipment from the typical electromagnetic environment of radiated and wire-conducted radio frequencies, magnetic fields, electrostatic and nearby lightning discharges and power line transients.

Upsets in the normal operation of the digital circuitry may result in an output which is undesirable. For most equipments such upsets will only cause an inconvenience. However, an upset in a vital equipment, such as a medical infusion controller or a reactor monitor, may cause a hazardous condition.

Manufacturers of digital equipment have realized for some time that the equipment must be immune to the normal (!) electromagnetic environment and they therefore test the equipment in such simulated fields. At the same time the manufacturers have been asking for an immunity standard which defines the test instrumentation and the stress levels.

The Accredited Standards Committee on EMC, C63, has had such a standard in progress since 1980. However, a draft copy has still not been approved for circulation. Since this is a voluntary effort, progress is slow and an immediate (1987) document is not expected. The primary problem with the national consensus approach is the requirement that the interests of all parties concerned must be considered. In the meantime, other organizations are releasing immunity standards which are being used. This paper summarizes the existing standards for commercial immunity requirements from international, national and industry organizations.

### 2. The Immunity Measurement Problem

The C63 study has defined the measurement problem as follows:

1) Establishing a known test level which describes the real world electromagnetic environment
2) Defining the field for repeatable stress levels
3) Exposing the entire equipment to a uniform field
4) Monitoring the degradation criteria
5) Establishing and maintaining an immunity test laboratory at minimum cost

### 3. Degradation Criteria

To perform meaningful immunity tests, the susceptibility characteristic of the equipment must be defined for the unwanted responses when exposed to the test requirement. C63 has established the following criteria:

Level 1: *No Degradation*
Equipment complies within design specifications.

Level 2: *Noticeable Degradation*
The equipment performance has been affected. However, the equipment continues to be functional without operator intervention. Examples are: increased noise in video or audio circuits, error rates below specified maximum, etc.

Level 3: *Serious Degradation*
The equipment does not provide satisfactory performance. Operator intervention is required to restore desired operation. Examples are: system lockups, resets, indiscriminate writing, altering memory, etc.

Level 4: *Failure*
Equipment is no longer functional. Normal operation cannot be restored. Equipment is taken out of service for repair.

### 4. Existing Immunity Specifications and Stress Levels

Some of the existing immunity specifications for commercial equipments are summarized in Table 1. Several of these documents have existed for many years, but the IEC 801 and the German, French and Swedish specifications were published during 1985 and 1986. The Swedish series of immunity documents, SEN SS 436-1523 (Radiated

| Standard or Specification | Radiated Susceptibility | Magnetic Susceptibility | RF Powerline Susceptibility | Powerline Transient | ESD |
|---|---|---|---|---|---|
| IEC 801, -1, -2, -3 | 1, 3 & 10 V/m 27-500 MHz | None | None | None | 2, 4, 8 & 10 kV 150 pF/150 Ohm 5 n-sec |
| CISPR Publication 1, 2 & 3 | 3 V/m 9 kHz-1,000 MHz | None | None | None | None |
| NEMA Standard XXX GFI | None | None | 0.5 VRMS 10-450 MHz | None | None |
| HEW MDS-201-0004 | 0.5-7 V/m 10 kHz-1 GHz | 120 dBpT 60 Hz | 1.5 to 4.5 V 100 Hz-30 MHz | 150 V pk 3/10 μsec | None |
| SAE J1113 | Not Specified 14 kHz-1 GHz | 200-80 dBpT 30 Hz-15 kHz | 200 W 30 Hz-100 MHz | 600 V pk 1/10 μsec | 15-20 kV 300 pF/5000 Ohm 34-60 mJ |
| SAE/AIR 1499 (Draft) | 5 V/m 0.15-3000 MHz | None | None | 400 V .05/10 μsec | 7 kV 100 pF/500 Ohms |
| SAMA PMC 33.11 1978 | 1-10 V/m 25-1000 MHz | None | None | None | None |
| FTZ 12R21 Part 10 Telephone Equipment, Germany | 1-10 V/m 10 kHz-150 MHz | None | 1.5-6 VRMS 10 kHz-150 MHz | 2,000 V 1.2/50 μsec 8/20 μsec | 5, 10 & 12 kV 150 pF/150 Ohm |
| SS 436 15 23E Sweden | 1, 3 & 10 V/m 25-500 MHz | None | None | 1-5 kV 1.2/50 μsec | 2-15 kV 150 pF/150 Ohm |
| C 98200 (Draft) Telephone Equipment, France | 1-3 V/m 10-500 MHz | None | 0.15-10 MHz 10-1 V | 500 V 5/100 n-sec | 8-15 kV 150 pF/150 Ohm |

**Table 1.** Summary of Some Existing Immunity Specifications.

Immunity), -1503 (Conducted Immunity) and -1522 (ESD) were developed by a Swedish committee with much practical insight. These documents could easily be used as a "World Standard" because of their detailed practicality. If one were to average and weigh the suggested parameters of Table 1, the following "Consensus" Immunity Standard could be developed. The levels listed represent the amplitude up to which no serious degradation is observed (Level 3).

**Radiated RFI Immunity (E-Field)**

Limit: 10 V/m, 25 to 500 MHz

Rationale: The amplitude of 10 V/m is listed in most specifications. It is observed from nearby portable and stationary transmitters. The frequency range of 25 MHz to 500 MHz is suggested because:

1) Below 25 MHz the fields are not coupled to the EUT. Therefore conducted RFI immunity tests will be performed.
2) Most susceptibility problems occur where the test sample and cabling approaches or is greater than ¼ of a wavelength. Testing at frequencies below 25 MHz and above 500 MHz is a waste of time and resources. It would be better instead to rescan the 25 to 500 MHz frequency range with various modulation types and different scan rates.

**Magnetic Immunity (H-Field)**

Limit: 160-124dBpT*, 50 Hz to 50 kHz

(*Decreasing 12dB per decade with increasing frequency)

Rationale: Leakage fields from magnetic devices are typically 120dBpT. Switching and flyback techniques tend to cause upsets in magnetic media or magnetic circuits.

**RF Power Line Immunity**

Limit: 5 Volts RMS, 10 kHz to 30 MHz

Rationale: RF signals can be induced and conducted onto power lines. The frequency range of 10 kHz to 30 MHz is used since the radiated E-Field test is performed above 25 MHz.

**Power Line Transient**

Limit: 500 Volts peak, 10/100 nanoseconds

Rationale: The small geometry electronic devices are upset by fast risetime signals. Transients with a 10 nanosecond risetime are generated by devices adjacent to the circuit that may be upset.

**Electrostatic Discharge**

Limit: 12 kV, 150 pF/150 ohms

Rationale: This ESD level is widely used by different organizations. It simulates the human discharge. For discharges from other objects and for lightning, higher energy levels may be required.

**5. Immunity Measurement Techniques**

The prevailing immunity measurement techniques are based upon the techniques of MIL-STD-462. These methods seem to be firmly entrenched because of the available test equipment. In some specifications, alternate methods such as the Crawford Cell are suggested for the radiated immunity test.

All specifications mention the importance of establishing known stress levels for repeatability of the immunity measurement. Consequently, the stress levels must not only be generated but must also be monitored for all immunity tests.

# BOOK REVIEWS

by Jim Hill, The EMXX Corp.

In this issue we review a book on shielding design by one of our EMC Society members, Don White. The book is timely in that it introduces the use of a software program for computer-aided shielding design for various applications. The review was prepared by Bob Haislmaier.

Our second review for this issue has been taken from *Computer,* the monthly magazine of the IEEE Computer Society. We thought the subject of this book, digital electronics, would be of interest to those of us who grew up with analog systems and are still looking to improve our familiarization with digital systems.

We solicit comments from our readers and suggestions for books which are of interest to members working in the EMC field.

## SHIELDING DESIGN METHODOLOGY AND PROCEDURES

by Donald R.J. White, MSEE/PE
Interference Control Technologies, Inc.
P.O. Box D
Gainesville, VA 22065

January 1986. $49.00

The fly-leaf correctly identifies this as a *Handbook* on Shielding Design Methodologies and Procedures. Don White wrote it to document his approach to the design of shielded boxes, cases and cabinets. It is the approach taught in the Interference Control Technologies (ICT) *Grounding and Shielding* course, and automated in the ICT software program *Design of Shielded Boxes* (#5500).

