IEEE EMC SOCIETY NEWSLETTER

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"Why Digital Engineers Don't Believe in EMC" by Dr. Howard Johnson
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President's Message

DAN HOOLIHAN
PRESIDENT,
EMC SOCIETY

Education, Education, and Education

ecause I am President of the EMC Society, I get the opportunity to write a message to all our members with every EMCS Newsletter. This is a privilege that I look forward to and that I hope to take suitable advantage of.

My keyword for my two-year term (1998 and 1999) is **Education.**

The EMC Society is approximately 5000 members and we represent about 1.5% of the total IEEE membership. It is apparent to anyone who has spent some time in the field of electromagnetic compatibility engineering that a large part of our job is educating people to the "ins and outs" of EMC technology. We are constantly educating our fellow EMC personnel, the other electrical engineers in the IEEE (98.5% of the largest engineering professional organization in the world), the remaining electro-technology experts on the planet Earth, and the remaining members of the general population.

The formal education community (colleges and universities) are teaching more and more EMC principles either as part of a larger course or as a stand-alone EMC engineering course.

Once a technical person starts working in the real-world, the opportunities for education may be presented as seminars and workshops by various sources. Most of these sources charge a price for selling their expertise and so the dollars per dB of knowledge can be fairly expensive.

The local EMC Chapters can provide an inexpensive solution to the education challenge by striving to put on a variety of educational opportunities to their members. The opportunities can range from a 1-hour session once a month to a full blown workshop with all home-grown speakers.

The once-a-month meetings of the local chapters are the most common form of on-going education. We should be considering expanding these meetings to 1/2-day and full day sessions and making sure that other members of the local section get invited to the educational sessions. On-going education of trained personnel is important to our industries and to our economy. We should be instrumental in aiding that training effort.

Take advantage of your expertise and volunteer to give training talks for your local EMCS Chapter. Encourage your local Chapter officers to plan local educational events with sufficient notice so that members of other Societies in your Section may attend and benefit from the home-grown EMC engineering expertise.

Dan Hoolihan
President EMC Society
IEEE

IEEE ELECTROMAGNETIC COMPATIBILITYSOCIETY NEWSLETTER

INSIDE

IEEE
Networking the World™

TODD HUBING
ASSOCIATE EDITOR

Why do many digital circuit designers have trouble with basic EMC concepts? Be sure to read Howard Johnson's article in this issue.

Dr. Johnson makes two important points:

1. You can learn a lot at an EMC Society Chapter meeting
2. Digital circuit designers tend to view the world differently than EMC engineers

We use Dr. Johnson's book, *High-Speed Digital Design: A Handbook of Black Magic* as the main text in our High-Speed Digital Design course at UMR. It's a well-written and interesting text with useful information for both digital designers and EMC engineers. As the title suggests, digital designers do not always feel that the laws of physics apply to high-speed circuit design. The same can also be said of many EMC engineers. After all, how many EMC laboratories don't have a rubber chicken (or similar tool-of-last-resort) squirreled away in a secret place?

Nevertheless, as Dr. Johnson points out in his article, digital design engineers view things differently than EMC engineers. To further illustrate this point, I asked one EMC engineer and two digital designers to briefly describe their experiences in the EMC lab. Their responses are printed below. I had to edit them a little to remove profanity and identifying remarks. (They wished to remain anonymous for obvious reasons.) I also reduced their responses to7-or-8-syllable rhyming phrases. Other than that, they are just as I received them.

AN EMC ENGINEER'S VIEW

Set the unit on the table.
Then connect the power cable.
Boot it up if you are able.
Wait until the level's stable.
Check the spectrum analyzer.
Watch the peak spout like a geyser.
Find the marker. Utilize her.
Quantify the noisy riser.
If the peak's above the line,
Now's the time to redesign.
Grab some copper tape and twine.
This is when you really shine.
Reach into your bag of tricks.
Add a ferrite, maybe six.
Try to find that perfect fix,
Like the one in '86.
Keep close tabs on where you've been.
When the peak is down by ten,
Have a cup of coffee, then
Move the cable. Start again.

A NOVICE DIGITAL DESIGNER'S VIEW

After months of toil and sweat,
This is my best product yet.
All objectives have been met.
One approval still to get.
This design, from my perspective,
Is quite fast and cost-effective.
Now you say that it's defective.
What's this EMC Directive?
Your lab's very interesting.
Let's begin the EM testing.
Yes, I see those peaks are cresting.
Just what is it you're suggesting?
Your demands are quite unyielding.
I don't like this question fielding.
Or this talk of EM shielding.
What's that copper roll you're wielding?
My design was working great.
Now you've slowed down every gate,
Added parts and increased weight.
I might miss my shipping date!

AN EXPERIENCED DIGITAL DESIGNER'S VIEW

Please look over my design.
It won't ship 'til '99.
But I want an early sign.
Please tell me that all is fine.
I've reduced the lengths of traces.
Put small caps in lots of places.
Hope I've covered all the bases.
Bless my board with all your graces.
Yes! The system is quite good.
Passed your tests, as it well should.
Please stop cheering, if you would.
Let's tell no one, understood?
If my management should hear,
The reward would be severe.
For the rest of my career,
I would be an EMC'er.

Ouch! That last rhyme hurt. Hope to see all of you (EMC engineers and digital designers alike) at the 1998 IEEE EMC Symposium in Denver this August!

Atlanta

On December 2, 1997, Lockheed Martin Aeronautical Systems (LMAS) hosted a meeting of the Joint EMC/IM Society Atlanta Chapter. There were 31 attendees from 13 different local companies. The meeting opened with an hour long presentation by Bruce Crain and Greg Abernathy of LMAS titled "Aircraft-Lightning Protection," which discussed aircraft lightning protection using the C-130J FAA lightning protection certification program as an example. The presentation was followed by a tour of the C-130J and F-22 production areas. Visitors were then treated to a tour of the LMAS Electromagnetics lab for demonstrations of lightning testing.

[Congratulations to Bruce Crain and his wife on their newest addition to the family born April 8th. Bruce is now the proud father of four boys!]

Central New England

John Clarke reports that the February meeting of the Central New England Chapter featured Ismat Sheikh-Yassin, of Technology International in Richmond, Virginia. The topic of his presentation was "Gaining EMC and Safety Compliance for the Semiconductor Industry." The semiconductor industry is rapidly expanding. Its growth is having a major impact on the world economy according to the SIA (Semiconductor Industry Association). This growth results in an increase in compliance costs. The presentation addressed regulatory concerns by providing an overview of the guidance document Semi S2-93A and the EU's CE marking directives.

The topic of the March meeting was "The Technical Construction File." The speaker was Robert Martin of Intertek Testing Services in Boxboro, Massachusetts. In the European Union (EU), a Technical Construction File (TCF) can be used to show compliance with the EMC Directive. The EMC Directive alone uses TCFs as described in Section 10.2 of the directive. The presentation described the uses of a TCF and the preparation details. The relationship between TCFs and technical files, and requirements for approvals, were also discussed.

Chicago

The Chicago Chapter of the EMC Society met on Wednesday evening, April 1, to host Dick Ford, recently "retired" from NRL, as special Guest Speaker, and to install the 1998 slate of officers.

Dick treated those in attendance to his very interesting discussion about the NAVAIR EMC Excellence Program, and the impact it has had on the EMC industry for most of the past decade.

Long-time Chair of the Chicago Chapter, Don Sweeney (of D.L.S. Electronic Systems), has retired from the position and was awarded a plaque in honor of his decades of service, leadership, and dedication. (The EMC Society Official Photographer, Dick Ford, "just happened" to have his camera available to capture the moment.) The new Chicago

Continued on page 4

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Photo by Dick Ford

Long time Chicago Chapter Chairman Don Sweeney (R) was presented with a commemorative plaque to recognize his years of service to the chapter. Dale Svetanoff (L) is shown doing the honors.

Chapter Chair is Derek Walton (Barber-Coleman), who was an active participant on the 1994 IEEE EMC Symposium Committee in Chicago.

All Chicago Chapter members wish Don and Derek well in the exciting times ahead. Other Chicago Chapter officers are: Roger Swanburg, Vice-Chair; Raymond Klouda, Secretary; Bill Bumbliss, Treasurer, Jack Black, Membership; Tom Braxton and Dale Svetanoff, Programs.

Israel

The Israeli IEEE EMC Chapter held a meeting on March 11, 1998. This meeting – a full day workshop on EMI in Radio Communication Systems and Networks, was held jointly with the Israel IEEE Communications Chapter, and was sponsored by the Holon Center for Engineering Education, in Holon, Israel.

Participation in the meeting was great! Over 75 attendees. After a short welcome by the EMC and Communication Chapter Chairmen, Elya B. Joffe and Dr. Adam Livne, a welcome address on behalf of the Holon Center for Engineering Eduacation was given by Prof. Jacob Gavan, Head of the Communication and Propagation Department. Dr. Gavan also started the first undergraduate EMC course in any academic institute in Israel at the Holon Center.

