Issue No. 194 Summer 2002 ISSN 1089-0785 Janet O'Neil, Editor

http://www.emcs.org

EMC

IEEE EMC Society Newsletter

INSIDE:

How Much is a dB Worth?

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ABSTRACT

It is a very common practice to over specify the Quiet Zone performance requirements for an anechoic chamber. Very often what is done is a person who is in need of a chamber contacts someone with a similar facility, often a supplier or a customer, and simply patterns their performance requirement after what the other guy has done. This often results in a chamber, which is specified to a tighter performance requirement than is actually needed to perform the particular measurements required and can cost thousands of dollars more than is necessary.

Qualcomm had a requirement to build a chamber for the evaluation of various antenna designs for mobile communication equipment. Due to building and space limitations the "ideal" size for a chamber operating in the 800 Mhz to 6.0 Ghz was not available. Qualcomm worked with AEMI to define the performance parameters to provide them with the best performing chamber that could be built within the restricted space available.

Once the design parameters were defined adequately the chamber deign was developed and the chamber was built. Once the chamber was built Qualcomm went about defining the best test methods and parameters that could be achieved given the performance limitations that were evident in the design due to the compromises that had to be made in the limited space available to accommodate the chamber.

This paper will discuss the design process, the design limitations and the methods used to overcome the performance compromises made in the development of the chamber and its intended purpose.

Keywords: Absorber Material, Anechoic Chamber, Antenna Measurements, Range Equation, Phase Taper.

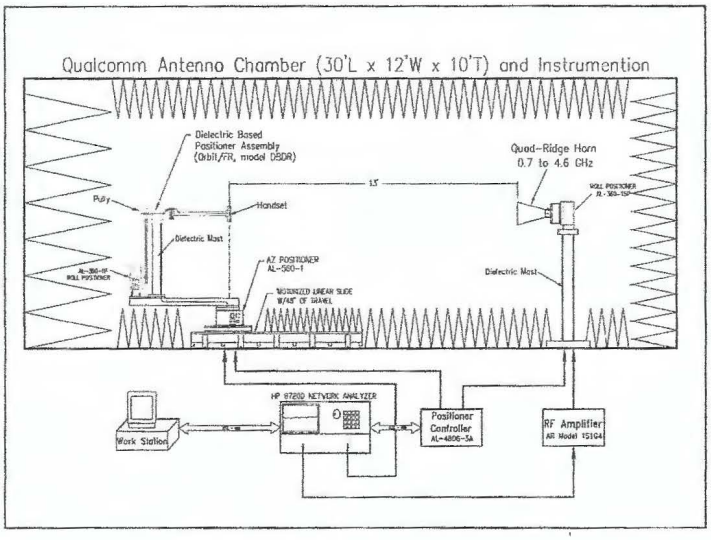

Figure 1. Chamber and Instrumentation

1.0 Introduction

This paper describes a joint effort between Advanced Electro-Magnetics, Inc and Qualcomm, Inc. to develop and build an antenna measurement facility for the development of mobile communication antennas.

Due to the fact that Qualcomm was in a leased facility and was growing at an incredible rate, laboratory space was at a premium. The space made available for the Anechoic Chamber was smaller that what would be ideal for the frequencies to be tested.

Given the limitation in space available, it was our task to define the minimum chamber performance levels that would allow accurate measurement of the subject antennas. Once this was established the chamber design would be completed, the shielded enclosure built, the absorber installed and finally the

continued on page 16

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Letter from the Editor

Photo by Stephen Stimac

Stephen Berger of TEM Consulting and Ghery Pettit of Intel joined Newsletter Editor Janet O'Neil (L-R) for dinner prior to the April meeting of the Seattle EMC Chapter. Stephen and Ghery were the meeting speakers who shared a little history on CISPR 22 and ANSI C63 test methods.

Janet O'Neil
Editor, EMC Society Newsletter

I don't know about you, but I've been thinking about history the past few months. Maybe it started as a result of my involvement in IMS 2002 in early June at the Seattle Convention Center. This was the 50th Anniversary Symposium of the IEEE MTT Society. They had a very nice, museum quality display of historical equipment related to the development of microwave theory and techniques in the registration area. In the back of my mind, I was thinking about the upcoming 50th anniversary of our EMC Society in 2007. I know that Dan Hoolihan, Chairman of the 2007 EMCS Anniversary Committee, will be spearheading a history subcommittee that will create a similar display of EMC "antiques" for our anniversary symposium. That will be exciting to see.

I've also been thinking about history as a result of the NIST 100 Year Anniversary article that appeared in our last Newsletter. This article by Dennis Friday prompted Bob Olsen, our Technical Editor, to encourage the EMC folks at NIST to share with our readers their history as specifically related to EMC. The result is the extensive article that appears on page 19 of this Newsletter. I think you will find this article on NIST's history in EMC very interesting. I'd like to thank Chris Holloway and Perry Wilson of NIST, among others, for their tremendous efforts in putting this article, photos and references together. Thanks too to EMCS Photographer Dick Ford for providing some special photos to complement this article.

Lastly, EMCS Treasurer Warren Kesselman recently provided an informal history of this Newsletter as follows:

Janet,

Here's the history of the EMC Society Newsletter. In January 2002, it celebrated its 44th birthday. The following information tracks the name changes through the years.

Issue #1 dated January 2, 1958 was distributed by The Institute of Radio Engineers, Inc. (IRE), Professional Group on Radio Frequency Interference.

Issue #25 dated January, 1963 was distributed by The Institute of Electrical & Electronics Engineers, Inc. (IEEE), Professional Group on Radio Frequency Interference.

Issue #27 dated April, 1963 was distributed by IEEE, Professional Technical Group on Radio Frequency Interference.

continued on page 50

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IEEE EMC Society Newsletter Publication Schedule

Publication Dates	*Editorial Deadlines*	*Advertising Deadlines*
Summer	July 1	July 12
Fall	October 1	October 11
Winter	January 1	January 14
Spring	April 1	April 11

IEEE EMC SOCIETY NEWSLETTER (ISSN 1089-0785) is published quarterly by the Electromagnetic Compatibility Society of the Institute of Electrical and Electronic Engineers, Inc., 3 Park Avenue, 17th Floor, New York, NY 10016-5997. One dollar ($1.00 USD) per member per year (included in the Society fee) for each member of the EMC Society. Periodicals postage paid at New York, NY and additional mailing offices. This newsletter is printed in the USA. Postmaster: Send address changes to IEEE EMC Society Newsletter to 445 Hoes Lane, Piscataway, NJ 08855.

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President's Message

Todd Hubing
President, EMC Society

Throughout history, scientists and engineers have played an important role in building lasting relations between countries and cultures that view the world differently. Perhaps this is because scientists and engineers as a group have learned to be open and objective. Perhaps it's because we speak a common technical "language." Whatever the reason, technical cooperation among people from different countries tends to be relatively easy and it is often the first step toward social and political cooperation.

As many of you are aware, the IEEE EMC Society was co-sponsoring an International EMC Symposium scheduled to be held in Tel Aviv, Israel next May. Tel Aviv is a beautiful city. It is in an area with a rich cultural history and very nice convention facilities. Several years ago, when the decision was made to hold a symposium there, it was a logical choice. However, the recent escalation of tension in the region forced the local symposium committee to make some difficult decisions. Recognizing that they would not be likely to attract a large, global audience to a symposium in Tel Aviv, the local committee made the bold decision to work with the EMC Society chapter in Turkey to host the symposium in Istanbul. The result has been a model of international cooperation. Two "local" committees comprised of engineers from different countries have accomplished more in the past few months than most symposium organizing committees accomplish in a year. Hotel contracts have been negotiated, technical and social programs have been organized, exhibitors have been lined up and everything seems to be on track for an excellent EMC event.

Throughout history, scientists and engineers have played an important role in building lasting relations between countries and cultures that view the world differently. Perhaps this is because scientists and engineers as a group have learned to be open and objective. Perhaps it's because we speak a common technical "language." Whatever the reason, technical cooperation among people from different countries tends to be relatively easy and it is often the first step toward social and political cooperation.

Istanbul is a good choice for the symposium venue. My colleagues from Turkey describe Istanbul as a beautiful and historic city. This opinion has been reinforced by other colleagues who have attended conferences there. Actually, I've wanted to visit Istanbul ever since "They Might Be Giants" released their version of "Istanbul (Not Constantinople)" a few years ago. What a great song!

Istanbul is unique in the sense that it is built on two continents, Europe and Asia. It is the former capital of three successive empires - Roman, Byzantine and Ottoman. Although Istanbul preserves the legacy of its past, it has become a modern, vital economic center. The symposium will take place at the Hilton Istanbul Hotel, situated in beautiful gardens overlooking the Bosphorus Straits and within walking distance to business, shopping and entertainment areas.

Symbolically, Turkey is an excellent choice for a symposium designed to showcase international cooperation. Located at a crossroads between the East, the Middle East and the West, Turkey has managed to maintain peaceful relations with its neighbors. They have a low crime rate and have been ranked as one of the safest holiday destinations in Europe.

I'm personally looking forward to attending this symposium. If you would like to participate as an author, there is still time to submit a paper. Abstracts and summaries are due October 13, 2002. You can find the call for papers and more information about the symposium on their web page at http://www.ortra.com/emc2003/. I hope to see you there! **EMC**

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Chapter Chatter

Todd Robinson, Associate Editor

"Summertime EMC reading should be brief, relaxing, thought provoking and mildly humorous" (anonymous). Many thanks to Chris Kendall (CKC Laboratories) for sharing a brief EMC tale.

Why Mom Told You Not To Point . . . The Other Reason

In 1979, Chris was consulting for Rockwell International on the Hellfire Missile program. The helicopter mounted version of the Hellfire had to undergo a 300 kV ESD test (discharged from a 500 pF capacitor). The testing was being conducted at the Redstone National Armory EMC laboratory (Huntsville, Alabama), at that time under the direction of Charlie Ponds. "This was the largest ESD discharge I had ever heard about and I was excited to be able to witness it," says Chris. During the test that Chris was witnessing, the laboratory staff shared an incredible story from a few weeks earlier. One of the Hellfire project engineers had been rightfully amazed at the arc created by 300 kV discharges. He couldn't help but point and exclaim, "Look at that!" The next discharge went to the engineer's finger instead of the EUT! The impact knocked him some 15 feet from where he was standing. Charlie Pond's sage wisdom from the event: "Never point at 300 kV."

Austria

Kurt Lamedschwandner (ARC Seibersdorf Research), Chapter Chair, tells us that on June 12, the Austria Chapter of the EMC Society re-elected its chairman (Dipl.-Ing. Kurt Lamedschwandner), its secretary (Dr. Gerhard Diendorfer) and its treasurer (Dipl.-Ing. Gerhard Horak). A new vice chairman (Assistant Professor Dipl.-Ing. Dr. Gunter Winkler from the Technical University of Graz) was elected. The former vice chairman (Dipl.-Ing. Helmut Habel) stepped down because of lack of time. Mr. Lamedschwandner thanked Mr. Habel for his contributions to the Society! After the election, Dr. Gerhard Diendorfer gave a very interesting lecture about actual results of lightning discharge research in Austria. After Dr. Diendorfer's presentation, chapter members enjoyed socializing.

The Austrian Chapter learned (not firsthand) about the results of lightning discharge.

Beijing

The 3rd International Symposium on Electromagnetic Compatibility was held in Beijing, China on 21 to 24 May 2002. The Symposium was sponsored by the Chinese Institute of Electronics and Technically Co-Sponsored by the IEEE EMC Society. Len Carlson, a member of the EMC Society Board of Directors, was the general co-chair of the Beijing EMC Symposium. Some 200 international and national experts, scholars and scientists attended the conference. A total of 230 papers were received of which 193 were accepted and collected in the Symposium Record. The papers were presented in 24 technical sessions which was more than the 1992 and 1997 symposia combined. It is clear that the field of EMC technology has expanded dramatically in the last ten years. During the closing ceremony, Symposium Chairman Professor Gao Yougang expressed his deep

Professor and Mrs. Masashi Hayakawa visited with Professor Gao Yougang (R-L) during the EMC conference held in Beijing.

The closing ceremonies of the Beijing EMC conference featured unique entertainment by local artists.

Len Carlson (right), EMCS Vice President for Communication Services, joined Professor Gao Yougang, Beijing EMC Symposium Chairman, (center) and Professor Zhang Linchang, Chairman of the Technical Program Committee (left) at a reception held during the 3rd International Beijing Symposium on EMC.

appreciation for the support given to the symposium by the IEEE EMC Society and the URSI E-Commission. He announced that the next International Symposium on EMC will be held in China in 2007. (NOTE: This issue of the EMCABS contains abstracts from papers presented in Beijing, China during May 21-24, 2002. Please refer to page 46 to view these papers.)

Central New England

John Clarke, Chapter Chair, advised there has been one meeting since those reported in the previous Spring issue of the Newsletter. Doug Smith presented a topic to the CNE members concerning "Computer Security" on Wednesday, June 26th. This was not an official meeting of the IEEE Boston Section (official Chapter meetings are not usually held in June, July or August). Vice Chair Boris Shusterman hosted the meeting as usual. The annual joint EMCS/NPSS meeting will be held in September (note: NPSS is Northeast Product Safety Society). We are pleased that DL Bud Hoeft will present a topic to our chapter on October

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Frank Krozel (left) of Electronic Instrument Associates-Central (Chapter Treasurer, Web-writer, and Mini-Symposium 2002 Chairman) hands Randy Dister of Grayhill one of the many gift certificates raffled.

Ray Klouda (left) of Elite Engineering, Chicago Chapter Chairman, is shown handing the "EMC Person of the Year" Award to Steve Laya of Elite Engineering. Steve was recognized for his handling of Chapter Publicity.

Tom Braxton (left) of Braxton EMC & Safety Engineering, Chapter Program Chair, visited with Craig Dinsmore of Elite Engineering, one the of tabletop exhibitors present at the Chicago Mini-Symposium.

Leroy Heersink of Smith Industries, Jack Black of DLS, Membership Chair, and Ray Klouda of Elite Engineering, Chapter Chair (L-R) caught up on EMC matters during the Chicago Mini-Symposium.

Lee Hill gave a great presentation to the Chicago EMC Chapter members and guests.

Mike Keppert (left) and Frank Krozel of Electronic Instrument Associates enjoyed a quiet moment before the crowd arrived to attend the Chicago Chapter Mini-Symposium.

18th, during his "East Coast chapter presentation tour." The 2003 IEEE EMC Symposium Steering Committee met on May 7th. Vice Chair Boris Shusterman attended as the assigned Hospitality Coordinator. A number of other EMCS members are on the 2003 Committee, some with specific committee assignments. EMCS Distinguished Lecturer Committee Chairman Lee Hill and Isidor Straus are Technical Program Co-Chairs. The Symposium will be held August 18-22, 2003 in Boston. Please watch EMCS publications for more details!

Chicago

Frank Krozel (Electronic Instrument Associates), Chapter Treasurer, shared highlights from the recent mini-symposium in Chicago. They had twenty tables booked by enthusiastic exhibitors and approximately 120 program attendees. It is interesting to note that 50% or more of the attendees were non-members! Hopefully, this will mean a positive influx of new people into the EMC Society in the Chicago area! This year, the chapter tried to have several symposium sessions with a variety of topics, rather than only one or two main sessions. The sessions varied from 1/2 hour to 2 hours in length. The new format was well received by the attendees. Frank also reports that they have booked a date for next year's mini-symposium. Watch the chapter Website, http://www.ewh.ieee.org/soc/emcs/chicago/ for details!

France

André Berthon, Chapter Chair, reports that the French chapter recently held a board meeting dedicated to the planning of further meetings. The chapter will be supporting an EMC event being organized by INSA Toulouse. The upcoming workshop, dedicated to electromagnetic compatibility for ICs, will be held in Toulouse, France, Nov 14-15th, 2002. The IEEE France section will be sponsoring the event. More information may be found at www.insa-tlse.fr/~emccompo. An official call for papers has been issued for such topics as measurement methods for emissions of integrated circuits, use of IC models in printed circuit board simulation, tools to handle EMC at the IC level and more. Please E-mail etienne.sicard@insa-tlse.fr for more information.

Japan

Yoshio Kami (University of Electro-Communications), Chapter Chair, shared that the IEEE EMCS Japan Chapter is growing steadily, with their current chapter membership at 276, as of December 31, 2001. They held numerous technical meetings this past year. Regular EMC technical meetings are held ten times per year at various venues. These meetings are co-sponsored with meetings of the EMC Technical Group of the Institute of Electronics, Information, and Communication Engineers (IEICE). Many technical papers are presented every year, the majority of these being in Japanese. In 2001, about 130 papers were presented as shown in the following table.

Date(2001)	Site	# of Papers
January 25	Koganei	11
March 22	Tokyo	11
April 19	Tokyo	6
May 20	Kitakyusyu	10
June 22	Sapporo	11
July 13	Tokyo	15
September 4	Kyoto	7
October 26	Akita	28
November 22	Tokyo	8
December 21	Gifu	16

One of the biggest news items from Japan is the formation of the Sendai chapter. Please see their chapter report for details! Many members in Japan attend the IEEE International Symposium every year. In 2004, Japan will host an "international" EMC Symposium in Sendai on June 1 through 4. This will be the fifth EMC symposium held in Japan over the past 25 years. Professor Sugiura of Tohoku University was appointed as a Chair of the Organizing Committee.

Korea

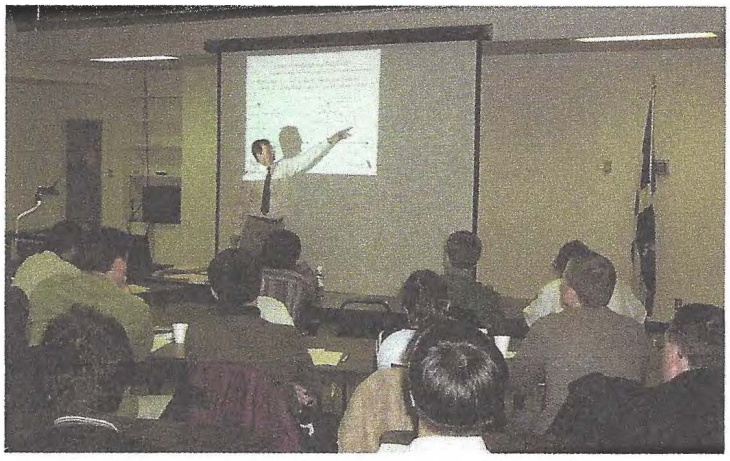
Professor Dong Il Kim (Korea Maritime University), Chairman, reports that the Korea Chapter hosted a "Workshop on Antenna Technology" at the Seoul Education Center on April 26, 2002. The six presentations covered various aspects of antenna theory, including Professor Tatsuo Itoh's paper titled "Active Integrated Antenna Approach for New RF Front End Configuration." The workshop was attended by 200 participants and was coordinated by the Korea Electromagnetic Engineering Society (KEES) and IEEE AP/MTT Korea Chapter. Also, the Korean chapter co-sponsored the "2002 Spring Conference on Microwave/Radio" at SungKyunKwan University on May 25, 2002. Papers presented at the conference covered various aspects of the electromagnetic field including active/passive circuits and components, EMI/EMC, antenna and scattering. A total of 143 papers were given and about 270 participants attended the conference, which was coordinated by KEES and the IEEE AP/MTT Korea Chapter.

Minneapolis

Curt Sponberg (Medtronic), Chapter Chair and Symposium Vice-Chair, reports that the Twin Cities chapter is very busy with preparations for the 2002 IEEE International Symposium on EMC which will be held August 19 to 23 at the Minneapolis Convention Center. Please visit the web site at http://www.2002-ieee-emc.org/ for information on registration, exhibits, technical presentations and registrations. The chapter hopes that you all can make it to Minneapolis this year!

Montréal

Benoît Nadeau (Matrox), Chapter Chair, told Chapter Chatter that organizing the 2001 Symposium limited the "normal" chapter activities of the Montreal Chapter last year. In 2002, they returned to a traditional Chapter meeting schedule. They have had three meetings since January 1. The first presentation, by Keith Hardin, Distinguished Lecturer, was held April 23, 2002. Keith combined two of his popular topics into one presentation entitled "Two Layer PCB Design and Design Techniques." The meeting



Keith Hardin of Lexmark presents "Two Layer PCB Design and Design Techniques" to a full-house in Montreal.

Donald Davis of McGill University during the May EMC Chapter meeting in Montreal, Canada.

Colin Brench explains antenna behavior to an enthusiastic audience in Montreal.

was a huge success with more than 30 participants, including attendees who traveled from Ontario and Quebec City! On May 21, 20 people attended a presentation that was arranged as a direct result of the 2001 Symposium. Donald Davis (Ph.D. student of the famous Dr. Tom Pavlasek at McGill University) and Dr. Bernard Segal (also from McGill and Workshop Chairman for the 2001 Symposium). The subjects of their talks were, respectively, "Volumetric 1.9-GHz Fields in a Hospital: EMC Implications" and "Risk of Patient Injury Due to EMI: Estimation & Minimization." Both papers were originally presented during the 2001 Symposium. The third meeting, held on June 5, was headlined by another IEEE EMCS Distinguished Lecturer. Mr. Colin Brench presented "Antenna Behavior and Use (What Really Goes on During a Test?!)." This time, the outside temperature did not help. After many days of bad weather, the weather on June 5 was very nice and many potential attendees stayed home to barbecue! Nevertheless, they achieved an audience of 13 enthusiastic engineers.

Nanjing

Professor Wen Xun Zhang, Chapter Chair, reports that the Nanjing Chapter hosted a busy Spring schedule of meetings and technical presentations! Professor Ismo Lindell of Helsinki University of Technology gave four well-attended lectures on April 6, 9, 11 and 20. His topics included "Conditions for Field Media," "Field Duality and Affine Transformation," "Electromagnetic Field Solutions" and "Field Decomposition." On May 17 and 21, audiences of 64 and 61 (respectively), enjoyed a lecture by Professor Ke Wu entitled, "RF & Microwave Techniques in Wireless Communications Systems." Professor Wu is from the Ecole Polytechnique Institute of Montreal, Canada. The next evening, the chapter sponsored a presentation by senior engineer Yong-Sheng Dai on "Modeling and Design of Control Circuits." The presentation was enjoyed by 24 members and guests. The chapter capped off an incredible six day run with 61 people enjoying a double-header presentation by Professor Jin-Ping Xu of Southeast University and Professor Ru-Shan Chen of Nanjing University of Science and Technology. The presentation by Professor Xu was entitled "Vector Finite Element & Domain Decomposition Hybrid Techniques" and Professor Chen spoke about "Finite Element Short-Open Calibration for Extracting Microwave Network Parameters."

Doug Smith is shown getting ready for his demonstration on shielding effectiveness in Orange County.

A full house eagerly awaits Doug Smith's presentation to the Orange County EMC Chapter.

Orange County

Robert Tozier (CKC Laboratories), Chapter Chair, reports that the Orange County Chapter met on May 14th at CKC Laboratories in Brea. The topic was, "Shielding Effectiveness: A Practical View." Speaker Douglas Smith held an FCC First Class Radiotelephone license by age 16 and a General Class amateur radio license at age 12. He received a B.E.E.E. degree from Vanderbilt University in 1969 and an M.S.E.E. degree from the California Institute of Technology in 1970. In 1970, he joined AT&T Bell Laboratories as a Member of the Technical Staff. He retired in 1996 as a Distinguished Member of the Technical Staff. Doug's talk covered shielding effectiveness from different points of view including cable and system shielding. Examples and demonstrations of shielding problems and fixes were presented. Douglas demonstrated a method of measuring shielding effectiveness that is easy to perform and gives better results.