Using the proven method for effective teaching, the book first tells us what we are going to learn, then it teaches us, after which it tells us what we learned. Chapter One presents the process rationale and flow diagram for step-by-step design of shielding for a victim system, from requirements to finished cabinet. The design process and data consider electric fields only. Chapters Two, Three and Four present the gist of the process. Chapter Five repeats what has been said by calculating demonstration shielding designs. Chapter Six introduces the reader to the use of special 5500 software for computer-aided shielding design.

The first task of chapter Two is to specify the threat to the victim system. The book uses a table with seven columns spanning 10kHz to 10GHz by decade. If the radiated threat is not specified, parameters for typical sources are given. One is a table of field strengths from known licensed emitters as a function of distance, such as: paging and land mobile systems, amateur transmitters, AM, FM and TV broadcast stations, commercial and military navigational aids, ship harbor and military surveillance radars and air traffic control and weather radars. Tables are also given of spectral densities for a generic remote lightning stroke and for a generic electromagnetic pulse (EMP) from a high altitude nuclear burst. The reader is shown how to make adjustments for attenuation of threat field levels when penetrating buildings and vehicles housing the victim to be shielded. Finally, some equations are given to help calculate the conducted threat to the victim, namely energy coupled from threat fields to wires and cables connected to the victim.

The second task is to determine the susceptibility of the victim system. The book offers broad brush help—bandwidth-limited white noise (N) for analog devices and noise-immunity level (NIL) for typical logic families. Threat/susceptibility ratios are used to calculate shielding effectiveness requirements for the box. A design margin is added to arrive at shielding effectiveness objectives.

Chapter Three deals with shielding design of the box. Six types of box skin are considered, ranging from sheet-metal through wire mesh, conductive plastic and metallized plastic to metal-framed plastic. Rule-of-thumb data comes from various sources, such as another ICT book, *Electromagnetic Shielding Materials and Performance.*

Chapter Four grapples with reality. Boxes cannot be both solid and useful. Real boxes must have construction seams and holes for meters, fans, switches, fuses, connectors, etc. The task is to determine to what extent the shielding effectiveness calculated in chapter Three is degraded by leakage through these breaches. Avoiding the temptation to follow the spoor of aperture coupling theorists into the forest of Greens functions, the book presents summary tables, formulas and rules of thumb adequate for the engineering job at hand. Sections deal with leakage from single and multiple apertures and specific calculations for slots, cooling apertures, screen mesh, mating panel members and convection cooling slots. Openings for displays, switches, connectors, etc, are

treated as slots of circular cross section. As the reader follows through the treatment of leakages in the shield trauma sets in when he is brought up short in the discussion of mating panel members (e.g. covers) by being told, "Since EMI gaskets are discussed in length elsewhere in the literature, they are not described here." Up to this point in the book, just about anything the designer needs is at least summarized for ready reference, including libraries of esoteric calculations of coupling through apertures. Because a gasket can be the Achilles heel of shielded box design, we do hope that an addendum will soon be issued to guide readers with the data they need for design.

Test time arrives in Chapter Five with a sample calculation of a typical box. Thanks to a well-designed worksheet, sources of failure to meet shielding effectiveness requirements are easily detected, additional EMI control measures applied and shielding effectiveness recalculated. The process is iterated until a product emerges for which shielding effectiveness is neither less than, nor much more than, the requirement established at the outset. This ability to apply the design process iteratively makes it readily applicable also to retrofit design of shielded boxes. What are now needed are laboratory data to validate the procedure/data presented in the book.

The book is written clearly. It starts out in White's characteristic homey style, but yields quickly to the editor's truncation for brevity and conciseness. Typical of most first editions, some editorial glitches slipped through, such as the reference in section 5.1.3A to illustrative example 4.4 rather than to 4.3, which makes more sense.

All things considered, this is a good book which can help the design and packaging engineers make an adequately shielded box for sensitive equipment even though they are not versed in EMI control. That alone justifies it.

Reviewed by
Dr. Robert J. Haislmaier
3021 Gumwood Drive
Hyattsville, MD 20783

## FUNDAMENTALS OF DIGITAL ELECTRONICS

by George Rutkowski and Jerome Oleksy
Prentice-Hall, Englewood Cliffs, NJ
1985, 273 pp., $24.95

(Reprinted from the IEEE Computer Society Magazine, *Computer* January, 1987)

Targeted to technicians in industry, this book can also be used as a primer for undergraduate students having trouble understanding digital concepts. The authors, in a summary of their goals, have expressed the need to teach digital electronics in an interesting and dynamic way by including easy-to-visualize problems and "many blinking lights" in the laboratory experiments. The line diagrams are clear and easy to understand, and the chapter summaries at the end of each chapter provide a quick overview.

The philosophy of the authors has been to provide hands-on experience immediately after exposure to the concepts in the text and, in this way, to produce a technician who is not just a textbook expert but also is actually familiar with the hardware.

Some highlights: Chapter One deals with diodes and their applications, Chapter Two with transistors and their applications and Chapter Three with field-effect transistors for logic circuits. A brief introduction is given in each chapter. Chapter Three mentions the construction and behavior of the FET. Practical CMOS inverters and ICs are also discussed, and a quiz is provided at the end of the text to test understanding of the material. Finally, toward the end of the chapter, two experiments are treated in detail.

Other chapters deal with monostables, counters, flip-flops, square-wave generators, gates and binary numbers. I think it would be unreasonable to expect a chapter on microprocessors that could do justice to the subject, but it is an inescapable fact that microprocessors have become an integral part of digital electronics.

Chapter Sixteen on digital applications ties together many concepts and circuits introduced in previous chapters. The aim of the authors in this final chapter is to familiarize the student with complete digital systems and with the interaction of several circuits working together to do a task.

I think the authors have succeeded in their goal of exposing the student to a broad range of digital fundamentals and hardware, while preparing them to easily adapt to more extensive systems. However, I did not quite understand how the book encourages teamwork, one of the authors' stated goals. Synergy is an attitude that cannot, perhaps, be taught so easily. On the whole, the authors should be congratulated on an important job well done.

Reviewed by
Chanden Sen
Research Triangle Institute

## 24th ANNUAL CONFERENCE ON NUCLEAR AND SPACE RADIATION EFFECTS IN ELECTRONICS

The NSREC will be held at Snowmass Village, Colorado. It will be sponsored by the Radiation Effects Committee of the IEEE Nuclear and Plasma Sciences Society and co-sponsored by DNA/DOD, SNL/DOE and JPL/NASA. The program, consisting of eight to ten sessions of contributed papers, several invited papers, a panel discussion and a poster session including demonstrations, will be held July 28 through July 31, 1987.

The conference will cover the impact of hazardous and extreme environments including nuclear and space radiation, electromagnetic pulse (IEMP, SGEMP and SREMP) and interference, temperature and pressure extremes and shock on electronic devices, materials, circuits and systems. Semiconductor processing technology and techniques for producing radiation-tolerant, highly-reliable devices, integrated circuits and sensors will also be included.

A tutorial Short Course on the effects of radiation and other hazardous environments on electronic devices and circuits will be offered on July 27. This course will provide an excellent foundation for applying the broad range of technical information presented in the conference. Tentative topics include:

- **Interactions of hazardous environments with electronic devices**
- **Hardened technologies for hazardous environments**
- **Circuit designs for reliable operation in hazardous environments**
- **Packaging, testing and hardness assurance**

General inquiries may be directed to the Publicity Chairman, David W. Bushmire, Sandia National Laboratories, DW 2157, Albuquerque, NM 87185, telephone (505) 844-6572.

As usual, this conference is held at a place highly suitable for family vacationing. Aspen/Snowmass has activities going on across a wide spectrum from athletics to dance and ballet. There will be a western barbecue and tours.

## IEEE/EAB CREATES VIDEOTAPE LIBRARY

The Educational Activities Board of the IEEE announces the creation of an IEEE Videotape Library. The purpose of the Library will be to collect videotapes of engineering-related courses, presentations, seminars and other materials from sections, societies and other groups which will then be made available to IEEE members and sections.

To encourage wide use of the tapes, fees for use of the tapes from the granting source are discouraged. The Library will charge fees to cover the cost of duplicating, handling, replacement and other services necessary to operate the Library. It is expected that no more than $30 will be charged for a tape rental. The IEEE/EAB Library will provide a listing of available engineering-related tapes upon request. A release granting permission to copy the tapes and circulate them must be provided by anyone presenting tapes to the Library. Any organization, company or IEEE group which has tapes they wish to provide are encouraged to contact Dr. Robert G. Kahrmann in the IEEE Education Department, 445 Hoes Lane, Piscataway, NJ 08854-4150 or telephone (201) 981-0060, ext. 410.