Following the welcome address, the following technical presentations were given: "RFI Skirt in Cellular Systems" by Mr. David Peso of Telrad; "Interference in Cellular Systems" by Dr. Dan Shklarskey of Cellcom; "Propagation Interference in Mobile Satellite Communications" by Dr. Zvi Muninner of the Asher Space Research Agency, the Technion; "Propagation and Interference in a Universal Cell, from Mega Cells to Cento-Cells" by Prof. Jacob Gavan of the Holon Center for Technological Education; "EMC and a Frequency Spectrum Management and Analysis System" by Lt. Col. Moshe Ravfogel of the Israel Defence Forces; "Co-existence between Transmitting Services and Passive Services" by Mr. Peleg Lapid; "The Development and Future of the National Communication Services in Israel" by Mr. Moshe Galili of the Ministry of Communications; "A Comparison of the Coupling between Antennas Installed on a Common Mast in Various Configurations" by Mr. Elya B. Joffe of K.T.M. Project Engineering; and "High Definition TV (HDTV)" by Dr. Ezra Nuriel of Nitrino.

Oregon and SW Washington

The Oregon and SW Washington Chapter has continued to be active this past winter. Attendance at monthly meetings has been consistently between 30 and 35 people. And, more attendees have been joining the IEEE and EMC Society.

In January, Mr. Daryl Gerke of Kimmel Gerke Associates, Ltd., gave a very informative presentation on printed circuit board design. Daryl did an excellent job giving practical examples to go along with basic EMC theory.

In February, Mr. Bill Ritenour of EMC Compliance, LLC gave his now famous presentation entitled "Truckers, Fat Ladies and EMI at the Gas Pump". His talk was very illuminating and humorous. Despite the picketing outside, Bill gave a very informative talk. I guess the truckers did not like the advertised affiliation with EMI!!

Photo by Henry Benitez

Speaker Bill Ritenour shown making his point at the Oregon Chapter meeting.

At the March meeting, Mr. Scott Roleson of Hewlett-Packard in San Diego, gave a presentation on "Gaining Insight from EMI Radiation Patterns". He gave several examples of how these patterns have helped to lead EMI teams to an understanding of the physical mechanisms that generate these patterns.

We have received very positive feedback from the membership on all the winter meetings. We will not have a meeting in April, but instead encourage attendance at the Seattle EMC '98 Workshop on April 28 featuring Henry Ott. The Oregon and SW Washington Chapter will host an EMC Colloquium in April 1999 as the Portland and Seattle EMC Chapters continue to alternate events.

The EMC Chapter has encouraged another interchapter Oregon Section Summer event for this year. This event will be the second annual summer section networking mixer and will be held on July 15th. The focus of the event is to facilitate interaction among all the varied chapter members in the Oregon & Southwest Washington Section.

San Diego

Dave Bernardin reports that Mr. Robert Dockey of Hewlett Packard gave an excellent talk at the March meeting of the San Diego chapter. The presentation was titled: "New Techniques For Printed Circuit Board Common-Mode Radiation" Forty one people attended the meeting at TUV Product Services. The meal prior to the meeting was also a huge success, featuring home made lasagne with spaghetti and meat balls prepared and served by Barbara Bernardin. The meal was a terrific beginning for a well-received talk on some unconventional ideas for CM radiation from circuit boards. The question and answer session after the talk was very interesting and brought out even more enthusiasm from a very interested group of EMC-oriented participants.

Seattle

In January, the Seattle Chapter invited Daryl Gerke of Kimmel Gerke Associates to speak on the topic "How to Design to Fail FCC and CE Tests in 20 Easy Steps." Although presented in a humorous way, Daryl's presentation illustrated a number of EMI problems that often occur at the design stage. Topics included "Avoid Ferrites Like the Plague" and "You Can Never Have Too Many Pigtails". Over 40 people from the growing EMC community in Seattle attended the meeting.

Photo by Janet O'Neil

Tom Lindgren (L) and John Kuras (R) of Boeing are busy working on plans for the Seattle Chapter's EMC '98 Tutorial with Henry Ott on April 28. Tom is the Seattle Chapter Treasurer who did double duty on the event by handling registration and finances. John is the Chapter Secretary who promoted the event through the Chapter's Newsletter and Web Page. Jeannie Olson of Kalmus (C) handled the exhibits and facilitated operations.

Photo by Janet O'Neil

Can you guess who provided the witch's hat and clown wig for Helene and Henry O'Neil? (Hint: The hat and wig were gifts from the Seattle Chapter speaker who appeared in costume on October 30. Thank you Mr. W!)

Mr. Bill Ritenour of EMC Compliance, LLC. spoke at the February Chapter meeting on the now legendary topic "Truckers, Fat Ladies, and EMI at the Gas Pump". This presentation was definitely non-politically correct, but very humorous. Through cartoons of Herman, "the Spark Gap" kid (i.e. a greatly put upon gas pump), the effects of EMI in a present day filling station on any given day were discussed. The problems ranged from ESD due to a generously proportioned human sliding out of a car on a cold day, to RF interference from a 500 watt illegal CB mounted on a large commercial conveyance, and finally to an electrically "abrupt" large induction motor operating in an adjacent car wash. The chapter members appreciated this new slant on EMI and ESD.

Photo by Janet O'Neil

Scott Roleson of Hewlett-Packard (L) spoke at the Seattle Chapter's March meeting. He is shown with the ever friendly Leo Smale (R) of Kalmus in Bothell.

In March, the ever popular Scott Roleson of the Hewlett-Packard Company in San Diego, spoke on the topic "Gaining Insight from EMI Radiation Patterns". Mr. Roleson stated that when radiated EMI amplitude is plotted as a function of rotational angle, and when these patterns fall into recognizable shapes, specific antenna-like structures can be inferred as the source of this EMI in some cases. In this way, antenna-like azimuthal radiated emissions patterns can lend useful insight into EMI problems in computing and other electronic equipment. Mr. Roleson's presentation described the methodologies for obtaining EMI radiation patterns and how they can be used to infer antenna structures. Examples were provided and the limitations of this tech-

Photo by Janet O'Neil

After the February Seattle Chapter meeting, speaker Bill Ritenour (R) enjoyed a spontaneous technical exercise with chapter member, Dr. Howard Johnson (L), which lasted until close to midnight.

nique were addressed. It was definitely an insightful presentation.

The Seattle Chapter is excited about the positive response to the Henry Ott one day tutorial and exhibition scheduled for April 28. Also, at the May Chapter meeting, Lee Hill of Silent Solutions EMC Consulting will speak on "Inductance, Ground Plane Gaps, and Radiated EMI in PC Boards." Everyone is welcome to attend the Seattle Chapter meetings. To receive the Seattle Chapter Newsletter, contact John Kuras at 425-717-1363 or john.c.kuras@boeing.com

Southeastern Michigan

Kimball Williams reports that on February 9, 1998 the Southeastern Michigan Chapter featured John D. M. Osburn, of EMC Test Systems in Austin, Texas. John discussed "The State-of-the-Art of Reverberation Chamber Testing." The meeting took place at Eaton Corporation in Southfield, Michigan. Snacks and refreshments were provided. Reverberation chamber testing technology is a radical departure from traditional EMC testing approaches. As with any test approach, there are advantages and disadvantages. John began with his own definition of a reverberation chamber, then proceeded to the theory of a reverberant enclosure to show how reverberation chambers work. John then reviewed reverberation chamber test applications as they currently appear in domestic and international standards. He also discussed reverberant operation performance validation requirements for domestic and international specifications, and described the conduct of reverberation chamber testing, specifically taking into account the special characteristics of reverberation chambers. He also discussed potential pitfalls of reverberation chamber testing.

Kimball Williams of Eaton (C) is shown with Professor Donald Zinger (L) and Vincent McGinn (R) of the Northern Illinois University Department of Electrical Engineering. Mr. Williams, on behalf of the Southeastern Michigan Chapter and the EMC Society Education Committee, gave a presentation to students entitled "Introduction to Electromagnetic Compatibility" in March. After the presentation, Mr. Williams was pleased to award a check for $5,000 to the University. This represents an EMC Society grant for furthering EMC education.

At the Southeastern Michigan Chapter meeting, Kimball Williams (R) enjoyed talking shop with speaker Dick Ford (L) in the Eaton anechoic chamber.

John closed with a prediction of the future of reverberation chamber testing and a question and answer period. Twenty seven EMC engineers and technicians were present for John's presentation, and the discussion after the talk lasted forty five minutes with many probing and introspective questions.

Southern Maryland

The Southern Maryland Chapter conducted their first technical and organizational meeting for the year on April 7, 1998 at the Fort George G. Meade Officer's Club in Fort Meade. During the meeting, Mr. Ted Harwood, the Chapter Chairman, announced that the Chapter will continue to meet at the same location every other month, with technical meetings now scheduled for June 2, September 1, and November 3, 1998. The annual election of officers will be held during the September meeting. Other organizational reports came from Mr. Virgilio P. Arafiles, Vice Chairman, Mr. Charles Gaston, Secretary, and Mr. Fred Kirby, Treasurer. Mr. Arafiles reported that the EMC Society has been actively supporting the IEEE Baltimore Section effort to provide robot kits to area high schools for the purpose of generating interest in science and electrical engineering. Mr. Gaston provided reports on the past year's chapter meeting attendance, and Mr. Kirby completed the organizational meeting with his 1997 financial report.