Phoenix

Harry Gaul (General Dynamics), Chapter Secretary/Treasurer, reports on their May 2nd meeting where Daryl Gerke of Kimmel-Gerke Associates was the speaker. Daryl is also the Vice-Chair of the Phoenix EMC Chapter. The topic of Daryl's talk was the "Mysteries of Grounding" which covered one of the most important, yet most misunderstood aspects of EMC. Grounding tends to be mysterious because there's no one rule for all the different types of grounds such as analog, digital, safety, and chassis. Also, there are various approaches used for grounding including multi-point, single point, and hybrid. As many of us EMC practitioners know, it often seems that there are as many opinions as there are answers to the proper approach for grounding. When assessing the adequacy of grounds, Daryl recommends that one first look at the ground from a 60Hz perspective and then see what it looks like at 100MHz. Finally, one must ask, "What do I want it to look like?" Generally, a frequency of 10kHz is used as the dividing point between low frequency signals that should be single point grounded and high frequency signals that should be multi-point grounded. However, Daryl pointed out that power supply chopper frequencies often fall midway between low frequency and high frequency and that is why their emissions are so difficult to control. Daryl covered the entire gamut of grounding concepts for the 40 attendees. He stressed that earth ground has only one purpose and that is safety and it must prevail over all the other needs for grounding. Too often we defeat the safety ground in order to "improve" the signal-to-noise characteristics of our instrumentation and communication circuits. A variety of methods can be used to break ground loops at low frequencies such as balanced circuits, optoisolators, transformer coupling, and grounding the return at only one end. At high frequencies one needs to use multi-point grounding such as planes or grids with ground points spaced no further than 1/20 of a wavelength apart and bond straps with a length-to-width ratio no greater than 5:1. Daryl concluded his talk with several practical grounding examples includ-

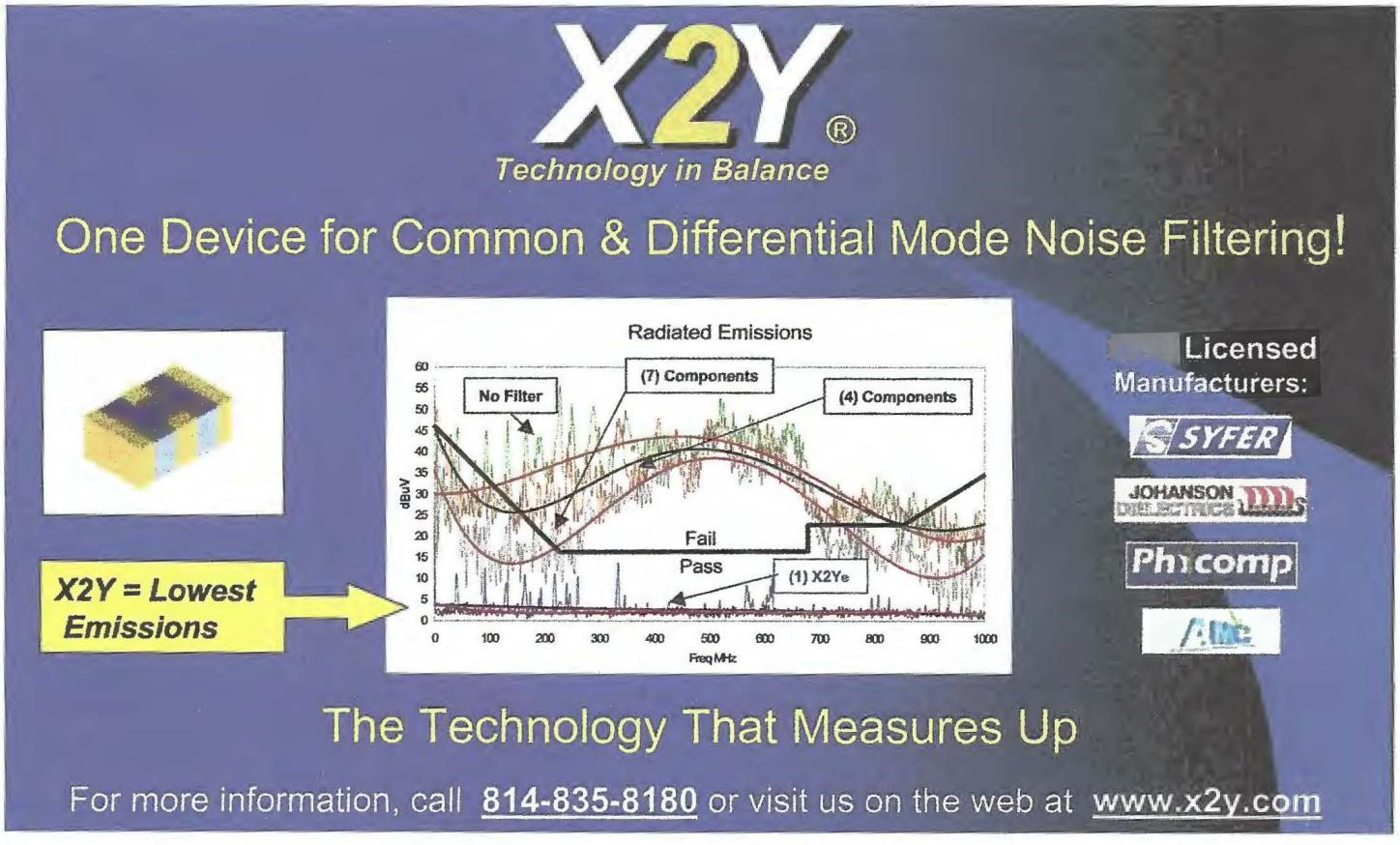


Photo by Steve Gerard

Daryl Gerke demystified the Phoenix EMC Chapter attendees with his expertise on how to provide an optimum ground for a variety of situations.

Photo by Steve Gerard

Daryl Gerke (Kimmel-Gerke Associates) finally on the receiving end of a jar of genuine Arizona Salsa from the Phoenix Chapter, presented to him by Harry Gaul (General Dynamics). The banquet room only accommodated 24 people so the crowd of attendees stretched back into the main restaurant during Daryl's presentation.

ing hybrid grounds, which combine low and high frequency grounding schemes so that one can "have their cake and eat it too!" Please check out the Phoenix web site at http://www.ewh.ieee.org/r6/phoenix/phoenixemc/ for the latest schedule on upcoming meetings.

Seattle

In August of 2000, the IEC published Amendment 1 to CISPR 22. This amendment adds ferrite clamps to all cables leaving the turntable when testing tabletop equipment. The purpose of these clamps is to improve repeatability between different laboratories when performing radiated emissions measurements. The immediate practical effect of this amendment is a significant difference in measurement methods between CISPR 22 and ANSI C63.4-2000. As a result, when this amendment is adopted in countries which use CISPR 22 (or EN 55022 as it is known in Europe), a manufacturer will be forced to perform radiated emissions tests on a product twice, once with the clamp and once without the clamp. In the interest of harmonization, ANSI C63.4 may need to be updated to include these clamps. At the April Seattle EMC Chapter meeting, two speakers familiar with this issue gave presentations. First, Ghery Pettit of Intel, Dupont described Amendment 1 to CISPR 22, and provided some of the history of the change and work that was performed by Intel Corporation and Hewlett Packard to evaluate the change as it worked its way through CISPR Subcommittee I in 1999 and 2000. He showed the effectiveness of these clamps in improving repeatability between labs and a key design consideration for the clamps that was not considered in the amendment. Stephen Berger of TEM Consulting then presented information on the work that is on-going in ANSI C63 to possibly add ferrite clamps to ANSI C63.4. This work is being done by people representing test equipment manufacturers, as well as representatives from companies manufacturing products which are tested for immunity to ESD events. The presentations concluded with time for questions and answers about this new requirement and how it might impact product testing efforts. In May, EMCS Distinguished Lecturer Keith Hardin of Lexmark presented "Various Aspects of Spread Spectrum Clock Generation, (SSCG)" to the Seattle EMC Chapter. Dr. Hardin explained how SSCG intentionally broadbands a normally narrowband signal by frequency modulating the trapezoidal clock signal with a unique modulating waveform. The modulating waveform causes a digital clock signal to have a spectrum with sideband har-

Photo by Stephen Stimac

Over 30 people came to hear Stephen Berger and Ghery Pettit as duo-speakers at the April Seattle Chapter meeting.

Photo by Stephen Stimac

Several folks lingered after the April Seattle Chapter meeting to visit with speaker Ghery Pettit of Intel Dupont (far left) and just chat awhile before hitting the road.

Photo by Stephen Stimac

Speaker Stephen Berger of TEM Consulting in Austin discussed "the ferrite clamp issue" of CISPR 22 at the April Seattle Chapter meeting. He also provided information on the ANSI ASC C63 activities related to this issue, most notably the possible effect on ANSI C63.4. Meeting attendees were encouraged to get involved in ANSI C63 activities. Check out www.C63.org for more information.

Photo by Pat André

EMCS Distinguished Lecturer Keith Hardin of Lexmark gave an interesting presentation on the history and usage of spread spectrum clock generation at the May Seattle Chapter meeting.

Photo by Mark Chase

Pat André, Seattle EMC Chapter Vice-Chair, of Patrick G. André Consulting (left) visited with Leo Smale of Lionheart Northwest following the May meeting. We have no idea what they were talking about, but it was certainly an animated discussion!

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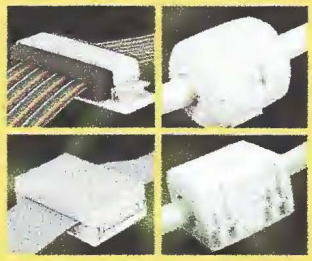

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Ukraine Chapter members Professors Gennadiy Churyumov (left), Volodymyr Popovskiy (center) and Igor Koryttsev (right) from the Kharkov National University of Radio Electronics.

Sendai

Akira Sugiura, Chapter Secretary, shared the background and coming events of the new Sendai (Japan) Chapter. Considered to be the birthplace of the Japanese EMC Society, the Sendai district has long been one of the more active areas for EMC in Japan. In 1977, Professors R. Sato and T. Takagi organized the first EMC Technical Group for the IEICE Japan, and then organized the IEEE EMC Society Tokyo Chapter the following year. It is with great pleasure that we announce that a Sendai Chapter was officially approved by the IEEE EMC Society on December 20th, 2001. The new Chapter has 33 members including Professor Sato (Chair), Professor Takagi (Vice-chair), and Professor Sone (Treasurer). The chapter is now focusing every effort to make arrangements for the 2004 EMC Sendai International Symposium (June 1 to 4, 2004). Why is Sendai the first "regional" EMC Chapter in Japan? The Japanese IEEE membership is so huge (more than 18,000 members) that it first established eight regional sections with "umbrella" chapters for each society. The EMC Japan Chapter will exist until all Regional Sections form EMC Chapters, such as was just formed at Sendai.

Toronto

Ramesh Abhari (University of Toronto), Chapter Chair, let us know that the most recent technical meeting held by the Toronto chapter was on February 15, 2002. The lecture was entitled, "Discrete Steps in Field Space: The Electromagnetic and Other Secrets of MEFiSTo," presented by Professor Wolfgang J.R. Hoefer, NSERC Research Chair in RF Eng., CERL, ECE Dept., University of Victoria, and the President of Faustus Scientific Corporation. The abstract of professor Hoefer's paper, including the presentation slides are available at: http://www.tor.ieee.ca/societies/electromag.htm.

Ukraine

Gennadiy Churyumov (Kharkov National University), Chapter Chair, reports that the new Joint AP/C/EMC/SP Chapter of the IEEE Ukraine Section (Kharkov), newly established in 2002 has been very active. This year, they are organizing several technical workshops and chapter meetings. On September 18 to 20, 2002, the First International Workshop on Noise Radar Technology (NRTW'02) will be held in Yalta (Crimea), Ukraine. On October 1, 2002, an International Workshop entitled "The Ultra Wideband and Ultra Short Impulse Signals" (UWB-USIS '02) will occur in Kharkov, Ukraine. The chapter hopes to see everyone at these international technical meetings! **EMC**

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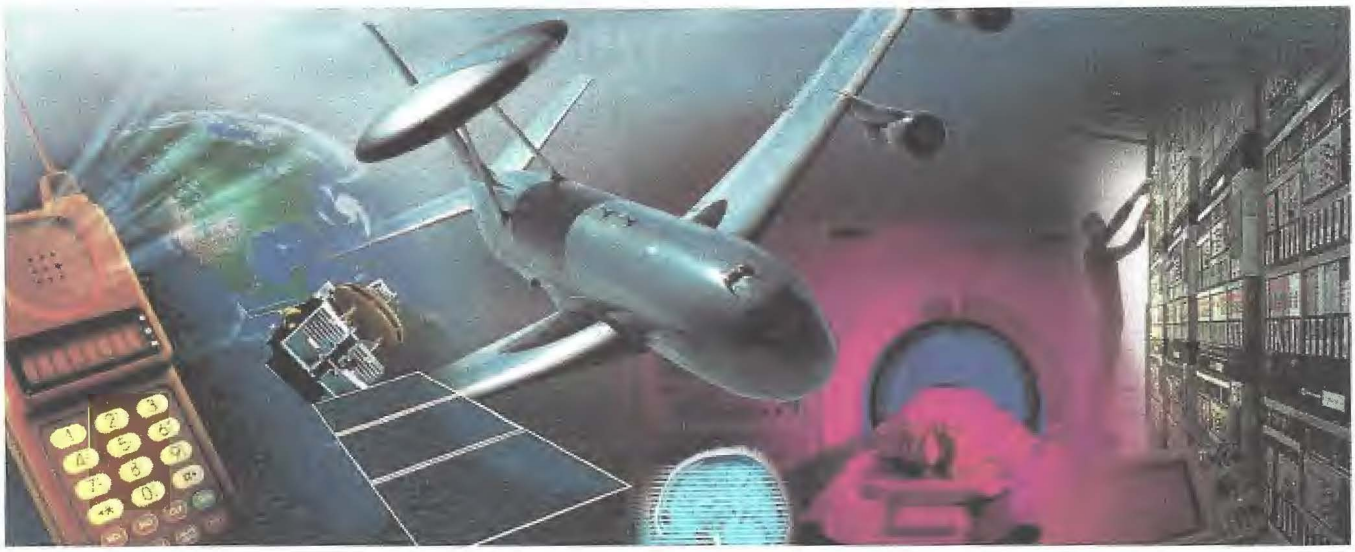
Colloquium speakers include EMC Society Board of Directors members: Don Heirman of Don HEIRMAN Consultants on Global EMC Emissions Standards, Ghery Pettit of Intel on the Worldwide Approval Process (especially as related to ITE), Todd Hubing of the University of Missouri-Rolla on Practical Design Techniques for Printed Circuit Boards, Dan Hoolihan of Hoolihan EMC Consulting on EMC Test Methodology and Site Considerations, Jose Perini of Syracuse University, New York providing an Overview of Numerical Methods, and Elya Joffe of KTL Project Engineering on EMC Considerations in On-Board System Integration.



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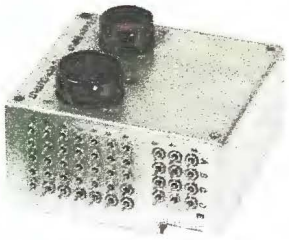

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Practical Papers, Articles and Application Notes

Bob Olsen, Associate Editor

In this issue you will find two practical papers that should be of interest to the EMC community. The first entitled, "How Much is a dB Worth?" by Gabe Sanchez and Pat Connor, was originally presented at the 2001 meeting of the Antenna Measurement and Techniques Association (AMTA) in Denver. It is featured on the cover of this issue. Gabe and Pat address the question of how much money should be spent on an anechoic chamber given its required performance. Is it worth it to buy that last dB of performance? Enough good comments were received about this paper that we thought wider dissemination was warranted. The second paper is the one promised in the last issue of the Newsletter and is about the history of EMC activities at the US National Institute of Standards and Technology (NIST). I think you will agree that much fundamental EMC work has been and is being carried out there. The resources available at NIST are a significant asset and should be better known among EMC engineers.

The purpose of this section is to disseminate practical information to the EMC community. In some cases the material is entirely original. In others, the material is not new but has been made either more understandable or accessible to the community. In others, the material has been previously presented at a conference but has been deemed especially worthy of wider dissemination. Readers wishing to share such information with colleagues in the EMC community are encouraged to submit papers or application notes for this section of the Newsletter. See page 3 for my e-mail, FAX and real mail address. While all material will be reviewed prior to acceptance, the criteria are different from those of Transactions papers. Specifically, while it is not necessary that the paper be archival, it is necessary that the paper be useful and of interest to readers of the Newsletter.

Comments from readers concerning these papers are welcome, either as a letter (or e-mail) to the Associate Editor or directly to the authors.

How Much is a dB Worth?

continued from page 1

chamber would be evaluated and the measurement system would be installed to accomplish the accurate measurement of the antennas developed for Qualcomm's requirements.

Once the chamber performance and design were established, the building was prepared to accommodate the chamber. The shielded enclosure was constructed, under separate contract, the absorbers were manufactured, the absorbers were installed, the chamber was tested, and finally the measurement equipment was installed and calibrated.

As final check, a "golden" antenna was used to evaluate the effectiveness of the chamber to correlate to existing data. Figure 1 shows the schematic of the chamber and instrumentation.

2.0 Chamber Performance Criteria

Due to the type of measurements that were to be conducted in this chamber, the following quiet zone performance levels were established.

Given the fact that office space at Qualcomm was at a premium the maximum chamber dimensions were set at 30' long x 12' wide x 10' high. The target length was determined to be 20' for these chamber dimensions. With these chamber dimensions the far-field equation (2D2/l) provides us with the following antenna apertures that can be tested in this chamber while maintaining the standard 22.5 degrees of phase taper across the aperture of the antenna under test.

3.0 Chamber Description

Based on the requirements listed in Section 2, Qualcomm contacted Lindgren RF Enclosures to build the 100 dB shielded enclosure. Utilizing standard modular shielded construction techniques, which incorporate a hat and flat clamp mechanism to join together double skin panels, the modular panel construction consists of zinc coated, 60 gauge steel laminated to both sides of a high-density particleboard core. The hat and flat clamping mechanism consists of cold rolled steel, which is designed to provide uniform clamping pressure along the whole perimeter of the attached panel. The fasteners used to clamp the shield together are hardened zinc plated TORX screws placed on nominal 100mm centers. The corner intersections of the enclosure are finished and sealed with cast bronze caps that are precision machined to match the framing members. The enclosure is assembled on an underlayment consisting of a polyethylene vapor barrier and a 3mm thick dielectric hardboard. This construction can be seen in Figure 2.

4.0 Chamber Configuration

As is typical in the establishment of the absorber design, the lowest frequency of use of the facility determines the largest absorbers to be utilized in the design as well as the overall absorber thickness and placement. For this design the –25 dB @ 825 MHz drives the chamber design.

First, the back wall absorbers are chosen to provide an efficient termination to the range. In order to terminate this range AEP-36 absorbers were chosen which provides –30 dB absorption at

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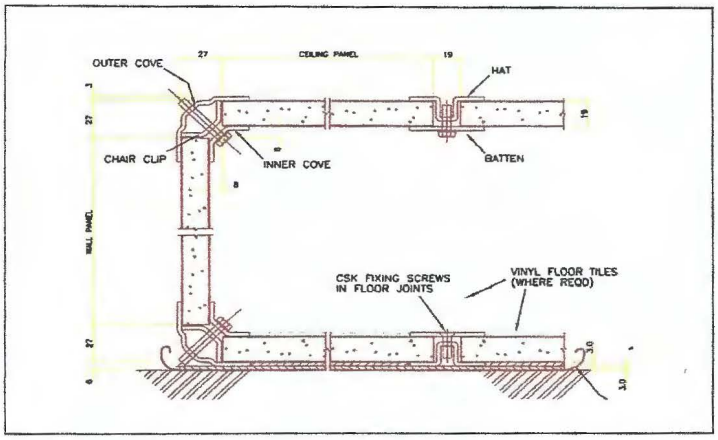

Figure 2. Shielded Enclosure Construction

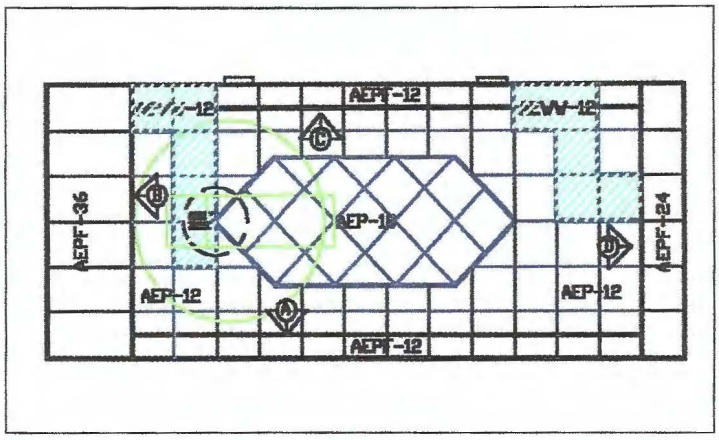

Figure 3. Chamber Absorber Layout

825 MHz and –45 dB absorption at 2.0 GHz thus providing a 5 dB safety margin.

With the back wall established the transmit wall is next. Due to the fact that we are using a standard gain horn we can be assured that the front to back ratio is in the order of 10 dB to 15 dB. This allows the absorbers mounted on the transmit wall to be required to absorb only –15 dB at 825 MHz. In order to provide a decent safety margin on the transmit wall treatment, it was decided to utilize AEP-24 absorbers which provides for –25 dB absorption at 825 MHz.

Frequency (GHz)	Test Zone Performance
.825	-25 dB
1.0	-28 dB
1.8	-30 dB
2.0	-35 dB

Table 1. Test Zone Performance versus Frequency

Frequency (GHz)	Test Zone Size
.825	3.45′
1.0	3.14′
1.8	2.34′
2.0	2.22′

Table 2. Test Zone Size versus Frequency

The next design parameter to be established is the size of the absorbers to be utilized in the specular region of the sidewalls, floor, and ceiling. For this analysis the smallest cross sectional dimension is used, which in this case is the height dimension of 10 feet. Utilizing standard ray tracing techniques it was determined that the materials required in the specular region must attenuate –25 dB at an angle of 60 degrees. This translates into absorber thickness of 1.5 lambda at 825 MHz, which in turn defines the specular absorber to be a minimum of 18" thick. The specular absorbers are to be AEP-18 with the balance of the sidewalls, floor, and ceiling to be treated with AEP-12 absorbers. See Figure 3 for the absorber layout. Figure 4 shows the chamber and instrumentation.

5.0 Microwave Instrumentation

The RF equipment consists of an HP 8720D Vector Network Analyzer and a 1-watt solid-state amplifier (AR model 1S1G4) to improve dynamic range. The transmit source antenna is a quad-ridged dual-linear horn built by Condor Systems (model AS-48410), covering 0.7 to 4.5GHz. For Handset EIRP and Sensitivity tests a Tektronix CMD-80 Base Station Simulator and/or an Agilent 8960-Series-10 E5515C Wireless Communications Test Set are being used.

