IEEE EMC SOCIETY NEWSLETTER

ISSUE NO. 157 SPRING 1993 (ISSN 0164-7644) ROBERT D. GOLDBLUM, *Editor*

EMC ENGINEERS ANNUAL EMPLOYMENT SURVEY

BILL JOHNSON

EMC engineers have been hit with the economic recession just like members of other technical disciplines. According to the results of the 1992 IEEE Salary and Employment Survey results, the average salary of EMC engineers responding dropped 3% from a similar survey conducted in 1991. This latest survey shows that EMC engineers are still being paid more than engineers in some other electronics disciplines. Even with the decline in 1992, salaries for EMC engineers responding to the survey are up 24% since 1989. The current survey was taken at the 1992 IEEE EMC Symposium in Anaheim last August. Figure 1 provides a historic picture of the salary, age and experience of the average attendee from 1989 to 1992 which indicates a graying community.

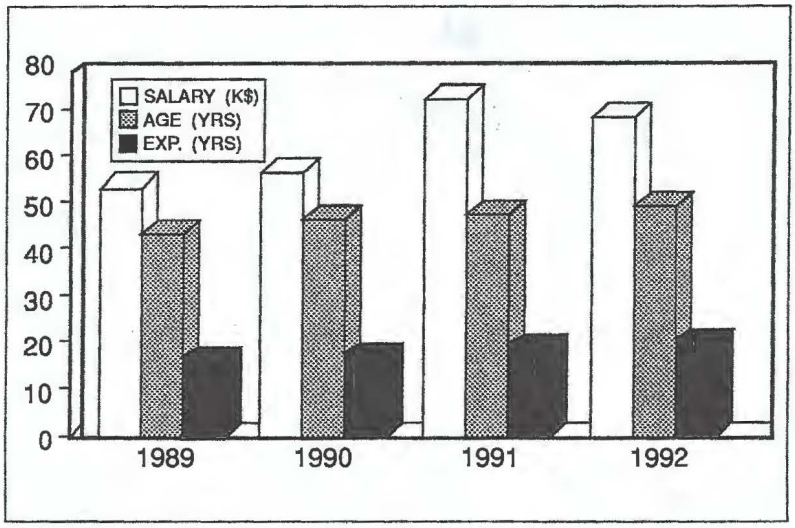

FIGURE 1. Average Attendees.

Overall the job prospects in the EMC marketplace look positive with a 75% confidence rating in military business and 83% in the commercial sector. Confidence rating is based upon those responding that jobs will either increase or remain at the same level for the foreseeable future. While these ratings are optimistic, they are considerably below previous ratings, indicating a less positive position. The decline in military EMC activity seems to be matched by an increase of opportunities in the commercial sector. By comparing the time spent by all respondents in military versus commercial activities we can easily see the trends. In 1989, 41% of the time of those responding was spent in military EMC activities, including TEMPEST, EMP, RADHAZ, and HERO, with only 40% in commercial (See Figure 2). In

Continued on page 18

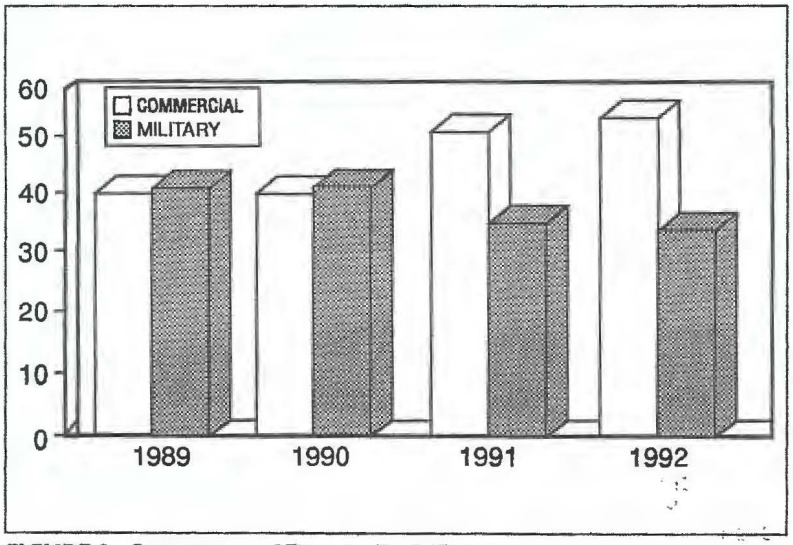

FIGURE 2. Percentage of Time in Each Category.

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IEEE NEWSLETTER PUBLICATION SCHEDULE

PUBLICATION DATES	EDITORIAL DEADLINES
August	June 15
November	September 15
February	December 15
May	March 15

Editorial contributions for the August 93 issue should be received by June 15.

BACK ISSUES OF THE EMC NEWSLETTERS ON MICROFICHE

We still have a few sets of the uFiche copies of the back issues of the IEEE EMC Society Newsletters from the present to 1955 when it was called "Quasies and Peaks." The price is $25.00 postpaid. If you would like to have one of these sets you can order it from: Dr. Chester L. Smith, EMC Society Historian, 2 Jonathan Lane, Bedford, MA 01730.

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EMCS BoD ACTIVITIES

DON HEIRMAN
ASSOCIATE EDITOR

The first EMCS Board of Directors Meeting for 1993 was held on February 11-12 at the Bahia Hotel in San Diego. The meeting was called to order at 1 PM by President Bob Hofmann. Board members present were Don Weber, Walt McKerchar, Janet O'Neil, Herb Mertel, Don Heirman, John Adams, Al Mills, Hugh Denny, Warren Kesselman, Andy Podgorski, Gene Cory, Don Clark, Bill Gjertson, Henry Ott, Dan Hoolihan, Dave Staggs, Ed Bronaugh, and Dick Ford. Members absent were Yaso Akao and Pat Coles.

The minutes of the November meeting were presented by Secretary Janet O'Neil and were then approved by the BoD. Treasurer Ford gave his report that the Society's net worth at the end of 1992 was $381K.

The various directors gave their reports and introduced their chairmen who were present. The following briefly summarizes the various reports and actions taken by the BoD.

Dan Hoolihan, Director for Membership Services presented his reports first. The new Chapter Handbook written by Dave Staggs will be sent out to the chapter chairs immediately. John Adams, Distinguished Lecturer Chair, was authorized to consider individuals other than distinguished lecturers in emergency cases where a lecturer cannot make a lecture commitment. In that situation, John can call upon a local expert to present the program.

Next, Bruce Gjertson, Director of Communications Services, gave his reports. The Board approved a motion to send a copy of the Society's history, being developed by Chester Smith, to each BoD member. The history includes microfilms of past EMC conference/symposia records. Gene Cory presented a review of the symposium activity. The budget for the Dallas symposium was presented. Hugh Denny is in the process of tracking overseas (outside the United States) EMC symposia to try to avoid scheduling conflicts where possible. The Board approved being a nonfinancial cooperating sponsor for the NEMP Symposium to be held in France in 1994. Dr. Kanda, Transactions chair, is soliciting more practical EMC papers. Prospective authors in this specialty should forward manuscripts as soon as possible.

Walt McKerchar, Professional Services, presented his reports. A current project involves acquisition of an insulated mug for distribution at the Dallas symposium. Herb Zajac is looking into this. Herb Mertel, Transnational chair, reviewed the EMC Society booth activity at various international symposia, the most recent one being the Zurich Symposium in March. He moved that the special "Worldwide EMC Standards" tutorial be published by the Society and made available to attendees for a fee in Dallas. The Board approved.

Don Heirman, Director for Technical Services, presented all of his committees reports. As chairman of the EMCS Standards committee, Don indicated that Steve Berger was appointed Vice-chair and Dave Traver was designated Co-secretary for Minutes and John Osborn as Co-secretary for WG progress and reports tracking. Also Standards 139, 213, and 376 were reaffirmed by ballot. Kimball Williams, Ed. chair, indicated in his report that the exhibit to perform the EMC experiments is set up for the Dallas Symposium.

The EMC Bibliography was loaded onto Internet by Todd Hubing and is available for anyone who wishes to copy it. Wilf Lauber, TAC chair, presented in his report the year-end activity of the technical committees. The Board approved the formation of a new TC on Electromagnetic Computations. Joe Butler's RAC report was entered into the minutes.

Other business included the following:
President Hofmann reviewed the activity of the IEEE TAB. Warren Kesselman, Vice President, presented his update to the EMCS BoD Planning Guide for 1993 and beyond. Dick Ford was appointed to the Engineering R&D Policy USAB Committee. Andy Podgorski was suggested as the next Treasurer as Dick Ford will be stepping down next year. Directors Don Heirman and Gene Cory also indicated that this will be their last year on the Board.

The Board also approved refunding up to $750/meeting for travel and per diem for Board members to attend regularly scheduled BoD meetings. Several Board members, due to recent company funding problems, need some support to finish up the current year's commitment on the Board.

The meeting adjourned at 1 PM on Friday, February 12. The next meeting is planned for Ottawa on June 5-6. This meeting will run over the weekend to keep air cost down so BoD members do not need excessive time away from their jobs. For further information on the meeting call Janet O'Neil at 213-870-9383.

CHAPTER CHATTER

TODD HUBING
ASSOCIATE EDITOR

Chapter meetings are an excellent way to meet other engineers in your area and to keep yourself informed of progress and friends in EMC. I had a chance to attend my first chapter meeting this past January in Santa Clara. Approximately 100 people showed up on a rainy California night for this meeting. After the opening announcements and introductions, the Santa Clara Valley chapter permits attendees who are offering or looking for employment to stand and say a few words about positions that are available or positions that they are seeking. What a great idea! At this particular meeting there were two people seeking new positions and two people from companies that were looking for additional engineers or technicians. Also at this meeting, Lee Hill gave an excellent presentation on decoupling. There were many informal discussions on decoupling and other EMC topics that continued well beyond the close of the meeting. I can't imagine a better way to keep up with the developments that could affect your career than to attend meetings of your local EMC chapter.

I had the pleasure of meeting Ralph Herkert, chairman of the Atlanta chapter, at the Ninth Annual Review of Progress in Applied Computational Electromagnetics this past March. Atlanta will be hosting the 1995 EMCS International Symposium. If you are a member of the EMC Society living in the Atlanta area, this is a rare opportunity to participate in the organization and planning of the biggest annual event sponsored by our society.

The 1993 symposium will be held in Dallas the week of August 9-13. The theme is "On the Frontier of Change," which is highly appropriate given the large number of new techniques and ideas that are changing the way engineers approach and solve many kinds of EMC problems. This is sure to be an enjoyable and enlightening event.

Of course, Atlanta and Dallas are nice cities to visit, but someday I hope that we will have a chance to host the EMCS International Symposium in Rolla, Missouri. After all, we are conveniently located just 100 miles west of the St. Louis airport and we have two very nice hotels that feature indoor pools and free color TV in every room. Besides, I've got a great theme for the next EMC Symposium that is held in the Show-Me state. "EMCing is Believing...." Well, OK, maybe it's not quite as good as "Radiating Compatibility from Missouri," but that one's been done.

Speaking of great themes, I've been told that a sign on the wall of the EMC laboratory in a prestigious upstate New York research center reads, "It's the common-mode current on the cable, Stupid!" I think they're onto something.

ATLANTA

There were 27 attendees, including most of the EMC Society Board of Directors, at the November 1992 meeting of the Atlanta chapter. The chapter meeting was held at Georgia Tech's Manufacturing Research Center. The board was in town for the BoD meeting at the Atlanta Marriott Marquis, the site of the 1995 EMCS International Symposium. The featured speaker at the chapter meeting was Andrew Dugenske, a research engineer in the Manufacturing Research Center. He provided an overview of the center, which is funded by many different companies to conduct research into novel manufacturing methods and technologies.

CENTRAL NEW ENGLAND

John M. Clarke reports that Michael Hopkins of Keytek Instrument Corporation was the speaker at a January 12th meeting of the Central New England chapter. Mr. Hopkins discussed the susceptibility of consumer and industrial products to electrostatic discharge. He also reported on the current status of pending ESD requirements in Europe.