Mr. Jerry Hodges, Technical Director of the Joint Spectrum Center, Annapolis, MD, was the featured guest speaker. He discussed changes at the Joint Spectrum Center (formerly the Electromagnetic Compatibility Analysis Center or ECAC) which were brought about by the recent FCC Spectrum Auction. He also talked about the impact of the auction on the Department of Defense (DoD) and the JSC Executive Agency move from the US Air Force to the Defense Information Agency (DISA). Mr. Hodges intimated that the well-publicized spectrum auction will end up costing taxpayers and the DoD billions of dollars. For example, the 1997 auction of 75 MHz could cost between $1B to $5B as the DoD modifies both developmental and existing weapon systems to operate outside the frequencies being sold to commercial bidders. He also mentioned that commercial encroachment on current US government frequency assignments could result in widespread safety and operational disruptions. For example, an INMARSAT proposal to re-allocate one of the GPS frequencies could cause severe, costly disruptions on global users of the DoD-developed global positioning system. Finally, Mr. Hodges mentioned that the cost and operational impact of the spectrum auctions have created concerns up to the ASD/C3I and Joint Chief of Staff level, prompting the immediate move of the JSC executive agency from the Air Force to DISA.

Photo by Dan Hoolihan

(L to R) Bill Mack, Rosemary Hoolihan, Curt and Colleen Sponberg, Professor Jose Perini, and Sue Mack are shown celebrating St. Patrick's Day on March 17 at Champp's restaurant in St. Paul, Minnesota. Professor Perini had the luck of the Irish with him (and a "small" beer) during his visit to the Twin Cities Chapter.

Twin Cities, Southeastern Michigan And Chicago

Recently retired after thirty years with the US Navy, long time EMCS Board of Director member, Dick Ford, nce & Independent Consultant, was invited to speak at the Minneapolis, Chicago and Detroit EMC Chapter meetings held on three consecutive nights March 31st, April 1st and 2nd. His topic at all three meetings was the Navy's NAVAIR Model Program for EMC Excellence.

During the 1970s and 80s, the Navy was plagued with a host of electromagnetic incompatibility problems. In response, the Navy implemented a number of initiatives to redress these problems. Between 1973 and 1985, each of the three major Navy systems commands, NAVSEA, NAVAIR and SPAWAR each established their own corrective action programs. Though each program was more or less successful in identifying and correcting EMI deficiencies, EMI problems kept occurring. By 1989, many felt that corrective action programs were just not enough. The Navy had to get out of the fix- it mode and get into a preventative mode. To address this challenge, the Chief of Naval Operations requested the Naval Air Systems Command lead a task force to brainstorm the problem, define a possible successful program, and then establish a model Navy Program for EMC Excellence (NPfE) within the air community.

Dan Hoolihan (L) presents the nostalgic Amador t-shirt to speaker Dick Ford (R) after his presentation to the Twin Cities Chapter. Mr. Hoolihan was a co-founder of Amador Corporation which was later acquired by TUV Product Service.

In his presentation, Dick described the evolution of NPfE over the past nine years. He described the two major parts of the program, NARTE certification of EMC engineers and technicians, and the National Institute of Standards and Technology's (NIST) National Voluntary Laboratory Accreditation Program (NVLAP) and then gave his views of how NPfE fits in with the challenges posed today by DOD downsizing, Non Development Item (NDI) & Commercial Off The Shelf (COTS) procurement processes, DOD use of commercial specs and increased emphasis on NATO (and hence) EMC standardization. Dick was a central participant in the original task force and played an active role in defining the particulars of the program.

Photo by Dick Ford

Speaker Kenn Atkinson (L) is congratulated on a successful presentation by Washington DC/Northern Virginia Chapter Chairman Larry Cohen (R).

Next year will be the tenth anniversary of the NAVAIR model program. NAVAIR has recently announced its continued commitment to the program and has reinvigorated it support to NIST/NVLAP. Dick is supporting NAVAIR's Anthony Iacono, EMC Team Leader for the NAVAL Air System's Command, in this effort.

Asked how the presentations were received, Dick replied that they went great, but noted that of the six airplane legs to travel to/from the various locations, three times the planes were cancelled and/or had significant delays making an otherwise tight schedule much more than exciting.

Washington DC/Northern Virginia

Kenn Atkinson of Atkinson Engineering presented "Demystifying Measurement Uncertainty" at the 19 February luncheon meeting of the Washington DC/Northern VA Chapter. The presentation included an overview of measurement uncertainty requirements for EMC measurements as well as a quick review of the calculations and statistics used to determine measurement uncertainty. He then discussed the practical application of uncertainty for EMC labs and presented a simplified approach for calculating the total expanded uncertainty needed for measurement reports. Mr. Atkinson also displayed examples of EMC measurement uncertainty using the "AEsoft Uncertainty Software" which calculates the uncertainty from the measurement equation and applies the resulting uncertainty values to measurement data.

This commentary was submitted by Dr. Howard Johnson of Signal Consulting, Inc., author of *High-Speed Digital Design: A Handbook of Black Magic* (published by Prentice-Hall, 1993). Comments, either to the Newsletter Editor or directly to Dr. Johnson (howiej@sigcon.com), are encouraged.

One Reader's Opinion ....

WHY DIGITAL ENGINEERS DON'T BELIEVE IN EMC

by Dr. Howard Johnson

I recently dropped in on a meeting of my local (Seattle) chapter of the IEEE EMC Society. This is not my usual hangout, but I can highly recommend it to digital people like myself as a way to learn more about EMC in general, and also as a cheap way to collect lots of free advice.

Anyway, after a charming lecture by Bill Ritenour on the need for electrostatic shielding at gasoline pumps, we turned our attention to the problem of how best to teach EMC concepts to persons with a pure-digital background. As a result of this discussion, and much thought afterwards, I am now finally able to put my finger on the basic reasons why many digital engineers have such a difficult time dealing with EMC problems. Contrary to the opinion of some in the analog world, it is not because they are dumb (far from it). Neither is it because they didn't study hard enough in school (most did). It actually has little to do with the individual engineer at all. The underlying, root cause of many of our present-day difficulties with EMC is a matter of attitude: digital engineers don't believe in EMC. This unfortunate situation has been brought about by a confluence of circumstances. Our educational institutions, our vendors of instrumentation, integrated circuits, and simulation tools, and the lackluster performance of some of those in engineering management all share part of the blame.

Without intending any harm, our institutions, vendors, and managers have propagated five great misconceptions which prevent many, if not most, new digital designers from understanding EMC at any level, and, in fact, from even believing in its existence. To the new digital engineer fresh out of school, EMC is, at best, a myth.

The better you understand these five great misconceptions, the better equipped you will be to understand the point of view of many digital engineers, and to help them overcome the EMC difficulties they will inevitably face.

I. DIGITAL ENGINEERS DON'T BELIEVE CURRENT FLOWS IN LOOPS

Look at a digital schematic. Consider the logic nets that carry digital signals from gate to gate. We all know these signals are propagated in the form of electron currents, and that these currents always flow in loops – yet, on the schematic, the paths for returning signal currents are not shown.

Many digital engineers believe the return paths are irrelevant. After all, they reason, if the logic drivers act as voltage sources, and the inputs act as voltage receivers, why worry about the current? This great misconception is reinforced by manufacturers of oscilloscopes and logic analyzers who primarily market voltage-mode probes. If we had good current-sensing probes with a pinpoint proximity-activated head small enough to see the current flowing on an individual BGA ball, the flow of current would suddenly become a "reality" for many engineers rather than a merely theoretical concept.

If you are going to work with a digital engineer on a common-mode cable radiation problem, for example, first establish whether the engineer really understands that current really does flow in a loop.

II. DIGITAL ENGINEERS DON'T BELIEVE IN THE H-FIELD

I attribute this misconception to our educational system, with its disproportionate focus on electric field effects, as opposed to magnetic. This is a relic of the tube era, which was characterized by very high-impedance circuits. For example, the plate circuit of a tube might have an impedance of 100,000 ohms, much higher than the impedance of free space (377 ohms). Therefore, most of the near-field energy surrounding the plate circuit would be in the electric field mode, and most cross-coupling and parasitic coupling problems would involve electric-field, or capacitive, effects.

Today's high-speed digital systems have low-impedance circuits, near 50 ohms, much lower than the 377-ohm impedance of free space. Most of the near-field energy surrounding a digital circuit is in the magnetic-field mode, not electric. Therefore, most crosstalk, ground bounce, and interference problems in high-speed digital systems involve loops of current, magnetic fields, and inductance.