6.0 Positioning Equipment

The antenna positioner system consists of a roll-over-azimuth positioner system mounted on a dielectric model tower built by Orbit/FR, shown in Figure 5. The azimuth positioner (axis 'A') consists of an Orbit/FR Al-560, which is mounted on top of Orbit/FR Al-4701 motorized linear slide. The roll (axis 'B') axis is a belt-pulley system, driven by an AL-360 positioner. The roll positioner is as low profile as possible and mounted well below the horizontal antenna boom to minimize RF interference. The horizontal boom consists of low profile dielectric materials with interchangeable assemblies. The model tower can support 40lb loads such as a phantom head. See Figure 6.

3D measurements are performed so that the elevation angle (axis 'A') is changed in discrete steps and at each of these elevation positions the DUT is rotated 360 degrees in azimuth by the Axis 'B' roll positioner. The data is sampled in intervals of azimuth, typically every 4 degrees. The transmit source horn is equipped with an Orbit/FR Al-360 roll positioner for spinning linear or changing source polarization. All positioners are controlled by an Al-4806-3A Positioner Controller.

Figure 4. Qualcomm Chamber and Instrumentation

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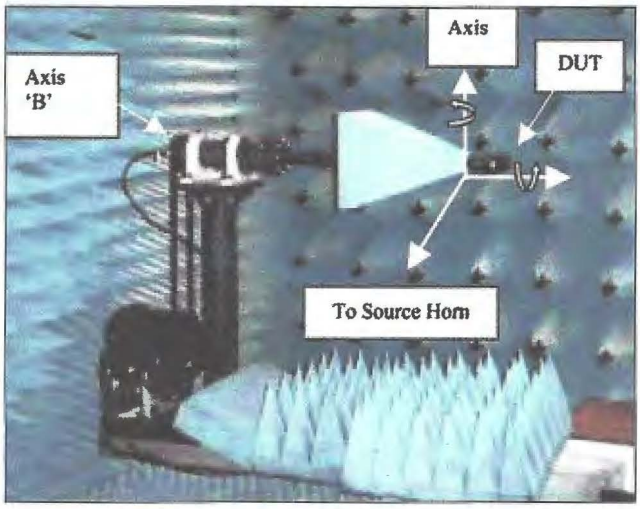

Figure 5. Tower Positioner System

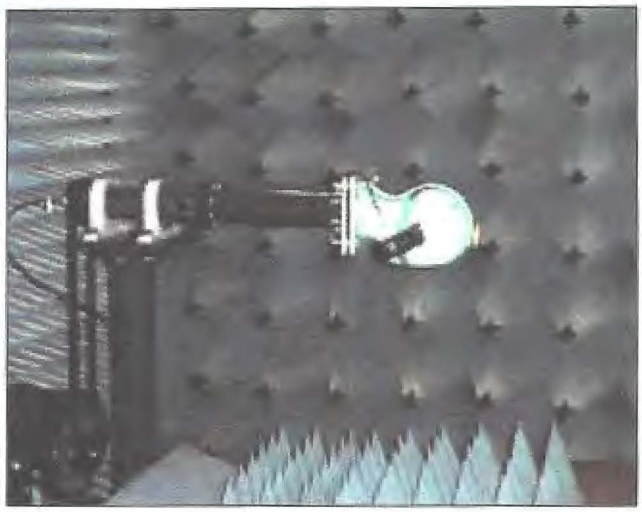

Figure 6. Handset on Phantom Head

7.0 Measurement Software

The antenna measurement system is controlled by Orbit/FR 959-Plus software. The computer is a Compaq Pentium III 500MHz with Dual-Processors, running Windows NT 4.0. A National Instruments I-EEE-488.2 card is used to control the Network Analyzer and Positioner Controller. Post processing of antenna data is performed using MATLAB scripts to calculate gain, directivity, efficiency, average gain, and 3D radiation patterns.

8.0 Overall System Performance

The chamber was tested for shielding effectiveness and Free Space VSWR. The shielding effectiveness met the 100dB requirement. Free Space VSWR method was used to assess the quiet zone. The probe (horn antenna) was traversed through a 1.2-meter area to measure a 1-meter quiet zone. The test range distance is 13 feet. The probe was raster scanned in two-dimensions within the quite zone. The scan was repeated at different look angles and amplitude data was recorded. This method measures the standing wave set up by the interference of direct signal and the vector sum of the signals reflected from the chamber absorbers. Measurements were performed from 824 to 2000MHz at both vertical and horizontal polarizations. At PCS band the results showed reflectivity of approximately -35dB for both polarizations. For AMPS band the reflectivity in vertical polarization was approximately –25dB, while the horizontal polarization reflectivity was approximately –20dB at the low end of the band.

Further investigation involved probing the quiet zone with a sleeve dipole. The probe was positioned through the 14-inch test zone in transversal (cross-range) direction. The amplitude ripple at 825 and 1900 MHz is less than ±0.35dB. The magnitude variation at 1900 MHz is shown in Figure 7.

Scientific Atlanta standard gain horns are used for calibration to establish absolute gain levels. A set of calibrated balanced dipoles (which have broad beamwidths similar to the DUT) are used to validate DUT gain results.

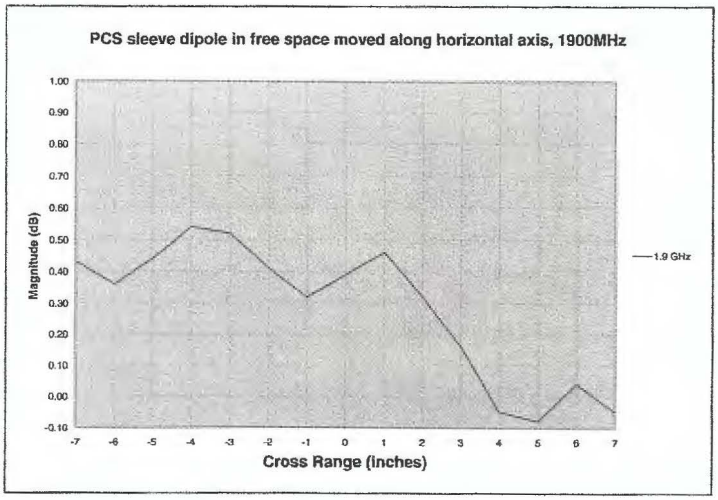

Figure 7. Plot of Quiet Zone Probe, Cross-Range, 1.9GHz

9.0 Summary

So what does all of this have to do with the price of a dB you ask? Well here is what we are driving at. In this instance the chamber performance was specified as –25 dB @ 825 MHz. The size of the chamber was restricted to 30' x 12' x 10'. Given these restrictions the chamber was designed and built with the knowledge that these were not the ideal dimensions for the performance requested. For the sake of this discussion, let's say that the cost to build this facility was as follows: Shielded enclosure $54,000.00 + Anechoic treatment $43,000.00 = $97,000.00 or $3,880.00 per dB. Let us now assume that the performance level had been specified at –30 dB @ 825 MHz.

Thus, we keep the target length at 20' but due to the increased chamber performance requirement, the performance required in the specular region has been increased by 5 dB. This is a very significant increase which is driven by the angle of arrival of the energy in the specular region which will in turn increase the thickness of the absorbers in the specular region which in turn will increase the overall width and height of the chamber. The length will also have to be increased slightly due to the higher performance requirements.

The design will look something like this. In order to increase the performance from –25 dB to –30 dB the back wall absorber

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will have to be increased from 36" to 48" maintaining the 5 dB safety margin. This increases the length of the chamber by 1' but since the shielded enclosure is made up of modular panels the length would be increased by an increment of 2' thus providing the new length of 32'. In order to provide –30 dB of performance in the specular region, this would require absorber thickness of 3 lambda VS the 1.5 lambda of the original design basically doubling the thickness of the materials placed in the specular area of the chamber. In order to keep the test zone from experiencing aperture blockage from the specular material, the chamber must be widened by 4' and the height must be increased by 4'. Test zone performance and test zone size are shown in Tables 1 and 2.

With these new dimensions the chamber has now grown to 32' long x 16' wide x 14' high. The absorber thickness has significantly increased in size as well. This new chamber design will now cost the following: Shielded enclosure $82,000.00 + Anechoic treatment $59,000.00 = $141,000.00 or $4,700.00 per dB. What we are saying here is: Why spend $141,000 USD for a facility when with careful analysis of your true requirements, it can be built for $97,000.00?

10.0 References

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2. Dr. Ed Joy, Dr. Stan Gillespi and others, "Far Field Anechoic Chamber, Compact Range, and Near Field Antenna Measurements", Short course at Georgia Tech 1998.
3. J. D. Kraus "Antennas" McGraw Hill 1988.
4. M. Skolnik "Radar Handbook."

Gabriel A. Sanchez is the President and Founder of Advanced ElectroMagnetics, Inc. a wholly owned subsidiary of Orbit/FR. Mr. Sanchez received his Associate of Arts Degree from Los Angeles Harbor College in 1972 and his Bachelor of Science degree in Engineering Technology from California Polytechnic University, Pomona in 1974. After a short time as a Quality Assurance Specialist for the Defense Contract Administration he joined Emerson & Cuming in their Gardena, California plant. After four years with Emerson & Cuming he moved to San Diego to join Plessey Microwave in the Kearney Mesa area. Upon the closure of the anechoic product line at Plessey Mr. Sanchez established AEMI in 1980. Mr. Sanchez's duties consist of general management, technical design, sales and marketing for AEMI's absorbers and anechoic chambers. Mr. Sanchez has authored numerous technical papers on absorbing materials and anechoic chamber design. Mr. Sanchez also holds three patents for absorber design, chamber design and measurement techniques. He may be reached at gsanchez@aemi-inc.com.

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Electromagnetic Compatibility Research at NIST, Boulder

*P. Wilson, D. Camell, C. Holloway, R. Johnk, G. Koepke, J. Ladbury, K. Masterson, A. Ondrejka**

1. Introduction

In the early 1950s, the National Bureau of Standards (now the National Institute of Standards and Technology, or NIST) determined that it needed a remote field site, away from their Washington DC laboratories, for radio-frequency (RF) propagation and measurement studies. Boulder, Colorado was chosen over several contenders as the new laboratory site. Boulder, at that time, offered (a) a relatively quiet radio-frequency electromagnetic environment, which enabled more accurate measurements and experiments, (b) a varied geographic terrain, which facilitated the study of radio propagation, (c) the presence of a major university (the University of Colorado, CU), and (d) proximity to a large city (Denver). The new Radio Building was completed in 1953 and dedicated by President Eisenhower in 1954, as shown in Figure 1. The technical mission of the NIST (NBS) Boulder laboratory was to develop the most accurate reference standards and calibration services possible to ensure compatibility of the emerging radio, microwave, and radar technologies that the nation was then developing. NBS (NIST) was part of a Boulder scientific community, which included the National Oceanic and Atmospheric Administration (NOAA), the Institute for Telecommunication Sciences (ITS), the Cooperative Institute for Research in Environmental Sciences (CIRES), CU Boulder, the National Center for Atmospheric Research (NCAR), and other laboratories. Research on radio propagation was fundamental to this work, and as higher frequencies were explored, the interactions between electromagnetic waves and the atmosphere led to new directions of research. NIST research on accurate measurement systems and the development of standards and calibration services play an essential role in making possible many of the RF technologies that we now use daily.

Figure 1. President Eisenhower dedicates the Radio Building in 1954.

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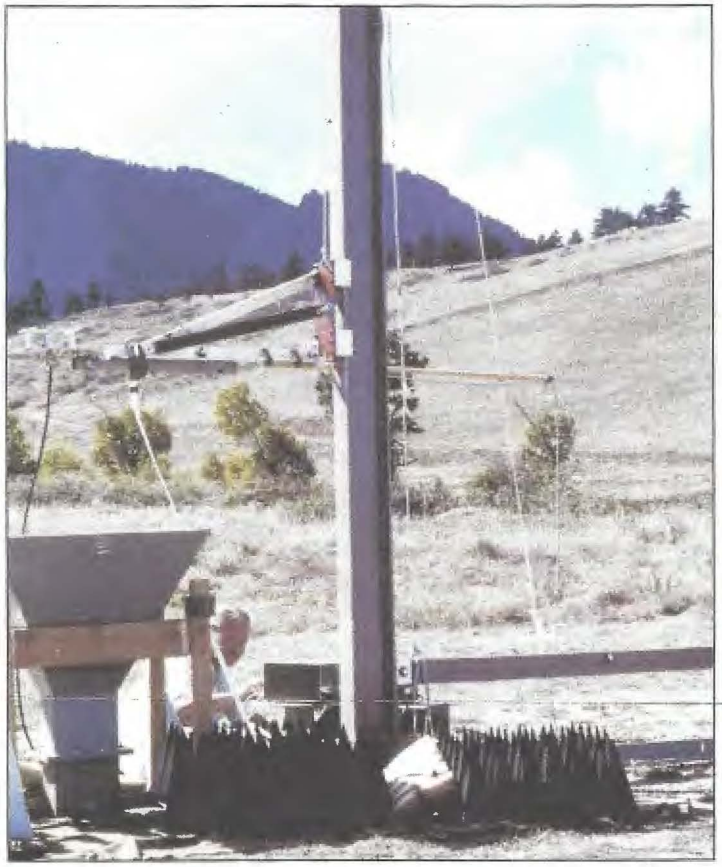

Figure 2. Harold "Bud" Taggert measures a horn antenna below Kohler Mesa.

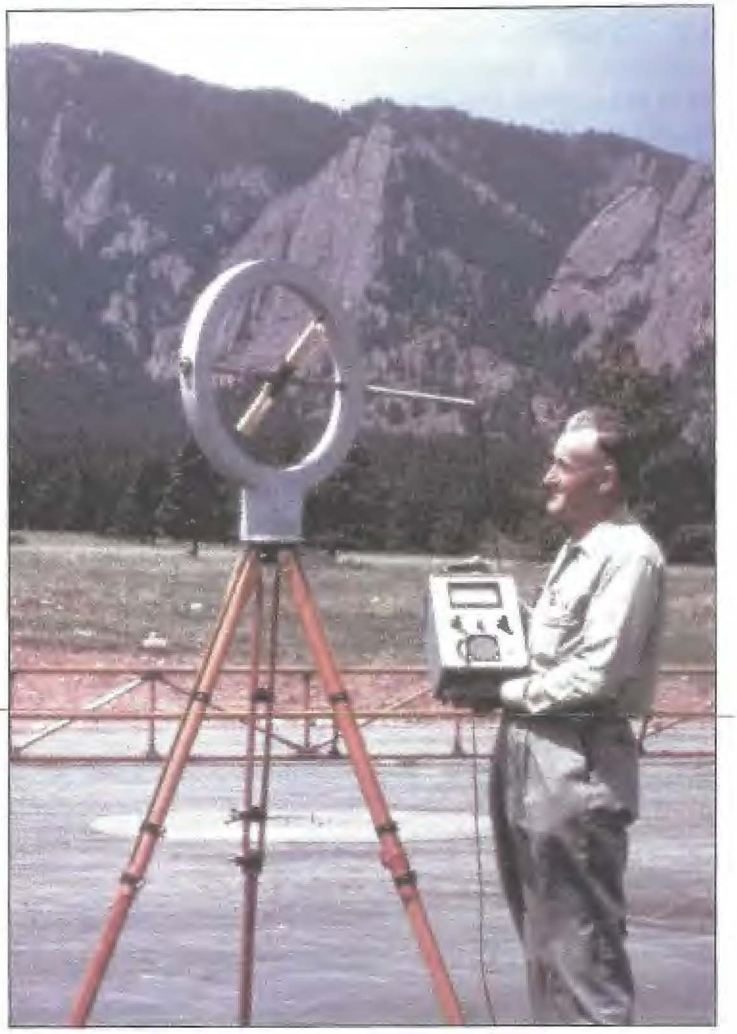

Figure 3. Tom Zaff measuring an early probe on an OATS on Kohler Mesa.

This article presents a brief overview describing the development of electromagnetic compatibility (EMC) test methods at the NIST Boulder laboratories. We will highlight both key research areas and some of the key contributors. The restricted length of the article does not allow for all topics, contributors, and references to be mentioned, and the authors apologize for any and all inadvertent omissions. In addition, while we cite references arising from NIST work, references cited cover only a small part of the overall work in the various technical programs. We again regret that a more inclusive set of references cannot be given. A list of contacts by research area is given in the paper. These individuals can be contacted to obtain more information.

2. Early NIST EMC Pioneers

The area of EMC at NIST, Boulder was first given impetus by Frank Green around 1968. His team instigated the standard antenna method on a flat earthen surface for both E-field and H-field measurements. By use of equations from R.W. Beatty, a horn antenna gain technique was also developed. In the early 1970s, horn antenna gain was measured by pointing the transmitting horn up toward space. This resulted in a hemispherical free-space facility. The two antennas were mounted on a rail system attached to a telephone pole and measured using extrapolation methods. See Figure 2.

This was the "initial" EMC test facility at NIST Boulder. In the subsequent years other facilities were developed, including an open-area test site (OATS), anechoic chambers, transverse electromagnetic cells (TEM cells), reverberation chambers, and time-domain ranges. Central to the use of these facilities was the development of accurate field probes and antenna calibration techniques. These facilities and the probe work will be briefly outlined in the following sections.

3. OATS

The NIST Boulder OATS has dimensions of 30.5 m by 61.0 m. The construction is a 6.4 mm wire mesh (1/4") stretched over a concrete pad with stainless steel sheets at the center measuring 10 m by 20 m. The mesh is grounded around the perimeter. A concrete tunnel underneath the pad leads to an equipment and measurement room. Ducts in the pad allow cables to be routed from the measurement room to various locations on the OATS. Figure 3 shows a mid-1970s probe measurement at the first NIST Boulder OATS.

Our OATS is presently used primarily for calibration of reference antennas and for emission studies; however, numerous topics have been addressed in the past as the standardization of OATS methods was developed. One of the key OATS tests is site attenuation. Site attenuation measurements, while conceptually simple, require a good site and careful measurement practice [1-5]. Richard Fitzgerrel, along with Ezra Larsen, Jose Cruz, and John Workman, played a leading role in refining this

test. In particular, the antenna characteristics (gain, pattern) are affected by its proximity to the ground plane [6]. The size of the ground plane is also important [7]. NIST has also analyzed the uncertainties present when calibrating reference antennas at OATS [8-9]. Repeatability also depends on the measurement methodology used, as well as the site characteristics. NIST is working toward improving repeatability via industrial and international intercomparisons [10]. These efforts highlight the need for reference emitters and antennas.

Weather can limit the use of an OATS. Thus, "low-reflecting" structures are often used to protect equipment and the equipment under test (EUT). These can be equipment sheds or complete OATS covers. Measuring the effect of these structures on measurement accuracy is an important and difficult task. NIST pioneered the use of time-domain techniques to separate out the contribution of the weather structure [11]. Measurements on a fiberglass structure show that emissions testing can be significantly affected at frequencies above 100 MHz. At one point in the mid 1980s, the Boulder OATS was covered with an inflatable bubble to make it an all season site. However, one of Boulder's notorious Chinook winds (100+ mph) proved too much for the bubble and the OATS was soon transformed back to a true open site. Figure 4 shows a time domain cone antenna installed under the bubble prior to its unfortunare demise.

OATS facilities are recognized as standard sites for EMC measurements. Increased ambient noise and the need to test at higher frequencies will place new challenges on OATS measurements. NIST is working on methods to improve repeatability and accuracy to meet these challenges. The primary areas for current and future research are:

- To analyze and refine emission measurement uncertainties at 30-1000 MHz.
- To extend site qualification methods to frequencies above 1 GHz.
- To extend sensor and antenna calibration capabilities to frequencies above 50 GHz.

Toward these goals the NIST OATS has been refurbished.

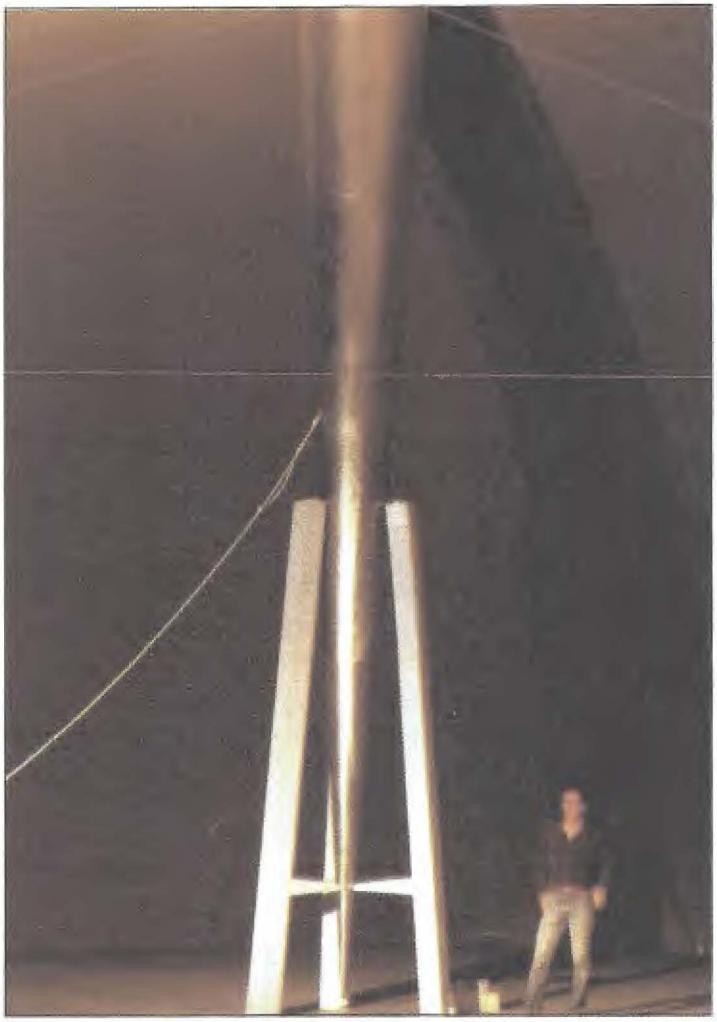

Figure 4. A 9.1 m cone under the ill-fated "all-weather" bubble.

Improvements include a solid steel sheet center, conductive caulking of joints, better ground contact at the edges, and additional weatherproofing. These improvements resulted in site attenuation values within +/- 2 dB of prediction. Moment-method calculations are being used to calculate the effective length and input impedance of NIST standard dipoles to further improve the comparison between measured and predicted site attenuation. NIST continues to collaborate closely with the U.S. industrial community through participation in standards and industry groups, such as ANSI C63 (American National Standards Institute) and USCEL (U.S. Council of Electromagnetic Laboratories).

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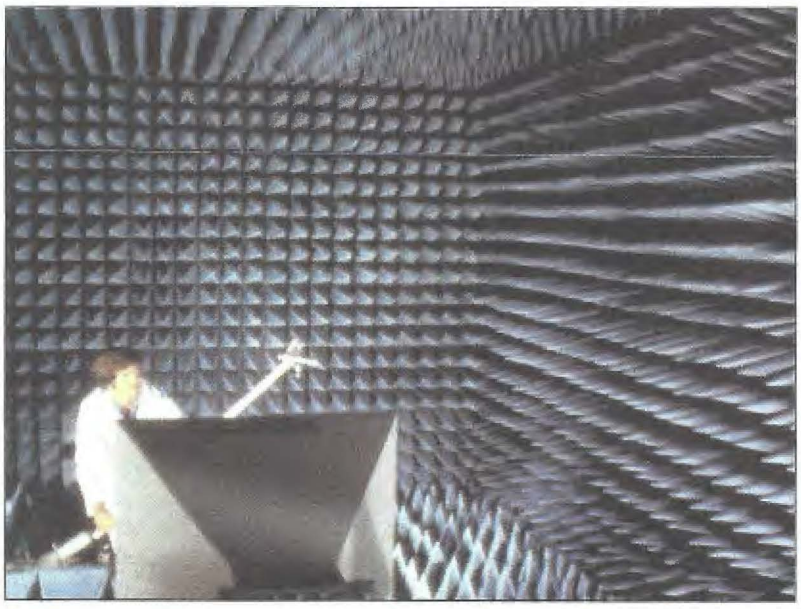

Figure 5. A probe measurement in an early anechoic chamber.