## PROCEEDINGS OF THE EIGHTH INTERNATIONAL WROCLAW SYMPOSIUM ON EMC STILL AVAILABLE

The eighth Wroclaw Poland EMC Symposium was held at the Wroclaw Technical University, Institute of Telecommunications, June 24–26, 1986. This meeting is held in even-numbered years, alternating with the Swiss Technical University sponsored EMC Symposium, which has been held in Zurich since 1981. The 1987 Zurich symposium took place on March 3–5.

The three-volume proceedings of the Wroclaw Symposium were reviewed on page 15 of the last issue (Winter 1987) of this Newsletter. Authors of the 130 papers included represent 19 countries, some new to the EMC community. The countries represented are Poland, the Netherlands, Japan, U.S.S.R., U.S.A., Bulgaria, Italy, United Kingdom, German Democratic Republic, Federal Republic of Germany, Czeckoslovakia, Libya, Spain, France, India, Sweden, Hungary, China and Malaysia. The 215 attendees represented these countries, as well as Vietnam and Jordan. Eighty of the papers are in English and 50 in Russian. At the symposium, simultaneous translations were available in both languages. In the proceedings each paper is accompanied by a summary or abstract with the figure titles translated. Translations of the Russian papers can be arranged with Dr. P.S. Excell of the University of Bradford, Bradford, West Yorkshire, BD7 IDP, United Kingdom, telephone +44 274 733466, Ext. 263/232, Telex 51309 UNIBFD G. (see Newsletter Issue No. 124, Book Review, page 7 for details).

Copies of the 1191-page proceedings are still available from the EMXX Corporation, 6706 Deland Drive, Springfield, VA, telephone (703) 451-4619. For shipment in the U.S.A., Canada or Mexico send a check in the amount of $30.00 made payable to the "IEEE EMC Society." For shipment to other countries add $6.00 for additional postage.

## 1987 URSI GENERAL ASSEMBLY TRAVEL INFORMATION

The XXIInd General Assembly of the International Radio Science Union (URSI) will be held in Tel Aviv, Israel, August 24–September 2, 1987. A blue "First Announcement" booklet, describing the General Assembly and the technical program and providing registration and travel information, has been distributed. Copies are available from the Secretariat, URSI General Assembly, POB 50006, Tel Aviv 61500, Israel, telephone 03-65471, Telex 341171 KENS IL.

Kenes Travel of Israel is the agency identified in this announcement for those wishing to use their services in connection with travel. Note, however, that their United States representative is no longer that given in the above First Announcement. Their U.S. representative is now the following:

Mr. Gilbert Garber
Garber Travel
1047 Commonwealth Avenue
Boston, MA 02215
Telephone: (617) 787-0600
Telex: 200230 GARBUR
Cable: GARTRAV

Mailing address: P.O. Box 404
Brookline, MA 02146

(Reprinted from the IEEE Antennas and Propagation Newsletter, February, 1987)

## A GUIDE TO IEEE PROGRAM RESOURCES

The Regional Activities Board is offering a new brochure entitled *A Guide to IEEE Program Resources.* Its purpose is to provide a convenient source of information on IEEE audiovisual presentations and Technical Society Distinguished Lecturer Programs—especially for Section, Chapter and Student Branch program planners and others.

The *Guide* contains a listing of IEEE-produced 16mm films, slide/audiotape presentations and videotapes, including a brief description and ordering information for each. IEEE Technical Societies that sponsor Distinguished Lecturer Programs are also listed, along with the names and telephone numbers of the program coordinators. To receive a copy, contact the IEEE Service Center, 445 Hoes Lane, Piscataway, New Jersey 08854, or telephone (201) 981-0060.

## GUIDE TO CALIBRATION SERVICES

The physical measurement services of NBS are designed to help the makers and users of precision measurements achieve the highest possible levels of measurement quality and productivity. The Commerce Department's National Bureau of Standards (NBS) has published a new free "users guide" listing calibration services, special test services and measurement assurance programs (MAPs) available from the Bureau.

The hundreds of individual services described in the guide are the most accurate calibrations of their type available in the United States. The calibrations directly link a customer's precision equipment or transfer standards to national measurement standards. The calibrations and special tests include NBS services that check, adjust or characterize instruments, devices and sets of standards. The MAPs are quality control programs for calibrating a customer's entire measurement system.

Electromagnetic measurement calibration areas include ac, dc, RF and microwave. Other areas include dimensional, mechanical and thermodynamic. The guide explains fees, types of services, measurement criteria, reports of test results, references to NBS in advertisements, traceability of calibrations and shipment of equipment. A fee schedule for the calibration services is published every six months as a supplement. Free copies of the new *NBS Calibration Services Users Guide* (SP 250) are available from the Office of Physical Measurement Services, B362 Physics Building, National Bureau of Standards, Gaithersburg, MD 20899 or telephone (301) 921-2805.

## ASSESSING ELECTROEXPLOSIVE DEVICE VULNERABILITY

Hot-wire electroexplosive devices (EEDs) are electrically fired explosive initiators. They are used as automotive air bag initiators, separation devices in aerospace applications (explosive bolts), and many other military, mining, and construction applications. A new and rigorous approach for assessing an EED's vulnerability to pulsed electromagnetic interference is given in *A Statistical Characterization of Electroexplosive Devices Relevant to Electromagnetic Compatibility Assessment* (TN 1094).

This method uses statistical theory and thermodynamic modeling to determine the probability that an electrical pulse of a given duration and power will detonate the EED, and to determine thermodynamic parameters. The "Firing Likelihood Plot" is introduced to represent an EED's characteristic in a readily interpretable manner. The report can be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, for $2.75 prepaid. (Order by stock no. 003-003-02744-8).

# CALENDAR
# 1987

June 1-3

IEEE Vehicular Technology Conference
Holiday Inn Hotel & Conference Center
Tampa, FL
Contact: Professor Gerard Lachs
Dept. of Electrical Engineering
University of South Florida
Tampa, FL 33620
(813) 626-7111

June 15-19

1987 IEEE Antenna and Propagation Society Symposium and International Union of Radio Science (URSI) Meeting
Virginia Polytechnic Institute and State University
Blacksburg, VA
Contact: Warren L. Stutzman
Department of Electrical Engineering
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061
Telephone: (703) 961-6835

July 28-31

24th Annual Conference on Nuclear and Space Radiation Effects in Electronics
Snowmass Village, CO
Contact: David W. Bushmire
Sandia National Laboratories
DW 2157
Albuquerque, NM 87185
Telephone (505) 844-6572

August 25-27

IEEE International Symposium on EMC
Marriott Downtown
Atlanta, GA
Contact: Hugh W. Denny
Telephone: (404) 894-3535

August 25-28

COMPUMAG 87 Conference on the Computation of Electromagnetic Fields
Graz, Austria
Contact: K. Preis, M. Konigswieser
INTERCONVENTION
P. O. Box 80
A-1107 Vienna, Austria

August 25-September 2

22nd General Assembly of URSI
Tel Aviv Hilton & Tel Aviv Palace Hotels
Tel Aviv, Isreal

Contact: Secretariat
URSI General Assembly
P. O. Box 50006
Tel Aviv 61500, Israel
Telephone: 03-654571
Telex: 341171 KENS IL.

September 7-10

17th European Microwave Conference
Ergife Palace Hotel
Rome, Italy
Contact: Professor F. Fedi
17th European Microwave Conference
Fondazione "Ugo Bordoni"
Via Baldassarre Castiglione, 59
00142 Roma, Italy

September 7–9

INCEMIC Workshops (see below)

September 10–11

International Conference on EMI & Compatibility (INCEMIC)
Bangalore, India
Contact: G.R. Nagabhushana
Convener, INCEMIC
Department of High Voltage Engineering
Indian Institute of Science
Bangalore-560 012, India
Telephone: 364411, ext. 376
Telex: 0845-8349 Issc IN
Telegraph: Nagabhushana
High Voltage Science
Bangalore India

# EMCABS

In this issue, we are publishing 36 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.

MELVIN J. JOHNSON

L.F. Babcock, Ford Aerospace Textron
E.L. Bronaugh, Electro-Metrics/Penril Corp.
R.N. Hokkanen, Harris Corporation
R. Jacobson, Sperry Flight System
S. Kuniyoshi, Naval Sea Systems Command
D.R. Kerns, Southwest Research Institute
R.B. Schulz, Xerox Corp./Off. Products 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: 01-02-87**

Response of Coaxial Cable Over a Finite Ground Plane to an External Electromagnetic Field

Jian-hua Guo* and R.M. Showers**
*Designing Institute of the Ministry of Posts and Communications, CHINA
**Moore School of Electrical Engineering,
U. of Pennsylvania, Philadelphia, PA 19104

1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0220, September 16-18, 1986, pp. 220-224

**ABSTRACT:** The resonance properties of a coaxial cable over a restricted ground "plane" structure to an externally impressed field are discussed. Experimental data have been obtained as the size of the ground structure was varied. The advantages of multipoint grounding are indicated in a quantitative manner.