In the EMC world, it is common knowledge that the near-field energy surrounding a digital board is mostly magnetic. Digital people don't know about that.

III. DIGITAL ENGINEERS DON'T BELIEVE GATES ARE DIFFERENTIAL AMPLIFIERS

On a typical product data sheet, the input voltage sensitivity is rated in units of absolute volts. It is not clearly stated that the gate responds only to the difference between the voltage on the input pin and whatever voltage happens to be present on its designated reference pin. Nor are we clear about which is the designated reference pin. (For TTL it's the most negative power rail; for ECL it's the most positive.)

This ambiguity leads many engineers to think that a gate can sense "absolute zero" volts, as if it had a magic wire leading out of the chip to the center of the earth where it could pick up a "true" ground reference potential. As a consequence, they fail to comprehend the difficulties that arise when the ground voltages at two points in a system are unequal.

This is a case where digital specsmanship has not served us very well. Of course, no vendor wants to admit that their chips are susceptible to ground shifts, so we can't expect them to talk much about it. On the other hand, we all need to understand that those system architectures which permit large ground shifts between chips are likely to malfunction in addition to generating massive amounts of EMI and falling subject to ESD and other immunity problems. This is serious stuff.

You will find that most inexperienced digital designers have spent little time thinking about the existence of different ground potentials in their systems, the effect that would have on performance, or the mechanisms that create ground shifts.

IV. DIGITAL ENGINEERS DON'T BELIEVE IN ELECTROMAGNETIC WAVES

Despite the many obvious examples of electromagnetic fields at work (like microwave popcorn and television), many digital engineers do not believe these effects happen inside digital systems. The root of this belief is that waves do not exist in Spice. We have trained a whole generation of circuit designers to believe that the world of Spice-based software simulation is a manifestation of real circuits operating under real conditions. We have done a poor job training them to understand its limitations. In the mind of a digital designer, fresh from school, Spice doesn't do E&M fields, ergo, they must not exist (or they don't matter).

I don't mean to knock simulation. It certainly has its place. In general, simulation can work wonders if you know what it is you are modeling. If, on the other hand, you are working with something like EMC the benefits of simulation are oversold. For EMC, where the whole problem is that we rarely know which effect matters the most, simulation doesn't work. In the immortal words of Samuel Clemens, "The calamity that comes is never the one we had prepared ourselves for."

V. DIGITAL ENGINEERS DON'T BELIEVE AN UNDERSTANDING OF EMC WILL ADVANCE THEIR CAREERS

This is a management problem. It's easy to see how it comes about. Imagine that Joe is a top-notch product designer and digital guru. He has just demonstrated his mastery of EMC by getting his latest product to pass FCC and EC regulations on the first scan. He's a genius!

What happens next is highly predictable. Joe's design career is over. He will never design another processor at that company. He will instead be asked to debug Fred's EMC problems, and then Bob's, and then every other piece of junk that comes down the pike. He's effectively banished to the test range, to repeating over and over his EMC experience, while others reap the rewards of having gotten their sloppy processor boards to "function".

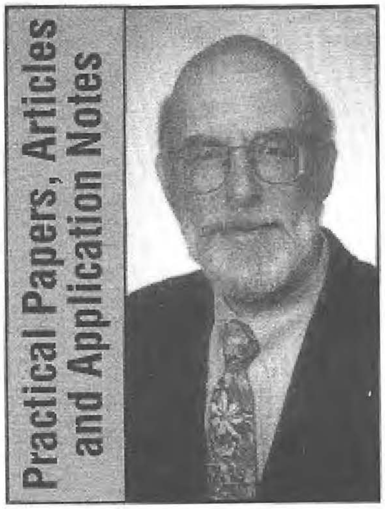
In today's business world, the typical digital engineer is rewarded for mere digital functionality rather than total readiness for manufacturing.

CONCLUSION

I'd like to think that we can turn this situation around. I'd like to think we can count on our EMC professionals, our signal integrity experts, and all the smart researchers at our universities to help undo these five great misconceptions, and to help us make some real inroads into the EMC difficulties that will face us in the coming decades. I'd like to think that if we did, it would make a big difference for the future of the computer industry.

At the very least, I hope we can get some more digital folks to show up at local EMC Society meetings. It's worth the trip.

Howard Johnson, PhD, is the author of High-Speed Digital Design: A Handbook of Black Magic (Prentice-Hall, 1993). He frequently conducts technical workshops for digital engineers at Oxford University and other sites worldwide. Comments invited! www.signalintegrity.com, howiej@signalintegrity.com.
Dr. Johnson is based in Redmond, Washington



BOB ROTHENBERG
ASSOCIATE EDITOR

This column is devoted to articles, papers or application notes which would be of interest to EMC practitioners as opposed to EMC academicians. Ideally, such papers should be about 1-3 Newsletter pages in length. If editing for length is required, it will only be with the author's concurrence. Please submit in double-spaced form, as hard copy, disk or e-mail (see page 3 for address, fax and e-mail info).

Digital Clock Transmission Lines and Terminations on Printed Circuit Boards — Part II

by Lee Hill, Silent Solutions (Hollis, NH)

INTRO:

In my view, the sharing of knowledge gained from experience is an important responsibility of all professional engineers. In fact, this responsibility is a major reason for the existence of the IEEE EMC Society. And this column in the Society's Newsletter is one of the many opportunities for you to share some of your knowledge. As its title suggests, anything from a short paper to an application note is appropriate for these pages. If editing is required, it will only be with the author's concurrence.

This issue's contribution is the second part of an article on PCB signal integrity by Lee Hill of Silent Solutions (Hollis, NH). Part I appeared in the last issue of the Newsletter. Lee served as an IEEE EMC Society Distinguished Lecturer from 1992-1994, and received the Society President's Memorial Scholarship in 1993. He holds an MSEE from the University of Missouri-Rolla.

In the first part of this article (see the Winter 1998 issue of the IEEE EMC Society Newsletter), we reviewed the motivation of EMC and digital design engineers to maintain good signal integrity in high speed digital systems. In addition, we discussed a simple qualitative and quantitative method to determine the relative length of a digital transmission line, and thus determine whether or not we should add termination components to ensure that signals on the line will look "nice" in the time and frequency domains. In this article we will examine the nature of signal reflections on digital clock transmission lines, and the termination components and methods used to control them.

As shown in Figure 1, a typical PCB digital clock circuit consists of a driver, transmission line, and load. Here we will consider only circuits that have one driver, and one or more loads. A summary of good digital transmission line design, and the rest of this article for that matter, goes likes this: We would like the signal on the PCB trace to "crash" into a resistor of value Zo either at the source or at the load? The signal is launched from the driver, the signal tells the load what to do, and then its associated energy is absorbed either at the load or at the source. If not, signal energy will bounce back and forth between the source and the load with a frequency equal to 1/(length of line/propagation velocity). If this happens, we will have lousy signal integrity, poor system reliability, and heaps of radiated EMI.

Real Digital Circuits Today

Today's high performance CMOS clock drivers have the capability to drive a five volt digital signal into loads in excess of 50 pF, while maintaining signal edge rates close to one nanosecond! At this edge rate, we know that we must expect to observe transmission line behavior if the signal trace is only five centimeters (or more) in length. "Transmission line behavior" is microwave engineer talk that means "look out for signal reflections" at both ends (the source and load) of the PCB trace. A well designed circuit will allow no reflections at all, or at most a single reflection at the load, which subsequently will be absorbed at the source.

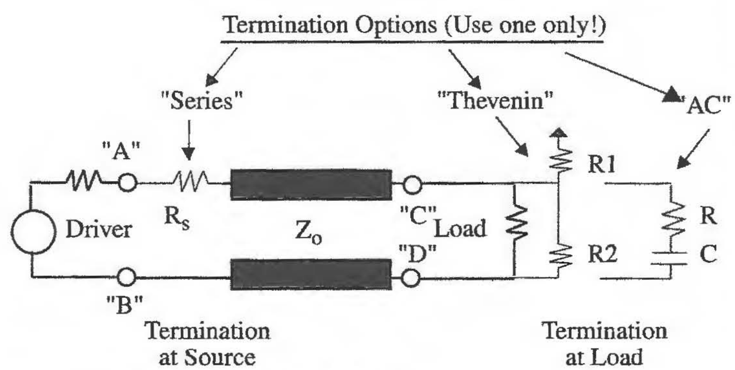


Figure 1: Simple PC board circuit model

What Happens on the Transmission Line

In a world without perfectly matched and EMI-quiet transmission lines, we should observe the following: 1) The signal is launched from the driver onto and down the transmission line as an "outgoing pulse" V+. 2) As the pulse travels down the line, the amplitudes of the outgoing traveling voltage and current waveforms satisfy the relationship $Z_o = V/I$, the characteristic impedance of the transmission line. Since digital circuits usually convey information by propagating a time-changing *voltage* level, we can see that the higher the impedance of the line, the less current (and power) the driver will have to supply. Conversely, lower impedance lines will require more current and more power to propagate a digital pulse at a given voltage level. 3) When the pulse arrives at the load, a "reflected pulse", V-, will be generated if the impedance of the load does not match the impedance of the transmission line. If we want to know the size and polarity of the reflected pulse, we can define and evaluate a reflection coefficient Γ at the load as:

$$\Gamma = (Z_L - Z_O) / (Z_L + Z_O)$$

The amplitude of the reflected wave is then

$$V- = \Gamma V+$$

The "load" for a digital clock is usually a clock input pin of a high impedance integrated circuit. IC datasheets usually characterize a single input pin to be the equivalent of a five picofarad capacitor. Suppose we are driving a 25 MHz clock signal down a 50 ohm line to a single load at the end of a "long" trace. Do we get a reflection? As just stated, a reflection will be generated if the load impedance does not match the trace impedance. To answer this question, we must calculate the impedance of the load at the highest frequency component of the pulse that we think is "important" or "non-trivial". Experienced EMC engineers may give a knee-jerk reaction and say "the tenth clock harmonic is the highest frequency that I will ever consider to be important". Others may resort to a bandwidth rule-of-thumb that equates an upper signal bandwidth equal to 1/(π * risetime). Using both these ideas for the given signal, we get 25 MHz * 10 = 250 MHz, or 1 / (π * 1 nanosecond) = 318 MHz. To remain employed, let's be careful and pessimistic, and choose the higher of the two results, 318 MHz. The load impedance is that of a five picofarad capacitor (Z = 1/(ωC) calculated at 318 MHz, equal to 1/ (2 * π * 3.18 E+08 * 5 E-12) = 100 ohms. The load impedance Z_L (100 ohms) is not equal to the given line impedance Z_o (50 ohms), and therefore a reflected pulse "V -" will be generated.

If we want to dramatically reduce the amplitude of the load reflection, we can add one or more termination components at the load to force the impedance at the end of line to equal approximately 50 ohms, the PCB trace

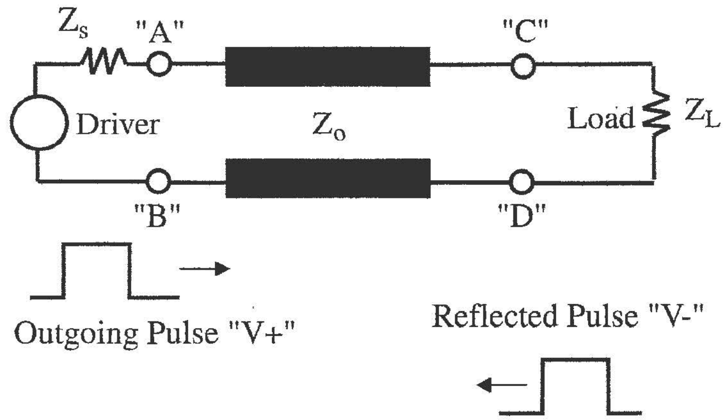


Figure 2: Transmission line with termination components

characteristic impedance Z_o, in our example. As shown in Figure 2, we generally have a choice of two termination configurations at the load: 1) Two resistors that comprise a voltage divider with a Thevenin equivalent impedance (R1 in parallel with R2) of Z_o, or 2) A series resistor and capacitor combination with R = ~Zo, and C = ~ 10^2 pF. Configuration "1" is often referred as a "Thevenin" termination; "2", an "AC" termination. The Thevenin termination makes the driver work much harder at low frequency harmonics, since a high impedance, "light" load will be swamped by a shunt resistance of 45 to 70 ohms to match the Z of a modern digital PCB. Note also that the "Thevenin" termination consumes real DC power. The "AC" termination eliminates DC power consumption and reduces low frequency harmonic loading by making the termination resistor R "appear" in the circuit only at higher frequencies, where the capacitor's impedance is comparable to or less than the impedance of the line.

In the event that there is more than one capacitive load at the end of the line, we may be able to model all the loads together as a single lumped capacitance. Beware of "heavy" capacitive loads where the equivalent load impedance is much less than the line impedance. In such circumstances, a "Thevenin" or "AC" termination that appears in parallel with the load cannot be used, since it can only reduce the aggregate load impedance. A too-low load impedance resulting from heavy capacitive loading might actually require additional series impedance to increase the aggregate load impedance to that of the line impedance Z_o.

Instead of using a load termination to prevent the generation of a reflected pulse at the load, many digital circuits use a series termination resistor at the source (also shown in Figure 2). In this case, the outgoing pulse that is launched down the line is reduced in amplitude by the voltage divider formed by the series resistor and the characteristic impedance of the line;

$$V^+ = V_{AB} * (Zo)/(Zo + Rs).$$

Now we *depend* upon the positive reflection that occurs at the light capacitve load to "bounce up" the load voltage to an acceptable digital threshold. The value of series resistor is usually chosen to be approximately (Z_0 - Z_S), so that when the reflected pulse V- arrives back at the source, it "sees" Z_S + (Z_0 - Z_S), or just Z_0. When using a series terminator for extremely fast and strong drivers (i.e., R_S very small), the terminator resistance must approach Z_0. The outgoing pulse voltage V^+ then will be attenuated by as much as one-half the source voltage V_{AB}. In such cases, the outgoing pulse voltage may be so small that the reflection at the load is *required* to cause the load to reliably change state. If we try to add additional loads between the two ends of a transmission line with series termination, we may not be able to reliably switch these devices in a predictable manner, since the outgoing pulse is so small and the reflected pulse is heavily dependent upon the source edge rate and characteristics of the load. IC application notes wisely warn us about the perils of using series termination methods in conjunction with heavily loaded lines with distributed loads.

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DON HEIRMAN
ASSOCIATE EDITOR

Lots Happening in Standards

by
Don Heirman,
Vice President for Standards and Chairman of Standards Committee

New IEEE Standards Association

Starting this year, the IEEE standards activity has been reorganized into a new organization within the IEEE called the Standards Association (SA). This Association has two main entities: The Board of Governors and the Standards Board supported by the IEEE Standards Association staff in Piscataway, NJ.

The Standards Board, comprised of 26 members from the various standards writing bodies as well as other standards developing organizations, remains intact as it was before to facilitate and approve all new, revised, reaffirmed, and withdrawn standards by the over dozen active standards-writing IEEE Societies including our own Electromagnetic Compatibility standards operation. Our EMCS standards operation has also been reorganized in part to support the SA. We will discuss this later in this article.

The SA Board of Governors with its 12 members serves as the policymaking, finance, and business strategy body for the SA. The SA has as its goals the support of such industry focused standards activities as those now offered by trade organizations and consortia. Hence, there will be corporate membership including voting privileges as well as the traditional IEEE individual member contributions.

To facilitate the individual as well as corporate contribution, there is now a matrix of dues necessary to achieve the goals of the SA. For any IEEE member as well as Associate member to become a member of the SA, the annual dues are $10. This allows a member, for example, to be on standards balloting groups and vote as well as take part in special SA membership offerings. The EMC Society standards committee is now fully comprised of members who have paid their SA dues and are hence fully qualified to be on our balloting groups. It is interesting to note that if you were not an IEEE member, the annual fee rises to $125 per annum. For corporate membership, the annual dues start at $1000 per annum (for corporations with less than $1M in Total Annual Revenue to $5000 for corporations with over a billion dollars total annual revenue).

For more information on the Standards Association, visit their website at: http://standards.ieee.org/sa/index.html or email to ieee.sa.exec@ieee.org

Finally, your EMCS Vice President for Standards—Don Heirman—was elected for the year 1998 as the Vice-chair of the Standards Board. With his participation on the SA Standards Board Review Committee (which oversees the standards approval process and reviews all standards before recommending approval to the Standards Board) and this new role, the EMC Society is well-represented in this important part of the Institute.

EMCS Vice President for Standards

At the November 1997 EMCS Board of Directors meeting in Atlanta, a new position was filled by election—Vice President for Standards. Don Heirman was elected to fill that new position. In the past five months, considerable work has been undertaken by the EMCS Board as well as the VP for Standards to restructure not only the new position, but to reorganize the other vice-presidential areas (formerly called Technical Directors).

The result at this juncture is that the VP for Standards has two committees:

EMCS Standards Advisory Committee (SAC) which is made up of those representatives from the EMCS Representative Advisory Committee (RAC) as follows:

1. Special International Committee on Radio Interference (CISPR)
   - i. Subcommittee A: Radio Interference Measurements and Statistical Methods (Publication 16)
   - ii. Subcommittee B: Interference Relating to Industrial, Scientific and Medical Radio-frequency Apparatus (Publication 11)
   - iii. Subcommittee E: Interference Relating to Radio Receivers (Publications 13 (emission) and 20 (immunity)
   - iv. Subcommittee G: Interference Relating to Information Technology Equipment (Publications 22 (emissions) and 24 (immunity)
2. ANSI Accredited Standards Committee C63 (EMC)
3. SAE (Society of Automotive Engineers) EMI and EMR Committees
4. SAE AE-4 (EMC)
5. ESD Association
6. EIA (Electronics Industry Alliance) G-46 and its EIA/CEMA (Consumer Electronics Manufacturers Association) R1/R2 Commercial EMC/Safety Committee
7. RTCA (Radio Technical Commission for Aeronautics)
8. ASTM (American Society for Testing Material) D09.12.14 (Electromagnetic Shielding) Committee and E06.53 Committee
9. ETSI (European Telecommunications Standards Institute) TC ERM (EMC) Committee
10. IEEE Metric Policy Committee

The final structure and scope for the SAC is being handled by Joe Butler who will be serving as interim chair of the SAC until a replacement can be found. Joe can be reached on jbemc@aol.com.