At the February 9th meeting, Robert Goldblum of R&B Enterprises presented an overview of U.S. military EMI training practices. Beginning with the 1960's vintage MIL-STD-461, he discussed the progress and changes that have evolved into the soon-to-be-released MIL-STD-461D. Mr. Goldblum emphasized the historical differences between military and commercial EMI tests and explained how some of the differences are vanishing. He also discussed the EMC impact of the current DoD emphasis on purchasing commercial off-the-shelf equipment.

CENTRAL TEXAS

A meeting held jointly with the Power Engineering Society in January featured Dr. Walter R. Rogers from Southwest Research Institute, who spoke on "Bioeffects of ELF Fields." Dr. Rogers directs a large international research program for the Department of Energy using baboons to examine the effects of exposure to electric and magnetic fields from high voltage transmission lines.

Dr. David Gavenda of the University of Texas in Austin was the featured speaker at a meeting held on

Continued on page 19

KIMBALL WILLIAMS
ASSOCIATE EDITOR

Many of us on the EMCS Education Committee have long held the opinion that the most effective way to expand the awareness of electronic designers to encompass electromagnetic compatibility is to bring the teaching of EMC into our colleges at the undergraduate level. Dr. Clayton Paul has described the problems facing educators in adding another required course, however well intentioned or necessary, to already overburdened curricula. I find his argument for including EMC as a senior level elective compelling. In addition to Dr. Paul's approach, I would like to explore another possibility.

A single EMC course, taught as a senior level elective, is an excellent step in the education of potential EMC engineers, and an effective way for an electrical engineer to pull together many of the diverse elements of his craft. However, we may have many electrical engineering students who never take that elective, and whose education will, to some extent, remain incomplete.

IEEE EAB MEETINGS

I recently had the opportunity to share ideas with heads of electrical engineering departments from all over the United States, Canada and South America when I attended the IEEE Education Activities Board (EAB) meeting in Chicago, IL. In the subcommittee meetings and in general discussions, I heard a recurring theme. Many of these educators are waging a continuing battle on their campuses against a rising tide of pressure to remove electromagnetic theory completely from the required curricula. Several told me that they were the only ones on their faculty who would (or could) teach the subject.

Most proponents for removing electromagnetic theory from the electrical engineering curricula claim that the subject is "too theoretical" and "not relevant." How familiar! I know just how that feels. I remember that when I studied E-Mag in school I was absolutely convinced that I would NEVER use that information in my career. I had no interest in the subject, and no understanding of what field theory would do for me as an electrical engineer. Nor did the course material do anything to change that mind set.

It came as no surprise to find that several of the educators I talked with had the same reaction to electromagnetic theory when they took it as undergraduate students. These are the same people who are now holding the line at their home institutions against removing E-Mag from the curricula. Obviously, later experience showed them how valuable and essential the course was to the full appreciation of electrical engineering.

'RELEVANT' ELECTROMAGNETIC THEORY

For many of us working in electromagnetic compatibility, the 'relevance' of E-Mag theory became obvious only as we began to deal with the problems caused by ignoring the effects of E-Mag phenomenon. For myself, it was only then that I truly began to 'learn' electromagnetic theory. One head of an EE department told me that he had gotten through E-Mag in undergraduate school by memorizing formula and being careful with his units, and that he didn't understand the theory until well into his Master's Degree work.

Given this situation, at least two possible solutions present themselves. One is to substitute a practical course in EMC for what is currently taught under the title of electromagnetic theory. I am certain that undergraduate students would respond better to a course which deals in a down-to-earth manner with problems that they are sure to encounter as working engineers than with a course which consists primarily of vector mathematics and 'ideal case' problems.

The second approach would be to completely re-invent the way in which we teach electromagnetic theory. Those of us in EMC know the relevance of E-Mag theory through our work. We see it in action all around us every day. So, why not teach that relevance as part of the fundamental course(s) in E-Mag theory? Once the theoretical equations are developed for a section, could we not derive the useful result and demonstrate its application? Might we not proceed from "two line charges of infinite length" to "two bus bars 5 meters long in a power plant under short circuit conditions"? Could we not extend the study of electrostatics to include the ESD phenomena that can wipe out our chips? I am sure that many of the relevant practical examples can be developed to help teach the theory.

Of the two approaches that I have mentioned, I find the second more difficult, yet more satisfying. I shudder to think what eliminating electromagnetic theory from the standard EE curricula would do to the future growth potential of EE students. Yet, I know from my experience and that of many others that the present methods of teaching undergraduate E-Mag theory are inadequate for the task at hand. We are not doing our students a service if we force feed them theory that they forget as soon as the last exam is over when we could give them a working tool to aid them in their chosen field.

THE TASK AT HAND

What I am proposing is a revolution in the approach to teaching electromagnetic theory. I am not an educator. I cannot effect this change myself. However, *our society* has the knowledge, opportunities and the will to make it happen if we so choose.

Continued on page 19

JOSEPH BUTLER
ASSOCIATE EDITOR

SAE AEROSPACE EMC STANDARDS ACTIVITIES

SAE AE-4 Electromagnetic Compatibility - Herb Mertel, RAC Representative

SAE-ARP for antenna calibration was released and can be ordered from SAE headquarters (Tel. 412-776-4841). The draft of AIR 1499 on commercial equipment immunity requirements is in the committee review process. The next meeting will be from 11 to 13 May 1993 in Stroudsburg, PA.

SAE AE-4R Radiated Environment Work continues on needed revisions to the HIRF User's Guide with the most recent meeting held the second week in March in Austin, Texas. Discussions on the helicopter HIRF environment also continue, with the most recent meeting the second week in January in Tampa, Florida. The RTCA DO-160C working group also met in Tampa to discuss a needed revision to Part 20 of DO-160C which will make avionics level radiated susceptibility tests consistent with proposed aircraft level HIRF requirements. A revision to DO-160C has been proposed to the parent RTCA committee which will allow bench level testing of essential equipment testing for HIRF. Further modifications aimed at improving critical equipment test requirements will be proposed for a DO-160D version.

SAE SURFACE VEHICLE EMC SAE Automotive EMI and EMR Committees - Ed Bronaugh, RAC Representative

Work on SAE J551 and SAE J1113 continues, along with parallel work on international standards in ISO and CISPR. Also under the EMR TC, the integrated circuit EMI task force has a standard in its second draft for measuring emissions from integrated circuits.

Electrical Overstress/Electrostatic Discharge Association - T.J. (Bill) Ritenour, RAC Representative

1993 has jumped out to a great start! In the last 10 years, the EOS/ESD Association has grown from 100 to 2000 members. Last year was eventful too. After a three-year effort the Association achieved recognition by the American National Standards Institute as an ANSI Accredited Standards Development Organization. In 1992 the Association published one full standard, three draft standards (one of which is the long awaited Machine Model draft) and one advisory document. During the year other activities have been initiated: four regional tutorials, a standards catalog, and enhanced publicity via editorial coverage in *ITEM, Circuit Assembly, Compliance Engineering, EMC Test and Design, EOS/ESD Technology, and Evaluation Engineering*. A quick summary of other activities include eight new chapters in development and last, but not least; our 1993 President is Ginger Hansel of Motorola (Austin, Texas).

IEC/CISPR Working Groups A/G - Don Heirman, RAC Representative

The new Pub 16 is going to press and the revision to Pub 22 is in editing with a release due date the end of this year. Of special interest is that Pub 22 will, for the first time, contain measurement of and limits for conducted emissions on signal cables which attach to long communication lines (telcom, LANs, etc.) In CISPR/G, the Pub 24 (Immunity of ITE) document is starting to take shape along the lines of the IEC 801-X documents with notable exceptions such as calibration of radiated field for 801-3 type measurements. The next CISPR/G Subcommittee meeting will be in the Netherlands the first week in April. I will be attending as one of the US experts from the US TAG for CISPR/G.

IEEE Technology Policy Council Committee - Aerospace R&D - Len Carlson, RAC Representative

The committee was briefed by John Gregory, Chairman of the Integrated Avionics Panel of the IEEE Aerospace and Electronic Systems Society (AESS), on their efforts to develop a position statement on "US Competitiveness in Avionics and Electronic Systems" and a proposal for collaboration. The committee offered advice and resolved to assist this effort. Gregory also presented the committee with an October 1990 AESS position paper on "NASA Program Acquisition Strategy" for consideration of endorsement.

The committee approved a proposed letter to the Chairman of the Federal Interagency committee which provides oversight of the Global Climate Change Research Program. The letter urged broader user access to and involvement in the Earth Observing System - Data Information System (EOSDIS) and supports a strong government role in promoting the commercialization of EOSDIS technologies.

The committee approved a revised entity position statement on "NASA's Role in Research and Development for Satellite Communications." The statement will be presented for approval by the IEEE Technology Policy Council and the U.S. Activities Board.

The committee agreed to request that the International Astronautical Federation (IAF) outline the benefits to IEEE of continuing its membership for 1993. Committee members Richard Marsten and David Hinkley will also approach the TAB Aerospace & Electronics Systems Society to discern its interest in assuming the lead role in sponsoring IEEE's membership.

The committee resolved to seek opportunities to testify before Congress in 1993 on specific issues addressed in recent position statements (satellite communications, civil space goals, and EOSDIS). Congressional staff for the responsible authorization and appropriations committee will be contacted on hearing plans and invited to brief the committee as appropriate.

Committee member David Hinkley was authorized to contact AT&T, Corning, and Sun Microsystems, which are utilizing former Soviet Engineers and scientists for contract research on the committee's behalf to survey their experience and solicit suggestions on needed government support and roles for organizations such as the IEEE.

IEEE Technology Policy Council Committee - Defense R&D Dick Ford, RAC Representative

A Defense Policy R&D Committee was held on 30 November 1992. Three issues were discussed: cooperative research (CREDAs); our (IEEE USAB) draft statements on defense conversion, which makes recommendations to Congress; and a proposed bill (H.R. 5310/S2803) on defense reinvestment, which proposes technology consortia, simulation of technology infrastructure, and consideration of the welfare of communities and individuals impacted by the defense "drawdown" etc.

W.K. DAWSON

"Data without generalization is just gossip." Robert Pirsig's admonition is, I believe, an appropriate introduction to the results of last November's IEEE election. The basic data are Dawson 2345, Johnson 2339. Clearly the Board had nominated two equally acceptable candidates. If seven more had voted, or four had voted differently, the result could well have changed. So the first generalization is the well-known adage, every vote counts. I thank all of you who made the effort to vote and ask for your help in making the IEEE better serve our technical and professional needs as well as be a stronger voice for the profession.

There are more data and, of course, a generalization. Inside the United States the count was Dawson 1701, Johnson 2086, while outside the United States the count was Dawson 644, Johnson 253. In percentage terms the numbers are quite striking. Inside the United States Dawson got 45% of the vote, outside 74%. This difference of opinion is significant. The President-Elect results show a similar but slightly weaker trend. Troy Nagle received 48% of the United States vote and 69% of the non-United States vote. In both cases the outcome was determined by the non-United States vote. This was not the case in the five other Divisional elections where the preferences of voters inside and outside the United States differed in only two cases and by small, possibly insignificant amounts.

Why should this be? (Here comes the generalization!) The position statements of the candidates in both the President-Elect and Division IV elections showed a clear difference in attitude towards a transnational IEEE. The difference could well have been the major deciding issue for non-United States voters, while playing a much lesser role for United States voters. But the difference was crucial and it determined the outcome.

What can we learn from this? We must all be sensitive to the declared goal of the IEEE to strengthen its global character. A global IEEE must try to fairly and equitably represent the needs and aspirations of all its members. In order to succeed, the IEEE has to adapt its program to fit the individual needs of many national groups. For some regions of the world this may be done by establishing agreements with existing national associations concerning joint membership and programs, while in other places, such as the United States, the IEEE can best serve its members by also taking on the role of a national organization which presents and represents members' needs and aspirations to governmental and other national agencies. And all this diversity must be made into a coherent structure.

Within the IEEE we have the engineering, scientific and technical pursuits and interests that bind us together into a strong organization. These important aspects of our work are shared through conferences, publications and educational programs. I hope that these ties are strong enough to overcome any differences caused by national concerns. I will work to promote the knowledge and understanding required to deal fairly with these issues. But this cannot be done without your assistance. Together we can make the IEEE serve all its members . . . everywhere.