4. Anechoic Chamber

The NIST Boulder anechoic chamber is a shielded fully anechoic chamber of dimensions 8.5 m by 6.7 m by 4.9 m. The pyramidal absorbers used throughout are 90 cm (36") in length, except in corners and on the transmit antenna wall, where 60 cm (24") cones are used. The lower-frequency limit for typical use is approximately

Figure 6. Oblique-incidence measurement of an absorber sample.

300 MHz. A precision 6-axis automated positioner within the chamber is used to orient the test antenna as needed. Originally, the lab where the anechoic chamber is presently located was used for microwave measurements of the speed of light. NIST presently uses the fully anechoic chamber for probe calibrations, standard antenna measurements, general EMC measurements, and research. Figure 5 shows a probe calibration in an earlier NIST Boulder anechoic chamber, prior to refurbishment.

Absorber characterization is basic to the design and performance of anechoic chambers. NIST has been active in characterizing absorber, both theoretically and using in-situ measurements [12-36]. Simulations are very important in the design stage since they allow absorber performance to be optimized as a function of size, shape, bandwidth, angle of incidence, polarization, material properties, layer thickness, number of layers, and so forth, as needed for a particular application. Ideal plane layered absorber, such as ferrite tiles, is straightforward to analyze. In practice, installed ferrite tiles may have gaps between them which can affect performance [12, 26]. Shaped absorber poses a more difficult problem. At higher frequencies, when the wavelength is small compared with the absorber dimensions, geometric optics and ray-tracing techniques may be used. At lower frequencies, when the absorber dimensions are small when compared to the wavelength, a homogenization approach may be used [13-18]. In effect, the air and absorber media are "averaged" as a function of their relative volume fill along the taper direction. The result is effective bulk parameters (generally anisotropic) for an equivalent transversely uniform medium. An excellent review of the homogenization technique and its application to a variety of tapered and hybrid absorber is given in [17].

Direct absorber measurements, using conventional CW far-field scattering, are made difficult by the size of the absorber. Typical tapered cones have lengths along the taper direction of 30 cm to 2 m. At relatively high frequencies, dual directive antennas, one transmitting and one receiving, may be used. However, this method suffers from direct path coupling between the antennas and is generally not appropriate for the usual 30 to 1000 MHz EMC measurement range. An alternative approach is to use some form of coaxial or rectangular waveguide. These work well over a limited frequency range but determine only normal-incidence reflectivity. This underscores the need for simulations and alternative in-situ measurement techniques.

NIST has worked to overcome the difficulties inherent in conventional CW free-space and coaxial waveguide systems through the development of two free-space measurement systems. The first technique consists of placing a free-space reflectometer, consisting of either one or two TEM horn antennas, inside an anechoic chamber and measuring the performance of the installed absorber system in-situ. An efficient sequence of positioning the system and signal processing yields either oblique or normal absorber reflectivity characteristics for a selected area of absorber over the frequency range of 30 to 1000 MHz. A second technique consists of placing a sample of absorber, typically with dimensions of 2 m x 2 m or greater, on a moveable Styrofoam support structure, as shown in Figure 6. The sample is moved into close proximity to a fixed, free-space reflectometer system, consisting of either one TEM horn antenna for normal-incidence characteristics, or two TEM horn antennas to evaluate either oblique incidence or cross-polarized performance. The effects of the small sample are ameliorated by time-gating out the small-sample edge diffraction, yielding accurate reflectivity results from 30 to 1000 MHz. The realization and results obtained with these systems are discussed in [19-26].

Fully anechoic chambers, such as the NIST Boulder chamber, are used for generating standard fields for probe and antenna calibrations [27]. The accuracy requirements may require a more careful chamber evaluation than is required for the EMC standards measurements [28-29]. The field distribution is one metric [30-31] including both on- and off-axis values [32]. The field distribution over a specified volume can be controlled using a near-field array [33] rather than a single antenna. Measuring the transmission loss and comparing it to an ideal free space is another approach [34-35]. Time-domain methods have also been investigated [24-26, 36-37]. Another important issue is resonances that may be insufficiently damped by the absorber. Detection of resonances in an anechoic chamber is difficult if direct field coupling between two antennas largely masks the resonance perturbation. The matrix pencil method is being explored as a means of extracting the contribution of resonances [38-39].

A common thread between the anechoic chamber and OATS research was the development of the standard dipole, which is now used worldwide. R. Fitzgerrel was instrumental in the development of the standard dipole.

Areas for current and future research are:

- To develop new quality-factor measures for chamber assessment.
- To develop site-qualification techniques for higher frequencies.
- To develop enhanced signal-processing algorithms for more accurate evaluations of chamber absorbers.

We continue to upgrade equipment and software used at our anechoic chamber in order to achieve these goals. We continue work on numerical models for simulating absorber and chamber performance. We are also participating in standards groups, such as ANSI C63 and CISPRA, to support their efforts in these areas.

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5. TEM Cell

NIST has several TEM cells with cross-section heights ranging from a few cm to 3 m. Myron Crawford initiated much of the work on TEM cells at NIST and popularized their use for EMC applications. Figure 7 shows "Mike" squatting next to the NIST 3 m TEM cell. Some authors still refer to TEM cells as "Crawford Cells". Other early NIST contributors were Ezra Larsen, Mark Ma, Moto Kanda, and John Workman. The initial application for TEM cells was to generate a uniform electromagnetic field for probe calibration at frequencies below typical anechoic chamber capabilities [40]. As TEM cell usage matured, broader EMC applications emerged, such as emission and immunity testing, source characterization, shielding effectiveness, and even bioelectromagnetics applications. The first step was to characterize the basic transmission line and waveguide properties, and here NIST played an important role.

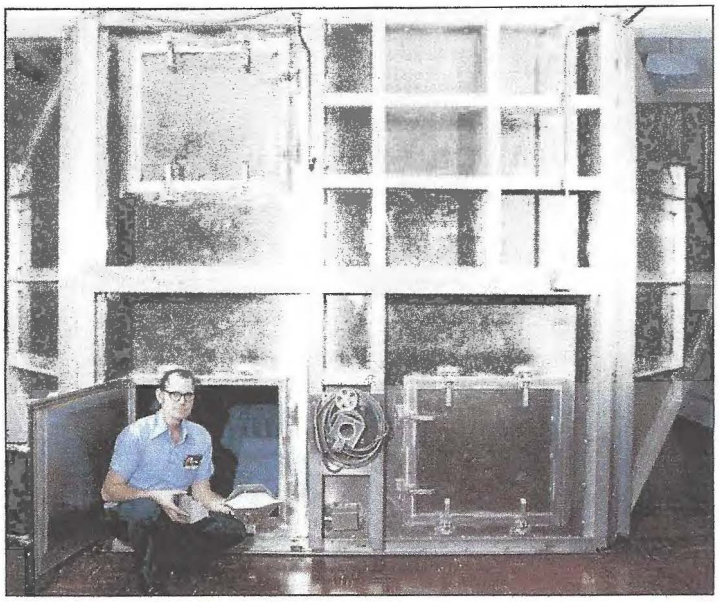

Figure 7. Myron Crawford shows the size range of NIST TEM cells.

TEM cells consist typically of a section of rectangular coaxial transmission line (RCTL) tapered at each end to 50 Ω connectors. This cross section does not lend itself to a simple analysis, as is the case with circular coaxial cable. Thus, one of the first TEM cell related problems considered was the transmission line properties of a RCTL of uniform cross section. In particular, the field distribution of the TEM mode and the characteristic impedance of the RCTL were of interest.

The TEM-mode field distribution determines the uniform area in the cell. The field distribution in a cell can be determined directly via measurements [41]; however, the design of a TEM cell requires analytical and/or numerical solutions. Excitation of the cell by an ideal point source is one method of analyzing the field distribution [42-43] and also provides a comparison to measurement. The TEM-mode field distribution may also be directly analyzed. Solution methods include conformal mappings [44], integral equation methods [45-46], moment-method solutions, and other approximations [47]. In addition, numerous numerical approaches have been applied. This work developed guidelines for the construction of TEM cells [48] and the conversion of shielded enclosures to TEM cells [49]. During this initial phase of TEM cell research, NIST had a close cooperation with the University of Colorado in Boulder and was greatly assisted by David Chang, John Tippet, I. Sreenivasiah, and others.

Higher-order modes perturb the intended TEM-mode field distribution. In many types of cells the cutoff frequency for the initial higher-order mode determines the upper limit of the cell's usable frequency range. The cutoff frequency of a higher-order mode is inversely proportional to the size of the RCTL. Thus, larger TEM cells have lower cutoff frequencies. This limits the usage of TEM cells for large test objects. NIST investigated higher-order modes using various analytical approaches [50-54], reflecting the limited computing power available at the time. Current researchers are taking advantage of numerical tools to consider the structure of whole TEM cells, including tapers.

Characteristics of TEM cells, such as the field distribution and the characteristic impedance, are typically defined for an empty cell. Introducing a test object will influence these characteristics [55-58]. The papers investigate mostly the perturbation in the TEM-mode field structure due to the test object presence. A rule of thumb developed from this work is to limit the test object's size to less than one-third of the test volume's height [59]. This consideration is based on avoiding significant perturbations to the induced currents on the EUT (when compared to free space) and the input impedance into the cell [57-58].

Some TEM cell loading is intentional. As noted, higher-order modes limit TEM cell usage. Absorber can be used to damp the resonance effect of these modes and thereby extend the usable frequency range of a cell [60-62]. However, the presence of the absorbing material near the test volume may perturb the intended TEM mode field distribution. An alternate form of loading is to vary the end termination impedance. Typically, a 50 Ω termination is used to match the RCTL impedance and avoid reflections. However, reflections can also be used intentionally to control the wave impedance and simulate near field conditions [63].

Generating a known TEM-mode field distribution in a TEM cell is useful for testing the immunity of an EUT. Conversely, allowing an EUT to radiate and couple to the TEM mode gives information as to the emissions from the EUT. Various approaches to analyzing EUT emissions have been developed. The approach considered at NIST was to model the EUT as a set of multipole moments [40, 64-76]. A sequence of EUT orientations is used to determine the coefficients of the multipole moments. Usually the electric and magnetic dipole moments are determined, which limits the EUT type to electrically small objects. However, quadrupole and higher moments may be determined at the expense of a significantly more complicated measurement sequence. Monopole radiation models were also developed [46].

Measurement errors and uncertainties due to positioning are also important. The multipole moment coefficients depend on the location within the EUT volume chosen for the multipole expansion. If all the multipole moment coefficients are determined then the expansion location is arbitrary. However, if the expansion is truncated, typically the

Figure 8. Immunity test on a small rocket in the NIST reverberation chamber circa 1984.

case for TEM cell measurements, then any deviation of the assumed expansion location and the actual source location will cause errors [72].

The TEM cell is a widely accepted EMC/EMI test method. NIST regularly uses TEM cells to calibrate probes and for characterizing emissions from electrically small objects. A number of areas need further work. The higher-order mode behavior in flared TEM cells and their interaction with broadband terminations needs examination. Correlating TEM cell immunity and emission measurements under conditions more general than for electrically small objects would further expand usage. Devising a scheme to extract phase data from single-port TEM cells would reduce possible phase-related errors. TEM cells are useful for measuring EUT total radiated power at lower frequencies. There is a need to relate total radiated power to maximum field level statistics in typical EUT application environments to assess the EMC/EMI threat. This question applies to the reverberation chamber as well.

Areas for current and future research are:

- To investigate the use of broadband TEM cells at higher frequencies.
- To extend EUT emission models to electrically large objects.
- To improve probe calibrations in TEM cells.

We are actively participating in the IEC Joint Task Force on TEM cells which is developing an independent standard covering emission, immunity, and pulse testing in TEM cells. We also continue to explore methods to reduce the uncertainty of probe calibrations in TEM cells.

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6. Reverberation Chamber

The primary NIST reverberation chamber has dimensions 2.74 m x 3.05 m x 4.57 m. The construction is welded cold-rolled steel. NIST uses reverberation chambers for testing large EUTs, generating high field levels, and shielding studies. NIST has been active in developing the statistical methods necessary to characterize reverberation chambers and in developing standard measurement methods. Good overviews of NIST research on reverberation chambers are given in [77-78].

Myron Crawford, along with Mark Ma, gave initial impetus to work on reverberation chambers within NIST. The University of Colorado again supported NIST, with contributions from I. Sreenivasiah, Bing-Hope Lui, Doris Wu, and David Chang. Some of the key issues studied include basic design, mode density, the quality factor (Q-factor), field uniformity statistics, variable-boundary-condition performance (paddle mixing), electronic stirring, spatial correlation, EUT directivity, and hybrid TEM/reverberating chambers. Some important applications are immunity measurements, shielding effectiveness measurements of cables and connectors, and total radiated power measurements. One of the first applications of the reverberation chamber was tests on military equipment at high field levels, as shown in Figure 8.

The modal spectral distribution and bandwidths of a chamber are important design considerations. The larger the number of modes in a reverberation chamber, the better the effective density of plane waves coupled to the EUT. The number of modes increases with frequency in a monotonic fashion. NIST investigated approximations for the number of modes in a cavity as an alternative to computing and counting them [79]. The distribution of the modes over frequency is another important quantity. Ideally, the modes are uniformly distributed within the operating bandwidth. This suggests that degenerate modes (i.e., modes with the same resonant frequency) should be avoided. For this reason the NIST reverberation chamber was designed with unequal dimensions that do not yield easy integer ratios. Mode density may be estimated by differentiating the mode number approximation. If we use 1 mode per MHz as a reasonable lower mode density criterion and use the NIST chamber dimensions above, we find a lower usage frequency of approximately 170 MHz. Field uniformity measurements in the NIST chamber show that performance is good above about 200 MHz which agrees well with this estimate [80-81].

The Q-factor is a measure of the energy stored versus the energy lost in the chamber. At high frequencies oss occurs primarily in the chamber walls due to non perfect conductors while at lower frequencies the antennas account for most of the ener-

Photo by Dick Ford

Galen Koepke and John Ladbury of NIST Boulder visit with Larry Cohen (from left to right) of the Naval Research Laboratory in Washington, DC. These gentlemen share a common interest in reverberation chamber technology, pioneered by NIST. This photo was taken, however, when the threesome were testing phased array modules.

gy absorption. The Q-factor of an individual mode is readily determined. However, defining an effective Q-factor for the chamber when multiple modes are present is less straightforward [82-84]. NIST investigated approximations for the effective Q-factor. The quality factor is an important design quantity that must be balanced between the need for low conductor losses (high Q) and broad modal coverage (low Q). EUT loading will reduce the Q during actual tests. However, introducing absorbing material into a chamber to reduce the Q may be desirable at times. Time-domain methods may also be used to determine the effective Q of a chamber [85-86]. The basic approach is to ring-up the chamber with a pulsed signal and then use the decay time to determine the effective Q. This method can be used to quickly determine the loading effect of an EUT or paddle.

A primary measure of reverberation chamber performance is the field uniformity [80-81, 87-96]. Ideally, the field will have the same statistical behavior regardless of location in the measurement volume. This implies that the variable boundary condition, due to the presence of a mode-stirrer, is sufficient to create over a rotation a dense set of equivalent plane-wave orientations at all points in the measurement volume [96-101]. Spatial correlation is also an important measure of chamber performance [102-103]. One measure is the correlation between points within the measurement volume. Another is how quickly points become reasonably uncorrelated as a function of the distance to the fixed boundary conditions at the walls. This determines the size of the usable measurement volume.

In addition to field at a point (polarization, strength), the voltage standing wave ratio (VSWR) and the net input power into the chamber are monitored. As mentioned above, one or more paddles rotating about an axis are usually used as the variable boundary condition. The paddles need to be electrically large, and they typically have some bends or flaps to further randomize the field. Two measurement methods are typically used, mode-stirred and mode-tuned. In the mode-stirred case, paddles are turned continuously and the field is sampled at a rate much higher than the rotational frequency. In the mode-tuned case, paddles are stepped in discrete intervals and the parameters of interest (e.g., VSWR, net input power, test-object response) are measured between steps. The latter method allows the field strength to be corrected as a function of VSWR. A third method is to electronically stir modes by varying the bandwidth of the input signal [104-105]. As the bandwidth of excitation is increased, the number of modes increases and the statistical behavior of the fields improves.

The maximum response versus frequency of a test object may be determined via measurments in a reverberation chamber. However, because only the overall field statistics are known, the direction of maximum response and the gain of the test object are not determined. Similarly, in the emissions case the total radiated power from the test object may be determined, but not the antenna pattern. NIST is currently investigating methods for statistically estimating the directive characteristics of a test object based on the electrical size of the test object and the measured total radiated power [106-107]. Directivity is a key link between measurements in a reverberation chamber and by other methods, such as in an anechoic chamber [108]. The directivity of unintentional radiators is expected to become more important as EMC test methods move to frequencies above 1 GHz and most objects tested are electrically large.

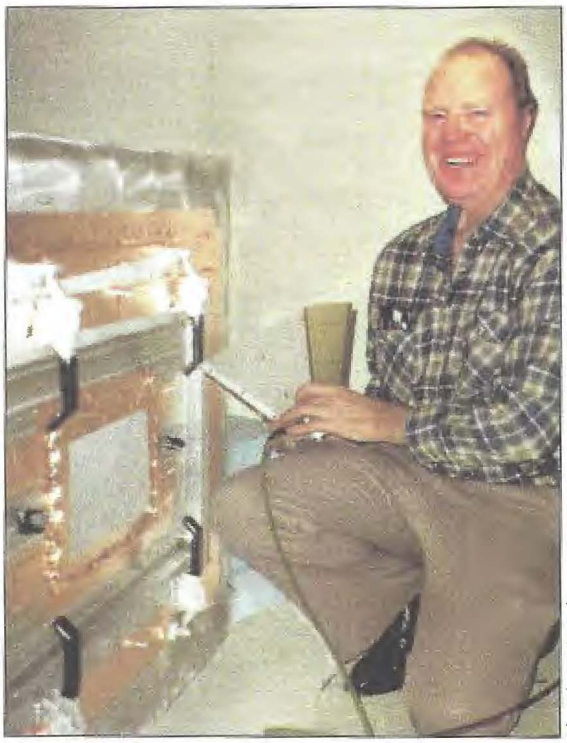

Photo by Dick Ford

Myron Crawford was one of the most widely respected members of the NIST EMC technical staff during his tenure at their Boulder facility. Now retired, he is long removed from his days developing mode-stirred chamber test technology, but his contributions will not soon be forgotten.

Due to the need for sufficient mode density in the cavity, the reverberation chamber is a high-frequency method. The TEM cell is a low-frequency method because the TEM mode on a transmission line has no cutoff frequency. NIST has worked to combine these two methods to create an extremely broadband test facility [109-113], although a transition region between the two regimes exist where the test field may not be acceptable. One advantage of such a hybrid is that very high field levels (> 200 V/m) can be achieved with modest input power.

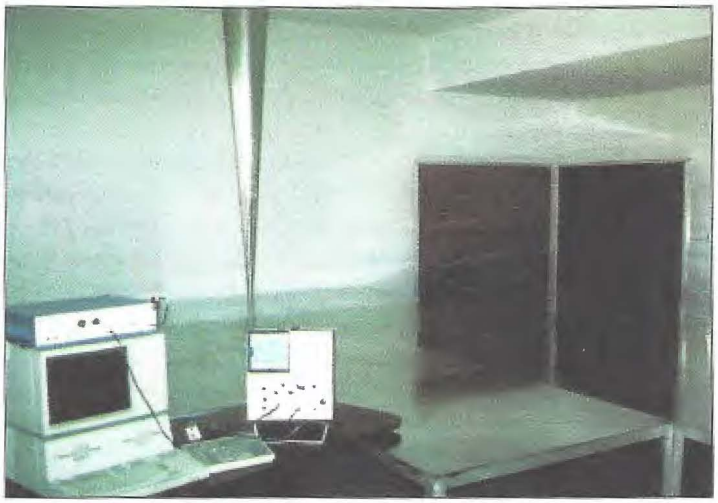

Figure 9. Early cone and ground screen for time-domain measurements.

The relatively high Q of the reverberation chamber means that high field levels are possible with moderate input power. Most EMC susceptibility testing requires modest fields levels on the order of 10 V/m or less. For most test objects these levels may be readily realized in anechoic chambers and TEM cells. However, some EMC testing (e.g., military, aerospace) requires testing to significantly higher field levels, on the order of 200 V/m or more. This can pose a problem for users of anechoic chambers due to expensive amplifier power needs and a possible fire risk for anechoic materials. Thus, the reverberation chamber has found wide application in the area of testing at high field levels [81,87,89,91,94].

High field levels also create a large dynamic range. This has found application to shielding effectiveness measurements of cables, connectors, and gaskets [114-126]. Gaskets are often measured by use of nested reverberation chambers. A small cavity with an internal paddle is placed inside a larger reverberation chamber. Coupling is then accomplished primarily through a large aperture that can be covered with a gasketed plate or a test material. An alternative under consideration is to use two large reverberation chambers placed side by side with a large coupling aperture. This would allow the testing of very large gasketed openings such as doors and large access panels.

There are many technical opportunities for future research in reverberation chambers and related technology. NIST is currently looking into:

- Techniques that reduce measurement uncertainties; this may open up applications other than EMC including high-frequency characterization of isotropic probes and antenna efficiency measurements.
- The meaningful comparison of reverberation chambers with other measurement facilities.
- Measurements of the shielding characteristics of materials by use of dual or nested reverberation chambers.
- Development of models to better understand the statistical nature of complex electromagnetic fields and their coupling into or between cavities, fields in "less controlled" cavities such as aircraft, vehicles, and buildings, and cavity characteristics with distributed losses.

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7. Time-Domain Range

A state-of-the-art cone and ground-plane range is currently being constructed at the NIST Boulder laboratories, and is scheduled for completion later this year. The range consists of a precision fabricated 7.4 m x 7.4 m aluminum ground plane with a flatness specification of ±0.1 mm. The cone height will be 4 m with a total angle of 4° forming a 200 Ω system. This facility will be used to generate a precision field that can be used to calibrate a wide variety of devices: D-dot sensors [127], microwave and UHF antennas, and some types of EMC antennas. In addition, this facility will be used to conduct scattering measurements and as a test bed for developing new techniques for qualifying EMC measurement facilities. Figure 9 shows an early cone and ground screen.

Figure 10. Ezra Larsen and one of the early NIST isotropic probes.

Our work on time-domain measurement began in the early 1960s. There was a need in the military to measure the peak RF power of a microwave radar pulse. Paul Hudson recommended that we measure not only the peak power but also the entire power characteristic of the pulse, as a function of time. Warner Ecklund, a graduate student working at NBS at the time, suggested that we build a fast diode switch that could sample the RF signal at any given position within the pulse. We measured the power in the sample using a thermal detector (the same thermocouple devices still in use in the RF voltage calibration facility) and compared the measured value to a similar sample taken from a continuous-wave (CW) RF source. We had the primary standards to measure CW

power at that time, so this was a natural step forward for us.