**INDEX TERMS:** Coaxial cable, impressed field, ground, multipoint grounding

**EMCABS: 02-02-87**

Electromagnetic Field-to-Wire Coupling in the SHF Frequency Range and Beyond

A.T. Adams, J. Perini, M. Miyabayashi, D.H. Shau, and K. Heidary
Department of Electrical and Computer Engineering,
Syracuse University, Syracuse, NY 13210

1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0213, September 16-18, 1986, pp. 213-219

**ABSTRACT:** Methods are shown for the treatment of field-to-wire coupling at SHF frequencies and beyond. Uniform and non-uniform transmission lines and coaxial multiconductor transmission lines have been examined. Current distributions are predominantly of a standing-wave or traveling-wave form. The higher order modes are not significant for those cases examined. Bounds may be obtained for induced currents in the field-to-wire problem by considering the transmission line as a receiving antenna. The behavior of the elements of the equivalent circuits are found to be predictable from computations or measurements at relatively low frequencies. The maximum value of induced current under conditions of maximum susceptibility is shown to vary little with frequency.

**INDEX TERMS:** Field-to-wire coupling, SHF, coaxial transmission lines, multiconductor transmission lines, standing-wave, traveling-wave, induced currents, susceptibility

**EMCABS: 03-02-87**

Radiation Model of Finite-Length Transmission Lines

Yoshio Kami* and Risaburo Sato**
*Jr. Technical College of Electrocommunications, JAPAN
**Faculty of Engineering, Tohokugakuin University, JAPAN

1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0206, September 16-18, 1986, pp. 206-212

**ABSTRACT:** Radiation from transmission lines of finite length is developed using a circuit-concept. Estimation of radiation power received in an antenna load is derived under the hypothetical theorem of reciprocity between "the coupling of external waves to transmission lines" and "the radiation from transmission lines." The fit of experimental results to the estimation confirms the reciprocity theorem, so that the prediction of radiation field can be carried out.

**INDEX TERMS:** Radiation, transmission lines, antenna load, reciprocity, coupling

**EMCABS: 04-02-87**

Use of Synthesized System Models and Frequency-Distance Criteria for a Parameter Sensitive Interference Prediction Model Developed for Tactical Radio Environment

Lt. Col. P.S. Gill
Faculty of EMC, MCTE-MHOW (MP) INDIA 453441

1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0201, September 16-18, 1986, pp. 201-205

**ABSTRACT:** The mathematical interference prediction model based on synthesized transmitter and receiver response evaluates the Freqency-Distance (F-D) separation criteria for electromagnetic compatibility for tactical radio (30-1000 MHz) environment. The synthesized modulation envelope at the fundamental tuned frequency of the culprit emitter is also transferred to harmonically/sub-harmonically related frequencies of the culprit emitter to construct the composite emission spectra. For many emitter/receptor combinations the F-D templates are superimposed for predicting compatibility. The model is parameter sensitive. The synthesized slopes when replaced with measured slopes will reduce the statistical deviations. The model utilizes the statistical descriptions of the individual contributors of interference.

**INDEX TERMS:** Interference, synthesized transmitter, receiver, Frequency-Distance (F-D) separation, electromagnetic compatibility, tactical radio, synthesized, emission spectra

**EMCABS: 05-02-87**

Overview of a Wideband Communications EMC Analysis System

M.N. Lustgarten and M.A. Maiuzzo*, J.W. Rockaway and S.T. Li**
*ECAC/IIT Research Institute, Annapolis, MD 21402
**Naval Ocean Systems Center, San Diego, CA 92152

1986 IEEE International Symposium on Electromagnetic Compatibility

September 16-18, 1986, pp. 196-200

**ABSTRACT:** This paper outlines the previously unpublished portion of a topside EMC analysis program applicable to a wideband HF communications system. That portion consists of procedures for predicting antenna-to-antenna coupling loss (including mismatch effects) and nonlinear effects in the preamplifier, associated with the receiving antenna and in receiving system multicouplers.

**INDEX TERMS:** EMC analysis, HF communications system, antenna-to-antenna coupling loss, mismatch effects, nonlinear effects, antenna, multicouplers

**EMCABS: 06-02-87**

Modeling of a Bulk Current Injection Setup for Susceptibility Threshold Measurements

Michel F. Sultan
Electronics Department, General Motors Research Laboratories,
Warren, MI 48090-9055

1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0188, September 16-18, 1986, pp. 188-195

**ABSTRACT:** A mathematical model is formulated for a Bulk Current Injection (BCI) setup to evaluate the susceptibility of electronic components to electromagnetic interference. A comparison of calculated and measured data shows that the model predicts current distributions with reasonable accuracy. The sensitivity of standing wave patterns to a number of parameters has been investigated. This information can be used to reduce measurement variability and increase the correlatability of BCI results with measurements from other techniques.

**INDEX TERMS:** Mathematical model, Bulk Current Injection (BCI), susceptibility, electromagnetic interference, measured data, current distributions, standing wave

**EMCABS: 07-02-87**

Cross-Polarization Components in Inter-Antenna Coupling Calculations
Asoke K. Bhattacharyya and Stanley J. Kubina
Concordia University/Loyola Campus, EMC Laboratory/Electrical Engineering, 7141 Sherbrooke St. W., Montreal, Quebec, CANADA H4B 1R6
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0184, September 16-18, 1986, pp. 184-187
**ABSTRACT:** This paper examines the co- and cross-polar characteristics of antennas on the surface of a cylinder when the transmitting antenna and the observer are arbitrarily positioned. The theory is based on the analytical approach used by Pathak and Wang for the fields of a source radiating on a convex surface. It takes care of torsion. There is a different cross-polarization effect when both the transmitting and the receiving antennas are in the equatorial planes. The cross-polarized components $E_{z,\rho}$ and $E_{\rho,z}$ are not zeros even in the equatorial planes. The cross-polarized ratios have been computed and their variations with different parameters are presented.
**INDEX TERMS:** Inter-antenna coupling, antenna, fields, cross-polarization, cross-polarized

**EMCABS: 08-02-87**

Assessment of Communication System Susceptibility to the PAVE PAWS Radar
Ernest E. Donaldson, Jr.* and Robert P. Burdett, Jr.**
*Georgia Tech Research Institute, Atlanta, GA 30332
**Telecommunication Department, Georgia Power Company, Atlanta, GA 30303
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0176, September 16-18, 1986, pp. 176-183
**ABSTRACT:** This paper summarizes the results of a program directed to an assessment of the potential for interference to Georgia Power Company communications systems from the PAVE PAWS radar at Robins Air Force Base, Georgia. Susceptibility data were recorded on selected UHF and microwave receivers and compared to predicted PAVE PAWS field strength levels to identify potential interference problems. Several potential problems were identified which must be addressed to preclude PAVE PAWS related interference effects on communication system performance.
**INDEX TERMS:** Interference, communications system, PAVE PAWS radar, susceptibility, field strength levels, communication system

**EMCABS: 09-02-87**

Analysis of N-Conductor Transmission Line Systems with Non-Linear Loads with Application to CAD Design of Digital Circuits
Steven P. Castillo, Chi H. Chan, and Raj Mittra
University of Illinois, 1406 West Green Street, Urbana, IL 61801
1986 International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0174, September 16-18, 1986, pp. 174-175
**ABSTRACT:** A computer model has been developed for simulating N-conductor transmission lines terminated with non-linear complex loads. A model analysis is used to describe incident and reflected waves on the transmission lines. The loads are modeled as parallel R-C networks with a voltage dependent resistance and source. For each load a matrix differential equation is written for the unknown load voltage due to some incident voltage. The matrix equation is solved numerically using a first order finite difference approximation.
**INDEX TERMS:** N-conductor transmission lines, complex loads, incident and reflected waves, transmission lines, parallel R-C networks, matrix equation

**EMCABS: 10-02-87**

Prediction of Conducted Emissions in Switched Mode Power Supplies
Mark J. Nave
E-Systems, Inc., ECI Division, P.O. Box 12248, St. Pettersburg, FL 33733-2248
1986 International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0167, September 16-18, 1986, pp. 167-173
**ABSTRACT:** The article discusses the generation and modeling of EMI in switched mode power supplies. Other authors have investigated the mechanism of generation of EMI in switched mode power supplies, but no model has been advanced to predict what the emanations will be. Discussion of common mode and differential mode noise is given, and a method for developing quick predictions in the frequency domain is given.
**INDEX TERMS:** EMI, switched mode power supplies, common mode, differential mode, noise, frequency domain