J. ARTHUR ZOELLNER

J. Arthur (Art) Zoellner's electronics career began in the US Navy, where he says he learned more about communications-electronics systems theory and maintenance than most universities taught. By the time he matriculated after leaving the Navy he had garnered extensive operational experience with sonar, radar, fire control, navigation and communications systems.

Due to the scarcity of universities teaching modern electronics systems technology, Art majored in mathematics, specializing in statistics, and minored in physics. He received his Master's Degree from Iowa State University in 1953 and joined the staff of the General Engineering Laboratory of the General Electric Company in Schenectady, New York.

For nine years Art headed the analytical engineering section which performed technical work for almost one hundred operating departments of General Electric. During that time, Art participated in the development of the first mass-produced aircraft jet engine in the United States, the J47. He was involved in many areas of the project, including metal cutting, large steam turbine failure analysis, transformers, locomotives, commercial air conditioners, appliances, air traffic control systems, semiconductors, instruments and manufacturing quality control.

In 1961, he joined the small Amour Research Foundation team to build an enterprise which became an internationally recognized center of excellence in electromagnetic compatibility (EMC) concerned with antenna-coupled radiation effects in large electromagnetic environments. This center, located in Annapolis, MD, is the Department of Defense Electromagnetic Compatibility Analysis Center (ECAC). The Armour Research Foundation later became the IIT Research Institute.

EMC data bases and technology had to be built from the ground up. While much was known about bonding, shielding and grounding at the time, little had been done to develop computer automated data bases and systems to expeditiously analyze dense, complex electromagnetic environments containing thousands of emitter and receivers. The Department of Defense recognized the void in the late fifties when trouble surfaced because forces were becoming more heavily equipped with communications and electronics equipment. Even in 1961 it wasn't possible to get a handle on who was doing what in the use of the spectrum. The surge in the application of such equipment has never abated. In fact, it has continued to accelerate.

Among the many accomplishments during the early years at the Center was the development of an "expert" propagation loss prediction system. This system automatically retrieves terrain profile information from digitized terrain elevation files supplied by the Defense Mapping Agency and chooses the most appropriate algorithm for the situation at hand. All algorithms used in the system are based on the work of scientists and universities recognized throughout the world. The "expert" section of the system simulates the choice of algorithm that would be made by a panel of experts in the field of propagation. The use of digitized terrain data and expert system concepts was only two of many "firsts" attributed to the team which built the ECAC.

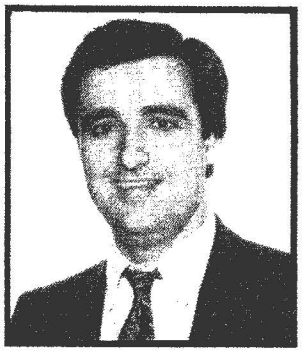
WILLIAM G. DUFF
ASSOCIATE EDITOR

In 1976 Art became the Technical Director and Deputy Director of the Center, first as a PL-313 supergrade government staff member and later as a charter member of the Senior Executive Service. After 15 years in this position, Art recently retired to pursue other interests.

He has many publications to his credit. Those which best suggest the nature of his contributions to EMC technology include "Frequency Assignment Games and Strategies," and "A Breakthrough in Frequency Assignment Technology," which were published in the *IEEE Transactions on EMC* and "The Effect of Pulse Interference on a Peak-Riding Detector" which was published in the *IEEE Transactions on Information Theory*. He is also co-author of the book *Subminiature Electron Tube Life Factors*, Reinhold, New York 1961.

During his career Art has been a Senior Member of the IEEE and a member of numerous other professional organizations. Art and his wife, Frances, reside in Annapolis, MD.

BOOK REVIEW



REINALDO PEREZ
ASSOCIATE EDITOR

HANDBOOK OF BIOLOGICAL EFFECTS OF ELECTROMAGNETIC FIELDS

Charles Polk and Elliot Postow, Editors
CRC Press, Boca Raton, FL, 1986.
$280.00

For the second time in two years this editor has chosen to review a book on the subject of biological effects of electromagnetic fields. There are two reasons for this: a) this subject is still a current and controversial one; b) the book reviewed here is a more advanced version than the one previously reviewed on this subject (see EMC Newsletter, Fall 1991, Issue 151). This topic will not be addressed again by this editor (in the Book Review column of this Newsletter) until new significant information is published on the subject, probably in the form of technical reports. Such information may not be available for three or four years, when the results of major studies, presently underway, become public (this editor knows of two such studies). In reviewing this large book (about 500 pages) this editor decided not to focus attention on this voluminous amount of experimental data discussed by the authors, but instead to concentrate on important theoretical issues that show some insight to the understanding of this subject.

The handbook was written by 14 contributors from diverse backgrounds and with different areas of expertise. They contributed to one introductory chapter plus 11 additional chapters and two appendices. The handbook is divided into three parts. Part I describes the theoretical and experimental aspects of dielectric permittivity and electrical conductivity in biological materials. Part II deals with dc and low frequency fields as they interact with biological tissue. Part III addresses RF and MW fields and their effects on biological systems. The introductory chapter of this handbook discusses electric and magnetic fields (dc, low frequency and RF/MW) in general, focusing on such topics as near/far fields, and field penetration into biological tissue (e.g., transmission/reflection coefficients in membranes). The material is typical of that found in electromagnetic textbooks, except that the derived mathematical expressions are tailored to the air/biological tissue boundary conditions.

When discussing the type of fields exposed to biological systems we must realize that field exposure varies tremendously with the type of "radiator." For example, most man-made devices that have recently been associated with biological effects (e.g., 60 Hz power lines, electric blankets, CRTs on personal computers, etc.) are really very poor radiators, almost incapable of producing any thermal effect on the surface or inside a living object. Hence, the interaction of such fields with biological tissue must be addressed through very different mechanisms. Consider for example "radiation" from the now famous 60-Hz power line. For such a structure to behave as a good radiating antenna its size must be comparable to its wavelength ($L=\lambda=5000$ Km!). The poor radiation efficiency in free space of electrically small structures ($L<<\lambda$) can be further illustrated for a linear antenna by considering a 50-Km, 60-Hz power line with uniform current distribution along its length. The radiation resistance can be approximated by $R_r=80\pi^2(L/\lambda)^2$. Thus for $L=0.01\lambda$, $R_r=0.025$ ohms. Notice that the dc resistance is $R_d=6.65$ ohms (50-Km long, 0.5-inch copper wire). Hence, the radiated power, $P_r=I^2R_r$ is less than the dissipated power, $P_d=I^2R_d$, where I is the "antenna" terminal current.

At RF/MW frequencies, common radiators (e.g., two-way radios, cellular phones, etc.), in which the radiating element(s) are comparable in size to wavelength, have sufficient radiated power to induce significant eddy currents on biological tissues which can produce thermal effects and other possible biological effects. Another issue of importance is that the interaction between biological tissue and electromagnetic fields must be through mechanisms which are far different than those occurring with the other type of well-known radiation — ionizing radiation. While x-rays, for example, have an average energy/quantum of about 4.12×10^5 eV, a quantized MW wave ($\lambda=0.001$m) has only about 1.2×10^{-3} eV ($E=h\nu$, h is Plank's constant, ν is the frequency) which is far below the required energy to break the binding energy of covalent and ionic bonds in biological molecules.

Part I of the handbook provides extensive information on the dielectric properties of tissues. Some specific aims of Part I are: 1) review the basic concepts of dielectric phenomena with the formulations that are used to describe these phenomena in biological materials. The most important realization mechanisms are summarized as they relate to tissues, 2) review the dielectric properties of several tissues at frequencies ranging from audio through MW, 3) examine the limits of dielectric relaxation spectroscopy in particular to explore the limits to which the distribution of relaxation times can be inferred from dielectric data, and finally 4) review the dielectric relaxation properties of tissue water and their relation to other transport properties of biological systems.

Part II is divided into five chapters and it discusses the effects of dc and low

Continued . . .

frequency fields on biological tissues. The first chapter covers the interaction of dc electric fields with living matter. The purpose of this chapter is to bring together some of the physics which underlie the interactions between electric fields and biological material with the objective of providing background for determining safe levels of exposure and new applications for the use of electricity in therapy. The chapter begins by examining some of the forces that are exerted on charged particles in fluids, proceeds to some of the effects of electric fields on membranes and looks at secondary effects of current flow due to heating. This is followed by a description of a few growth effects on whole animals. All this information is presented with the objective of specifying the general level of intensity of fields, currents, and temperatures where one can observe a given class of biological responses.

Chapters 2 and 3 discuss a number of mechanisms by which extremely low frequency (ELF) fields can affect biological systems. The purpose of these chapters is to review the ELF bioeffects literature with a view toward understanding mechanisms of ELF frequencies from 45 Hz to 75 Hz. The chapter indicates that the nonlinearities of membrane resistances and capacitances in the presence of ELF fields can generate dc currents which could in turn upset ion balances (e.g., Ca^{+2} efflux). There are still large gaps in our knowledge of the effects of ELF fields on living systems. This is particularly true for long term, low level effects. At levels of 25 kV/m there are some clear warnings that long-term exposure may be dangerous. Additionally there are a few indications that fields as low as a few volts per meter may cause changes in biological systems.

Chapters 4 and 5 cover the biological effects of static and ELF magnetic fields respectively. For static magnetic fields research is important because of increasing human exposure to higher fields in connection with NMR imaging and other techniques involving high magnetic field devices. At present this area remains an empirical science with little elucidation of effect in terms of mechanisms. Some reports show, however, the possible interaction of fields with cell membranes for several physiological effects. For ELF magnetic fields the author shows a series of publications that describe time-varying effects on a variety of cellular and tissue systems. However, the author concludes that it is difficult to draw conclusions concerning the bioeffects of these fields due to: 1) a wide range of intensities, frequencies, waveforms, and exposure duration which have been used, 2) lack of independent verification of acquired data, and 3) apparent inconsistencies found in the data on similar test specimens.

Part III addresses RF/MW fields and their effects on biological tissue. Chapter I is probably one of the most important chapters in the handbook because it deals with standard RF/MW dosimetry and metrology guidelines in performing the needed measurements for bioelectromagnetic effects. Carefully performed experiments are crucial for verification of theoretical predictions and delineation of their limitations. For instance, experimentally obtained whole-body average Specific Absorption Rate (SAR) for humans are three to four times greater than those calculated theoretically. Chapter 1 starts with the concept used in SAR, followed by an explanation of the techniques used in external/internal field measurements, calibration techniques, thermal measurements and descriptions of general facilities for exposure measurements (e.g., TEM cells, anechoic rooms, etc.).

Chapter 2 outlines some computational methods for field intensity predictions. However, about half of the chapter is spent in outlining analytical expressions for describing field intensities inside planar and spherical geometries and only a brief outline is made of computer methods for complex tissue analysis. Among the techniques described are volume/surface integral equation methods and finite differential time domain (FDTD) methods. Chapter 3 addresses the little known subject of how biological tissues thermoregulate their internal environment as a result of RF/MW fields. Chapter 4 describes a long series of RF/MW effects on biological systems at the cellular/molecular level, effects on reproduction, growth, nervous systems, cardiovascular systems, endocrine systems, immune systems, and auditory/ocular systems. The authors suggest that based on the experimental data the effects of MW exposure is primarily a response to hyperthermia. A critical review of studies into biological effects of RF/MW shows that many past investigations suffered from inadequate experimental facilities and energy measurement skills, or insufficient control of the biological specimens and the criteria for biological change. More sophisticated conceptual approaches and more rigorous experimental designs must be developed.

Chapter 5 covers a very interesting subject — the "window" effect. Basically it consists of the biological effects experienced only within narrow ranges of values and not observed anywhere else. Both frequency and field strength "windows" have been reported in the literature for which very little, if any, mechanisms are suggested. The book ends with two appendices. Appendix 1 defines some basic terminology and Appendix 2 provides very detailed tables of several well-known and some not so well-known safety standards.

The handbook can be recommended as a reference for those EMC engineers involved in the RADHAZ area as well as medical practitioners where the use of electromagnetic fields is used for analysis or therapeutic reasons. As you may have noticed, however, this book is quite costly.