This work began in the radar band between 950 MHz and 1250 MHz. Ecklund built the first switch using the fastest switching diode available at that time, the 1N4153. It had a switching speed of about 10 ns, and provided clean switching characteristics for sampling applications. To obtain 60 dB of isolation, Ecklund used six diodes in series forming the center conductor of a coaxial transmission line. Since the diodes had significant reactive impedance at the radar frequencies, he added a capacitive tuning stub at the connection between each pair of diodes. In this way, he was able to reduce the VSWR of the switch to a very reasonable amount. The effort was very successful and launched our time-domain work. This became the reference standard for a peak-power calibration service developed later by Phil Simpson and Lee Saulsbury.

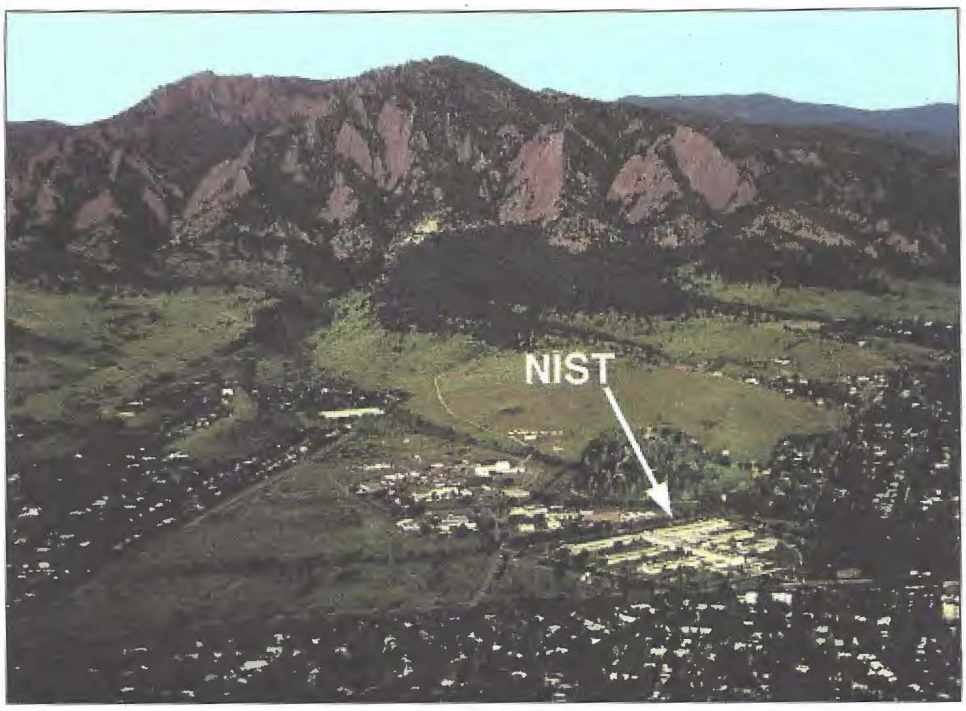

Figure 11. Aerial view of the Department of Commerce Boulder campus.

Later in the 1960s, Norris Nahman joined our staff and began our first serious effort in very-high-speed time domain measurement. The focus was on picosecond-duration pulses. He was supported by Chuck Manney, Bill McCaa, and Jim Andrews (who later founded Picosecond Pulse Labs). Still later, Sedki Riad and Bill Gans joined the group, again moving us forward by another order of magnitude in speed. This group built our first computer controlled sampling oscilloscope. We developed software to average samples and process the data with digital deconvolution [128]. These advances allowed us to reduce the noise and remove the flaws of the oscilloscope from the measured data, significantly improving the accuracy of the system.

Up to this time, all of our work was done in precision coaxial transmission lines. It was in the mid-1970s that work first began on the free-field time-domain range. It was to be a vertical metal cone positioned over a metal ground plane. The resulting conical transmission line had been well analyzed theoretically. The initial ground plane was only 1.2 m square (4') with a 91.4 cm cone (3'). The system was designed to generate a spherically symmetric calculable field. This field was then used to characterize a wide variety of antenna and sensor types [129]. Around the same time, the first NBS picosecond impulse generator was designed and built. It could produce a roughly Gaussian-shaped pulse several volts in amplitude and about 350 picoseconds in duration. After purchasing a new sampling oscilloscope that had about 100-picosecond rise-time, NBS was in business.

During the 1980s NBS fabricated a 9.1 m cone (30'), shown in Figure 4, to be used in conjunction with the OATS ground plane. This facility was highly useful for the calibrations of EMC antennas such as the log-spiral antenna in the frequency range of 20 MHz to 2 GHz.

The ground plane was enlarged several times over the subsequent years, reaching 6.1 m square (20') around 1980. Norris Nahman initiated a new ultra-high-speed optical sampling device intended for the measurement of electromagnetic fields. A sub-picosecond sampling impulse would be transmitted to the sampler over an optical fiber, eliminating the need for conductive wires. The sampler was to be used in EM environments where the wires would distort the fields we were trying to measure. Bob Lawton developed the solid-state sampler, which produced a five picosecond optical pulse from a mode-locked neodymium glass laser.

More recently, work has focused on practical measurements and techniques. We have developed a family of measurement systems and techniques for the evaluation of RF absorbers and RF absorber-lined chambers. NIST has extended this capability to other types of facilities such as OATS with shelters, and developed a new capability in the measurement of time-domain emissions when we participated in a National Telecommunications and Information Administration (NTIA) evaluation of the time- and frequency-domain emissions characteristics of commercially available ultrawideband devices [130]. NIST has also been quite active in the evaluation of shielding properties of aircraft [131], in which NIST has recently performed an extensive set of shielding performance measurements on a commercial jet airliner in a hanger environment.

Current and future work in the time domain area includes:

- The characterization of the temporal and spectral characteristics of ultrawideband signals of commercial devices.
- The development of antennas for the reception of ultrawideband systems.
- To investigate the shielding performance of aircraft using time-domain techniques.
- To continue to develop efficient signal processing algorithms using joint time-frequency analysis.

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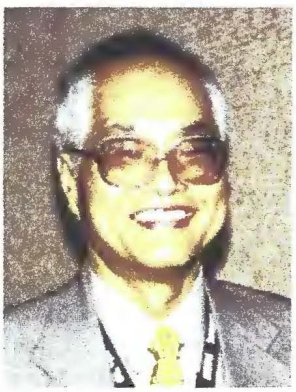
8. Probe Development

NIST has developed electromagnetic-field probes for a variety of applications over many years. The probes include prototypes for CW field measurements, pulse or broad-bandwidth field measurements in the time domain, and measurements in the near field where the electric and magnetic components do not maintain plane-wave relationships. They also include probes, used as check standards, for measuring the standard fields used to calibrate antennas and commercial probe systems, and as transfer standards for use by various test laboratories.

The earlier work was mostly directed toward CW measurements and use of isotropic probes for environmental assessments. A probe developed by Ezra Larsen and Jim Andrews [132], shown in Figure 10, used optical fibers to reduce the coupling between the leads and the probe elements in an isotropic probe. A broadband electric-field monitor was developed by Jose Cruz [133] and an isotropic magnetic-field meter was developed by Lanny Driver and Jose Cruz [134].

Probes formed from resistively tapered dipole elements were developed at NIST during the 1980s [135] and now serve in several of the applications noted above. A key contributor to the development of these probes at NIST was the late Motohisa Kanda who was recently honored with a special issue of the IEEE Transactions on Electromagnetic Compatibility [136]. The tapered resistance provides an impedance match between the gap and free space that suppresses resonances and increases the useable bandwidth over that from a metallic dipole of equivalent length. These probes are also well suited for waveform measurements of electromagnetic pulses used in time domain analysis of antennas and materials.

More recently, NIST has used advancements in fiber optic and electro-optic technologies to further develop probes that provide both electrical isolation from signal processing instrumentation and minimal perturbation of the measured field [137]. The amplitude and phase of the electromagnetic signals are maintained so that vector field measurements can be obtained. In one implementation of this technology, we combined the photonic signal leads with a loop antenna having two resistively loaded gaps. This probe has the capability of simultaneously measuring electric and magnetic field components at the same point in space [138-139]. Another application of the double-gap loops is a three-loop system that has been analyzed [140] and tested [141] for measuring the electric and magnetic dipole moments of unknown radiators placed at the center of three orthogonal loops.



Motohisa Kanda

In a slightly different application of photonic technologies, Jim Randa, Moto Kanda, and David Orr [142] developed power-absorbing tips for an optical-fiber, temperature-sensing unit that could measure electromagnetic fields at frequencies above 10 GHz.

Current and future work in this area includes:

- The design of optically linked RF-dipole probes and loop antennas with resistively loaded gaps.
- The research and development of optically linked probes with frequency responses in the 100 GHz range.

Contact: Keith Masterson (303-497-3756, masterson@boulder.nist.gov)

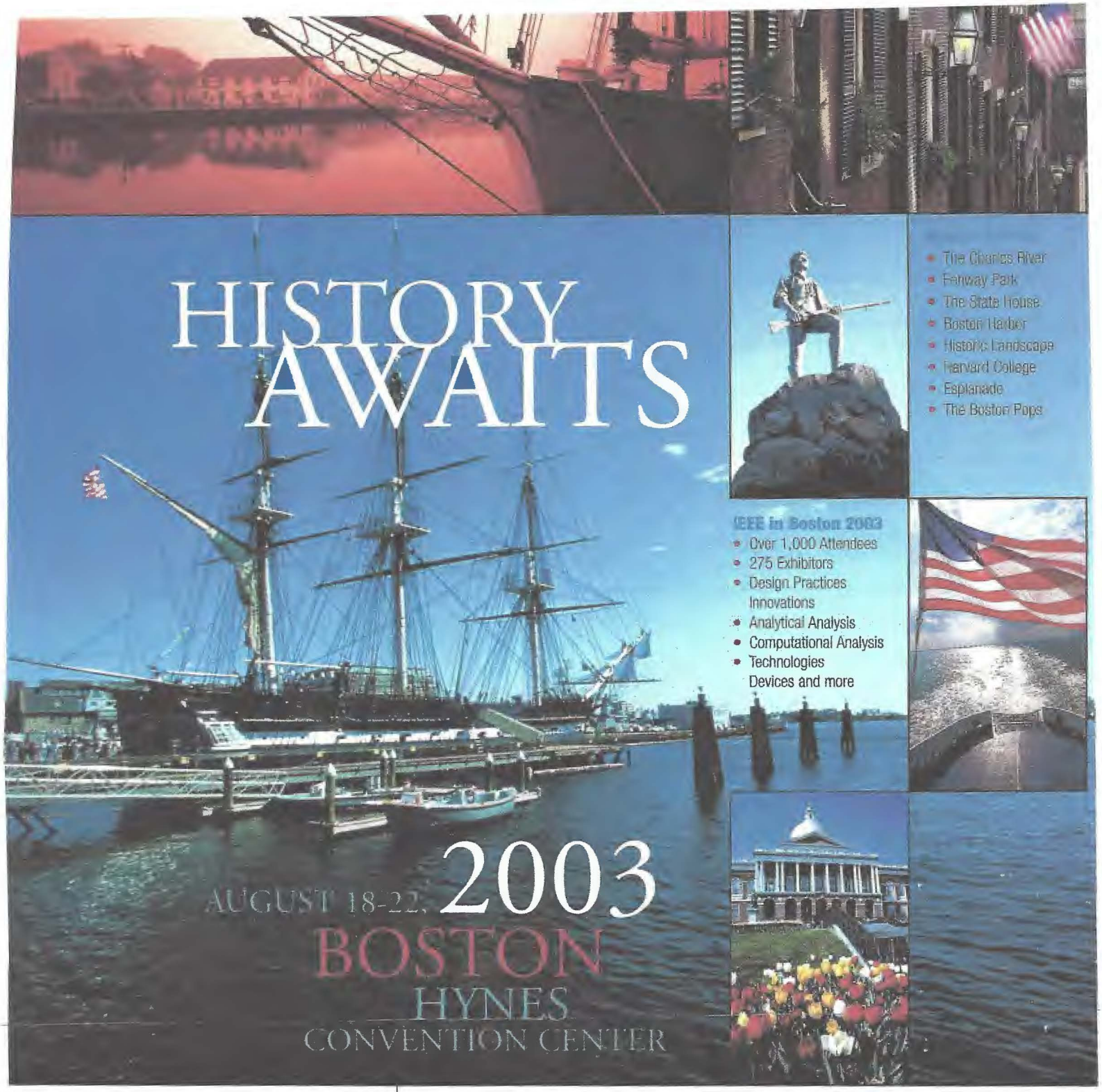
9. Conclusion

The world of EMC has changed significantly in the almost 50 years since President Eisenhower dedicated the Radio Building in Boulder. An aerial photo of the growing Department of Commerce (DOC) Boulder campus is shown in Figure 11. NBS has changed to NIST and Boulder has grown from a sleepy college town to part of a growing metro area. What has not changed is the dedication of the NIST staff to making accurate measurements and serving the public and technical community. We look forward to the challenges of the next 50 years.

10. References

The references are not reproduced here due to space limitations. They may be found on the IEEE EMC Society Website at http://www.ewh.ieee.org/soc/emcs/. Click on Newsletter and then go to the Summer 2002 Issue of the Newsletter. **EMC**

The authors are with the RF Fields Group, part of the RF Technology Division, National Institute of Standards and Technology, Boulder, Colorado. Shown from left to right are Galen Koepke, John Ladbury, Robert Johnk, Chris Holloway, and Perry Wilson. Missing are Dennis Camell, Keith Masterson, and Andy Ondrejka.



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Inter-Society Activities

David A. Case, Associate Editor

There are no guarantees in compliance, nor in most cases can we offer them. For example, a request was made by a customer who wanted me to sign a paper guaranteeing that our wireless system when installed in his medical facility would not cause any, repeat "any," harmful interference to his systems operating in a facility I had never seen.

With the knowledge that if I signed such a document our legal department would have me stood up in front of a wall and shot, common sense reigned and I did not sign any document to that effect. There was just no way to guarantee that.

I thought the matter had died until I was informed by the vendor bidding on the project that I had lost the account to his competitor who had signed such a document for the facility. I asked the vendor why he did not sign the document since he was designing and installing the system and it was his responsibility to make sure the systems complied. He stated that we as the manufacturer are responsible for compliance and should guarantee compliance in all cases per the FCC rules.

There are no guarantees in compliance, nor in most cases can we offer them.

Unfortunately, that is the belief of some, that the manufacturer is responsible for the compliant operation of wireless systems. This, however, is not true. The manufacturer is responsible for designing the system to the required regulatory specifications and making sure the product is properly certified before placing it on the market. The manufacturer is also responsible to make sure that information on operation and proper accessories such as approved antennas is provided.

However, the system operator, whether a service provider, licensed radio operator or, in the case of a Part 15 device, the user is responsible for compliant operation of the device. Therefore, if a vendor or customer buys a Part 15 WLAN radio and makes any undue changes such as using a non approved antenna, a third party amplifier, or makes any unauthorized changes, or installs it or operates it improperly, then they are the responsible party for addressing compliance.

Once again there will be a joint meeting of the RAC and SAC committees at the 2002 IEEE International Symposium on EMC in Minneapolis. It will be held on Monday, August 19th at noon at the Hyatt Regency Hotel. At this time, I invite the RAC and SAC members to attend this luncheon as well as the members of the EMC Society Board of Directors. We will discuss several issues including possible changes to the RAC. Hope to see everyone there. **EMC**

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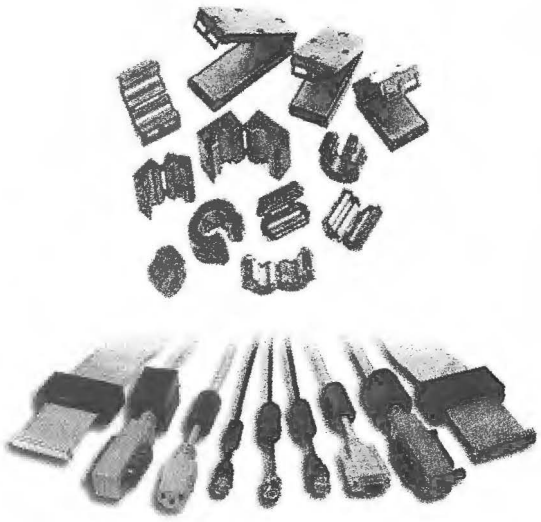

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EMC Personality Profile

Bill Duff, Associate Editor

Last year, we had four new Fellows elected from the candidates that were evaluated by the EMC Society Fellow Evaluation Committee. Our four new Fellows are:

Dr. Gerard T. Capraro
Andrew L.S. Drozd
Dr. Valeri YA Kontorovitch
Dr. Thomas Van Doren

Two of our new Fellows were featured in the last issue of the ***EMC Newsletter***. The other two are featured in this issue. Congratulations to all four gentlemen!

Introducing Gerry Capraro

Dr. Gerry Capraro was elected to the grade of IEEE Fellow for "*Leadership in identifying and establishing a methodology to apply computing technologies for assessing the electromagnetic compatibility of systems.*"

Gerry received a B.A. in 1996 from Utica College of Syracuse University. He received a M.S. in 1973 and a Ph.D. in 1978 from Syracuse University.

Dr. Capraro started his career at the USAF/Rome Laboratory in 1966. Gerry worked on several projects to develop EMC analysis models for communication systems. He played a major role in the development of the Intrasystem Electro-Magnetic Compatibility Analysis Program (IEMCAP). The introduction of standardized computerized analytical tools, such as IEMCAP, for use by contractors in the 1970's provided a new way of doing business.

Prior to the development of IEMCAP, each contractor used their limited set of proprietary tools to justify their designs. There was no standard that could be used to compare results. IEMCAP was the first basic tool for intrasystem EMC analysis that allowed the USAF to assess the design of complex systems using a standard computerized tool. Contractors had to assess their system and subsystem using IEMCAP as a baseline. This provided the government and contractors with a standard digitized database and software tool for risk reduction and for further analysis of potential EMI problems. Government and industry personnel for both military and commercial applications are still using the IEMCAP today.

Dr. Capraro was the technical leader for the USAF Intrasystem Analysis Program (IAP). His technical leadership resulted in the development of a series of computerized electromagnetic compatibility (EMC) analysis tools for use by the government and industry for the development of complex ground and aerospace systems. Over 100 US organizations and 50 foreign governments and their contractors are still using the IAP analysis tools.

Gerry worked for Kaman Sciences from 1984 to 1993 and then he founded Capraro Technologies Inc. He is currently the President, Senior Scientist, Manager and Technical Leader performing research and development for the USAF and software development for the government and industry.

Dr. Capraro has been active in the IEEE EMC Society. He was Chairman of the Mohawk Valley Chapter, a member of the Board of Directors of the EMC Society, and Co-Technical Chairman for the 1985 IEEE International Symposium on EMC. He has authored and co-authored over 40 published papers and he is a NARTE Certified EMC Engineer.

Gerry acknowledges that he had a good time over the years working in both the EMC community and in the computer field. One of his major goals was to bring software tools into the engineering field. Gerry is pleased that we have progressed from databases with cardboard cards to very sophisticated database management systems operating over the Internet. Gerry states "we truly have come a long way in the last 36 years. When we designed IEMCAP we were worried that it would not run efficiently because of the number of equipments and the number of frequencies we could assign to model the emission and susceptibility levels of a particular port. Memory and speed were a major concern back then."

"For the last eighteen years I have been working on bringing database management and artificial intelligence techniques to the signal processing arena. We have had great success and are pushing technologies to embed more intelligence in numerical processing. Another major area we are pushing is to extend the Internet to bandwidth and processing deprived devices like cell phones, personal digital assistants, and hand-held computing devices in general. Our goal is to provide information to a user anytime, anywhere, and on any device."

"The above provides a brief overview of my career for the past 36 years. However, it doesn't say much about the jour-

ney I traveled and the great times along the way. Working in the EMC community all these years has brought me many challenges, much happiness, and above all the fortunate gift of meeting and working with some of the best people in the IEEE to include: Bud Adams, Jack Edwards, Roger Harrington, John Norgard, Clayton Paul, Jose Perini, Jake Scherer, Ken Siarkiewicz, John Spina, Brad Strait, and Don Weiner. I also want to thank all the people I have worked with within the EMC Society over the years who were not mentioned above. Some of these people are: Dick Ford, Larry Cohen, Don Heirman, Ed Bronaugh, Henry Ott, and Chester Smith."

"There are numerous other people that should be noted but the list is too long. Therefore, I would like to thank all of the individuals that I have had the good fortune to work with for making the first part of my journey so fruitful and joyful."

Introducing Tom Van Doren

Dr. Tom Van Doren was elected to the grade of IEEE Fellow for *"Contributions to electromagnetic compatibility education at the undergraduate, graduate and post graduate level."*

Dr. Van Doren received the BSEE, MSEE, and PhD degrees from the University of Missouri- Rolla (UMR) in 1962, 1963, and 1969, respectively. He spent two years in the military as a Lieutenant with the Army Security Agency and then worked with Collins Radio Company as a Microwave engineer for three years in the late 1960s. He has worked as a Professor of Electrical Engineering at UMR for the past 33 years. He is now a Professor Emeritus at UMR.

Tom has devoted his professional career efforts to providing EMC education to students, experienced engineers and technicians. He has helped to educate approximately 2,000 undergraduate students. Tom developed the "Grounding and Shielding" course 19 years ago. It was one of the first EMC courses offered at a university and is still one of the most popular elective courses at UMR.

During the past 19 years, more than 16,000 persons have attended his short courses on "Grounding and Shielding" and "Circuit Board Layout." A significant fraction of all the engineers in the world that have to deal with EMI problems have benefited directly or indirectly from his work. His reputation as an excellent instructor has created a high demand for his courses. Tom has the ability to reduce complex ideas to their most fundamental components and convey these ideas to engineers and engineering students at all levels.

Tom has a passion for both learning and teaching. At the University of Missouri-Rolla, he leads research projects, supervises graduate students, teaches short courses, and contributes significantly to a wide range of projects. He has initiated several new courses and education projects that have been highly successful.

Tom spends a great deal of time and effort helping students and faculty to solve engineering problems and understand engineering concepts. His door is always open and Tom is often seen working with students or other faculty on projects in which he is not officially involved. This work has had a significant impact on the education and productivity of others. Tom is an outstanding educator because he truly enjoys learning and he truly enjoys teaching. He has helped thousands of people to solve EMC problems and become better engineers.

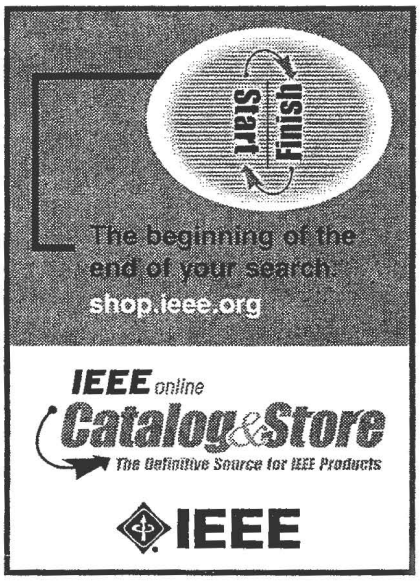
Tom emphasizes that: "There are several concepts that even experienced engineers have misunderstood. Many people believe that currents go to ground taking the path of least resistance. In actuality, sinusoidal currents return to their sources taking the path of least impedance. Many also believe that the current return path is the grounding connection, but in reality the routing of currents and the grounding of currents are two entirely different concepts. It is also incorrectly thought that a straight wire possesses the property of self-inductance, when a complete current loop is required to create self-inductance. I have enjoyed for many years the opportunity to work with students, engineers, and circuit board layout personnel to improve their understanding of EMC principles."