**EMCABS: 11-02-87**

A Positive Step Toward the EMC Education
Vichate Ungvichian
Department of Electrical and Computer Engineering, Florida Atlantic University, Boca Raton, FL 33431
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0249, September 16-18, 1986, pp. 249-250
**ABSTRACT:** In the past years Electromagnetic Compatibility (EMC) has become an important subject for the electronic industry as well as for U.S. and foreign government agencies. Many of the new EE graduates are not familiar with the EMC problems involving electromagnetic radiation and susceptibility of printed circuit boards and power supplies. Florida Atlantic University (FAU) is located on the Florida Gold Coast, where there is a high concentration of electronic industry with a demand for education in the EMC area. This paper which details the course structure, problems, such as prerequisites, and some solutions is a result of a one-semester course taught in the Spring of 1985.
**INDEX TERMS:** Electromagnetic compatibility, industry, government agencies, electromagnetic radiation, susceptibility, printed circuit boards, power supplies

**EMCABS: 12-02-87**

Linking Training to On-the-Job Performance
Gregory V. Gore
R&B Enterprises, 20 Clipper Road, West Conshohocken, PA 19428
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0247, September 16-18, 1986, pp. 247-248
**ABSTRACT:** Ideally, the only way to link training to job performance is to measure performance before and after the training process. In reality, such measurement would be both costly and difficult to perform. Moreover, intangibles that lead to performance such as motivation and enthusiasm cannot be measured at all. There are, however, practical guidelines that managers and prospective students can follow to link training to performance. This paper presents six guidelines which form the basis for turning training into job performance.
**INDEX TERMS:** Training, job performance, training process, guidelines, managers, students

**EMCABS: 13-02-87**

The Value and Methods of Evaluation of Computer Aided Design in the Classroom
John D.M. Osburn and Ronald R.J. White
Interference Control Technologies, Inc., Don White Consultants, Inc. (Subsidiary), Gainesville, VA 22065
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0244, September 16-18, 1986, pp. 244-246

**ABSTRACT:** The effectiveness of training and devices or methodology used to support training (training aids) are often discussed but, to date, actual evaluation of learning effectiveness is subjective. The use of Computer Aided Design (CAD) to support EMC education is a case in point. For specialized EMC training, this paper reviews traditional instructional approaches, CAD augmentation of such instruction and suggests an evaluation method that quantifies the performance of CAD as a training aid.

**INDEX TERMS:** Training, methodology, support training, (Training Aids), Computer Aided Design (CAD), EMC, education

**EMCABS: 14-02-87**

An Undergraduate Course in Electromagnetic Compatibility
Clayton R. Paul
Department of Electrical Engineering, University of Kentucky, Lexington, KY 40506
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0235, September 16-18, 1986, pp. 235-239

**ABSTRACT:** This paper describes the establishment, content and experience with an undergraduate course in Electromagnetic Compatibility in the Electrical Engineering program at the University of Kentucky that contains several innovative features designed to stimulate student interest and to enhance learning and principles. Several small laboratory experiments are used throughout the course to give hands-on experience with modern test equipment and to illustrate the basic principles. Students are required to construct a simple digital device and incorporate the EMC design principles of the course in order to have it pass the FCC Class B radiated and conducted emissions tests. A key ingredient in the success of this course is the cooperation and encouragement of the Information Products Division of IBM at Lexington.

**INDEX TERMS:** Undergraduate course, electromagnetic compatibility, electrical engineering, laboratory experiments, hands-on, digital device, EMC design, FCC Class B, radiated, conducted, emissions

**EMCABS: 15-02-87**

Calculation and Reduction of Low-Frequency Magnetic Fields Caused by Power Supply Systems
Rwth Aachen, Matthias Ehrich, and F.H. Bielefeld
Institut fuer Theoretische Elektrotechnik, Kopernikus-St. 16, D 5100 Aachen, West Germany
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0225, September 16-18, 1986, pp. 225-234

**ABSTRACT:** The use of sensitive measuring devices in big buildings can be restricted by power supply system component magnetic fields. The paper contains the derivation of simple far field models for bus bars, transformers, power cables and distributors. These models, numerically evaluated by a system of computer programs, were used to reorganize the power network of Germany's biggest hospital located in Aachen. The software enables the user to modify the components of the power system by simulation and thus to eliminate the magnetic disturbance in certain areas of the building. For this the distribution of magnetic induction for interesting cross-sections of the building is displayed in the form of maps, where the cross-sections are divided into grid squares which show the maximum of magnetic induction calculated for the center of each square.

**INDEX TERMS:** Magnetic fields, power supply, bus bars, transformers, power cables, distributors, numerical, computer programs, power network, hospital, magnetic induction

**EMCABS: 16-02-87**

Shielding Effectiveness Measurements Using an Apertured TEM Cell in a Reverberation Chamber
P.F. Wilson and M.T. Ma
Electromagnetic Fields Division, National Bureau of Standards, Boulder, CO 80303
1986 IEEE International Symposium on Electromagnetic Compatibility
U.S. Government work not protected by U.S. Copyright September 16-18, 1986, pp. 265-269

**ABSTRACT:** Measurements of near-field shielding effectiveness are performed in a reverberation chamber using an apertured transverse electromagnetic cell as the receiver. This configuration allows one to investigate the electric- and magnetic-field shielding properties of a material simultaneously. Coupling to the cell is modeled using small-aperture theory, and predicted results agree well with measured data.

**INDEX TERMS:** Near-field shielding effectiveness, reverberation chamber, transverse electromagnetic cell, electric- and magnetic-field shielding, material, small-aperture theory, measured data

**EMCABS: 17-02-87**

Shielding Effectiveness Measurements with a Duel TEM Cell and a Split TEM Cell
S. Kashyap
Division of Electrical Engineering, National Research Council of Canada, Ottawa, Ontario, CANADA K1A 0R8
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0262, September 16-18, 1986, pp. 262-264

**ABSTRACT:** This paper deals with the measurement of shielding effectiveness of various materials using a dual TEM cell and a split TEM cell. Comparison is made between the measurements made with the split TEM cell and those using the shielded room aproach.

**INDEX TERMS:** Measurement, shielding effectiveness, materials, dual TEM cell, split TEM cell, shielded room

**EMCABS: 18-02-87**

Generation of Electromagnetic Fields That Have a Variable Impedance for the Testing of a Magnetic Field Sensor
Mark Terrien
Hewlett-Packard Company, Signal Analysis Division, 1212 Valley House Drive, Rohnert Park, CA 94928-4999
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0251, September 16-18, 1986, pp. 251-255

**ABSTRACT:** A method for electronically varying the impedance of an electromagnetic field is discussed. The theory is presented followed by its application to the error testing of the HP 11940A Close-Field Probe. Applications to other forms of susceptibility testing are also discussed.

**INDEX TERMS:** Impedance, electromagnetic field, theory, application, error testing, Close-Field Probe, susceptibility testing

Application of a Rigorous Systems Engineering Process and Statistical Tools to the Definition and Solution of EMI Problems

**EMCABS: 19-02-87**

Walter V. Holmes
Atlantic Research Corporation, 5390 Cherokee Avenue,
Alexandria, VA 22312
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0322, September 16-18, 1986, pp. 322-328
**ABSTRACT:** A rigorous systems engineering process (SEP) was applied to investigate, define and solve a widespread EMI problem that existed in the U.S. Fleet. Extensive problem definition led to the identification and characterization of two separate and distinct interference mechanisms, involving multiple coupling paths and performance degradation effects. Following problem definition, eight solution approaches were identified and assessed, from which viable potential solution alternatives were developed and tested, and evaluated for their effectiveness. In what is believed to be a novel application of statistical regression analysis tools to EMI, a model was formulated to examine the correlation between interference parameters. Solution effectiveness test results confirmed the results of the analytical approach.
**INDEX TERMS:** Systems engineering process (SEP), EMI, interference mechanisms, multiple coupling paths, performance degradation effects, statistical regression analysis, solution effectiveness, EMI 'fixes'

A Model for Predicting Changes in the Probability of Television Interference by Industrial, Scientific, and Medical (ISM) Equipment