INTERESTED IN EMI GASKETS?

HUGH DENNY

A completely enclosed metal box with no seams or openings makes a near ideal shield. The metal does not even have to be perfectly conducting. Common materials such as aluminum, copper or steel come very close to ideal shield performance. Unfortunately, a completely closed box is somewhat impractical. Common construction techniques typically require seams. Openings must be provided for access, for control, for monitoring, and for cable penetrations. Each one of these apertures degrade the ideal performance of the shield. An essential tool for minimizing unwanted coupling through an unintended aperture is the EMI gasket, an appropriately configured conformable conductive material sandwiched between the shield members being joined. The gasket materials range from specially constructed wire mesh, oriented wires, metallic fingers and spirals, to conductive polymers and adhesives.

How does one know that the gasket does the job intended or needed? This is a question that has bedeviled our community for several years. If you want a spirited argument, just pose this question among certain groups at the annual symposium. The answer, however, is of vital interest to manufacturers of gaskets, to designers who want their equipment to meet specifications and perform as needed in the electromagnetic environment, and to purchasing agents who want the best product for the lowest price.

A special committee has been formed of manufacturers, users and general interest persons (affectionately known in standards' inner circles as the MUG list) to develop a *Guide for Electromagnetic Characterization of Conductive Gaskets in the Frequency Range dc to 18 GHz*. This group, operating under IEEE Standards Board approval as Project 1302 (P1302), is identifying and evaluating existing and proposed techniques for characterizing the electromagnetic performance of conductive gaskets. It seeks to describe the various techniques, highlight their features and limitations, and provide guidance on the utility of the various techniques. This group of some 30-35 EMC engineers has met at the last two symposia. Officers have been elected and various sub-groups have been formed. Another meeting is planned for the Dallas Symposium. Check the conference program for the meeting room and time.

The P1302 Working Group is especially looking for concerns, needs and recommendations from the users and persons with general interest (the UG's of the MUG's) in the electromagnetic characterization of EMI gaskets. Provide indications of your interest to Hugh Denny (404) 894-3906, or bring your inputs in person to the P1302 Committee Meeting at the Dallas Symposium.

OR THE MEASUREMENT OF SHIELDING ENCLOSURES?

While we're on the subject of IEEE EMC Standards, IEEE Standard 299, *Standard for Measuring the Shielding Effectiveness of Electromagnetic Shielding Enclosures*, has begun its required five-year review for affirmation or revision as appropriate. The EMC Society Standards Committee is soliciting inputs from manufacturers and purchasers of shielded rooms or enclosures, from manufacturers of test equipment, and from organizations who test and certify screen rooms and shielded enclosures as to limitations of IEEE 299 (and its cousin, MIL-STD-285) and for recommendations for its improvement. Provide your inputs to the Working Group Chair, Mr. R.B. Schultz, EMC Consultant, 2030 Cologne Drive, Carrolton, TX 75007, to Mr. J.K. Daher, Secretary of the 299 Working Group, (404) 894-8228 or (404) 894-3906 (Fax), or to Hugh Denny of the EMC Standards Committee (404) 894-3906.

REVIEWERS NEEDED IN AREA OF EMC

The IEEE Press is desperate for reviewers and advisors in the area of EMC! Our growth and activity have given us a toehold on several EMC book projects and several more are being developed. Calls for reviewers by Press Liaison Dr. Hugh Denny have not brought the response that we need.

Would you please help? Here's how:

- Identify your own areas of reviewing interest.
- Nominate several others to be sent information.

The Press recognizes the reviewers' efforts with complimentary copies of books, honoraria for in-depth reviews, and prominent recognition within the published book.

To discuss book ideas, or to nominate series editors contact either Dudley R. Kay, Executive Editor, IEEE Press, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, phone (908)562-3967, fax (908)562-3969, or Dr. Hugh Denny, EMC Liaison to the Press, Principal Research Engineer, Georgia Institute of Technology, 225 North Ave. NW, Atlanta, GA 30332, phone (404)894-3522, fax (404)894-3906.

EMI/EMC TESTING FOR GOVERNMENT CONTRACTS

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CONTACT
MR. CARLOS ALVARADO or MR. KENNETH PROCTOR (908)532-1441/1712 Fax (908)532-1413

CALL FOR BoD NOMINATIONS

Nominations are now being accepted for candidates for the IEEE EMC Society Board of Directors. In accordance with the Bylaws, nominations may be made by petition or by the Nominations Committee. The petition shall carry a minimum of 15 names of Society members, excluding those of students. Nominees should possess professional stature and significant technical skills in electromagnetic compatibility. They must have adequate financial support outside the Society and have approval of their organizations or employers to actively participate. Duties will include attendance at three or four Board meetings a year and participation on committees, both of which require telephone communications, correspondence, etc. Nominees must be full members of the IEEE and members of the EMC Society. Elected Directors must serve a three-year term starting January 1, 1994. No member can serve for more than six consecutive years, including partial terms. All nominees are required to submit a biographical summary to the Nominations Chairman. The summary must not exceed a one-half typewritten page and must be in the following format:

1st paragraph	Name, title, place of employment, educational background
2nd paragraph	Technical and professional experience
3rd paragraph	IEEE service and activities including offices, committees, awards, etc.

Please submit petitions and biographical summaries to the Nominations Chairman. Submissions must be postmarked no later than May 30, 1993.

Edwin L. Bronaugh,
Nominations Chairman
EMCO
P.O. Box 1546
Austin, TX 78767
Telephone: (512) 835-4684, Ext. 665
FAX: (512) 835-4729

Information can be obtained from the Nominations Chairman.
(Nomination petition is printed on facing page.)

THE USAB AND THE HISTORY OF PACE

A.H. MILLS
PACE COORDINATOR

When the IEEE was founded in 1963 by a merger of the American Institute of Electrical Engineers (AIEE) and the Institute of Radio Engineers (IRE), the members approved its Constitution by a large majority. Following the traditions of AIEE and IRE, the Constitution stated that the Institute's purposes were scientific and educational. Moreover, by omitting any reference to nontechnical purposes, the Constitution required that the IEEE severely limit any activities outside the technical sphere.

However, in 1972, PACE (Professional Activities Council for Engineers) got its start. In that year, Section 2, Article 1 of the IEEE constitution covering the purposes of the institute was expanded to include professional along with scientific and educational purposes. Section 3 of Article 1 was changed to say that in addition to its worldwide operations, the IEEE may engage in activities directed to the needs and interests of members residing in a particular country or geographic area. These changes were submitted to the membership in November 1972 and approved by 86.8 percent of the voting members.

IEEE Bylaw 312 was put in place in 1973 to implement the changes in the IEEE constitution. This bylaw states that "The United States Activities Board (USAB) shall recommend policies and implement programs specifically intended to serve the members in the United States in appropriate nontechnical professional areas of economic, ethical, legislative, and social concern, supported by funds provided by the Regional assessment paid by such members. The USAB shall appoint standing and adhoc committees to carry out such programs. The USAB shall receive and make proposals and suggestions to other IEEE entities . . . "

The USAB consists of 18 voting members and a USAB staff director. The staff works out of its IEEE Washington office and the USAB chairman is also the IEEE Vice President, Professional Activities — one of the seven Vice Presidents in the Institute. This board oversees the activities of the following five USAB councils: Government Activities Council, Career Activities Council, Technology Activities Council, Member Activities Council, and Professional Activities Council for Engineers. The PACE Council facilitates member input to USAB programs and assists in implementing the programs of the other four Councils.

NOMINATION PETITION
ELECTROMAGNETIC COMPATIBILITY SOCIETY
BOARD OF DIRECTORS

(Nomination guidelines given on facing page.)

I. **NOMINEE'S NAME** _____

MEMBERSHIP NO: _____

ADDRESS: _____

_____

PHONE: _____

II. **BIOGRAPHICAL SUMMARY:** ATTACH TYPED COPY

III. **SIGNATURES:** (Minimum of 15 names.)
We, the undersigned, all of whom are current IEEE Electromagnetic Compatibility Society (EMCS) members in good standing, nominate the above mentioned person to serve on the EMCS BoD for a three-year term beginning January 1, 1994.

	MEMBER'S NAME (PRINT)	SIGNATURE	MEMBERSHIP NO.
1.			
2.			
3.			
4.			
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EMI MATERIALS AS BANDPASS FILTERS

CRAIG A. GRIMES
SOUTHWALL TECHNOLOGIES
This tutorial is published at the request of TC-7 to serve as a prelude to the Special Session being organized by TC-7 at the Dallas EMCS Symposium.

INTRODUCTION

If electronics were totally contained within a thick, conducting box, EMI would not occur. However, electronics are only useful if they communicate with the outside world; input and output ports are generally necessary. These ports have edges and edges support surface charges and currents that support fields which carry power. Once interfering signals enter a protective chamber, the chamber tends to trap them until they are absorbed. It is generally better to absorb such power in materials designed for that purpose than by the internal electronics.

Control of EMI depends upon the frequency range, the quantity of shielding required, the physical characteristics of the devices being shielded, and cost. EMI shielding techniques are largely determined by electromagnetic boundary conditions, which are in turn often determined by the boundary conditions of conductors. For example, just off the surface of an ideal conductor the reflected electric field is tangential and vanishingly small. The magnetic field is also tangential, but a local maximum field value. Therefore, electrically thin absorbers with magnetic loss are useful, while thin absorbers with electric field loss are not. Although conductors are widely used as EMI shielding materials they are poor absorbers, generally reflecting or transmitting the incident wave. EMI absorption is a two part problem; the first part is to get the offending field to penetrate the absorber and the second part is to absorb it.

EMI and EMI shielding are not limited to certain frequencies. Although the terminology changes, the physics of low frequency and high frequency shielding are not the same. What does change with frequency are the properties of materials. I review here some of the physics inherent in the interaction of materials with electromagnetic waves. It is my objective to promote better understanding of the material design issues facing EMI engineers.

THIN ABSORBERS

A thin absorber has a thickness much less than the skin depth. A lossless, conductor backed layer of material of any thickness has the same power reflection coefficient as the conductor. A thin film material with loss supports a reflection from its front face and another from the penetrating wave that reflects off the backing conductor and returns through the front face. The two fields add as vectors; depending upon conditions, they augment or cancel. The design task with thin absorbers is chiefly front face phase cancellation.