"Even though EMC education has been my main contribution, I enjoy most the solving of EMI problems. Through the EEC Research Group at the University of Missouri—Rolla I have the opportunity to work with enthusiastic faculty and students on a variety of EMC problems. We currently have 19 companies sponsoring our research in nine different project areas. We have developed several experimental measurement and modeling techniques to help us understand EMI problems, especially the energy coupling mechanisms."

Tom received the EMC Society's Richard R. Stoddard award in 1993 for "Contributions to the advancement of EMC technology and the education of EMC engineers."

Regarding family, Tom says "I have had the blessing of being married to an angel for 42 years. We have successfully raised three sons. By "successfully" I mean that they have left the family home and appear to be financially independent. Now that we have four grandchildren, my wife and I mostly ignore our sons and focus on the grandkids."

As for hobbies, Tom says "I don't have much time for hobbies, but I do have two: slow dancing with my wife and gardening. EMC engineering may be based on science, but slow dancing is an art." **EMC**



Book Review

Reinaldo Perez, Associate Editor

Telecommunications Wiring, 3rd edition, **USBN: 0-13-028696-6**
Author: Clyde N. Herrick
Publisher: Prentice Hall PTR, 2001

A great number of people in the EMC community have become interested in telecommunications issues (e.g. wireless LAN, Bluetooth, etc) due to the EMC and EMI implications. Though the telecommunication business has received a severe pounding in the stock market, the future still looks promising, in the long term, by any measure or standard you want to use. Therefore, it is of interest that we review telecommunications books that are either related or have implications to EMC/EMI. The first of this type book we have chosen to review deals with telecommunications wiring. The purpose of this review is to introduce the concepts of telecommunications wiring to EMC engineers; there is a very good likelihood that one of the first EMI problems you may be asked to resolve has to do with wiring!

The book is composed of 15 chapters and it is written for those involved in the design and installation of wiring systems for telecommunication equipment. Therefore, the math is light and the amount of illustrations is large. It is easy reading, yet it is highly comprehensive and there is a lot of data put forward. The third edition was created to include digital subscriber line (DSL) technology, as well as current wiring and networking technology. Many books have been written on higher-level subjects in telecommunications such as local area networking, designing LANs, telecommunication systems, and so on. However, the cabling and wiring sections of such books seldom offer any practical information. The cabling should be treated as a "dynamic source" rather than a static one. From the EMC point of view, we know that wiring is dynamic.

Chapter 1 starts with the electrical characteristics of wire. A wiring system is a form of electrical circuit and it is treated as such. The concepts of resistance, inductance, signal to noise ratio, capacitance, and impedance of wiring circuits are discussed. Other EMC related concepts such as digital and analog grounding, cross-talk, and signal attenuation are also discussed. Chapter 2 is a natural progression from chapter 1 since it talks about transmission media, in particular the twisted pair. Twisted pair wiring is, and will be for years, the most often used telecommunications medium. A new driving technology is to use new techniques of transmission to maximize the transmission rate of twisted pairs. New inventions and new transmission techniques have increased the bandwidth capability of twisted pair far beyond what was thought the maximum a few years past. In this chapter, the two types of twisted pair wiring are described in detail: unshielded twisted pairs (UTP), and shielded twisted pairs (STP), together with the concept of cross-talk. A detailed discussion is made of the different applications of twisted pairs. Twisted pair terminations are covered in the chapter as well as the electrical characteristics of twisted pair cabling. The chapter ends with a discussion of flat/ribbon cabling and the tools used for installing twisted pairs.

Chapter 3 discusses coaxial cables. Coax is a time proven cabling medium that can be utilized in most audio/data communication systems and with most telecommunications devices. The additional expense of coaxial cable is usually justified over twisted pair cable if information security and signal bandwidth are important. The book follows the same approach, as used with twisted pairs, in the outline of chapter 3. The chapter also discusses the grounding of coaxial cables and the advantages/disadvantages of coaxial cables over twisted pairs. Chapter 4 is the last to address transmission media and it discusses fiber optics cabling. The chapter spends some time on the principles of fiber optics communications, but then it quickly jumps to address practical matters such as cable construction, cable terminations, specification of the type of fiber optic cable, installation, data rate issues, cable splicing (different types), and the advantages and disadvantages of fiber optics cabling. There is a need to balance the advantages of the three cable types against the cost of installation, cost of maintenance, availability, and future needs before selecting a cable type. Chapter 5 covers the National Electric Code (NEC) set of telecommunication wiring requirements, mostly geared to minimize hazards of electrical shocks, explosions, and fires caused by electrical wiring.

Chapter 6 starts with network topologies, which is really a short introduction to LAN. It covers the different types of network topologies such as BUS, STAR, and RING. Chapter 7 discusses DSL. DSL is a modem-like technology that allows the transmission of voice, video, and data over existing copper telephone lines at megabit speed. DSL provides dedicated bandwidth that is 143 times faster than a 56K modem, 62 times faster than ISDN, and 4 times faster than T1 connection.

From chapter 8 through chapter 15, the author takes the reader through every single step needed for the wiring of a telecommunications system. Chapter 8 starts with the premise that you need to plan for the installation process. It is important that planning and installation guidelines be established and adhered to whenever any major system needs to be installed, upgraded or removed. The chapter presents some of the most important aspects that must be addressed and the reasons behind them. Chapter 9 deals with the actual installation strategy of cabling. There are as many cable schemes as there are buildings. The building topology, the present inventory of data processing equipment, the current in-place wiring, and the future telecommunications plan will all dictate the type of network and wiring media employed. The wiring media and wiring methods should be tailored to the facility and the present and future needs of the business. EMC engineers must first become familiar with the wiring of the facility if an

continued on page 45

EMC Standards Activities

Don Heirman, Associate Editor

Do You Really Know the RF Environment?

That's a question we all are asking ourselves especially as new radio services and wireless LANs and applications are coming on board. If we really need to know the answer, how in the world will you attack a measurement program of this RF environment? Well, we have a start with IEEE Standard 473 on EM Site Surveying. This has been around for over 20 years. But it is time to update it using modern instrumentation, measurement techniques, and statistical data processing and storage. If this is your bag, please read on as we are now launching a revision of the document and need your help.

Your Personal Invitation to Join... IEEE WG 473

Revision of IEEE Recommended Practice for an Electromagnetic Site Survey (10 kHz to 40 GHz)

By Elya B. Joffe, Working Group 473 Chairman

I. IEEE Standard 473: 1991 at a Glance

IEEE STD 473 describes a systematic approach for performing an EM site survey, commencing from preparation of the planning of the test until completion, data analysis and documentation of the measurement results. The Standard outlines procedures and information regarding the methods for conducting EM site surveys particularly for EMR bio-effects and equipment effects applications.

II. The Revision is Under Way

IEEE approved a PAR for the revision of IEEE Standard 473 and a Working Group has been formed. The Working Group held its first meeting in Montreal, during the 2001 IEEE International Symposium on EMC.

The main objectives of this effort are to expand the coverage of the Standard from 10 GHz to 40 GHz and update measurement techniques to reflect current state of the art and technology.

Membership of the Working Group includes members from the original committee who wrote the first issue of IEEE Standard 473, who provide their insight as to the original considerations on the development of the Standard as well as new members from a broad spectrum of activities, users and equipment manufacturers alike.

III. Why the Need for Revision?

The current Standard extensively covers a broad spectrum of considerations in conducting EM site surveys, however, a detailed review indicates that an extensive revision is necessary.

The proposed revision will:

1) **Expand the *current* scope of the Standard**, including the characterization of the performance of an existing or planned electronic system as well as for the evaluation of the expected human exposure to EMF, due to emitters on site, to incorporate methods and considerations in conducting electromagnetic site surveys for the purpose of RF compatibility and collocation purposes – a field requiring a major revision and extension of measurement techniques and considerations! This expansion requires that specific parameters such as modulation waveforms, signal bandwidth, spectral distribution, signal waveform characteristics, field polarization, etc, be measured. The existing Standard addresses these parameters only to a limited extent.
   Due to recent changes in frequency allocations, the upper frequency range needs to be extended from the current 10 GHz to 40 GHz.
2) **Update and incorporate the usage of modern test and measurement equipment and procedures.** These include not only the usage of similar test methods with modern test equipment, but also the consideration of brand new measurement techniques and approaches, even to incorporate time domain considerations and statistical methods in spectral analysis for pulsed RF emitters (e.g. radars).
   Special consideration of new measurement technologies and techniques, enabling one to make the most of available test equipment, are going to be developed. These include the application of modern detector type, digital measurement equipment providing measurement and processing capabilities never before used, etc.
3) **Incorporate statistical techniques and measurement uncertainty considerations into the Standard.** This is of utmost importance, especially due to the expanded applications of the Standard.
   Measurement of EMF for HERP (Hazard of EM Fields to Personnel) requires not only a qualitative knowledge of the EME, but rather a high level of certainty and confidence in the measurement results. This turns out to be one of the most important items under consideration in the development of the Standard.

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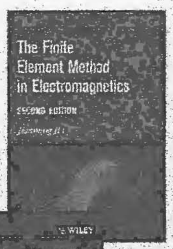

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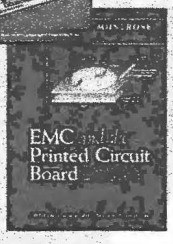

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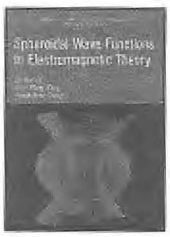
Spheroidal Wave Functions in Electromagnetic Theory

Le-Wei Li, Xiao-Kang Kang, Mook-Seng Leong



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4) **Discuss post-survey data processing, keeping in mind the various applications of the Standard**, each requiring different processing approaches and analysis. Since no project is complete until the paperwork is done, survey documentation outlines and structure are also developed.
5) **Update the database**; this, of course, is performed to incorporate updated bibliography and references to be applied especially in the informative appendices added to the Standard.

IV. New Outline, New Topics

Following almost six months of hard work, the Working Group has developed a new, revised outline of the Standard, reflecting the major update of the document, both in concept, in techniques and in technology.

Beginning from a revised and well-structured approach to the very planning of the site survey, the document leads the reader through detailed recommended procedures for actually conducting the survey, and reporting its results after due analysis and predictions, according to application.

The following is a high-level outline of the proposed Standard, which forms the basis for work in the months and years to come. It may give some fair idea on the topics and scope of the revised Standard:

1. Introduction
2. Definitions and Acronyms
3. References
4. Electromagnetic Environment
5. Survey Planning
6. Site Survey Procedures
7. Measurement Equipment
8. Detector Functions
9. Measurement Uncertainty and Errors
10. Data Handling, Reporting and Documentation

Appendices

Appendix A: Derivation of External Noise Figure (Fa) for Several Types of Antennae

Appendix B: Summary of Permissible Human Exposure Limits to RF Fields

Appendix C: Bibliography

V. Call for Volunteers

Would you be interested in being involved in this activity? If you are:

- Involved in RF site studies
- Experienced in running "on site" RF measurements
- Familiar with statistical analysis techniques
- Or simply have interest in this field

and would like to contribute to this activity, WE NEED YOU!

The working group is seeking technical expert volunteers to join.

Geographical location is NOT an issue. This Working Groups spans over more than 10 time zones, but thanks to technology, particularly the Internet, communication is easier than ever. Members span from the US and Canada all the way to Israel (home of the undersigned WG Chair).

The Working Group does plan to hold at least two meetings a year, one of them in conjunction with the IEEE EMC International Symposium, where attendance is recommended, but event technical contributions and e-mail communications keep you in touch.

If all of the above has encouraged you to seek new horizons for channeling your experience, your knowledge and your willingness to contribute to the benefit of the EMC Society, please do not hesitate to let us know.

Our goal is to prepare a useful, up-to-date Standard. Would you like to be a part of it?

For further information, please contact Elya B. Joffe, WG 473 Chairman, at: eb.joffe@ieee.org **EMC**

Elya B. Joffe

IEEE

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EMC SOCIETY

Dear Colleagues and Fellow EMC Engineers,

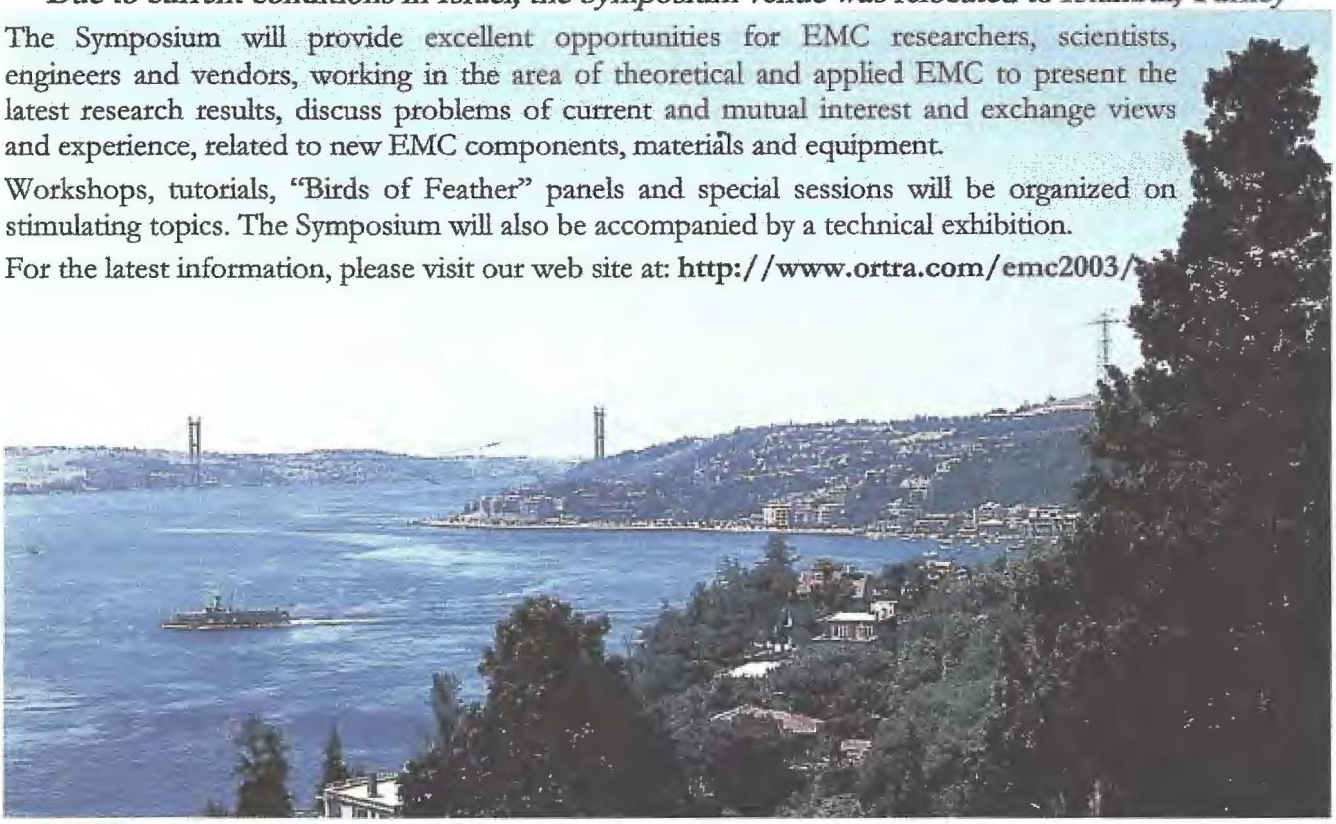
We are delighted to announce that the **2003 IEEE International Symposium on EMC** will be held in **Istanbul, Turkey**, on **May 11–16, 2003.**

Due to current conditions in Israel, the Symposium venue was relocated to Istanbul, Turkey

The Symposium will provide excellent opportunities for EMC researchers, scientists, engineers and vendors, working in the area of theoretical and applied EMC to present the latest research results, discuss problems of current and mutual interest and exchange views and experience, related to new EMC components, materials and equipment.

Workshops, tutorials, "Birds of Feather" panels and special sessions will be organized on stimulating topics. The Symposium will also be accompanied by a technical exhibition.

For the latest information, please visit our web site at: **http://www.ortra.com/emc2003/**



The Symposium will take place in the **Hilton Istanbul Hotel**, a spacious, elegant and comfortable hotel, ideally situated, overlooking the spectacular view of the Bosphorus, magically attractive amid the glittering lights of the City.

Istanbul is a thriving vibrant metropolis! As an exciting and cosmopolitan city, blending east and west, Istanbul offers something for everyone: outdoor cafes, ethnic restaurants and cultural centers will compete for your attention with historic sites and open oriental markets a haven for the dedicated shoppers.

Istanbul - built on two continents, bridging across Europe and Asia, connecting East and West with two suspension bridges over the Bosphorus Straits. Those bridges symbolize the bridge these International Symposia make across the EMC professional world and EMC professionals worldwide, bringing them together, experts and students alike.

FOR FURTHER INFORMATION PLEASE CONTACT THE SYMPOSIUM SECRETARIAT:

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Association of Engineers and Architects in Israel (AEAI)

IEE
Institution of Electrical Engineers (IEE)

URSI
International Union of Radio Science (URSI) Commission E

IEEE Fiscal State of Affairs: V

Peter Staecker, Divison IV Director (p.staecker@ieee.org)

June 2002

As we left 2001, IEEE finances suffered from the double whammy of an optimistic view of investments vs. the actual market slump. Even a heroic performance in operations could not offset the red ink from investment losses. Halfway through 2002, the operating lessons have been remembered and augmented, the investment lesions have not worsened, and the 02 forecast is tracking the budget expectations. As we review financial events since our last report, four headings of our previous discussions are still appropriate:

1. Selection and management of initiative programs within the Institute,
2. Periodic review of the Corporate Infrastructure activities,
3. A closer look at (read "simplification of") the complicated set of business rules that are required to support the many offerings of the Societies and Councils,
4. A financial model that more properly allocates expenses among users.

1. Initiative Programs

As one of the principles of the IEEE financial model (see 4. below), new and continuing initiatives will be capped by dividend and interest income. A process for initiative approval has been established. The New Initiative Committee of the Board of Directors has met to review initial submissions of ideas for possible funding in 2003. Of the 17 ideas submitted, the Committee has asked that 9 be developed into formal business plans for further consideration. These refined proposals are due to the Committee by 8 July. Following those submissions, the Committee will review the proposals and make a recommendation to the IEEE Executive Committee (ExCom) at its August meeting as to which initiatives should be funded. In turn, the ExCom will then send forth a recommendation to the IEEE Board of Directors for incorporation into the 2003 IEEE Operating Budget on which the Board will vote at its November meeting. If you have any questions about the process or status of any initiatives, please feel free to contact Matt Loeb in Piscataway at +1 732 562 5320 or via email at m.loeb@ieee.org

2. Infrastructure Charge Distribution within TAB

Recall that past discussion in this column dealt with the distribution among TAB Societies and Councils of the *direct* infrastructure costs, so-called because of the relatively "direct" relationship of these costs to activities such as headcount, membership, and expenses. We developed *pay-by-the-drink* philosophy to deal with these within TAB, and called it the *Principles Method*. And finally, this method of distributing these direct infrastructure expenses will be phased in over a 3-year period. Some follow-up activities to this process have been identified, since our last discussion, including:

a. Collecting accurate cost data for these expenses and benchmarking them to "competitive" costs for similar services.
b. Preparing a collection of "best practices" that S/Cs can use when considering changes in their operations that may reduce their share of Infrastructure allocations.

In short, the process of identifying these costs, distributing them equitably among the operating units of the Institute, and within each operating unit (of which TAB is one) is complete. The next part of the process, benchmarking and lowering these costs, has now been defined and both of these activities encourage proper financial behavior and will work toward lowering these direct infrastructure costs.

Well what of the *indirect* infrastructure costs? For the 2002 budget, indirect costs are allocated based on three methodologies: ASPP revenue tax, Book Broker revenue tax, and Reserves. The first pass 2003 budget has those costs allocated based on expenses (less conference expenses). A TAB committee reported on its recommendations for assigning these costs at the June TAB meeting, but lack of consensus around the suggestions will require additional refinements and another try at the November meeting.

3. Membership Services-Related Business Rule Simplification

In November 2001, the BoD charged RAB and TAB with identifying business rule changes to realize a possible $3M annual savings in infrastructure charges associated with membership services. RAB and TAB Business Rule Simplification teams have been working the details since February. TAB committee discussion has focussed on simplifying the options available for Society membership, and the subscription process for members regarding optional Society publications. The TAB Strategic Planning and Review Committee led a wider discussion on the value proposition of Society Membership and optional publications. TAB FinCom became involved on issues of pricing strategy. Two principles of membership and publication pricing were socialized at TAB:

1. Membership dues should recover the variable costs of servicing Members (Here and in the following, *variable* cost is the cost of servicing the *next* Member).
2. Prices for Society optional publications to Members should recover their variable costs.

The reception of these principles within the June TAB meeting was mixed, and broader consensus needs to be reached. The simplification exercise is to reduce the number of options to select Society membership and optional publications available from Societies. Reducing the distinction among members eligible for reduced rates will help. This category

presently includes student, unemployed, low income, retired, permanent member, and life member grades. Can business rule simplification take place while maintaining member benefits? Stay tuned; better yet, participate.

RAB is addressing other details of Membership Business Rules simplification. Already, rule simplifications have been put into place that will realize annual savings of about $300K, starting in 2003.

4. Financial Model and the Budget Update

IEEE Budget principles adopted at the November Board of Directors Meeting for the 2002 Budget are serving as a template for the 2003 Budget development. The first order principles, approved at the June BoD meeting, include:

- The operating budget will be balanced (bottom line equal to or greater than zero). Individual Operating Units (OUs), which includes TAB, will also have balanced operating budgets, including any applied infrastructure charges.
- Investment income is NOT part of the operating budget. Dividends & Interest (D&I) will be budgeted, but used specifically to fund new and continuing initiatives. Any excess D&I income will be used to reduce infrastructure charges.
- Other investment income surplus/loss will be distributed proportionally to those OUs with reserves.

In addition, a process and timeline have been identified for developing the budget. With principles and process now well defined, 2003 budget development has begun, but is a bit behind schedule because of the lingering approval period for the 2002 budget.

The April 2002 Institute forecast is on target to break-even. TAB and Standards are feeling the strain of their challenge budgets, but increases in revenue and savings in infrastructure make up their shortfalls.