EMCS Standards Committee (SCOM) (unchanged from before the restructuring)

The EMC Society Standards Committee continues to be one of the most active committees in the Society meeting up to four times each year including its major meeting at the annual symposium. 1997 and the first quarter of 1998 have been very active times for your Standards Committee.

In particular, the following list shows the status of our projects as of 1 May 1998:

STD / DATE / TITLE / STATUS

STD 139-1988 IEEE Recommended Practice for the Measurement of Radio Frequency Emission from Industrial, Scientific, and Medical (ISM) Equipment Installed on the Users Premises — Reaffirmed 1993

STD 140-1990 IEEE Recommended Practice for the Minimization of Interference from Radio Frequency Heating Equipment (ISBN 1-55937-043-2) — Reaffirmed 1995

STD 187-1990 IEEE Standard on Radio Receivers: Open Field Method of Measurement of Spurious Radiation from FM and Television Broadcast Receivers (ISBN 1-55937-062-9) — Reaffirmed 1995

STD 213-1987 IEEE Standard Procedure for Measuring Conducted Emissions in the Range of 300 kHz to 25 MHz from Television and Next Reaffirmation FM Broadcast Receivers to Power Lines (ANSI recognized) being processed — Reaffirmed 1993

STD 299-1998 IEEE Standard Method of Measuring the Effectiveness of Electromagnetic Shielding Enclosures (ANSI recognized) (ISBN 55937-108-0) — Published in March

STD 376-1975 IEEE Standard for the Measurement of Impulse Bandwidth (ANSI recognized) — Reaffirmed 1993 Next reaffirmation being processed.

STD 377-1980 IEEE Recommended Practice for Communication Transmitters (ANSI recognized) — Reaffirmed 1997

STD 473-1985 IEEE Practice for an Electromagnetic Site Survey (10 kHz to 10 GHz) (ANSI recognized) — Reaffirmed 1997

STD 475-1983 (Reaff 1994) IEEE Measurement Procedure for Field Disturbance Sensor (rf Intrusion Alarm) (ANSI Recognized) — Revision due in 1998

PAR 482 Cable and Connector Shielding Characterization — CANCELLED (See PAR 1530 below)

STD 1128-1998 IEEE Recommended Practice for RF Absorber Evaluation in the Range of 30 MHz to 5 GHz — Published in March

STD 1140-1994 Standard Procedures for the Measurement of Electric and Magnetic Fields from Video Display Terminals (VDTs) from 5 Hz to 400 kHz — Reaffirmation in 1999

STD 1302 Guide for the Electromagnetic Characterization of Conductive Gaskets in the Frequency Range of DC to 18 GHz — Copyright release of figure being resolved; Expected to be published by June 1998

STD 1309-1996 IEEE Standard Method for the Calibration of Electromagnetic Field Sensors and Field Probes, Excluding Antennas, from 9 kHz to 40 GHz — Errata to be published by mid year.

PAR 1530 Recommended Practice for the Design and Construction of Calibration Artifacts for Cable and Connector

Continued on page 24

J.L. NORMAN VIOLETTE
ASSOCIATE EDITOR

EMC Analysis Methods and Computational Models by Frederick M. Tesche Michel V. Ianoz Torbjorn Karlsson

Publisher: John Wiley & Sons, Inc. New York, 1997
(623 pages)

This "meaty", 623-page book is organized by starting with a Preface followed by five parts, Parts I - V. This review follows the same sequence.

PREFACE

The Preface provides a background of the progress through the years in numerical computation and applications to models to visualize electromagnetic interference and to assist in its mitigation. The usefulness of mathematical models is described as well as their limitations. Many past and present engineers and scientists involved in modeling and computation of electromagnetic (EM) phenomena are acknowledged in the PREFACE and ACKNOWLEDGMENTS sections of the book. Many topics pertaining to EM modeling and computation are described briefly as they are presented in the respective chapters in the book.

PART I PRELIMINARIES

Chapter 1. Introduction to Modeling and EMC

Modeling of physical processes in general is presented as a useful tool for analysts and for use in EMC applications. Modeling in general is discussed and suggestions presented on various ways of how they may be used in studies and other aspects of EMC.

Topics developed in subsections of this chapter include the concept of modeling, the experimental and nonexperimental validation of models, and the building of models in electromagnetics. An historical overview is provided on EMC modeling. The classification of EMC problems is outlined and typical EMC problems amenable to modeling are described. Different types of signal waveforms and their frequency spectra encountered in EMC models are tabulated. The limits of modeling accuracy due to the complexity of practical EMI situations are described. The chapter text ends with a section that identifies users of modeling.

Chapter 2. System Decomposition for EMC Modeling

This chapter introduces electromagnetic (EM) topology to accomplish system decomposition into simple parts for EMC modeling. This is considered key to the application of any mathematical model representing system behavior. Analytical methods in EMC can be used throughout the planning, design, and construction phases of an electrical system. A flow-chart is provided to illustrate the overall role of modeling analysis in system development.

The need for EMC verification is usually required and performed by immunity and emission testing. A summary is provided of the use of analytical models including the need for understanding their limitations and user expectations.

The topological description of systems is illustrated in terms of constructing one or more Faraday shields (EM barriers) between an EMI source and potentially sensitive equipment. Protective devices (filters, gaskets, surge suppressors, etc.) are needed at intended and other likely points of entry (POEs) through the shield. The basic technique of EM topology is illustrated diagrammatically. It is indicated that the topological design of a complex system is difficult to control and significant errors can occur in the analysis.

EM interaction (coupling) with the system must be determined to perform an approximate analysis of system response. This is developed with the EMI coupling process described with interaction sequence diagrams. Modeling accuracy and inherent errors are discussed.

PART II LOW-FREQUENCY CIRCUIT MODELS

Chapter 3. Lumped-Parameter Circuit Models

This section describes the applicability of models when the physical dimensions of the system are much smaller than the wavelength of the disturbing (EMI) signal(s). The approach should be quite familiar to electrical engineers who can recall the concepts of circuit theory that are taught in typical undergraduate EE curricula. The models developed herein can be applied when interfering sources are connected directly to the victim circuit or when the victim circuit is located near the source and is excited by the EM fields produced by the source. Examples are presented of these types of conducted or radiated interference situations.

The use of Thevenin and Norton equivalent circuits is described to develop models where the sources of EMI are connected directly (hard-wired) to another circuit. Models for passive, linear, two-port circuit parameters are described with circuit equations and also in matrix format. The relationships between two-port impedance, admittance, chain parameters, and two-port active sources are described and tabulated, with the development extended to multiport networks. Examples are provided of conducted disturbances in electrical power systems, and the generation of harmonic currents are described. The determination of the mains impedance is also described.

The disturbances in circuits induced by EM fields are described in terms of magnetic field coupling including weak-coupling approximations. Calculation techniques for mutual and self-inductance are presented. Electric field coupling is also described including weak-coupling approximations. Calculation techniques for mutual and self-capacitance are presented.

General field coupling is described where both electric and magnetic field coupling are active at low frequencies. This is followed by an example for determining crosstalk between two parallel traces on a PCB. General and specific methods are presented for reducing low-frequency interference.

A section describes disturbances caused by common ground returns. Part II ends with a section on the extension of circuit modeling to high frequencies.

PART III HIGH-FREQUENCY AND BROADBAND COUPLING MODELS

Chapter 4. Radiation Models for Wire Antennas

At higher frequencies, where the EM field wavelength dimension becomes comparable to equipment dimensions, the low-frequency models become incresingly less accurate with increasing frequency. Essentially, the EM fields become wavelike and alternative modeling techniques are required. Solutions to Maxwell's equations provide a more general description of the EM fields at both low and high frequencies. The details of radiation and scattering of EM energy from wire antennas at high frequencies are presented, with concentration on models that permit rapid calculations of antenna responses as opposed to the more accurate solutions that require considerably more computer resources.

The concepts are developed of the radiation of EM fields in the frequency domain. Radiation from elementary sources, electric and magnetic dipoles, extended sources, and center-fed wire antennas is presented. The solution of an integral equation (IE) is developed as a more general approach for determining the current distribution on a wire antenna. The Method of Moments (MoM) technique is illustrated to obtain an approximate solution for the IE. Other example calculations include dipole radiation in the presence of other bodies such as ground planes, in a parallel-plate region, in a cavity, near a sphere, and over an imperfectly conducting earth. The evaluation of magnetic field components from the electric fields is illustrated using Maxwell's equations.