**EMCABS: 20-02-87**

Daniel I. Weinberg, Sr. Engineer, IBM Corporation*
T. Lamont Wilson, Consultant-Dielectric Heating
*IBM Corp., 1311 Mamaroneck Avenue, White Plains, NY 10605
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0313, September 16-18, 1986, pp. 313-321
**ABSTRACT:** This model compares the probability of television reception interference from ISM equipment operating under theoretical "worst case" conditions (an isotropic radiator which radiates continuously at the maximum permitted emission) to that from ISM equipment operating under realistic conditions (e.g., lobed emission pattern, power variation, duty cycle less than 100%). One can calculate the change in effective emission of ISM equipment, in dB($\mu$V/m), which provides the same change in probability of interference as does the change in these "probability" operating conditions from theoretical "worst case" to realistic. The model shows that the emission limit developed using the "worst case" assumptions can be increased by at least 23dB($\mu$V/m) by including the probability operating conditions.
**INDEX TERMS:** Emission limits, ISM equipment, operating probabilities, operating power, non-isotropic radiation patterns, duty cycle, television reception interference, isotropic radiator

**EMCABS: 21-02-87**

Shielding Characteristics of Honeycomb Filters

George M. Kunkel
Spira Manufacturing Corporation, North Hollywood, CA
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0299, September 16-18, 1986, pp. 299-303
**ABSTRACT:** The EMI/RFI shielding provided by honeycomb filters are a function of many variables. These variables include the cell size of the honeycomb material, the thickness, the honeycomb material composition and fabrication methods, as well as the impedance between the honeycomb material and the frame, and between the frame and the chassis. The selection of the variables used in the fabrication of the filters is usually dictated by cost and/or convenience pertaining to fabrication methods, at the expense of the shielding effectiveness of the filter. This paper evaluates the various fabrication methods used in the manufacture of filters, some testing to substantiate the fabrication methods evaluated and specific conclusions.
**INDEX TERMS:** EMI/RFI shielding, honeycomb filters, cell size, honeycomb material, composition, fabrication methods, impedance, shielding effectiveness, filter

Ground Testing of an Operational Fighter Aircraft for P-Static Discharge Effects

**EMCABS: 22-02-87**

E.B. Joffe
12 Arazim Street, P.O. Box 264, Kfar-Sava 44102, ISRAEL
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0288, September 16-18, 1986, pp. 288-292
**ABSTRACT:** Static electrification of an aircraft in flight causes electrical discharges from the aircraft structure. These discharges are typically accompanied by radio frequency noise in the electromagnetic spectrum utilized by aircraft communication and radio navigation systems. Such interference frequently disrupts or totally disables communications, and has been demonstrated to cause significant navigation errors. It therefore becomes essential to isolate the sources of these electrical discharges and design appropriate fixes for these problems. In the paper, a case of p-static noise on an operational RF-4C aircraft is discussed. A method for the isolation of p-static noise sources is described, along with proposed solutions for the identified problems.
**INDEX TERMS:** Static electrification, aircraft, electrical discharges, electromagnetic spectrum, communication radio frequency noise, radio navigation, interference, p-static noise

**EMCABS: 23-02-87**

A Method of Characterizing ELF and VLF Electromagnetic Emissions from Video Display Terminals

J. Flinn
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1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0287, September 16-18, 1986, p. 287
**ABSTRACT:** Development of a new test approach for the characterization of ELF and VLF (10 Hz to 100K Hz) Electromagnetic emissions from VDTs is discussed. This method will yield more comprehensive data in a shorter time than previous techniques. Comparisons of usability are made between different types of antennas or sensors as well as receiving equipment. Data accuracy will be emphasized concurrent with ease of data reduction.
**INDEX TERMS:** Test approach, ELF, VLF, electromagnetic emissions, VDTs, sensors, receiving equipment, data accuracy, data reduction

**EMCABS: 24-02-87**

Use of the Compact Range for Radiative Susceptibility and Emission Testing

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1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0279, September 16-18, 1986, p. 279
**ABSTRACT:** The compact range technique enables the production of a quasi-plane wave (the ideal condition for susceptibility and, by reciprocity, emission testing) with no inherent frequency limits and with weaker image effects than occur in the parallel-plate line technique. Studies of the error levels in measurements undertaken in such a range are presented, with emphasis on the scope for reduction of the lower frequency limits of practical realizations in the context of typical EMC accuracy requirements.
**INDEX TERMS:** Compact range, quasi-plane wave, susceptibility, reciprocity, testing, frequency, image effects, parallel-plate line technique, EMC

**EMCABS: 25-02-87**

Preliminary Evaluation of Reverberation Chamber Method for Pulsed RF Immunity Testing
M.L. Crawford and G.H. Koepke
Electromagnetic Fields Division, National Bureau of Standards, Boulder, CO 80303
1986 IEEE International Symposium on Electromagnetic Compatibility
U.S. Government work not protected by U.S. Copyright September 16-18, 1986, pp. 270-278

**ABSTRACT:** This paper describes the evaluation of the performance characteristics of a reverberation chamber excited by pulsed RF (1.0 $\mu$s to 10 $\mu$s, 0.001 duty cycle) in the frequency range. 0.9 GHz to 10 GHz. The purpose of this work was to investigate the potential use of a reverberation chamber for pulsed RF immunity testing of electronic equipment. Information given includes a description of the reverberation chamber evaluated, the instrumentation used for performing the measurements, and results obtained showing the pulse dispersion characteristics of the chamber.

**INDEX TERMS:** Performance characteristics, pulsed RF, duty cycle, immunity testing, electronic equipment, pulse dispersion characteristics

**EMCABS: 26-02-87**

Sequential Ranging Integration Times in the Presence of CW Interference in the Ranging Channel
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1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/0000-0332, September 16-18, 1986, pp. 332-341

**ABSTRACT:** The Deep Space Network (DSN), managed by the Jet Propulsion Laboratory for NASA, is used primarily for communication with interplanetary spacecraft. The high sensitivity required to achieve planetary communications makes the DSN very susceptible to radio-frequency interference (RFI). In this paper, we present an analytical model of the performance degradation of the DSN sequential ranging subsystem in the presence of downlink CW interference in the ranging channel, and show a trade-off between the ranging component integration times and the ranging signal-to-noise ratio to achieve a desired level of range measurement accuracy and the probability of error in the code components. Numerical results presented illustrates the required trade-offs under various interference conditions.

**INDEX TERMS:** Deep Space Network (DSN), NASA, communication, interplanetary spacecraft, sensitivity, susceptible, radio-frequency interference, RFI, downlink CW interference, ranging channel, signal-to-noise ratio, numerical results

**EMCABS: 27-02-87**

A Lattice Approach to Complex Electromagnetic Environments
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National Bureau of Standards, Boulder, CO 80303
1986 IEEE International Symposium on Electromagnetic Compatibility
U.S. Government work not protected by U.S. Copyright
September 16-18, 1986, pp. 328-331

**ABSTRACT:** We outline an approach to the characterization of complicated electromagnetic environments based on a lattice (finite difference) approximation to Maxwell's equations. Approximate solutions to the equations are found numerically, subject to constraints imposed by boundary conditions and by measurements of the field at some number of points. The technique is illustrated by simple two- and three-dimensional examples.

**INDEX TERMS:** Electromagnetic environments, lattice (finite difference) approximation, Maxwell's equations, numerically, boundary conditions

**EMCABS: 28-02-87**

Vertical Site Attenuation—A Necessity!
Donald N. Heirman
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1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0342, September 16-18, 1986, pp. 342-346

**ABSTRACT:** This paper introduces a further improvement in determining the quality of an open area test site (OATS) for making radiated emission measurements. This technique extends present requirements suggested by the FCC in OST-55 to characterize the site attenuation of open area test facilities by using transmit and receive antennas which are vertically as well as horizontally aligned with respect to the metallic ground plane. Vertical polarization is generally more sensitive than horizontal in showing certain site imperfections, such as surrounding reflecting buildings, fences, and other obstructions that might adversely affect measurements. Vertical polarization measurements are also more sensitive to recording technique and measurement system (antenna factor, cable loss, and receiver/spectrum analyzer miscalibrations) inadequacies. Areas for further site attenuation analysis are also indicated.