Discussion

Direct infrastructure costs have been identified, and a method for distribution has been approved. The stage is now set for comparing these costs to others, determining best practices, and driving costs down in this area. Distribution methods for *indirect* infrastructure expenses are being addressed. Business Rules Simplification efforts have begun within the area of Membership Services. The financial model is defined, understood, and is being applied to the 2003 budget process. Additional substantial cuts to infrastructure are planned for 2003 to further streamline operations. Finally, at its June meeting, the BOD has approved an external review of the IEEE Corporate infrastructure expenses with the goal of determining their value and their costs. The RFP for this has been completed and the expectations are to have the engagement completed by November. In summary, methods for improving the financial health of the Institute are proceeding along both tactical and strategic fronts. If this keeps up, I will have to talk about one of my other interests, Publications activities, next time! As always, your comments and suggestions are welcome. **EMC**

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Board of Directors Activities

Friday, May 31, 2002
Boston, Massachusetts

THE PRESIDENT'S OPENING REMARKS

President-elect Todd Hubing called the meeting to order at 8:30 am. A round of introductions was made. Board members present included H. Benitez, R. Brewer, J. Butler, L. Cohen, B. Crain, A. Drozd, R. Ford, F. Heather, D. Heirman, T. Hubing, E. Joffe, W. Kesselman, M. Montrose, J. Muccioli, J. Norgard, J. O'Neil, H. Ott, Z. Pantic-Tanner, J. Perini, G. Pettit, A. Podgorski, C. Sartori, K. Williams, and T. Yoshino. Members absent included, L. Carlson and T. Chesworth. Guests present included G. Brox, J. Curtis, R. Goldblum, D. Hoolihan and D. Picard. The agenda was approved as presented. President Hubing discussed EMCS representation at upcoming international EMC symposia. Regarding the Wroclaw symposium in June, Andy Drozd will be heading a delegation to represent the EMCS. Elya Joffe and Andrew Podgorski also plan to attend. For the Sorrento EMC symposium in September, there will be a meeting with the European EMC conference organizers during the conference. President Hubing will lead this EMCS delegation. Janet O'Neil will also attend. For the Istanbul EMC conference next May, President Hubing would like to hold a Board meeting there, but with the current economic climate it will not be possible to financially support all Board members to attend. A partial travel subsidy may be available.

TREASURER'S REPORT

Treasurer Warren Kesselman presented his report. IEEE's 2001 pre-audit financials indicate the EMCS's year-end operational net will be a deficit of $345K. The poor performance of the IEEE corporate investment fund resulted in increased infrastructure expenses to be shared by Organizational Units (OUs) with reserves. EMCS reserves on 31 December 2001 are $876K. Regarding the budget for 2002, the EMCS's IEEE approved operating budget projects a deficit of $65.5K. This projection includes estimates for corporate recovery and infrastructure expenses. Regarding the budget for 2003, TAB's first pass budget was received on April 3. This budget contained a $51.4K deficit. All Societies with deficit budgets were requested to increase revenues and reduce expenses to achieve a balanced budget and return the revision by April 24. Following TAB's suggestions, an "improved" budget with a deficit of $15.5K was submitted. Mr. Kesselman noted that the cost of services provided to each EMCS member is approximately $44; EMCS dues per member are currently $20. IEEE would like to see each Society's membership dues fully cover the cost of the services it provides. The Board approved a 2003 non-member subscription rate of $275. The Board approved a 2003 Transactions on EMC budget of 4 issues/670 pages. The Board approved a 2003 EMCS member fee of $25. Lastly, the Board approved a 2003 EMCS committee expense budget of $233,600.

Photo by Dick Ford

EMCS Board Members took a lunch break during their meeting held in Boston, Massachusetts on May 31. The meeting was held at the Sheraton, host hotel for the 2003 IEEE National Symposium on EMC. Shown left to right are Greg Brox of Enterasys Networks, Zorica Pantic-Tanner with the University of Texas at San Antonio, Todd Hubing with the University of Missouri at Rolla and Henry Benitez of Hewlett Packard. Mr. Brox is a member of the 2003 Boston Symposium steering committee. He accompanied the Board on their tour of the Symposium host hotel and nearby convention center.

SECRETARY'S REPORT

Secretary O'Neil presented the minutes from the Board meeting on February 13, 2002 for review. The minutes were approved as presented.

COMMUNICATION SERVICES

In the absence of Len Carlson, Vice-President for Communication Services, Assistant VP Ghery Pettit presented his report. Regarding the *Transactions on EMC*, Professor Marcello D'Amore, Transactions on EMC Editor-in-Chief, advised that the electronic review of papers has been working very well with the IEEE. This has greatly speeded up production of each issue. The issue of term limits for the Transactions editor will be discussed at the next Board meeting. Professor D'Amore will attend the Wroclaw Symposium in June and will present his "Overview of EMC Transactions" during the plenary session. Next, Janet O'Neil, Newsletter Editor, presented her report. A lighter weight paper stock was used for the last issue to cut back on production and postage expenses. Chapter Chatter continues to be a long running article and Todd Robinson has done a good job of encouraging more chapters to contribute with articles and photos. The Newsletter put attention on the relocation of the Tel Aviv symposium to Istanbul, Turkey with a full-page ad and arricle by Elya Joffe. EMCS Awards

Photo by Dick Ford

A tour of the Hynes Conventer Center was scheduled during the Board of Directors meeting in Boston. Rafael Gutierrez, Convention Services Coordinator, (far left) led the tour group including Dave Picard of Maxtor Corporation, Jon Curtis of Curtis-Straus, Greg Brox, and Todd Hubing (from left).

Nominations were solicited through a small ad. The activities of the Product Safety Technical Committee were promoted. The practical paper included was about the history of NIST who celebrated their 100-year anniversary in 2001. There was a new guest book review associate editor for the last issue. Ray Perez had asked for additional assistance and Ray Adams volunteered. This was his first contribution. For the Personality Profile section, we covered two newly elected Fellows. The next issue will feature the other two newly elected Fellows. All four gentlemen had their Fellow applications evaluated by the EMCS. There were some IEEE ads as well as paid advertising in the Spring 2002 issue. Susan Schneiderman of IEEE Media has secured the advertising for the Newsletter. There were 8.92 pages of advertising in this issue (up from 7.58 pages in the Winter 2002 issue). 500 copies of this issue will be shipped to Minneapolis for distribution at the EMCS membership booth. Several copies are also being handed out to exhibitors (potential advertisers) at the MTT annual symposium in Seattle, June 3-7, 2002. Susan Schneiderman will be at this symposium to solicit advertisers. Mark Montrose then verbally presented his report as IEEE press liaison. Activity remains quiet since the merger of IEEE Press with Wiley & Sons. There is one new EMCS sponsored book recently published on anechoic chambers by Leland Hemming. Next, Andy Drozd presented his report as EMCS Webmaster. He advised that he is continuing to work with the technical committees to update their websites and update the IEEE logo to reflect current IEEE policy. He would like to work with Henry Ott to formalize the look of the EMC Society logo. Current EMCS publications are showing different variations of the EMCS logo. Dick Ford volunteered to obtain the correct EMCS logo and distribute this to all Board members. A web guideline is being prepared for the technical committees which is tailored to their specific needs. Regarding web advertising, Mr. Drozd would like to work closer with Susan Schneiderman of IEEE Media to promote advertising on the EMCS website. It is hoped that this website advertising promotion can be combined with the Newsletter advertising sales efforts. Regarding the History Committee, Mr. Pettit advised that Chet Smith would like to be replaced as the EMCS Historian. This will be a critical position for the upcoming 50th anniversary of the EMCS in 2007. Mr. Carlson has heard from a few members who have volunteered for this position. Mr. Ott suggested that the new historian look at creating a pamphlet that summarizes the history of the EMCS. A historical video was also discussed. Ron Brewer lastly reported for Tom Chesworth, chair of the Publicity Committee. The committee would like to create promotional materials designed to encourage high school and college level students to become EMC engineers. It was suggested that a banner be created for the EMCS membership booth that specifically lists the benefits EMCS members receive for their dues (i.e. annual symposium record, Transactions on EMC, Newsletter).

STANDARDS SERVICES

Don Heirman, Vice-President of Standards, presented his report. It was noted that the webpage (http://www.ewh.ieee.org/soc/emcs/) for EMC Standards is now operational. Standards activity is currently at an all time high and covers three major areas: The Standards Education and Training Committee (SETCom) chaired by Hugh Denny, the Standards Advisory and Coordination Committee (SACCom) chaired by Elya Joffe and the Standards Development Committee (SDCom) chaired by Stephen Berger. Mr. Heirman reported that the SDCom meeting was held on 30 May 2002. Attending the meeting were eight committee members and four visitors. A matrix of currently active standards and PARs was presented. A high level of activity is underway to ensure that the standards remain active and continue to reflect current state-of-the-art and meet the needs of the EMC community. Those no longer needed are being retired. For example, Std-140 has been retired; however, anyone needing to consult the standard can obtain copies from the IEEE Standards Association. Std-213 will be retired when it expires on December 31, 2003. Its requirements are being incorporated into the revision of Std-187 which is proceeding on schedule. Standards 299, 473, 1302 and 1309 are being revised under currently approved PAR's. Standards 139, 376, 1128, and 1140 are currently being evaluated for revision and/or reaffirmation. Working Group chairs have been identified for Standards 1128 (absorber effectiveness measurements) and 1140 (near field electric field measurements next to VDTs) and the committee is attempting to identify and recruit chairs for Standards 139 (in situ ISM emission measurements) and 376 (impulse bandwidth measurement). Developmental efforts for P1560 (RF filter capability) and P1597 (validation of computational EM modeling) are well underway. P1530 (cable/connector shielding test fixtures) has been withdrawn; the activity is continuing as a study effort under the sponsorship of TC-4. The SDCom is also supporting the revision of ANSI C63.4 (emission measurements) and C63.16 (ESD testing) and the development of Standard P1583 on Voting Equipment requirements. The format for the meet-

ings at the Annual Symposium in Minneapolis will follow that of Montreal in that each Working Group will present a summary of accomplishments on their respective PAR's with an assessment of their current schedule. This format serves to both provide an update on their efforts as well as inform the greater community of the standards development activities of the EMC Society. The Committee voted to hold the November meeting in conjunction with the Board of Directors meeting in Sao Paolo, Brazil. Regarding the Standards Education and Training Committee (SETCom), Mr. Heirman reported for Chair Hugh Denny. Several articles have been prepared for publication in the EMCS Newsletter. The purpose of these articles is to inform the greater EMCS membership of the existence and activities of the Standards Committees. There will be a special session organized by the SETCom for the Monday of the Symposium week in Minneapolis to inform the greater community of EMC standards and of the activities to prepare new standards and/or update/revise existing standards. Elya Joffe lastly reported as chair of the Standards Advisory and Coordination Committee (SACCom). They also held a meeting on May 30 prior to the Board meeting. 13 people attended the meeting. Topics covered at the meeting included CISPR B, H, and I, IEC TC77, RTCA Special Committee 135, and ITIC TC 5. A roster was distributed which shows the EMCS liaisons to the various SACCom organizations.

MEMBER SERVICES REPORT

Andy Drozd presented his report as Vice-President for Membership Services. Total active EMCS members as of March 2002 are 4,759. This is down approximately 4.6% compared to the same time in 2001. Regarding the dissemination of excess EMCS material, the Board approved Mr. Drozd's proposal regarding the distribution and handling of (excess inventory) EMCS technical products and materials. Membership Chair Bruce Crain advised that there was little response to his Newsletter article on the Senior Member program. Nevertheless, he will continue to promote this. He is taking care of arrangements for the two EMCS membership booths at the Minneapolis symposium. Mr. Drozd reported for Lee Hill, chair of the Distinguished Lecturer program. The program is proceeding successfully and all positions for DLs are filled. Mr. Hill's report provided a detailed summary of DL activity for 2001 and 2002. Mr. Hill is currently working on securing additional DL candidates to fill slots that will become available during 2003-2004. Henry Benitez next reported briefly on Awards. The awards will be presented in Minneapolis again as a two-part ceremony (i.e. during the Tuesday evening reception and during the awards luncheon). Ghery Pettit then presented his report as Chapter Activities Chair. He received a request for Angel funding from the newly formed SP/AP/Computer/EMC Joint Chapter of the Ukraine Section (Kharkov) in order to initiate chapter and local conference activities. This request is being evaluated. He has sent out the applications to the chapter chairmen for the "Chapter of the Year" and "Most Improved Chapter" awards. Elya Joffe next presented his report on IEEE Region 8 EMC activity. The next international Region 8 EMC symposia will be the 16th International Wroclaw Symposium and Exhibition from June 25-28, 2002 in Poland. He will attend this symposium as well as the upcoming EMC Europe 2002 Symposium in Sorrento this September 9-13. The EMCS membership material and booth have been ordered and will be shipped to these shows. The 2003 IEEE International Symposium on EMC has been moved to Istanbul, Turkey from Tel-Aviv. He discussed various new member initiatives that he would like the Board to consider. He emphasized that face to face contact is essential in recruiting new members; such as when Board members attend chapter meetings outside of their respective base cities and/or holding a regional international EMC chapter chairmen retreat. The number of EMC chapters in Region 8 has expanded to 11, including: Austria, Benelux, France, Germany, Israel, Italy, Russia, Switzerland, Turkey, UK and Ireland, and Ukraine. Jose Perini then reported on IEEE Region 9 EMC activity. He advised that there is not much EMC activity in South America, with the exception of Sao Paulo, Brazil that has a very active chapter. Carlos Sartori advised that there would be a one-day EMC colloquium and tabletop exhibition in Sao Paulo on Friday, November 22, 2002. This will be held at the Renaissance Hotel. He is planning this event with Janet O'Neil, EMCS Regional Conference Coordinator, and Sherry Russ of IEEE Meeting Planning Services. An advance program will be issued soon. Takeo Yoshino reported on EMC activity in IEEE Region 10. He distributed a copy of the "Final Call for Papers" for the ICEMC 2002 conference in Bangkok on July 24-27 at the last Board meeting. Professor Yoshino will staff an EMCS membership tabletop display or booth at this event. Details are being worked out with the secretary of the conference committee. The Sendai, Japan chapter was established on December 21, 2001. They are now operating as a full-fledged chapter under the auspices of the IEEE Japan Section. Dr. Risaburo Sato is the new Chapter Chair. There will be a Japanese International EMC Symposium on May 17-20, 2004 in the Sendai-city of Miyagi prefecture. Mr. Drozd reported for Bill Duff and Tom Chesworth that two Fellow nominations were received and evaluated by the EMCS this year. Last year there were six candidates and four were elected. Mr. Drozd is evaluating the role of PACE in relation to the EMCS. There has not been any activity in this area under the chairmanship of Bill McGinnis. Dick Ford then distributed a copy of the annual symposium survey. He is planning a major change to the survey this year. People will be asked first if they are a member and if not, they are asked to skip to question 10. As Society photographer, he submitted several photos from the Montreal symposium to be published in the Newsletter. EMCS immediate past president Joe Butler presented his report on nominations and by-laws. He noted that the last Newsletter contained the "Call for Nominations" for the Board of Directors. The Nominations Committee consists of Terry Donohoe, Elya Joffe, Takeo Yoshino, and Tom Fagan. Ghery Pettit noted that he formally notified the chapters of the need for nominations for Directors-at-Large to the Board of Directors. Mr. Butler has worked with Dan Hoolihan, past Nominations Chair, to amend the by-laws to address returned ballots that result in a tie. It was suggested that the EMCS by-laws be added to the EMCS website. At the next Board meeting, he will propose a by-laws change to deal with tie votes for the sixth, and last, open slot in the BoD elections. He will also propose a by-laws change to address

term limits for elected officers, editors and committee officers. The proposed motions were included in his report for the Board to review and comment upon prior to the next Board meeting.

TECHNICAL SERVICES

Kimball Williams, Vice President for Technical Services, presented his report. The NARTE questions are being pooled and reviewed now. The resulting questions will be used for the NARTE exam to be held on the Friday of the symposium week. The TCs have reviewed 236 papers for the Minneapolis symposium. Multiple papers were sent to the various technical committees. They are working with IEEE to make the symposium paper review an electronic process. They are pursuing holding committee meetings on-line. The TAC status matrix was distributed. Mr. Williams noted that Representative Advisory Committee (RAC) Chair David Case has asked to be replaced. He has new work commitments such that he can no longer adequately address this committee work. The annual RAC/SAC lunch will take place as planned. Mr. Case will attend the Minneapolis Symposium and chair this luncheon, however, after this he will need to step down as the RAC chair. Mark Montrose reported that he attended the Nano Technology Conference and that this Council is very active. Their website is very good (visit http://ewh.ieee.org/tc/nanotech/). IEEE has approved their bylaws and constitution. Their next conference will be in Washington, DC following the Minneapolis symposium. Education Committee Chair Maqsood Mohd reported to Mr. Williams that the fundamentals tutorial and demonstrations are being planned for the Minneapolis symposium. Everything is on track. The student design contest and student paper contest each attracted several candidates. There are 14 applicants for the University Grant award from worthy institutions around the world.

CONFERENCE SERVICES

Henry Ott, Vice President for Conference Services, presented his report. He introduced Jon Curtis, the Chair of 2003 IEEE Symposium on EMC in Boston. Mr. Curtis introduced some of his symposium steering committee members, including Vice-Chairman Joe Butler, Arrangements Chair Dave Picard, and Secretary Greg Brox. He provided some of the highlights to date of committee activity. All of the hotel and exhibit space has been contracted. The Boston Science Museum will be the site of the Wednesday evening gala. A tour of the Hynes Convention Center, site of the exhibits and technical meetings, followed his presentation. Mr. Ott then introduced Barry Wallen to report on the various EMCS symposia as follows: 2001: Montreal: $200,000 USD was the surplus from the Montreal symposium in 2001. IEEE has received this payment. The audit has not been completed. There is still a question on the Canadian tax rebate; 2002 Minneapolis: Dan Hoolihan, chair of this symposium reported that all is going well and activity is on track. 235 booths have been sold to date. The advance program was mailed in mid April concurrently to posting the on-line registration. The budget for this symposium was revised to be consistent with past symposia. The surplus was revised to $217,333 (19% of income). The Board approved the revised 2002 Minneapolis Symposium budget that shows a surplus of $217,333; 2003 Boston: Jon Curtis provided a review of the advance expenses the committee expects prior to receiving income from the exhibitor fees. Committee expenses include advertising and promotion fees for advance marketing, costs to hold meetings, the cost to send one committee member to the 2002 IEEE EMC symposium, etc. The Board approved providing an additional loan of $35,000 to the 2003 IEEE Symposium on EMC; 2003 Istanbul: Elya Joffe presented a detailed written report on this symposium. The symposium venue was changed from Tel-Aviv to Istanbul due to the current political climate. Turkey was selected since there is existing established IEEE activity there. Henry Ott confirmed the relocation prior to the decision being made. The Board approved the change in venue for the 2003 IEEE International Symposium on EMC from Tel Aviv to Istanbul. The committee has toured the new hotel, the Hilton Istanbul, and is very pleased with the facility. The local chair of the Turkey chapter has been asked to be an honorary co-chair of this symposium. Mr. Ott noted that the EMCS has a 10% financial interest in this symposium. The Board approved a loan not to exceed $10,000 to the 2003 IEEE International Symposium on EMC. The loan must be repaid by April 1, 2003. Mr. Joffe's report included the First Announcement and Call for Papers at the new venue; 2004 Santa Clara: Mr. Wallen advised that Franz Gisin has stepped down as Chair of this symposium. A new chair is under consideration; 2005 Chicago: Tom Braxton, Chair of the 2005 Symposium steering committee, reports that all is going well with this symposium. All hotel and exhibit space contracts have been signed; 2006 Portland: Henry Benitez is the chair of this symposium. He has a core committee formed. The convention center has been reserved. Various conference management services firms, including IEEE, are being evaluated. Regarding the 2007 Symposium, at the last meeting Fred Heather volunteered to research different cities as potential locations for the 50th Anniversary symposium. Mr. Ott previously had suggested that San Diego be considered as a location for this symposium. Mr. Heather gave a presentation on four potential cities for the symposium, including Fort Lauderdale, Las Vegas, Orlando, and St. Louis. Janet O'Neil then presented her report as Exhibitor Liaison. She has been working with Vita Feuerstein of IEEE on various exhibitor issues as they come up these past few months. Most have been resolved with Barry Wallen's assistance or polling the informal exhibitor committee for comment/critique. No major problems have arisen with the exhibitors to date regarding the Minneapolis symposium. She viewed and proofed the copy of the exhibitor's diagram before it was printed in the advance program. The updated point policy and points status has been posted to the EMCS website. Ms. O'Neil also presented her report Regional Conference Chair. Several tabletop shows were

Photo by Dick Ford

Jon Curtis is the energetic Chairman of the 2003 IEEE National Symposium on EMC.

held in early 2002, including: February 25, 2002, Seattle EMC Chapter, Wireless 2002; March 11, 2002 Phoenix EMC Chapter, Fundamentals of EMC with Clayton Paul; March 13, 2002 Milwaukee EMC Chapter, Fundamentals of EMC with Clayton Paul; April 22, 2002 Southeastern Michigan Chapter, Automotive EMC; and May 21, 2002 Chicago Chapter, 4th Annual Chicago EMC Mini-Symposium. Each tabletop show realized a financial surplus. This surplus will be used by the chapters to sponsor dinners before chapter meetings, pay for travel expenses to obtain out of area speakers for chapter meetings, etc. Ms. O'Neil distributed some information received from the Milwaukee EMC Chaprer. It showed a typical revenue/expense budget for holding this type of one-day colloquium and exhibition. There was also a copy of a survey created for the attendees. Also included in the report was a memo from the Milwaukee Chapter that showed how they worked with IEEE to set up credit card payments for registration fees and exhibitor tabletop fees. Ms. O'Neil advised that she is working with the IEEE's Meeting Planning Services Department to schedule a venue for a November 22, 2002 colloquium and tabletop show with the Sao Paulo, Brazil EMC Chapter. Carlos Sartori is spearheading this effort. IEEE MPS is undergoing final contract negotiations with the Renaissance Hotel in Sao Paulo. In closing the report for the VP of Conferences, Mr. Ott advised that Todd Hubing received a request from Prof. Gao Yougang regarding CEEM-2003. The Board approved technical co-sponsorship of the Third Asia-Pacific Conference on Environmental Electromagnetics (CEEM-2003) to be held on November 4-6, 2003 in Hang Zhou, China.

OLD BUSINESS

Treasurer Warren Kesselman led a discussion concerning a draft on EMCS financial policy. The discussion was tabled until the next meeting.

NEW BUSINESS

Henry Benitez presented several EMCS key awards for voting upon. He also discussed problems with the wording on the Technical Achievement Award. The Board approved changing the wording on the award to read "To recognize significant technical accomplishments in the field of Electromagnetic Compatibility" and to making this award a plaque. Next, Andrew Podgorski reported on the latest activities of the Sensors Council. The IEEE SENSORS 2002 to be held in Orlando, Florida from June 12-14 is expected to be a great success. 624 abstract submissions were received from 38 countries; 429 were accepted. All 26 participating Societies (with some 260,000 members combined) have appointed AdCom members for 2003 and 2004. The Sensors Journal was published four times in 2001. Six issues are planned for 2002 with a page count budget based upon 720 total pages. At this point there is not much activity in electrical type sensors; much of the activity to date involves chemical sensors. President Hubing then confirmed that the first EMCS representative to the IEEE Intelligent Transportation Systems (ITS) Council is Andy Drozd and the second representative is John Norgard. Lastly, President Hubing then discussed the 2003 Board Meeting Schedule. These dates will be posted in the Calendar Section of each issue of the *EMCS Newsletter*.

ACTION ITEM REVIEW

President Todd Hubing reviewed the action items discussed during the meeting.

NEXT MEETING

The next meeting of the EMCS Board of Directors will be held on Sunday, August 18, 2002 at the Hyatt Regency Hotel in Minneapolis in conjunction with the EMC Symposium. The Fall meeting of the EMCS Board of Directors will be held on Sunday, November 24, 2002 at the Renaissance Hotel in Sao Paulo, Brazil. There being no further business, the meeting then adjourned at 5:30 pm.