The reception and scattering of EM fields in the frequency domain are described. Solutions to the electric field integral equations (EFIE) and the integro-differential equations in the time domain are outlined.

The singularity expansion method (SEM) is described as an extension of the IE solutions at complex frequencies. The natural (resonant) frequencies that characterize the frequency domain response of antennas and scatterers forms the basis for this method. A mathematical description of the SEM is provided with illustrative examples of SEM representations.

Chapter 5. Radiation, Diffraction, and Scattering Models for Apertures

This chapter addresses solutions to EM field leakage, or penetrations, through holes or other imperfections in a shield boundary. Techniques presented include scalar diffraction theory, Kirchhoff Approximation, Dirichlet and Neuman solutions, including Green's function formulation. Since EM fields are vector quantities, general vector field diffraction is presented with irradiance patterns for rectangular and circular apertures illustrated.

The application of an integral equation for the tangential E and H fields in the aperture is presented to obtain a more accurate solution for the EM field penetration through an aperture. An example is presented of an aperture field calculation.

Radiation from extended antennas is outlined. Equivalent polarized electric and magnetic dipoles are presented as a method for determining low frequency approximation of radiation through apertures. Wideband and transient responses of apertures are illustrated.

PART IV TRANSMISSION LINE MODELS

Chapter 6. Transmission Line Theory

The importance of transmission line theory and concepts are described for use in developing models for high frequency excitation where low frequency approximations become increasingly inaccurate. The many concepts presented include lumped and distributed parameters, two-conductor and multiconductor systems, transmission line and antenna mode responses, the telegrapher's equation, the evaluation of line parameters, frequency domain responses, two-port and chain parameter representations for a two-wire line, line termination and reflection coefficient, line responses, validation of transmission line models, multiconductor line impedance and admittance matrices, and the "BLT" (Baum-Liu-Tesche) equation development for multiconductor lines. Time-domain transmission line responses are illustrated including time-harmonic excitation, nonsinusoidal traveling waves, and the transformation from the frequency domain to the time-domain. Numerical solutions are illustrated including Bergeron's graphical solution in the time domain. A computer code called the Electromagnetic Transients Program (EMTP) is described briefly. The presentation of methods for determining line inductance and capacitance parameters conclude this detailed chapter.

Chapter 7. Field Coupling Using Transmission Line Theory

This chapter discusses transmission line models and illustrates their use for describing some typical EMC problems. Three different approaches are introduced for describing the coupling of an external EM field to a line by applying transmission line theory:

(1) line excitation by incident magnetic flux linking the two line conductors, and incident electric flux terminating on the two conductors giving rise to distributed voltage and current sources on the line (Taylor approach).

(2) EM scattering process where tangential E-field along the conductors viewed as distributed voltage sources (Agrawal method).

(3) Line excitation only by incident B-field components giving rise only to distributed current sources on the line (developed by Rashidi).

The two-wire transmission line model is used to derive what are called the first and second telegrapher's equations for lossless conditions, and the modification of the equations for a finitely conducting wire and for a lossy medium surrounding the line.

Alternative forms of the telegrapher's equations are presented including total and scattered voltage formulation. Numerical examples are provided of the two formulations. Solutions are provided for the line current and voltage and the load currents and voltages. Other extended applications of transmission line techniques are presented including frequency domain and transient responses.

A model is developed for a single line over a perfectly-conducting ground plane including line excitation from an EM scattering viewpoint. A treatment of highly resonant structures includes a single-wire line and an extension to multiconductor lines. Radiation from transmission lines is presented.

The analysis of transmission networks is illustrated including the development of the network BLT equation technique. Transmission lines with nonlinear loads are analyzed including the derivation of the Volterra integral equation. Examples are presented throughout this chapter.

Chapter 8. Effects of a Lossy Ground on Transmission Lines

This chapter extends the transmission line models discussed in Chapters 6 and 7 but includes the effects of a lossy earth serving as a return conductor. The telegrapher's equation is derived and frequency and time domain solutions are presented for lossy conditions. Mathematically, the formulations are in terms of integral relationships for the E and H fields separated into excitation and scattered components. From these relationships the telegrapher's equation is derived and boundary conditions applied. Per-unit length line parameters are derived and frequency and time domain representations are developed.

The remainder of the chapter illustrates numerous mathematical applications of lossy transmission line configurations and techniques with developments in the frequency and time domains.

Chapter 9. Shielded Cables

The introduction to this chapter states, regarding shielded cables:

"As such, one can define two distinct transmission lines: an external line having currents and charges flowing on the exterior of the cable, together with a possible ground-plane return, and an internal line consisting of the conductors inside the shield."

It is postulated that EMI fields can excite the external transmission line, and if the shield is imperfect, some of the external currents and charges can penetrate through the shield and excite the internal line and thus cause an unwanted response.

Fundamentals of cable shield coupling are developed with transfer impedance and admittance defined based on an external and internal circuit formulation. Coupling through a solid tubular shield is derived and models for EM field penetration through braided shields are formulated. Penetrations of EM fields through single and multiple apertures are developed, as well as impedance and admittance parameters. Graphical illustrations are provided for the variation of parameters with frequency. "Name-brand" models developed by Tyni, Demoulin, and Kley are presented and compared. The calculation of responses of a braided cable is illustrated.

High and low frequency models for cables with shield interruptions are presented, including the effects of cable connectors, pigtail terminations, and discontinuous shields.

Chapter 10. Shielding

This chapter discusses the principles of EM shielding and illustrates results from some of the simple models that can be used for predicting shielding performance. Shielding is presented as only one element of many that together create a complete protection system against EMI.

The general principles of shielding are presented including the properties of shielding materials and the impact of openings on shielding performance. Shielding of static electric and magnetic fields is presented, and then extended to time-varying fields. The concept of the eddy current shielding mechanism is discussed, whereby these currents produce E and H fields that oppose the fields incident on the conducting shield.

Skin depth and skin effect are described. Plane-wave shielding by a metal plate of infinite extent, but of finite thickness, is developed. Other shielding topics covered include volumetric shields, shielding of time- harmonic fields, E and H field shielding effectiveness, shielding of transient EM fields, closed metallic mesh shields, shielding of non-plane wave fields, and shielding between two circular loops.

Overall Book Evaluation

This book presents progressive, detailed mathematical developments of a relatively advanced nature, at a level beyond

Book Review
Continued from page 17

the usual undergraduate engineering curriculum (exceptions acknowledged). The mathematical developments should be useful to a potential reader interested in solving problems in advanced electromagnetics and applying relevant mathematical modeling and computational techniques. The book should be of interest for anyone interested in component and system response to conducted and radiated EMI for formulating EMC analysis and design. This also can be accomplished to some degree by reading this book and "get the bottom line" without fully having to follow the details of the mathematical developments. It is recommended for practicing engineers, scientists, and others interested in indepth electromagnetic model analysis and computational techniques.

The book is also recommended as a text or reference book for an advanced senior or graduate level engineering course in electromagnetic computational analysis and modeling. An adequate number of interesting problems are provided at the end of each chapter, which reinforce the material in the text.

Reviewed by:
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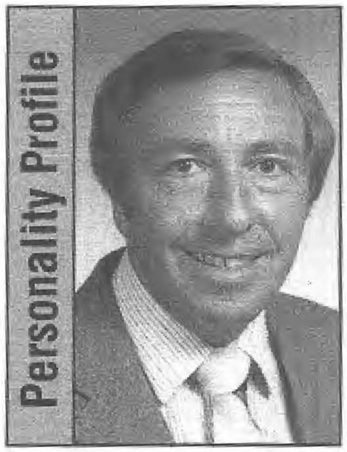


BILL DUFF
ASSOCIATE EDITOR

Barry Wallen is the Laboratory Director for Criterion Technology, a business unit of Fujitsu Computer Products of America. Criterion Technology is an EMC/EMI compliance laboratory specializing in design, troubleshooting and compliance testing to international standards.

Barry began his EMC career in 1988 when he became responsible for the regulatory compliance of products designed by the Intellistor Division of Fujitsu Computer Products of America. In 1991 he was given the responsibility for developing an EMC testing facility for FCPA. This has resulted in the creation of Criterion Technology. Over the past seven years he has worked as engineer, consultant, and manager.

Barry is a member of the IEEE, a past chair of the Rocky Mountain Chapter of the EMC Society and is the Chair for the 1998 IEEE International Symposium on Electromagnetic Compatibility, to be held in Denver, Colorado, August 24 through 28. He currently serves on three ANSI C63 subcommittees, SC - 1 Techniques and Development, SC - 6 Laboratory Accreditation/Conformity Assessment, and SC - 8 EMC Testing Standards for Electromedical Devices (EMD).


Barry Wallen

As the chair for the 1998 EMC Symposium, Barry would like to extend an invitation to join the EMC Society and the Rocky Mountain Chapter at this year's Symposium. Information about the Symposium can be found on the web at http://www.ball.com/aerospace/ieee_emc.html.