A single, uniform thin layer of material covers a conductor upon which a plane wave is normally incident. Inside the material the electric field E and magnetic field H may be written:

$$E=E_0[e^{-jkz} - e^{jkz}]$$
$$\eta\eta_0 H=E_0[e^{-jkz} + e^{jkz}] \quad (1)$$

where η is the relative impedance, k the wavenumber, and the subscript 'o' denotes free space. With the conductor impedance equal to zero, the impedance at the front face of the layer is

$$Z_f=j\eta_0\eta\tan k_0\gamma d \quad (2)$$

where d is the layer thickness, $\gamma=\sqrt{\mu\varepsilon}$, μ is the permeability of the material and ε is the permittivity of the materials relative to free space, and $\eta=\sqrt{\mu\varepsilon}$. If $k_0\gamma d<<1$ then

$$\tan k_0\gamma d = k_0\gamma d \quad (3)$$

and Eq. (2) may be written as

$$Z_f=j\eta_0\mu k_0 d \quad (4)$$

The voltage reflection coefficient from the front face is

$$\rho=\frac{\eta_0-Z_f}{\eta_0+Z_f} \quad (5)$$

Combining (4) and (5) shows that

$$\rho=\frac{1-j\mu k_0 d}{1+j\mu k_0 d} \quad (6)$$

Permeability is complex, $\mu = \mu' - j\mu''$. The power reflection coefficient is given by

$$R = \rho\rho^* \quad (7)$$

where * denotes complex conjugate. Eq. (7) may be written:

$$R=\frac{(1-\mu'' k_0 d)^2 + (\mu' k_0 d)^2}{(1+\mu'' k_0 d)^2 + (\mu' k_0 d)^2} \quad (8)$$

Clearly from (8), R is minimized if

$$\mu'' >> \mu' \text{ and } \mu'' k_0 d = 1 \quad (9)$$

The second term in (9) can be rewritten $\mu''=\frac{\lambda_0}{2\pi d}$. A broadband absorber must meet the condition of (9) over the frequency range of interest. Therefore μ'' must decrease linearly with frequency. A linearly decreasing μ'' is relatively easy to obtain when operating above the permeability resonance frequency of the material. However, Eq. (3) requires that

$$\sqrt{\mu\varepsilon} \ll \frac{\lambda_0}{2\pi d} \quad (10)$$

and therefore it is required that

$$\mu'' >> \varepsilon \quad (11)$$

Permeability mechanisms, either domain wall motion or rotation of the magnetization factor, are considerably slower than their electronic permittivity counterparts. As the frequency of the applied field

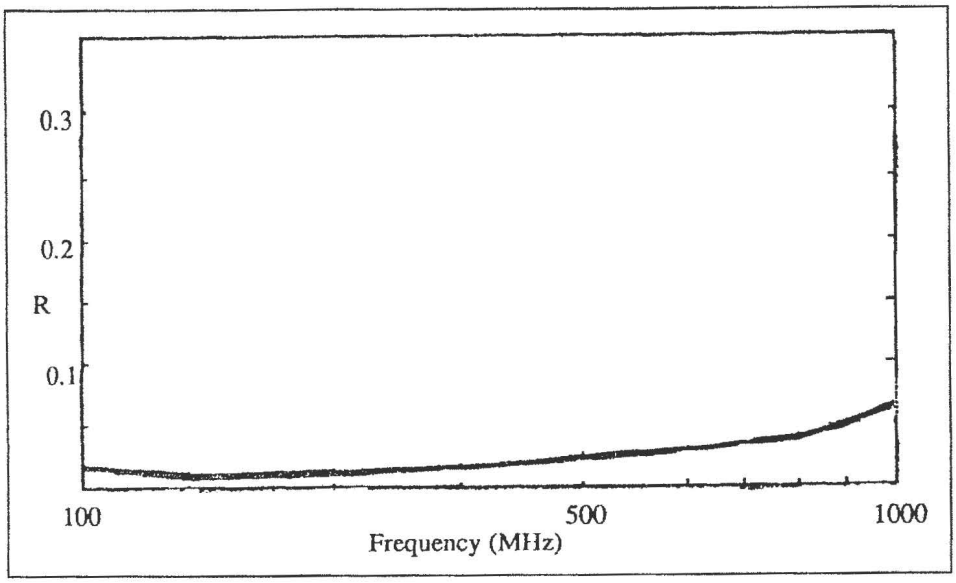

FIGURE 1. Percent power reflected from a copper backed 5 mm ferroxplana ferrite sheet as a function of frequency.

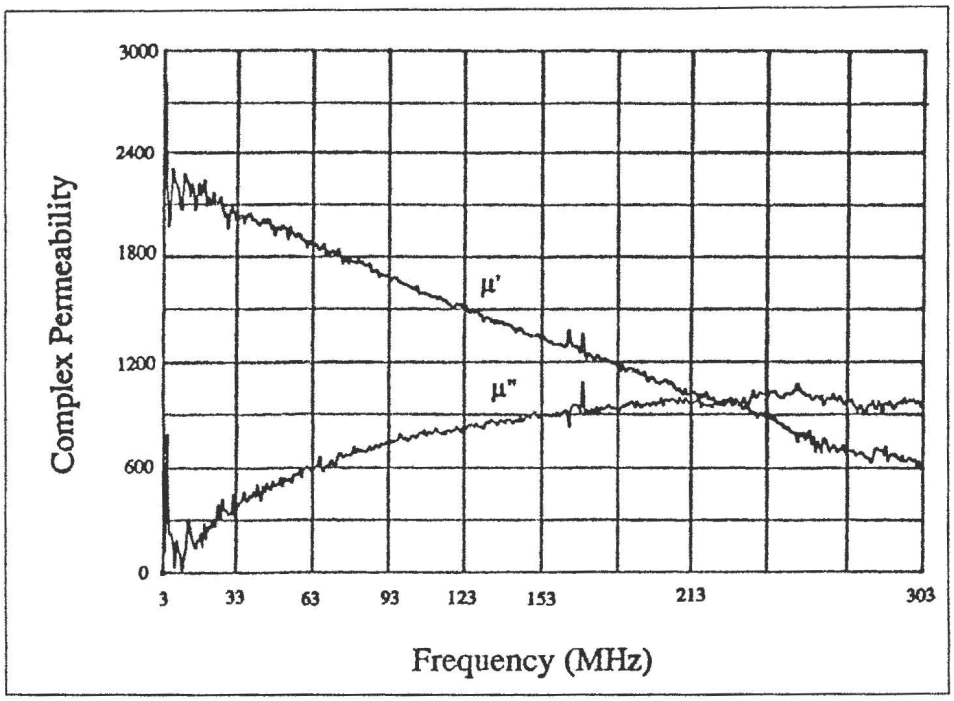

FIGURE 2. The complex permeability spectrum of a multilayer NiFe thin film where μ' decreases linearly and μ" increases reaching a constant value at approximately 150 MHz.

increases the magnetization vector is less able to respond. Therefore condition (11) becomes increasingly hard to meet as the frequency increases. Above 20 GHz the permeability of all materials is generally $\mu - 1 - j0$; the EMI incident upon the thin layer is no longer absorbed but reflected. Figure 1 is a plot of the power reflected from a 5 mm conductor backed ferroxplana ferrite sheet as a function of frequency.

The mathematics for an absorber about 1/4 thick is similar, except that the crucial parameter is ε, not μ.

THICK ABSORBERS

Thick, uniform layers operate independently of their backing; no significant amount of power returns to the front face to affect the impedance. For a normally incident plane wave reflection is dependent upon the permeability to permittivity ratio; an ideal thick absorber meets the condition

$$\mu = \varepsilon \qquad (12)$$

When this condition is met the reflection is zero, with power absorbed in the layer. This condition must be met over the frequency range of interest. Generally speaking, electric-based susceptibilities of solids are essentially independent of frequency and are small, in the range of five to fifteen. Conductive materials at optical and lower frequencies generally satisfy the relationship.

$$\varepsilon'' = \frac{\sigma}{\omega \varepsilon_0} \gg \varepsilon' \qquad (13)$$

where σ is the conductivity, and $\omega = 2\pi f$ the radian frequency. Even for poor conductors μ must generally be large to jointly meet the conditions of Equations (12) and (13). Since large permeabilities decrease the skin depth, highly resistive materials are needed such as CoFeB or CoFeZr amorphous alloys. If condition (12) is met, since ε'' generally decreases as $1/f$ and ε' remains small and constant, to operate over a wide frequency band μ' should go as $1/f$ and μ'' remain constant. Figure 2 is the complex permeability spectrum of a film composed of four 120 nm thick layers of permalloy with three 20 nm brass space layers. We see that μ' decreases linearly with frequency while μ'' increases up to approximately 150 MHz where it becomes constant. This material, used as a thick layer, might be suitable for absorption between 150 MHz and 300 MHz.

BANDPASS MATERIALS

EMI shielding materials can be viewed as bandpass filters. For example copper film acts as a lowpass filter; given a thickness

Continued . . .

suitable for shielding a certain frequency it is transparent (pass) to lower frequencies, and reflective (stop) to higher frequencies. This property can be clarified by considering the skin depth, a measure of the distance that electromagnetic radiation penetrates into non-perfect conductors. Letting E_S represent the intensity of an incident electric field on the surface of a conductor, it travels into the conductor in the z-direction with a changing phase and an exponentially decreasing magnitude as:

$$E = E_S e^{-(1+j)z/\delta} \qquad (14)$$

where z is the distance into the conductor and δ is the skin depth,

$$\delta = \sqrt{\frac{1}{\pi\mu f\sigma}} \qquad (15)$$

The skin depth is the distance into the conductor at which the field magnitude drops to 1/e of the surface value. Thicknesses less than the skin depth are effectively transparent, thicknesses greater than the skin depth are effectively opaque. The transmission coefficient for the electric field incident upon a given layer is:

$$\tau = \frac{2\eta}{2\eta\ \cos(kd) + j(1+\eta^2)\sin(kd)} \qquad (16)$$

where d is the thickness of the layer, η the layer impedance, and k the wavenumber inside the layer.

Highpass EMI shielding materials are currently receiving great interest. These materials are optically transparent but electrically conductive (EC) enough to provide RFI shielding. Transparent EC coatings are generally semiconductive metal oxides such as tin oxide or indium tin oxide (ITO). The conductivity of the metal oxide films is frequency dependent, undergoing a resonance at optical frequencies making them transparent. Therefore, relatively thick layers can be used to provide higher levels of EMI shielding. Since optically transparent magnetic materials are not available, the RFI

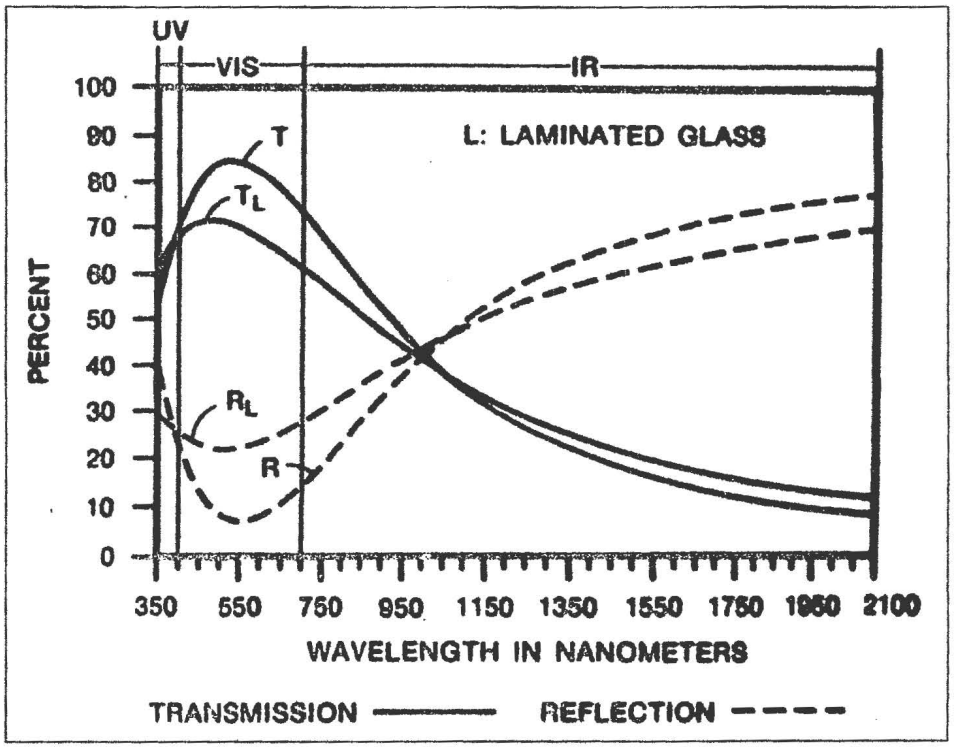

FIGURE 3. The UV to IR transmission spectrum of a 20 Ω/□ ITO | Au | ITO multilayer stack, deposited onto a 50μm PET substrate, free standing and laminated between glass.

shielding effectiveness of these films is determined by their conductivity and thickness. For many shielding applications of transparent EC films, such as video display terminals, the incident interfering wave is in the near field region. Letting 'r' represent the distance between the EMI source and shield, the near field region can be defined as $r<\lambda/2\pi$. The EMI absorption, in dB, of EC films in the near field region is given by [1]:

$$P_{ab|near\ field} = 8.686d\sqrt{\pi\mu f\sigma} \qquad (17)$$

The near field reflectance is given by:

$$R_{ab} = 20\log_{10}\frac{\beta d\sigma}{rf} \qquad (18)$$

where β is a very large constant, approximately 10^{10} depending upon the units. The absorption of EC transparent films is essentially zero; most of the shielding is achieved by reflection which is proportional to the logarithm of the coating conductivity.