**INDEX TERMS:** Open area test site, OATS, radiated emission measurements, FCC OST-55, transmit, receive antennas, metallic ground plane, verticle polarization, antenna factor, cable loss, receiver/spectrum analyzer

**EMCABS: 29-02-87**

Note on EMI Measurement at Open Field Test Site (2)—On the Shortened Dipole Antenna
Shigeru Takeya* and Atuya Maeda**
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**Matsushita Communication Industrial Co., Ltd., JAPAN
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0350, September 16-18, 1986, pp. 350-353

**ABSTRACT:** A shortened dipole antenna is recommended for use as the reference antenna for EMI measurements in the frequency range below 80 MHz down to 30 MHz by CISPR Publication 16, Amendment 1. Discrepancies between the technical requirements for shortened dipole antennas and nomographs and suggested revisions for achieving compatibility are given. A dipole antenna tuned to half wavelength is specified as a reference antenna for the frequency range from 30 MHz to 1 GHz. The CISPR Publication 16, Amendment 1 (Oct. 1980) specifies the use of shortened dipole antenna with antenna element of a length tuned to 80 MHz for measuring the frequency below 80 MHz. It also gives some precautions and nomographs to obtain antenna factors. This report first points out the discrepancies between the precautions and the nomographs, then describes the proposed improvements.

**INDEX TERMS:** Shortened dipole antenna, reference antenna, EMI, CISPR Publication 16, Amendment 1, antenna factors

**EMCABS: 30-02-87**

New Correction Factor for High-Precision Open-Site Attenuation Calculation (4)
Atsuya Maeda*, Shigeru Takeya, and Yoshio Kami
*Matsushita Communication Industrial Co., Ltd.
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0354, September 16-18, 1986, pp. 354-361

**ABSTRACT:** The papers that we have given so far on precise measurements and theoretical analysis values of site attenuation for open sites have all been for horizontal polarization. Good agreement within about 1dB has been obtained between actual measurements and calculated values. The individual terms influencing the attenuation were cumulatively added to the formula to account for all factors involved, and we think that we have achieved sufficient accuracy for practical purposes. This time we have extended the calculation to make it suitable for verticle polarization. The agreement of the measured and calculated height pattern of the attenuation value at the receiving point was studied in the same manner as for horizontal polarization and excellent agreement was obtained.

**INDEX TERMS:** Correction factor, open-site attenuation, horizontal polarization, attenuation, vertical polarization

**EMCABS: 31-02-87**

Correction Factor for Relating Measurements Made in an Absorber-Lined Chamber to Measurements Made at an Open Field Site
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1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0362, September 16-18, 1986, pp. 362-365

**ABSTRACT:** A method of correlating emitted radiation measurements made in an absorber-lined chamber with measurements made at an open field site is described. Accuracy of this method is a function of fixing the positions of the equipment under test (EUT) and measurement antenna in the chamber. Results are compared for measurements made in an absorber-lined chamber with those made at an open field site, using a simulated EUT as a transmitting antenna.

**INDEX TERMS:** Absorber-lined chamber, open field site, equipment under test (EUT), measurement antenna, transmitting antenna

**EMCABS: 32-02-87**

FCC/VDE Radiated Measurements—Potential Differences in Test Results Between Test Sites as a Function of Extrapolation and the Use of Published Antenna Factors
Albert J. Visek and Dan Mis
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1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0366, September 16-18, 1986, pp. 366-377

**ABSTRACT:** The draft edition to ANSI C63.4 covering open field test sites provides equations and a procedure for performing site calibration on open field test sites. Application of the equations to determine the theoretical site attenuation at different heights and distances and actual site calibration measurements reveal some causes and relationships that can contribute to potential differences in product emission measurements at different sites when measurements are made according to FCC rules or the VDE rules, and, in the near future, to agencies following the rules in CISPR 22. This paper will explore the problems revealed.

**INDEX TERMS:** ANSI C63.4, open field test sites, site calibration, theoretical site attenuation, emission measurements, FCC, VDE, CISPR 22

**EMCABS: 33-02-87**

RF Stabilization
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1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0383, September 16-18, 1986, pp. 383-386

**ABSTRACT:** This paper presents a new technique for emission control of electronic systems. The technique, called "RF Stabilization" reduces conducted and radiated emissions and raises immunity levels significantly. Three design areas are examined in implementation of this technique; Multipoint High Frequency Grounding, Circuit Board Design, and Internal Harness (Cable) Design. Conducted and radiated emission data is presented showing the reduction of the emissions due to changes in the design areas.

**INDEX TERMS:** Emission control, RF Stabilization, conducted, radiated, emissions, immunity levels, Multipoint High Frequency Grounding, Circuit Board Design, Internal Harness Cable

**EMCABS: 34-02-87**

Tailoring MIL-STD-461B for Naval Avionics Applications
Robert G. Siefker
1986 IEEE International Symposium on Electromagnetic Compatibility

September 16-18, 1986, pp. 387-395

**ABSTRACT:** Naval aviation electronics (avionics) systems are specified and procured using MIL-STD-461 to set the fundamental EMI requirements. MIL-STD-461 permits and encourages "tailoring" the EMI specifications for each equipment to the anticipated usage. In this paper, the Naval Avionics Center Staff Engineer for Electromagnetic Effects presents a typical tailored EMI specification as used within the Naval Air Systems Command to procure carrier-based aircraft avionics. Included are the rationale for, and the explanation of, each modification and an estimate of the electromagnetic environment found aboard the U.S. Navy aircraft carriers.

**INDEX TERMS:** Avionics, MIL-STD-461, EMI, electromagnetic effects, EMI, electromagnetic environment

**EMCABS: 35-02-87**

The Relationship Between MIL-SPEC and Commercial EMI Requirements
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1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0396, September 16-18, 1986, pp. 396-400

**ABSTRACT:** The MIL-STD-461B specification is significantly more comprehensive than either the VDE or FCC requirements. These controls are probably an accurate reflection of interference problems in the lower density industrial/commercial and higher density military environments. The absence of susceptibility standards in the VDE and FCC specifications may be a serious shortcoming. This means that sensitive electronics will be marketed which meets FCC and VDE requirements, but cannot be used after purchase because it malfunctions in the presence of ambient interference. The correction and prevention of susceptibility in sensitive devices without the guidance of a standard can have significant cost, usability and time delay impacts on consumer products, both now and in the future.

**INDEX TERMS:** MIL-STD-461B, VDE, FCC, interference, susceptibility, ambient interference

**EMCABS: 36-02-87**

The New British Standards on Radio-Frequency Ignition and Detonation Hazards—A Review
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1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0401, September 16-18, 1986, p. 401

**ABSTRACT:** The British Standards Institution (BSI) has recently published its new standards on radio frequency hazards to fuels and to electroexplosive devices (BS 6656 and 6657). A review of the basis of these standards, and of the research and other experience that influenced their drafting is presented, based on the author's 12-year association with them.

**INDEX TERMS:** British Standards Institution, BSI, radio frequency hazards, fuels, electroexplosive devices, BS 6656 and 6657

**EMCABS: 37-02-87**

A Model for Predicting the Surface Transfer Impedance of Braided Cable
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1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0402, September 16-18, 1986, pp. 402-404

**ABSTRACT:** A model for predicting the surface transfer impedance of non-optimized braided cables has been developed. This model is based on theory and is supported by extensive measurements. The transfer impedance of a braided cable is modeled as the sum of a transfer resistance and a transfer mutual inductance. The latter gives rise to a frequency dependent term. The transfer resistance is inversely proportional to cable diameter. The transfer mutual inductance is best modeled as being independent of diameter. A worst case cable overbraid model accounts for multiple layers of braid.

**INDEX TERMS:** Surface transfer impedance, non-optimized braided cables, transfer resistance, transfer mutual inductance

**EMCABS: 38-02-87**

The Case for Identifying Contact Impedance as the
Major Electromagnetic Hardness Degradation Factor
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1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0405, September 16-18, 1986, pp. 405-407

**ABSTRACT:** An examination of a wide range of experimental data shows that contact impedance, rather than enlargement of apertures or changes in material conductivity, is the major electromagnetic hardness degradation factor. It is also the least understood.

**INDEX TERMS:** Contact impedance, apertures, material conductivity, electromagnetic hardness, degradation factor

**EMCABS: 39-02-87**

Electromagnetic Field Distribution and Frequency Response for
EMP Excitation of an S-280 EMP Shelter
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Electro Magnetic Applications, Inc.
P.O. Box 26263, Denver, CO 80226
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0408, September 16-18, 1986, pp. 408-415

**ABSTRACT:** The electromagnetic field response has been calculated for an S-280 shelter with both resistive and inductive door seam impedances in an NEMP environment. Peak field distributions were calculated throughout the shelter showing the greatest amplitude near the seams. The frequency response, calculated at various points throughout the shelter, show a clear delineation between high frequency propagating modes and lower frequency evanescent modes. The propagating modes start with the lowest frequency near the fundamental resonance mode of the shelter. The shielding effectiveness of the shelter is calculated from the peak field magnitudes and related to the value of the seam transfer impedance for individual seams.