Submitted by:

Janet O'Neil
Secretary, EMC Society
Board of Directors

EMC

Book Review

continued from page 34

EMC problem is to be resolved. Chapter 10 covers premise wiring systems. Proper connectivity that allows for manageability, flexibility, versatility, and future expansion are needed in the design of the cable system. The cabling must support all logical configurations, such as point-to-point, bus, star, tree, and hybrid. Topics covered in this chapter include: fiber optics networks, commercial building telecommunication cabling standards, campus backbone, equipment rooms and network cabling, cabling architecture, centralized/distributed network architectures, and small business architectures.

Testing and troubleshooting and all the equipment needed for such endeavors are discussed in chapter 11. Testing, troubleshooting, and maintaining a communication system is an involved procedure that encompasses both hardware and software specialists. Some of the testing and troubleshooting can be accomplished by the use of a diagnostic software program. These functions of testing, troubleshooting, and maintaining fall in the lower level of system protocol. All the most common tests are described in the chapter. Documenting the wiring system is explained in chapter 12. Documentation of the cabling system is paramount for effective service to the user community and maintenance of the telecommunication system. Documentation should consist of all the information and data that would be necessary to understand and troubleshoot the system. EMC engineers are advised to look at the documentation in detail before attempting any fixing job. The goal of chapter 13 is to outline the requirements of a telecommunications database and give an example of one such system. A brief discussion on how to manage wiring problems is shown in chapter 14. The final chapter in the book, chapter 15, provides specifications on how to write a bid proposal for the installation of a wiring system for telecommunication equipment.

I found this book useful for those EMC engineers who want to be involved in the telecommunications industry. **EMC**

EMCABS

EMC Abstracts

Osamu Fujiwara, Associate Editor

Following are abstracts of papers from previous EMC symposia, related conferences, meetings and publications.

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Engineering college/university libraries, public libraries, company or corporate libraries, National Technical Information Services (NTIS), or the Defense Technical Information Center (DTIC) are all possible sources for copies of abstracted articles of papers. If the library you visit does not own the source document, the librarian can probably request the material or a copy from another library through interlibrary loan, or for a small fee, you can order it from NTIS or DTIC. Recently it became clear that EMCABs were more timely than publications which were being listed in data files. Therefore, additional information will be included, when available, to assist in obtaining desired articles or papers. Examples are: IEEE, SAE, ISBN, and Library of Congress identification numbers.

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 members in getting the information or contacting the author(s). We are particularly interested in symposium proceedings which have not been available for review in the past. Thank you for any assistance you can give to expand the EMCS knowledge base. **EMC**

EMCABS: 01-8-2002

CROSSTALK EFFECTS FROM A CASCADED LINE WITH DIFFERENT HEIGHTS TO A TRANSMISSION LINE

Weikun Liu and Yoshio Kami
University of Electro-Communications, Tokyo 185-8282, Japan
liu@ice.uec.ac.jp

Proceedings of 3rd International Symposium on EMC, Beijing, China, May 21-24, 2002, pp. 91-94.

Abstract: Crosstalk or coupling characteristics between a cascaded line with an abrupt step on the way and a straight transmission line of finite length are discussed comparing measured and calculated results. To analyze the coupling phenomenon, a modified telegrapher's equation including the effects of external fields to the lines system is derived. The fields can be obtained by estimating vector potentials of currents in the line and the terminal sections, where the terminals are fabricated like a configuration as "via". A four-port network expression on voltages and currents at each terminal is obtained from solutions of the equation. Some experiments have been done to appraise the utility of the theory used here by comparing transmission characteristics.
Index terms: Transmission line, cascaded line with different heights, crosstalk effects, modified telegrapher's equation, experiment.

EMCABS: 02-8-2002

ANALYSIS DESIGN AND APPLICATION OF SPHERE LOADED MONOPOLE ANTENNA

Qin Chunlan, Jin Xianglan and Gao Yougang
Department of Telegraphic Engineering, Beijing University of Post and Telecommunication, Beijing 100876, China

Proceedings of 3rd International Symposium on EMC, Beijing, China, May 21-24, 2002, pp. 131-134.

Abstract: This paper analyzed and studied the king of configurations of a rotationally symmetric monopole antenna by applying the extended moment method. Its terminal uses a sphere-loaded technique. The optimum angle of a cone is obtained and the curve of the low-cut frequency versus height has been discussed. A sphere load antenna is designed and fabricated for impulse radar. All are analyzed by the extended moment method. Theoretical calculation and partial experimental results are compared and reasonable agreement is obtained. The research provides the theoretical basis for practical design.
Index terms: Broadband antenna, sphere loaded monopole, moment method, cone angle.

EMCABS: 03-8-2002

MEASUREMENT OF THE ELECTROMAGNETIC CONSTANTS OF CONCRETE MATERIALS BY TIME-DOMAIN REFLECTOMETRY

Xu Qiwei Shi Lihua and Gao Cheng
EMP Lab, Nanjing Engineering Institute, Nanjing, 210007, China
emp.njei@public.ptt.js.cn

Proceedings of 3rd International Symposium on EMC, Beijing, China, May 21-24, 2002, pp. 230-233.

Abstract: A dielectric constant and electrical conductivity measurement system based on time-domain reflectometry (TDR) probes that can be embedded into concrete structures have been designed. The calibration data in distilled water has shown that the measuring system can measure the dielectric constant and conductivity accurately. By using the embedded probes in concrete structures, changes of the electromagnetic properties through the curing stage of Portland concrete specimens are measured and presented in this paper.
Index terms: Concrete materials, electrical parameters, time-domain reflectometry, three-rod transmission lines, measurement.

EMCABS: 04-8-2002

INNOVATIVE ABSORBING-BOUNDARY CONDITIONS FOR THE EFFICIENT FDTD ANALYSIS OF TRANSIENT EMP INTERACTION PROBLEMS
Zheng Hongxing
Dept. of Telecommunication Engineering, Civil Aviation University of China, Tianjin 300300, CHINA
Dept. of Electronic Engineering, City University of Hong Kong, Hong Kong
zhenghongxing@ieee.org
Proceedings of 3rd International Symposium on EMC, Beijing, China, May 21-24, 2002, pp. 238-241.

Abstract: The paper deals with a modified version of Fang-Mei's super-absorption algorithm for the truncation of three-dimensional finite-difference time-domain (FDTD) meshes combined with an innovative low pass filtered algorithm to assure numerical stability of the FDTD procedure for late time. The proposed method is usually applied to analysis of slow-decaying transient problems, such as the lightning or nuclear electromagnetic pulse interaction with a cable or complex structures. Numerical results have demonstrated the efficiency of the proposed method.
Index terms: Transient analysis, FDTD method, low pass filtered algorithm, numerical stability.

EMCABS: 05-8-2002

FDTD MODELING OF SKIN EFFECT
Chen Wang+, James L. Drewniak+, Min Li+++, Jun Fan++, James L. Knighten++, Norman W. Smith+, Ray Alexander++, Jingyu Huang++++
+Department of Electrical and Computer Engineering, University of Missouri – Rolla
drewniak@ece.umr.edu
++ NCR Corporation, San Diego, CA, USA
+++ Celiant Corp. Warren, NJ, USA
++++ Tsinghua University, P.R. China
Proceedings of 3rd International Symposium on EMC, Beijing, China, May 21-24, 2002, pp. 246-249.

Abstract: The data rates and clock speeds of current high-speed signals are increasing rapidly; consequently, not only the lossy nature of FR-4 but also the lossy nature of good conductors, such as copper, need to be taken into account in high-speed signal designs. In order to well predict the loss caused by both dielectric loss and skin effect loss, a suitable simulation tool is needed. A surface impedance boundary condition (SIBC) algorithm was implemented in FDTD modeling herein to accommodate the skin effect loss due to finite conductivity of good conductors. Good agreement between the FDTD result and the measurements as well as the SPICE result was obtained for a 14 mils wide strip line.
Index terms: Simulation tool, FDTD modeling, skin effect loss, surface impedance boundary condition.

EMCABS: 06-8-2002

FDTD SIMULATION OF THE ELECTRICAL ENVIRONMENT FOR VEHICLES BY USING CAD DATA
Peter Ankarson and Jan Carlsson
SP Swedish National Testing and Research Institute, Box 857, S-501 15 Boras, Sweden
Proceedings of 3rd International Symposium on EMC, Beijing, China, May 21-24, 2002, pp. 272-275.

Abstract: A method to make a CAD model of a vehicle suitable for electromagnetic (EM) simulations is presented. Three different EMC problems have been studied by using the derived CAD models in a Finite Difference Time Domain (FDTD) program: first, the coupling between antennas mounted on the vehicle; second, the locations of "hot spots", i.e. places with high field strength inside the vehicle; and third, the E-field probed in a circle around the vehicle. The agreement between simulations and measurements performed in a semi-anechoic chamber was found to be satisfactory.
Index terms: Vehicle, CAD model, electrical environment, FDTD simulation.

EMCABS: 07-8-2002

A TIME-DOMAIN MICROWAVE OVEN NOISE MODEL FOR EVALUATION OF INTERFERED COMMUNICATION SYSTEM PERFORMANCE
Morio Takeuchi+, Yasushi Matsumoto+, Akira Sugiura+, and Yukio Yamanaka++
+Tohoku University Research Institute of Electrical Communication 2-1-1, Katahira, Aoba-Ku Sendai, 980-8577, Japan
ymatsu@riec.tohoku.ac.jp
++ Communications Research Laboratory Yokosuka Radio Communications Research Center 3-4 Hikarinooka, Yokosuka, Kanagawa, 239-0847, Japan
Proceedings of 3rd International Symposium on EMC, Beijing, China, May 21-24, 2002, pp. 517-519.

Abstract: For analyzing the interference in a radio communication system caused by a microwave oven, a time-domain noise model is newly developed taking into account the noise generation mechanism. It is a very simple model made of an FM/AM modulator. Comparison between an actual noise and the proposed model in the waveforms and spectra clearly demonstrates the usefulness of the proposed model.
Index terms: Communication system, interference, microwave oven, time-domain noise model.

EMCABS: 08-8-2002

PREPARATION OF MODIFIED TEXTILE POSSESSED OF ABSORBING AND SHIELDING CHARACTERIZATIONS
Wang Qun, Zhang Xiaoning, Mao Qianjin, Ge Kaiyong, and Zhou Meiling
Key Laboratory of Advanced Functional Materials, Ministry of Education, School of Material Science and Engineering, Beijing Polytechnic University, Beijing, 100022, China
bpujohnson@yahoo.com

Proceedings of 3rd International Symposium on EMC, Beijing, China, May 21-24, 2002, pp. 589-594.

Abstract: The electromagnetic wave theory of Schelkunoff has been studied. The condition of energetics and the reaction mechanism on depositing Ni-P alloy are investigated. Moreover, the modified textile possessed of the duplex characterization of absorbing and shielding effectiveness property is prepared by electro-less coating. By analyzing three kinds of modified textile both in respect to microscopy and characterizations testing, the preparation conditions of the multifunctional and modified textile are put forward. The mol ratio of Ni2+ to H2PO2- in the electro-less Ni-P alloy coating solution directly influences the phosphorous proportion in the modified layer of textile. Three frequency bands are studied in this paper: 30MHz ~ 1000MHz for SE, 12G ~ 18GHz and 100K ~ 1.5GHz for AE. The maximum of corresponding results are –80dB (SE) at 265MHz, -24.67dB (AE) at 15.2GHz and –12.28dB (AE) at 435.1MHz, respectively.
Index terms: Absorbing materials, shielding materials, textile, electro-less coating.

EMCABS: 09-8-2002

FDTD SIMULATION OF THE SHIELDING EFFECTIVENESS OF METAL-COATING PLASTICS FOR INFORMATION TERMINALS

Tetsuji Tsuchikawa, Jianqing Wang, and Osamu Fujiwara
Faculty of Engineering, Nagoya Institute of Technology, Nagoya 466-8555, Japan
wang@odin.elcom.nitech.ac.jp
Proceedings of 3rd International Symposium on EMC, Beijing, China, May 21-24, 2002, pp. 595-598.

Abstract: Metal-coating plastics are being used as shielding materials for electronic and information terminals due to their light weight. In this paper, a finite-difference time-domain (FDTD) algorithm was newly proposed for analyzing the shielding effectiveness of metal-coating plastics in a broad frequency band. The method was based on the derivation of a time-domain representation of the surface resistance of an equivalent resistive film. The validity of the proposed algorithm, for both far-field and near-field shielding, was verified by comparing the calculated results with theoretical ones. Good agreement was found between them when the size of the shielding material was sufficiently large compared to the wavelength.
Index terms: Metal-coating plastics, shielding effectiveness, equivalent resistive film, FDTD algorithm.

EMCABS: 10-8-2002

A NOVEL MODEL OF CROSSTALK IN ULTRA-HIGH-FREQUENCY MICROSTRIP TRANSMISSION LINES

Sarunwitch Supaprasert+, Ut Goenchanart+, Settapong Malisuwan++, and Vichate Ungvichian+++
+MET Program, Rangsit University Bangkok, Thailand
++Department of Electrical Engineering Chulachomklao Royal Military Academy Nakhon-Nayok, Thailand
+++Professor and Director, EMI R&D LAB, Florida Atlantic University, FL33431, USA
Proceedings of 3rd International Symposium on EMC, Beijing, China, May 21-24, 2002, pp. 630-633.
Abstract: In this paper, a novel model of crosstalk in ultra-high-frequency micro-strip transmission lines is proposed. Analogous to dielectric relaxation considerations of Cole-Cole diagrams as applied to dielectric materials, a "reactive relaxation" concept is introduced to represent the frequency-dependent characteristics of coupled micro-strip lines. Relevant algorithms are shown to be useful in computer-aided circuit designs.
Index terms: Ultra-high-frequency micro-strip transmission lines, crosstalk model, reactive relaxation concept.

EMCABS: 11-8-2002

CROSSTALK PREDICTION IN TWISTED BUNDLES BY A NEURAL APPROACH

B. Cannas+, A. Fanni+, and F. Maradei++
+Department of Electrical and Electronic Engineering, University of Cagliari, Piazza d'Armi, 09123 Cagliari, Italy
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++Dept. of Electrical Engineering, University of Rome "La Sapienza", Via Eudossiana 18, 00184 Rome, Italy
maradei@elettrica.ing.uniromal.it
Proceedings of 3rd International Symposium on EMC, Beijing, China, May 21-24, 2002, pp. 638-641.

Abstract: A neural network based procedure is proposed for the crosstalk prediction in twisted bundles. The non-uniform bundle is approximated as a cascade of uniform sections and the neural network is suitably trained with few cross section configurations to learn the behavior of the per unit length parameters. The procedure allows a fast and accurate prediction tool.
Index terms: Non-uniform twisted bundles, crosstalk, prediction tool, neural network approach.

EMCABS: 12-8-2002

HEATSINK GROUNDING EFFECT ON THE RADIATED EMISSION OF AN ELECTRONIC DEVICE

Li Rong, and Zhang Lin-Chang
EMC Research Section, Northern Jiaotong University, Beijing 100044, China
Proceedings of 3rd International Symposium on EMC, Beijing, China, May 21-24, 2002, pp.704-709.

Abstract: Heat sink is an indispensable component in an electronic device. However, containing emission from heat sink is rapidly becoming a necessity caused by higher power levels and faster clocking digital circuits. It affects the sensitive circuit. In this paper, some grounding schemes of heat sink are presented and calculated applying the FDTD method. It is shown that different grounding points affect the electromagnetic characteristics of heat sink differently, and more grounding points don't necessarily result in the improvement of electromagnetic characteristics. Considering four grounding points, four edge centered ground points are selected for little electromagnetic field.
Index terms: Heat sink, radiated emission, FDTD method, grounding effect. **EMC**

Calendar

EMC Related Conferences & Symposia

2002

October 7-11
Technically Co-Sponsored by the IEEE EMC Society
2nd International Workshop on "Biological Effects of Electromagnetic Fields"
Rhodes, Greece
Ms. Kety Apostolou
Workshop Secretary
Conf2002@imm.demokritos.gr
http://imm.ariadne-t.gr/bioeffects
http://www.uoi.gr/conf_sem/bioeffects

November 3-8
AMTA 2002: 24th Annual Meeting and Symposium
Sponsored by the Antenna Measurement Techniques Association (AMTA)
Cleveland, OH
Sally Kronk, 614.888.2700 x218
Sally.kronk@lintek.aeroflex.com
http://www.amta.org

December (exact dates TBD)
Reverberation Chamber Course (with Experiments)
NSWC Dahlgren, Virginia
Mike Hatfield
Phone: 540.653.3451
E-mail: HatfieldMO@NSWC.navy.mil
http://www.egginc.com/dahlgren

2003

February 18-20
Sponsored by the Swiss Electrotechnical Association
EMC Zurich
Swiss Federal Institute of Technology
Zurich, Switzerland
Rudiger Vahldieck, Symposium President
E-mail: emc@nari.ee.ethz.ch
http://www.emc-zurich.ch

September 2003
V Symposium EMC-2003
Saint Petersburg Electrotechnical University
St. Petersburg, Russia
E-mail: discone@mail.ru

EMCS Cooperating Symposia

U.K.: Biannually, even years, in September

Zurich: Biannually, odd years, in February

Wroclaw: Biannually, even years, in June

EMCS Symposia Schedule

2003 May 11-16
(International IEEE)
Istanbul, Turkey
Elya Joffe
Fax: 972.9.765.7065
E-Mail: emc2003@ortra.co.il

2003 August 18-22
Boston, MA
Sheraton Boston
Jon Curtis
978.486.8880

2004 August 16-20
Santa Clara, CA
Franz Gisin
408.495.3783

2005 August 8-12
Chicago, IL
Tom Braxton
630.759.8674

2006 August (exact dates to be announced)
Portland, OR
Henry Benitez
360.212.0471

IEEE EMC Society Board of Directors Meetings

(For information on all meetings, contact Janet O'Neil, 425.868.2558)

November 24, 2002
Sao Paulo, Brazil

March 14, 2003
Honolulu, Hawaii

May 16, 2003
Istanbul, Turkey

August 17 and 21, 2003
Boston, Massachusetts

IEEE EMC Chapter Colloquium and Exhibition "Table-Top Shows"

November 22, 2002
Brazil EMC Chapter
Contact: Carlos Sartori
55.11.3818.5124
E-mail: sartori@pilar.pea.usp.br
Sao Paulo, Brazil
(See ad on page 14)

May 19, 2003
Southeastern Michigan EMC Chapter
Contact: Kimball Williams
248.354.2845
E-mail: k.williams@ieee.org
Dearborn, Michigan

If you would like to add your name to the list of exhibitors to receive direct announcements in advance of upcoming tabletop shows, please send an e-mail to *j.n.oneil@ieee.org*.

http://www.emcs.org

This newsletter is online!

Visit the web page address above and click on the "Newsletter" button.

ADVERTISER'S INDEX

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Letter from the Editor

continued from page 3

Issue #28 dated July, 1963 was distributed by IEEE, Professional Technical Group on Electromagnetic Compatibility.

Issue #34 dated August, 1964 was distributed by IEEE, Electromagnetic Compatibility Group.

Issue #98 dated Summer 1978 was distributed by IEEE, Electromagnetic Compatibility Society.

Regards,
Warren

Thanks to EMCS Past President, Ed Bronaugh, an entire set of these Newsletters will be provided for your reading pleasure at the 2007 EMCS Anniversary Symposium. It should be interesting to follow our development in EMC over the years since 1958.

If YOU are interested in history as well, consider participating in the 2007 EMCS Anniversary Committee that will address our EMCS history. Contact Dan Hoolihan at e-mail ***Hoolihan@citlink.net*** or phone 651.213.0966. I am sure that Mr. Hoolihan, Chairman of the 2002 IEEE International Symposium on EMC in Minneapolis, Minnesota, will be looking for something to do come September! **EMC**

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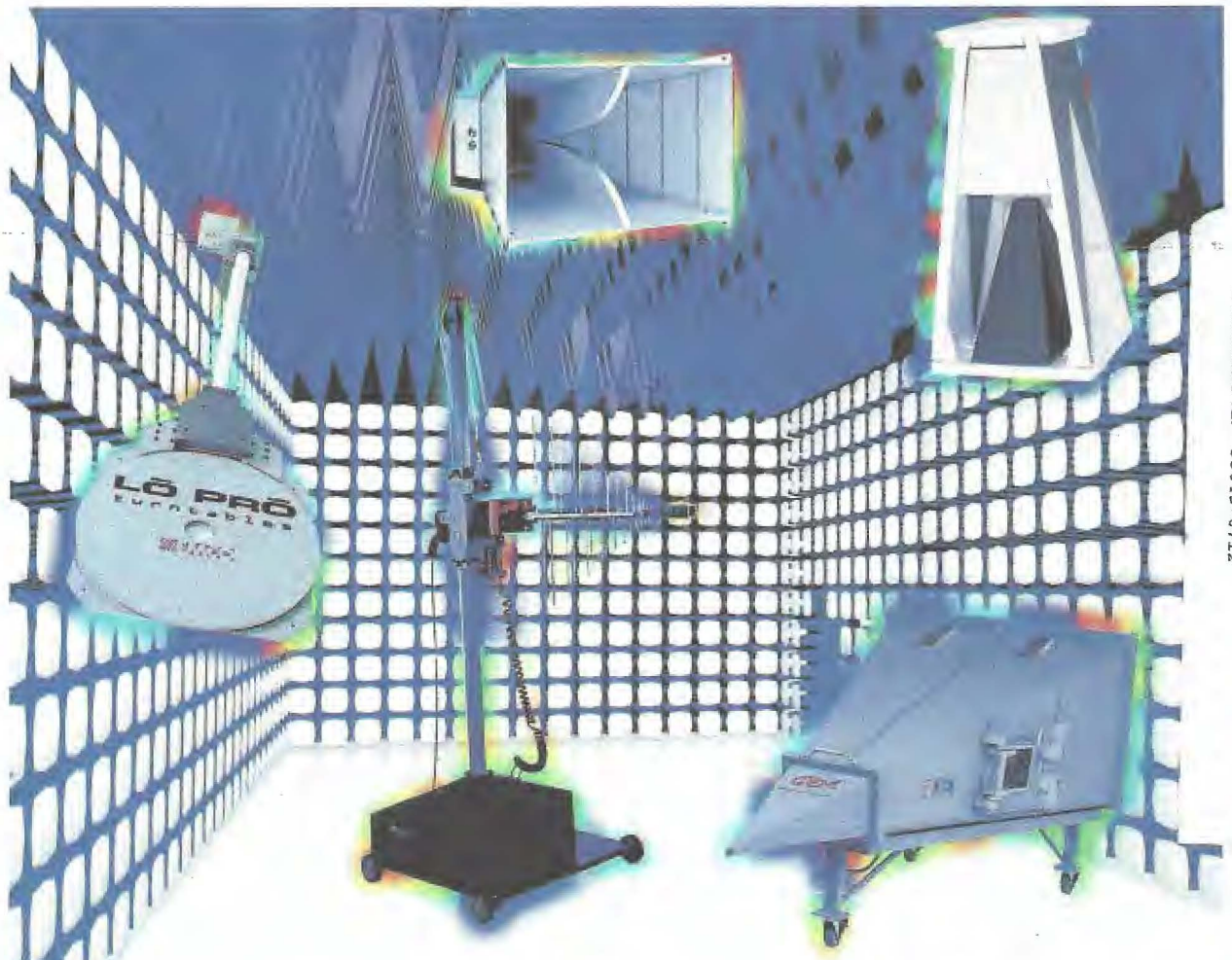

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