Very thin films of optically transparent EC metals such as copper or gold can be used to provide additional EMI shielding and control the transmission of IR frequencies. The thickness of the metal films is kept below the optical skin depth, approximately 20 nm. Although highpass metal oxide or thin metal films of equal conductivity can be used interchangeably to achieve a given level of attenuation the optical properties are quite different. For example, metal oxides are generally opaque in the UV band due to their band gap energies. A SnO_2 crystal with a band gap of about 3.7 eV will not transmit wavelengths below about 0.34 μm. In comparison, thin metal coatings transmit UV wavelengths down to 0.1 μm, corresponding to the plasma frequency of the charge carriers. Light transmittance is a function of the resistivity of the material and a compromise between the desired electrical and optical properties.

For IR frequencies and above very precise highpass filters can be made using multilayer thin films. The performance of multilayer stacks are

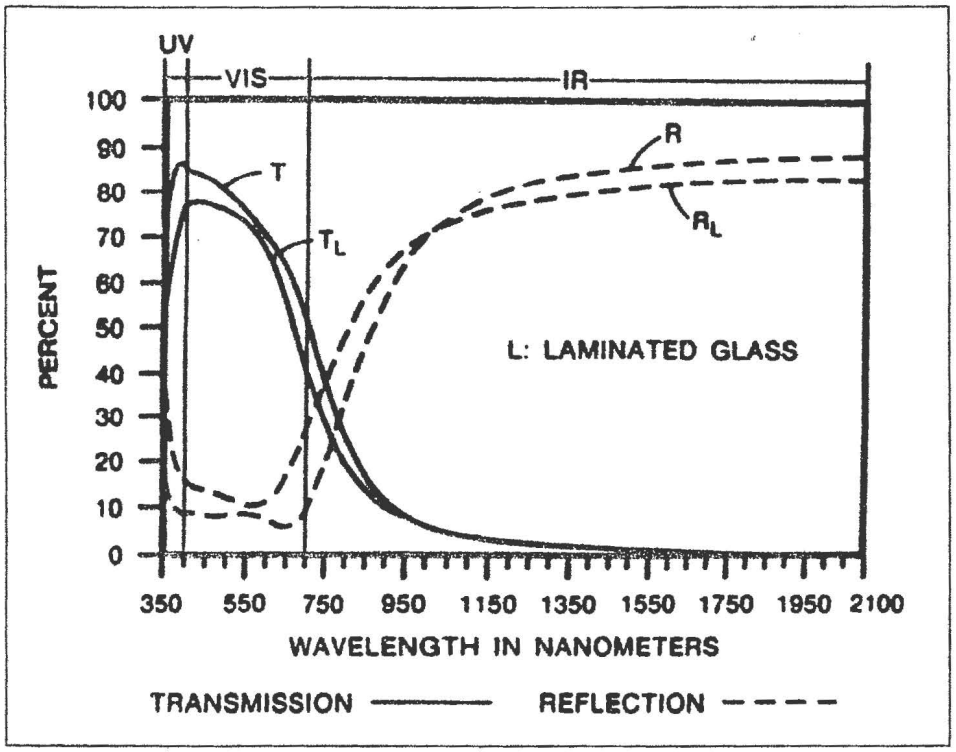

FIGURE 4. The UV to IR transmission spectrum of a 20 Ω/□ Au | ITO | Au multilayer stack, deposited onto a 50μm PET substrate, free standing and laminated between glass. The metal layers act as Fabry Perot filters to increase the wavelength selectivity.

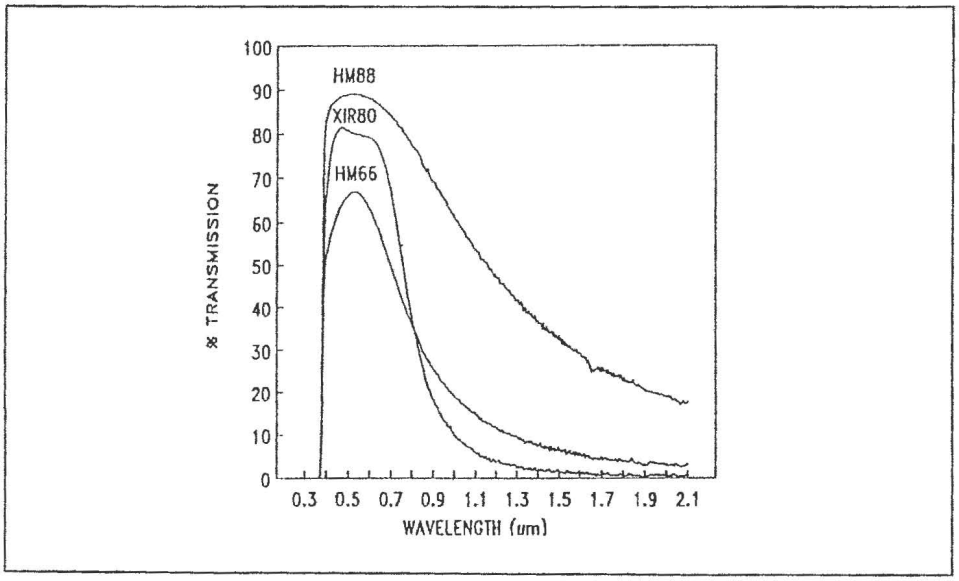

FIGURE 5. The UV to IR transmission spectrum of Southwall's electrically conductive EMI shielding films. HM88 and HM66 are ITO | Au | ITO multilayer stack of different thicknesses. XIR80 is an In_2O_3 | Ag | In_2O_3 | Ag | In_2O_3 thin film Fabry Perot filter.

dependent upon the internal details of the films. This can be clearly seen in Figures 3 and 4. Figure 3 is a plot of the UV to IR transmission spectrum of a 20Ω/□ ITO | Au | ITO multilayer stack deposited onto a 50 μm thick PET substrate. The two traces are for the film itself and the film laminated between two sheets of glass. Figure 4 is the transmission spectrum of 20Ω/□ Au | ITO | Au multilayer stack. The two metal layers act as Fabry Perot filters [2] to greatly improve the wavelength selectivity of the bandpass film. The bandpass frequency can be controlled by selection of the dielectric cavity material and its thickness. Figure 5 shows the bandpass nature of three commercial EMI shielding films made by Southwall. HM88 and HM66 are sputtered ITO | Ag | ITO multilayer films, on a PET substrate, that block the UV and IR wavelengths while passing the visible. The numbers refer to the nominal percentage of light transmission. For this stack design greater shielding of the IR requires thicker layers which reduce the optical transmission. The XIR80 coating is an In_2O_3 | Ag | In_2O_3 | Ag | In_2O_3 multilayer film on a PET substrate, which has greater IR rejection than HM66 while having visible optics similar to that of HM88.

An alternative to transparent EC coatings for highpass EMI shielding is to use wire grids and meshes. A periodic grid of highly conductive metallic bars will, depending upon the polarization of the incident wave, transmit and reflect without diffraction wavelengths much greater than the period. Both polarizations are reflected by a mesh formed by combining two orthogonal grids. Replacing the mesh by its complementary pattern, i.e. conducting squares and open wires, the transmittance and reflectance performance are interchanged. Therefore, a passband for a mesh pattern would become a stopband for the complementary pattern. For EMI shielding the most important mesh characteristic is the period of the mesh. For a given frequency, a smaller period results in higher shielding. Bar widths have a smaller effect of the shielding, but do increase it slightly. Bar thickness and conductivity have only a slight effect of shielding since most shielding is reflection, not absorption.

REFERENCES

[1] H.A. Lassiter, IEEE Trans. on EMC, vol. EMC-6, No. 3, pp. 17-30 (1964).
[2] P.H. Berning, Appl. Opt., Vol. 22, pp. 4127-4141 (1983).

Continued from page 1

1992, over 53% of the respondent's time was spent in commercial activities with only 33% spent in military activities. The hardest hit sector of military EMC has been in EMP, falling from 7.3% in 1989 to only 1% in 1992 and TEMPEST dropping from 6.7% to 3.3% over the same period (See Figure 3). Table 1 compares specific information for the past four years.

NARTE certification of technicians and engineers has become a popular method of peer recognition. Over 52% of the respondents are currently certified by NARTE. While the original impetus came from the military, it appears that there are as many NARTE certified engineers working in the commercial sector as there are in the military. Even EMC engineers from Europe, the Middle East and Asia have been certified.

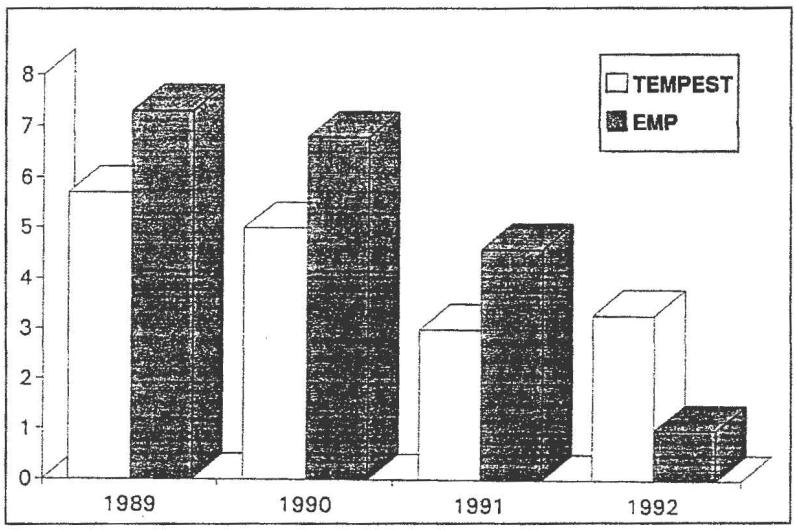

FIGURE 3. Percent of Time in Specific Areas.

The IEEE EMC Society board of directors is attempting to improve the methods of conducting surveys and providing information to the membership. We look forward to receiving comments for the improvement of our data gathering and surveys.

YEAR	SALARY	AGE	EXP.	COMMERCIAL %
1989	$53K	43	16	40
1990	$56.6K	44.8	18	40.1
1991	$71.8K	45.6	19.7	51.4
1992	$69K	49.9	22.2	53.3

TABLE 1. A comparison of data for the last four years.

EMC TRANSACTIONS EDITOR

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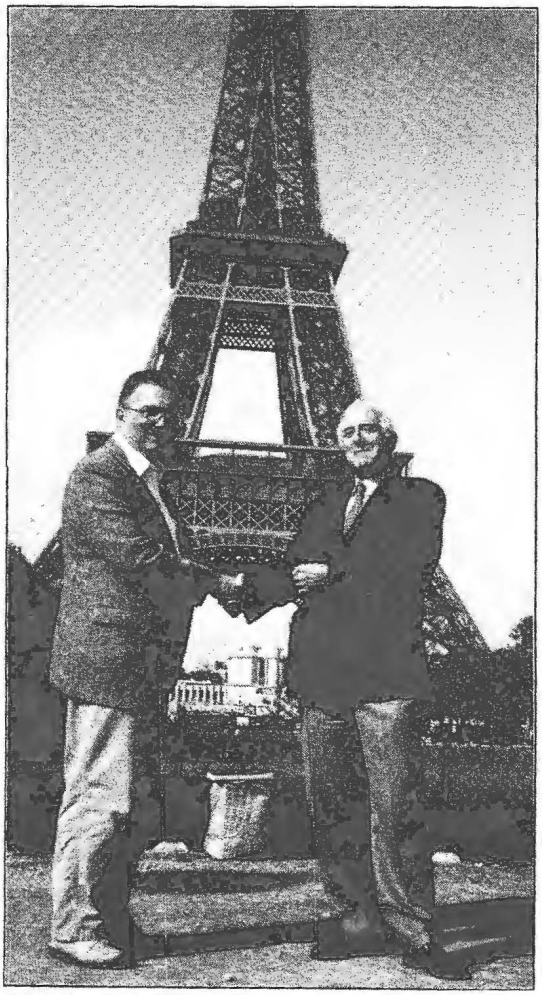
CHAPTER CHATTER . . . Continued from page 4

February 18th. Dr. Gavenda is a professor of physics who has been actively involved in EMC-related research for many years. His talk was entitled "Near Field and Log-Periodic Antenna Corrections to Site Attenuation Measurements."