**INDEX TERMS:** Electromagnetic field, S-280 shelter, door seam impedance, NEMP environment, peak field, shelter, propagating modes, evanescent modes, resonance spectrum, Maxwell's equations, shielding effectiveness

**EMCABS: 40-02-87**

Measurement of Seam Impedances of Tactical Shelters for Threat
Level NEMP Simulation
Peter B. Papazian, Rodney A. Perala, Calvin C. Easterbrook,
Paul M. McKenna
Electro Magnetic Applications, Inc.
P.O. Box 26263, Denver, CO 80226
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0416, September 16-18, 1986, pp. 416-422

**ABSTRACT:** Measurement of internal transient seam voltages utilizing AESOP excitation and a seam impedance measurement method (SIMM) are discussed. Data giving seam impedance values for an S280 shelter are presented. Using these values and 3-D finite difference modeling of Maxwell's equations, internal field responses were calculated and compared to measured responses obtained using the AESOP simulator, showing an average error in peak field predictions of about 4.5dB. It is concluded that reliable measurements of seam impedances needed in determining shelter shielding effectiveness can be made under in situ conditions using SIMM.

**INDEX TERMS:** Internal field, shelters, NEMP SIMM, seam transfer functions, transfer functions, internal transient seam voltages, AESOP excitation, seam impedance measurement, SIMM, S280 shelter, Maxwell's equations

**EMCABS: 41-02-87**

Correlation of MIL-STD-285 Measurements, Seam Transfer
Impedance and EMP Shielding Effectiveness
James R. Elliott, Terence Rudolph, Steven L. Parker,
Rodney A. Perala, Paul M. McKenna
Electro Magnetic Applications, Inc.
P.O. Box 26263, Denver, CO 80226
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0423, September 16-18, 1986, pp. 423-427

**ABSTRACT:** A model for the penetration of shielded enclosures by electromagnetic fields is developed. The dominant sources are seams, each of which is characterized by its own transfer impedance. This parameter is used to relate shielding effectiveness determined by RFCW MIL-STD-285 measurements to the EMP case. The results of measurements and computer simulations for both RFCW and EMP demonstrate the efficacy of the technique.

**INDEX TERMS:** Shielded enclosures, electromagnetic fields, seams, transfer impedance, shielding effectiveness, RFCW, MIL-STD-285, EMP

**EMCABS: 42-02-87**

Reduction of EMI/EMP Shield Currents Using an Improved Shield
Ground Adapter
David S. Dixon, Member, IEEE, and Stanley I. Sherman, Member, IEEE
Naval Underwater Systems Center
New London Laboratory, New London, CT 06320
1986 IEEE International Symposium on Electromagnetic Compatibility

September 16-18, 1986, pp. 428-434

**ABSTRACT:** A shield ground adapter (SGA) is a device utilized to establish a 360° low impedance electrical connection between a cable's shield and the ground structure through which the cable passes. This paper will briefly discuss the requirement for such a device and the measured EMI performance characteristics of a new SGA that utilizes a recently developed "smart" soldering technique and a unique cable shield-to-SGA connection method. The performance of the new SGA will be compared with the performance of an existing SGA presently being utilized to reduce shield currents. A physical/electrical dc model developed at NUSC will be discussed along with the details of one shipboard (topside-to-below decks) installation.

**INDEX TERMS:** Shield ground adapter, (SGA), low impedance electrical connection, ground, EMI, cable shield-to-SGA connection method

**EMCABS: 43-02-87**

Using the EMCAB to Your Advantage
Joseph E. Fos, Jr. and Tony T. Stelma
Lockheed Missiles and Space Company, Inc.
P.O. Box 3504, Sunnyvale, CA 94088-3504
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0435, September 16-18, 1986, pp. 435-438

**ABSTRACT:** Electromagnetic Compatibility Advisory Board (EMCAB) identified. Electromagnetic Compatibility Program Plan (EMCPP) identified. Authorization for EMCAB and responsibilities toward EMC discipline through EMCAB charter. Establishing control of the EMCAB through the co-chairmen. EMCAB members identified. Coordinated exchange of technical EMI/EMC problem resolution. Duties and responsibilities of EMCAB coordinator and members. Technical advisors and guest speakers identified. Conducting an EMCAB.

**INDEX TERMS:** Electromagnetic compatibility, EMCAB, Electromagnetic Compatibility Program Plan (EMCPP), EMC, EMI/EMC

**EMCABS: 44-02-87**

Classification of ESD Hand/Metal Current Waves Versus Approach Speed, Voltage, Electrode Geometry and Humidity
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KeyTek Instrument Corporation, 12 Cambridge Street, Burlington, MA 01803
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0451, September 16-18, 1986, pp. 451-460

**ABSTRACT:** ESD current waves for both real and simulated discharges are actually quite repeatable, at any given voltage and with specific electrode geometries. With these two variables fixed, discharge current waves are typically distributed among just two or three distinctive wave types. The controlling variable in this situation is approach speed of the charged, intruding mass with respect to the electronic victim. Waves are given as a function of all three variables. The waves are shown to be almost independent of relative humidity, for the specific test conditions of the investigation.

**INDEX TERMS:** ESD, current waves, discharges, electrode, approach speed, intruding mass, waves

**EMCABS: 45-02-87**

The Reproducibility of the Rising Slope in ESD Testing
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EMC Group, Research Dept., Hasler AG, SWITZERLAND
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0467, September 16-18, 1986, pp. 467-474

**ABSTRACT:** The paper treats the problems related to the rising part of ESD current waveforms ("fast discharge mode") in the case of testing electronic equipment as well as in the case of the natural event of a person discharging themselves to the electronic equipment. After some introductory comments on the discharge waveforms, the results of two series of tests are reported: 1) Comparison of the reproducibility of the rising slopes using different test methods, as well as during the natural event of persons discharging to the "victims," and 2) Comparison of the reproducibility of the ESD-tests on equipment, using different methods.

**INDEX TERMS:** ESD, current waveforms, "fast discharge mode," discharge waveforms

**EMCABS: 46-02-87**

A Standard Test to Determine the Susceptibility of a Machine to Electrostatic Discharge
Ralph J. Calcavecchio* and Daniel J. Pratt
*IBM Corporation, Kingston, NY 12401
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0475, September 16-18, 1986, pp. 475-482

**ABSTRACT:** Simulation equipment representative of office furniture and personnel has been developed with an appropriate procedure for testing the susceptibility of computers to discharge by such charged bodies. The testing philosophy and essentials of the simulation equipment are discussed.

**INDEX TERMS:** Electrostatic discharge, simulation equipment, susceptibility, discharge, charged bodies

**EMCABS: 47-02-87**

Transient Analysis of Multiconductor Lines Subject to Distributed Impulse Sources
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University of L'Aquila, L'Aquila, ITALY
1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0483, September 16-18, 1986, pp. 483-486

**ABSTRACT:** Propagation matrix models in the frequency domain are proposed for multiconductor nonuniform systems subject to distributed series and shunt sources. Reflection and refraction operators are associated with the discontinuity points. Voltage and current transmission operators are obtained for systems with per-unit length series-voltage and shunt-current sources. Fourier discrete transformation techniques are utilized for the transient analysis. Lightning-induced voltages on a multiconductor line are computed by using an accurate line simulation model.

**INDEX TERMS:** Propagation, matrix models, frequency domain, reflection, refraction, voltage, current, transmission operators, series-voltage, shunt-current, Fourier discrete transformation, transient analysis, lightning-induced, multiconductor line

**EMCABS: 48-02-87**

Transient Field of Earth Fault Currents
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1986 IEEE International Symposium on Electromagnetic Compatibility
CH2294-7/86/000-0487, September 16-18, 1986, pp. 487-492

**ABSTRACT:** This contribution deals with the calculation of the field in a simple model of an earth fault to ground by means of replacing the system by a coil of an arbitrary shape which connects two points on the surface of a conducting half space. At one point a current of any time dependence is fed on the surface and collected at a second one. The spatial current distribution is treated by superimposing two partial solutions. In the first one the field is excited by a current which is fed to the half space by thin linear conductors. Their contours are straight-lines normal to the surface from the feeding points to infinity. In the second solution the field is excited by a current of the same time dependence flowing in a coil which is closed in the nonconducting environment. Its contour consists of the original open loop completed by two thin linear conductors as mentioned in the first solution to a closed loop.

**INDEX TERMS:** Transient electromagnetic field, conducting half space, spatial current, linear conductors, induced current distribution

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