Many thanks to Bob Hunter for supplying the information above on the activities of the Central Texas chapter.

FRANCE

The first open meeting of the new EMC society chapter in France was held on November 26, 1992. The meeting was co-organized with the local SEE (Société des Electriciens et Electroniciens). The theme of the meeting was "Electromagnetic Compatibility and the European EMC Directive." There were two featured speakers, Mr. Jean-Claude Perrin, Director of the French National Laboratoire Central des Industries Electriques (LCIE), and Mr. Michel Mardiquian, Consultant in EMC.



Dick Ford, EMCS BoD Treasurer and Dr. Ferdy Mayer, President of the French, Belgium and Luxembourg IEEE EMCS Chapter, pause for a snapshot in front of a famous Paris landmark.

TWIN CITIES

This meeting report was initially lost during the change of associate editors. Hats off to Jerry Becker, Vice Chairman of the Twin Cities chapter, for realizing our mistake and sending a second copy of the report.

On October 20th, a joint meeting of the Twin Cities EMC and Power Engineering chapters was held in conjunction with the Minnesota EMC event. A social hour and dinner preceded presentations on the topic "Power Harmonics, Problems and Improvements."

Participating in the technical program were Larry LaCoursiere and Daryl Gerke of the EMC Society and Dan Nordell, Ellen Kresse, Mike Knights, and Bill Montcrieff of the Power Engineering Society. Thanks to all for an excellent program.

SANTA CLARA VALLEY

Mr. David Whitton, from Hewlett Packard, was the speaker at the March 9th meeting of the Santa Clara Valley chapter. He provided an interesting history of the spectrum analyzer from the World War II era to the present. He also discussed measurement strategies to achieve the best possible accuracy for different types of signals.

EMCS EDUCATION COMMITTEE NEWS . . . Continued from page 5

A first step was suggested by one of the participants at the EAB meetings. The suggestion was to design a set of class modules for inclusion in the traditional E-Mag theory course that illustrates particular aspects of the theory in the practical terms of EMC. If we can begin by introducing the subject of EMC to electromagnetic theory students, even in a small way, it may well be the beginning of the change we need.

A possible point of departure for several such modules may lie in the examples contained in the education committee's "EMC experiments manual." Examples with demonstrations would give students the practical application of the theory, and direct physical experience to tie the theory down. How many of us would have been delighted to have had such a link to the 'real world' in our introductory courses in electromagnetic theory?

TESTING THE WATERS

I am under no illusions about the forgoing proposal. I do not believe that this represents the only solution to a vexing problem. However, I do think that it is possible to effect change, and that a small number of determined men and women can change the world, if they are convinced that the change is right and good. I am asking us all to consider these ideas and to debate the possibilities.

I would appreciate hearing your views, suggestions, criticisms and comments. I hope that the ideas I have expressed have prompted some thoughts on your part, and that they promote discussion. Discussions that lead to a consensus of opinion and positive action would be the best of all possible outcomes.

CALL FOR PAPERS

1994 INTERNATIONAL SYMPOSIUM ON ELECTROMAGNETIC COMPATIBILITY

May 17 – 19, 1994, at SENDAI, JAPAN

The Technical Group on EMC of IEICE, IEE of Japan
The EMC Society of IEEE and Its Tokyo Chapter

The 1994 International Symposium on EMC (EMC '94/SENDAI) will be held in Sendai, Japan, during May 17–19. Authors are invited to submit papers on the current state of EMC technology and related disciplines. Original, unpublished papers will be considered in the following technical areas:

1. Noise, including Spurious and Harmonics
2. Contacts and Gap Discharge Phenomena
3. Lightning Surge, EMP and ESD
4. EM Field and Lines/ Coupling and Crosstalk
5. Scattering: TV Ghost Problem and Radar False Echoes
6. EM Wave Propagation and Fading
7. EM Environments
8. Interference and Damages
9. Noise and EM field Measurement and Analysis
10. EM Sensor, Probe and Antenna
11. Shielding and Grounding/ Technique and Material
12. EM Energy Absorber/Anechoic Chamber
13. Filter, Transformer and Isolator
14. EMI/EMC Test
15. Immunity and Susceptibility
16. Biological Effects
17. Hyperthermia
18. Non-sinusoidal Signal
19. Spread Spectrum Techniques
20. Optical and Ultrasonic Application
21. EMC in Communication and Automation Systems
22. EMC in Instrumentation
23. EMC in CPU/VLSI
24. EMC in Radio Navigation/ Aerospace
25. EMC in Mobile Communication
26. EMC in Consumer Products
27. EMC in Microelectronics
28. EMC in Transportation
29. EMC in High Energy Generation
30. EMC in Mines
31. Spectrum Economy and Management
32. Standards, Regulations, Limits and Specifications
33. EMC Education
34. Remote Sensing
35. EMC in Amateur Radio
36. Seismogenic EM Phenomena
37. Others

Official Language is English.

Author's Schedule:

Abstract and **Summary** (Original and 2 copies required)	**July 31, 1993**
Notification of Acceptance	**Oct. 31, 1993**
Camera-Ready Copy	**Jan. 31, 1994**

Prospective authors should submit both a 35–50 word abstract and a 500–700 word summary written in English (up to 6 illustrations) that clearly explain their contribution, its originality and its relevance to the EMC discipline. For anonymity of review, please identify author(s) only on the cover sheet. Upon acceptance, author(s) will receive forms and instructions for preparing materials to be printed in the symposium record.

Abstract and summary should be sent directly to:

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Tokyo Univ. of Agriculture and Technology
EMC '94 Technical Chairman
2-24-16 Nakamachi, Koganei-shi, Tokyo 184, JAPAN
TEL: +81-423-81-4221 FAX: +81-423-85-7204

For further information, please contact to :

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June 17-18, 1993	IEEE Investment Committee	Ritz Carlton Aspen, CO	Michael J. Sosa (908) 562-5324
June 28-30, 1993	TAB Meetings	Caribe Hotel San Juan, PR	Georgina Crane (908) 562-3920
July 1-4, 1993	1993 Sections Congress	Caribe Hilton San Juan, PR	Susan Sacks (908) 562-5512
July 4-5, 1993	IEEE Executive Committee	Caribe Hotel San Juan, PR	Mercy Kowalczyk (212) 705-7757
Nov. 4-5, 1993	IEEE Investment Committee	Manele Bay Hotel Lanai, Hawaii	Michael J. Sosa (908) 562-5324
Nov. 18-20, 1993	TAB Meetings	N. Raleigh Hilton Raleigh, NC	Georgina Crane (908) 562-3920
Nov. 21-22	IEEE Board of Directors	N. Raleigh Hilton Raleigh, NC	Mercy Kowalczyk (212) 705-7757
and Nov. 22, 1993	IEEE Executive Committee		

EUROEM94 CALL FOR PAPERS

The EUROEM94 International Symposium organized with the technical co-sponsorship of the IEEE Antennas and Propagation Society, the International Union of Radio and Science (Commission E), and the permanent NEM Committee will be held at the Bordeaux-Lac Convention Center from May 30 to June 3, 1994.

General information about the EUROEM94 Symposium may be obtained from: Ms. H.V. Dhur, Symposium Secretary - Phone: (33)-65-10-54-06, Fax: (33)-65-10-54-33, or Mr. D.J. Serafin, Symposium Coordinator - Phone: (33)-65-10-54-46, or Fax: (33)-65-10-54-09.

All abstracts and summaries must be received by January 10, 1994. Prospective authors can receive instructions from:
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Technical Program Committee
Centre d'Etudes de Gramat
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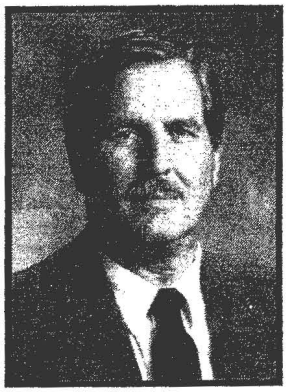
Fax: (33)-65-10-54-33

EMCABS



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ASSOCIATE EDITOR

Following are abstracts of papers from previous EMC Symposia, other conferences, meetings and publications.

EMCAB COMMITTEE
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Also, the steering staff of the Japan Technical Group and the EMC-J Tokyo chapter have offered to act as a central point for requests of papers abstracted here. Most of the papers will be available in Japanese only. The steering staff will assist in routing your request to the author(s) but will not do translating of the papers. The contact person is Prof. Yoshio Kami, the University of Electro-Communications, 1-5-1, Chofugaoka, Chofu-Shi, Tokyo 182, Japan. Abstracts of papers from EMC-J will be clearly identified.

Some of the Chinese papers are not available in English. Associate Professor Sha Fei, EMC Research Section, Northern Jiatong University has offered his time and assistance in routing requests for papers to the appropriate author(s). He is not furnishing a translation service.

As the EMC Society becomes more international, we will be adding additional worldwide abstractors who will be reviewing articles and papers in many languages. We will continue to set up these informal cooperation networks to assist requesters in getting the information or contacting the author(s). The library at Southwest Research Institute, 6220 Culebra Road, San Antonio, Texas, 78228-0510 has agreed to catalog, shelve, and have available for interlibrary loans proceedings from symposia and meetings which are donated to the library. Any such donations can be sent to me at the above address and I will review them for suitable articles and then forward them to the SWRI library. We are particularly interested in symposium proceedings which have not been available for review in the past. Neither the abstractors nor myself have a budget for acquiring proceedings; we rely on those we receive through attendance at symposia and from various subscriptions. Thank you for any assistance you can give in expanding the EMCS knowledge base.

DEVELOPMENT OF MULTIPATH MEASUREMENT & SIMULATION EQUIPMENT FOR WIDEBAND MOBILE RADIO

EMCABS: 01-5-93

E. Moriyama, M. Mizuno, T. Iwama, T. Ohgane, H. Ryuko, and S. Sekizawa
Comm. Research Lab., Ministry of Posts & Telecommunications of Japan, Tokyo
Proceedings of IEEE Vehicular Technology Society Conference IEEE Cat #92CH3159-1, ISBN 0-7803-0673-2 (Softbound), or Library of Congress #83-645418
May 10-13, 1992, Volume One, pp. 536-539

Abstract: Equipment which has the capabilities for multipath measurement and also for wideband (10MHz) digital simulation of a land mobile radio channel is described. Since the equipment has the capability for reproducing measured multipath, we propose to use measured data (successive impulse response sequences) to make a standard propagation model. This can then be used as an alternative to the conventional simplified model for developing and evaluating radio equipment operating in the land mobile multipath environment. In the multipath measurement mode, the equipment has the capability to store signals from multiple receiving antennas. We can use three-dimensional antenna array on vertical and horizontal polarizations simultaneously. Consequently, we can measure arbitrary incoming path directions. This capability is useful for developing and evaluating adaptive arrays and space diversity antennas as countermeasures to channel distortion in the multipath propagation environments.
Index Terms: Measurements, modeling, propagation

IMPACT OF A NON-FADING GAUSSIAN CHARACTERIZATION OF INTERFERENCE OF PORTABLE RADIO LINK ANALYSIS

EMCABS: 02-5-93

C.L. Despins, D.D. Falconer*, and S.A. Mahmoud*
Ecole Polytechnique de Montreal, Montreal and Carlton University, Ottawa, Canada
Proceedings of IEEE Vehicular Technology Society Conference IEEE Cat #92CH3159-1, ISBN 0-7803-0673-2 (Softbound), or Library of Congress #83-645418
May 10-13, 1992, Volume One, pp. 139-142

Abstract: In order to make the analytical evaluation of portable radio link performance tractable while avoiding lengthy simulations, intersymbol interference and cochannel interference are often modelled as non-fading Gaussian noise. This paper investigates the viability of such an approach for wideband channels where equalization and space diversity are used to combat interference and signal fading. The analytical results obtained using such a model of interference are compared to those of a semi-analytical approach based on the method of moments and Monte Carlo averaging over the fading statistics. It is shown that as long as the number of cochannel interference is smaller than the space diversity order, the variance of the Gaussian interfering symbols can be adjusted to provide a reasonable estimate of performance over error rates of interest.
Index Terms: Interference, communications, analysis

ANALYSIS OF FAST TRANSIENT ELECTROMAGNETIC FIELDS: A FREQUENCY DEPENDENT 2-D PROCEDURE

EMCABS: 03-5-93

S. Celozzi and M. Feliziani
Department of Electrical Engineering — University of Rome "La Sapienza" Rome, Italy
IEEE Transactions on Magnetics
March 28, 1992, pp. 1146-1149

Abstract: A computer method of analyzing fast transient electromagnetic fields is proposed. Frequency domain analyses use the Helmholtz equation solution based on the finite element method (FEM). A variable mesh size solution in the FEM permits faster computer runs with little loss of accuracy. Transients are then obtained by Fourier methods. The method is applicable to fast transient studies such as LEMP, NEMP and ESD where very fast rise times are found.

Index Terms: Fast transient electromagnetic fields, variable mesh size in Finite Element Methods (FEM), Helmholtz equations, discrete Fourier transforms and inverses, Impedance Boundary Conditions (IBC), LEMP, NEMP, ESD

TIME DOMAIN SIMULATION OF SKIN AND PROXIMITY EFFECTS IN MULTI-CONDUCTOR TRANSMISSION LINES

EMCABS: 04-5-93

E. Groteluschen, K.-P. Dyeck and H. Grabinski
E. Groteluschen, K. -P. Dyck Institut fur Theoretische Elektrotechnik; H. Grabinski, Labortorium fur Informationstechnologie Universitat Hannover, Hannover, FRG
Archiv für Elektrrotechnik
Vol. 75, 1992, pp. 255-260

Abstract: This paper describes a new method of modeling skin effects and coupling in multiconductor transmission lines, especially those in nonlinear circuits such as digital circuits. The time domain simulation of lossy transmission lines is based on a circuit model that includes a lossless section in tandem with an attenuation network. Numerical integration is avoided resulting in faster computer runs. The model predicts that a non-ideal ground plane has little effect on coupling (crosstalk). Results are also extended to transmission lines on a larger scale, e.g., on PWBs.

Index Terms: Time domain simulation, modeling skin- and proximity-effects, transmission lines in VLSI and PWBs, transient analysis of lossy transmission lines

ANALYSIS OF HIGH SPEED VSLI INTERCONNECTS USING THE ASYMPTOTIC WAVEFORM EVALUATION TECHNIQUE

EMCABS: 05-5-93

T.K. Tang (1) and M.S. Nakhla (2)
(1) Bell Northern Research, Ottawa, Canada; (2) Dept. of Electronics, Carleton University, Ottawa, Ontario, Canada
IEEE Transactions on Computer-Aided Design
Vol. 11, March 1992, pp. 341-352
Abstract: The analysis of delay and crosstalk in VSLI and PWB (PCB) interconnects now requires the use of distributed elements rather than the lumped elements historically used. The authors generalize the Asymptotic Waveform Evaluation (AWE) to produce the GAWE. The AWE methods are reviewed, then the GAWE methods are derived. Faster computer run times can be realized by adjusting the precision of the model. The results are compared with those of SPICE and HSPICE programs. GAWE methods can handle arbitrary numbers of multiconductor transmission lines with no topological constraints.
Index Terms: Crosstalk in transmission lines, distributed elements, AWE techniques, modified nodal analysis (MNA) matrix, Maclaurin's series, Laplace transforms, SPICE, HSPICE, PWB interconnects, fast computations

OPTICALLY SENSED EM-FIELD PROBES FOR PULSED FIELDS

EMCABS: 06-5-93

M. Kanda and K.D. Masterson
National Institute of Standards and Technology (NIST), Boulder, CO
Proceedings of the IEEE
Vol. 80, January 1992, pp. 209-213

Abstract: The use of photonic probes permit more accurate measurement of high level pulsed fields than was previously possible. Both amplitude and phase information is sensed. The probes are free of EMI and produce minimal perturbation of the field being measured. Laser light is conducted to an electooptic modular (probe) where it modulates the optical signal that is returned to the optical detector and signal processor. The system is analyzed with special attention to antenna transfer function, modulator transfer function, directional coupler configuration, system performance as determined by noise.

Index Terms: EM-field probes, optical sensing, probe system analysis, antenna transfer functions, modulator transfer functions, directional couplers, noise in probe systems, EMP measurements

AN EQUIVALENT "RADIATED EMISSION" VOLTAGE MEASUREMENT STANDARD FOR TEM CELLS

EMCABS: 07-5-93

E. Stinke (1), P. Wilson (2), and H. Gabe (2)
(1) Messelektronik Berlin GmbH, Berlin, Germany, (2) EMC Baden AG, Baden, Switzerland
11th International Wroclaw EMC Symposium, Wroclaw, Poland
Part 1, September 2-4, 1992, pp. 301-304

Abstract: The direct use of the voltages measured at the output of TEM and GTEM cells to evaluate the radiated emissions from electrical devices is considered. Most emission standards presently require that TEM cell measurements be correlated to OATS equivalent electric field values. A multipole model of the source as radiator is used to correlate between the two environments. In principle, however, it is possible to directly write a voltage standard for TEM cells which incorporates the multipole model correlation calculation. The result is a significant time savings since the calculation is not repeated for each individual device test. The paper explores the usefulness of such a direct standard through a set of measurements on two sample devices.

Index Terms: Measurements, TEM cell, GTEM

FAR FIELD AND RADAR CROSS-SECTION CALCULATION USING TLM METHOD

EMCABS: 08-5-93

Mohsine Khalladi, G. Gimenez, J.A. Morente, and J.A. Porti
Dpto. Fisica Aplicada, Facultad de Ciencias, Univ. Granada, Spain
11th International Wroclaw EMC Symposium and EMC Symposium, Wroclaw, Poland
Part 1, September 2-4, 1992, pp. 37-39

Abstract: The calculation of the far-scattered field and radar cross-section (RCS) of three-dimensional conducting complex bodies using the transmission-line-matrix (TLM) method with the symmetrical condensed node is presented. The calculation is based on a direct near- to far-field transformation in the time domain. Examples of far-zone-scattering results for traditional objects are given to validate the technique.

Index Terms: Radar cross-section (RCS), transmission-line-matrix (TLM)

ESTIMATION OF ELECTROMAGNETIC INTERFERENCE EMITTED FROM CABLES OF TELECOMMUNICATION EQUIPMENT

EMCABS: 09-05-93

Fujio Ameniya, Nobuo Kuwabara, and Tsuyoshi Ideguchi
Nippon Telegraph and Telephone Corp. NTT Telecommunication Networks Labs, Tokyo, Japan
11th International Wroclaw EMC Symposium and EMC Symposium, Wroclaw, Poland
Part 1, September 2-4, 1992, pp. 197-201

Abstract: An electric field is created around a telecommunications line by common-mode currents caused by oscillator clock signals, switching signals of a power supply, and digitally transmitted signals. This field can constitute a potential source of interference to radio reception. CISPR/SCG and CCITT/SGV have been investigating test methods and disturbance limits at telecommunications signal ports. This paper describes measurement results for the interference field radiated from a telecommunications line and estimates the conversion from a signal's differential-mode voltage to a common-mode voltage, to validate the draft disturbance limits at telecommunications signal ports.

Index Terms: Measurements, modeling

BONDING CONFIGURATIONS FOR TELECOMMUNICATIONS INSTALLATIONS

EMCABS: 10-5-93

Michael Parente
Bell Communications Research, Morristown, NJ
11th International Wroclaw EMC Symposium and EMC Symposium, Wroclaw, Poland
Part 1, September 2-4, 1992, pp. 202-206

Abstract: This paper describes the electromagnetic compatibility (EMC) measures that are included in the new CCITT Recommendation K.27 concerning bonding configurations and earthing inside telecommunications buildings. It introduces the definitions and configurations of the Recommendation, and presents qualitative rationales for the EMC measures. It also introduces efforts in CCITT Study Group Five concerning bonding configurations and earthing at subscribers' premises.

Index Terms: CCITT, bonding, earthing

INTERNAL BONDING TOPOLOGY FOR NEW COMMUNICATION EQUIPMENT

EMCABS: 11-5-93

N. Korbel, A. Ashdown, Bell-Northern Research Ltd., Ottawa, Canada
11th International Wroclaw EMC Symposium and EMC Symposium, Wroclaw, Poland
Part 1, September 2-4, 1992, pp. 207-210
Abstract: This paper discusses the design and testing requirements of equipment installed according to different national standards and operating company practices. In recent years, harmonization of communication system standards and safety standards became an important element of the evolution and growth of the international trade. International standards, such as the CCITT document K.27 [1], attempt to capture various standards used for grounding communication systems. This has resulted in various workable bonding and grounding topologies for both communication systems and computer systems. Suppliers and users of communication equipment are making significant efforts to ensure the effectiveness of bonding and grounding in their installations. In addition to personnel protection and proper equipment performance, requirements for electromagnetic compatibility (EMC) system robustness to surges of energy are being considered. Since the international standards are not specific enough in details, additional standards within a particular grounding topology are being written and implemented. In Europe, one of those new supplementary standards will be the ETSI/EE2[3] that is built upon the widely used CCITT Mesh-BN (Mesh-Bonding-Network) topology.
Index Terms: CCITT, Bonding

A TRANSMISSION LINE DEVICE FOR EMI SUSCEPTIBILITY MEASUREMENTS WITH ENHANCED FIELD UNIFORMITY

EMCABS: 12-5-93

Lorenzo Carbonini
Alenia Settore Sistemi Difesa, Italy
11th International Wroclaw EMC Symposium and EMC Symposium, Wroclaw, Poland
Part 1, September 2-4, 1992, pp. 219-223

Abstract: The subject of this paper is the analysis of a device for EMI measurements; the structure is similar to a TEM cell, with an inner wire array rather than a conducting septum. The transmission line is terminated in a resistor array at low frequencies, in anechoic material at higher frequencies. The device is referred to as wire TEM (WTEM) cell and is designed specifically to provide a high field uniformity in the test region. The performance of the WTEM cell is compared with that of TEM striplines. An enlarged quasi-static frequency band is available in the WTEM cell; moreover the coupling of the device under test with the structure is expected to be lower. The performance of the device as a standard EM fields generator has been predicted by a theoretical quasi-static analysis and estimated by measurements over a wide frequency band.
Index Terms: Measurements, Wire TEM (WTEM)

INSTITUTIONAL LISTINGS

The IEEE Electromagnetic Compatibility Society is grateful for the assistance given by the firms listed below and invites application for Institutional Listings from other firms interested in the electromagnetic compatibility field.

PATTON & ASSOCIATES, 4718 W. El Caminito Drive, Glendale, AZ 85302
Telephone: (602) 934-5458 FAX: (602) 242-7700
Worldwide Telecommunication Design Assistance and Agency Submittal

SPECTRUM CONTROL, INC., 2185 West 8th Street, Erie, PA 16505
Telephone: (814) 455-0966 FAX: (814) 455-2550
Complete EMC: FCC/MIL Consulting, Testing, Repair, Mfr. RFI Filters, RFI Gaskets, D-Subminiature Connectors.
Surface Mounted Devices: Chip Capacitors, Capacitor Networks, HIC and QUAD Fastbus Line Drivers

AMPLIFIER RESEARCH, 160 School House Road, Souderton, PA 18964-9990
Telephone: (215) 723-8181 TWX: 510-661-6094 FAX: (215) 723-5688
Broadband RF power amplifiers, 1 W to 10 kW, 10 kHz to 1 GHz; Antennas and accessories for RF susceptibility testing; broadband E-field monitors and fiberoptic links.

J. K. ECKERT & COMPANY, P.O. Box 648, Gainesville, VA 22065
Telephone: (703) 349-8592 FAX (703) 347-3049
Author clearinghouse and producer of technical books in electrical/electronic engineering, aviation, and medicine, including an expanding series of EMC books.

COMPLIANCE ENGINEERING, 629 Massachusetts Ave., Boxborough, MA 01719
Telephone: (508) 264-4208 FAX: (508) 635-9407
Complete source for EMC: Publications and Annual Design Handbook, Bimonthly Seminars, International Standards

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Delaware Water Gap, PA 18327-0136
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