Barry and his wife Marti live in Boulder, Colorado. Their daughter Amanda is working on the west coast for a major IC manufacturer and their son Rob is finishing his junior year of an EE program at the University of Colorado. His spare time activities include the CU Parents Association Board and enjoying the Colorado outdoors.

IEEE FELLOW NOMINATIONS

At least three of our EMC Society members were nominated for IEEE Fellow Award this March. There may have been others that I did not hear about. The IEEE Evaluation Committee will study all of the nominations received, usually about 500, and make its recommendations to the IEEE Board of Directors later this fall. The approximately 125 candidates who are selected will then become IEEE Fellows effective 1 January 1999.

It is now time to begin the search for candidates for the next review cycle. The nomination, reference, and endorsement forms will be due to IEEE on or before 15 March 1999.

The IEEE Bylaw requirement for Fellow grade is as follows:

"The grade of Fellow recognizes unusual distinction in the profession and shall be conferred only by invitation of the Board of Directors upon a person of outstanding and extraordinary qualifications and experience in IEEE designated fields (including electrical engineering, electronics, computer engineering and computer sciences, and in the allied branches of engineering and related arts and sciences), who has made important individual contributions to one or more of these fields.

The year of election to the grade of Fellow is the year following affirmation action by the Board of Directors in conferring the grade of Fellow. The candidate shall hold Senior Member grade at the time the nomination is submitted. Normally the candidate shall have been a member in any grade for a period of five years or more preceding January 1 of the year of the election, however, the five year membership requirement may be waived for a Fellow candidate who has been engaged in professional practice (as needed to qualify for Senior Member grade) in a geographical area where, in the judgment of the Board of Directors, it was difficult to become a member previously, as evidenced by the absence of a Section previously and the recent formation of a new Section to cover that geographical area. In such case, membership of five years or more in a recognized local electrical, electronics or computer engineering society may be substituted for the five year requirement, when the nomination is submitted within four years after the formation of the new Section."

Please send me names and addresses of any potential candidates that you feel should be considered. I will appreciate any suggestions that you can provide.

William E. Cory
Chair, EMC-S Fellow Search Committee
4135 High Sierra
San Antonio, Texas 78228
Tele/Fax: 210 736 0714
E-Mail: gcory@swri.org

AWARDS/FELLOW WEB SITE DEBUTS

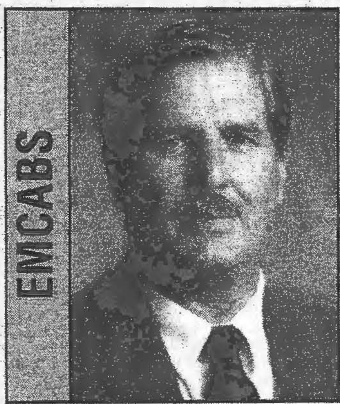
IEEE Awards/Fellow Activities has launched a Web site, www.ieee.org/awards, to promote the IEEE Awards program, encourage nominations, and recognize recipients and sponsors. The site also helps meet one of the IEEE strategic goals–to increase the visibility of the IEEE Awards/Fellow program.

The new site includes explanations of the IEEE medals, corporate recognitions, honorary membership, technical field, service and prize paper awards, and the Fortescue Fellowship. It also highlights the sponsors, lists past recipients with citations for each honor, and provides interactive electronic access to nomination forms. In addition, the site features the 235 members elected as 1998 IEEE fellows.

From the site, members can obtain forms and submit major award nominations via email. Members also can obtain Fellow Kits for the 1999 elections until 15 March, but Fellow nomination forms must be submitted in hard copy by first-class mail or express carrier.

The debut of this site on the Web represents a massive effort by Awards/Fellow staffers Joan Muzzio and Sandy Schumacher with the help of Reginald Hands and Sandy McConville, both of Information Technology.

Contact:
Marsha Longshore
732.562.6824
m.longshore@ieee.org



WILLIAM H. McGINNIS
ASSOCIATE EDITOR

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

EMCAB COMMITTEE

Mike Crawford, Consultant
Bob Hunter, Consultant
Prof. Fujiwara, Nagoya Inst. of Technology
Sha Fei, EMC Research Section,
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"HOW CAN I GET A COPY OF AN ABSTRACTED ARTICLE?"

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 or 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, 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.

Also, the steering staffs of the Japan Technical Group and the EMC Japan Tokyo Chapter have offered to act as a central point for requests of papers abstracted here. Most of the papers will be available in Japanese only. Abstracts of papers from EMC Japan will be clearly identified. The steering staff will assist in routing your request to the author(s) but will not translate the papers. The contact person is Professor Osamu Fujiwara, Department of Electrical and Computer Engineering, Nagoya Institute of Technology, Gokiso-Cho, Showa-ku, Nagoya 466, Japan. E-mail: sfujiwara@odin.elcom.nitech.ac.jp

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

As the EMC Society becomes more international, we will be adding additional worldwide abstractors who will be reviewing articles and papers in many languages. We will continue to set up these informal cooperation networks to assist members in getting the information or contacting the author(s). The library at Southwest Research Institute, 6220 Culebra Road, San Antonio, Texas, 78228-0510 has agreed to catalog, shelve, and have available for interlibrary loans proceedings from symposia and meetings which are donated to the library. Any such donations can be sent to my attention at my address shown on page 3 of this Newsletter. I will review them for suitable articles and then forward them to the SWRI library. We are particularly interested in symposium proceedings which have not been available for review in the past. Thank you for any assistance you can give to expand the EMCS knowledge base.

EMCABS: 5-3-98

DEMONSTRATION OF THE ACTIVE INTEGRATED AMP ANTENNA FOR MICROWAVE POWER TRANSMISSION
Yoshiharu Kido, Hidehisa Shiomi, Yoshihiro Naruo, Susumu Sasaki, Nobuhito Nagatomo, Tadashi Takano, and Shigeo Kawasaki
EMC-Japan meeting at Akita University, Akita
October 27, 1997, EMCJ97-71

Abstract: In this report, design, fabrication and experimental results of active integrated antenna arrays for microwave power transmission in the space solar power satellite system were described. An active integrated antenna and a two-element antenna array in a multi-layered fashion with an amplifier and a patch antenna were made. Then, from these results, the fundamental functions of these antennas such as amplification or antenna pattern were confirmed.

Index terms: Solar power satellite, microwave power transmission, active integrated antenna.

EMCABS: 6-3-98

AN EXPERIMENTAL STUDY ON THE WAVE ABSORBER USING EPOXY-URETHANE RUBBERS MIXED WITH CARBON PARTICLES AT 60 GHz FREQUENCY BAND
Osamu Hashimoto, Noriko Yoshioka, Kaori Nakamura, and Tetu Sou
EMC-Japan meeting at Akita University, Akita
October 27, 1997, EMCJ97-73

Abstract: As the practical use of the Automobile Collision Warning System, it is required that the wave absorber for proof of environment at 60 GHz frequency band, which is fitted up with guardrails, protects the Radar system from an interference due to unnecessary wave reflection. In this paper, we pay our attention to epoxy-modify urethane rubbers which has been studied at 60 GHz frequency band. In realizing this type wave absorber, at first we tried to measure the more precise complex permittivity of this material using the absolute value of reflection coefficient. As the result of this measurement, we present the new design chart, and high efficient wave absorber is realized using this material.

Index terms: mm-wave absorber, 60GHz frequency band, epoxy-modify urethane rubbers

PERFORMANCE OF TDMA RADIO COMMUNICATION SYSTEM WITH BCH CODING UNDER MAN-MADE NOISE ENVIRONMENT

EMCABS: 07-3-98

Kenichi Mizugaki, Shinichi Miyanoto, and Norihiko Morinaga
EMC-Japan meeting at Science University of Tokyo, Tokyo
November 26, 1997, EMCJ97-74

Abstract: It was already reported that the noise emitted from microwave oven significantly degrades the performance of digital radio communication system. In this paper, in order to obtain a good error performance under microwave oven noise environment, we employ the BCH error correction coding scheme and investigate the performance improvement achieved by BCH codes. Numerical results conclude that, by applying BCH coding and bit interleaving schemes, the performance of digital radio communication system can be greatly improved. Moreover, we also take a frame structure of TDMA-TDD into account and discuss the interleaving method which achieves much performance improvement with short decoding delay.

Index terms: Microwave oven noise, error correction coding, interleaving, 9/4-shift QDPSK, TDMA-TDD

PROPOSAL OF RADIATED IMMUNITY TEST METHOD USING ELECTROMAGNETIC FIELDS OF LOW SPEED ROTATION

EMCABS: 08-3-98

Kimitoshi Murano, and Yoshio Kami
EMC-Japan meeting at Science University of Tokyo, Tokyo
November 26, 1997, EMCJ97-75

Abstract: A new method of radiated immunity test applying electromagnetic fields of low speed rotation is described. The main purpose of this method is to find out the weak points of equipment under test for radiated immunity. Two different double-sideband waves are indispensable for the generation of rotating electromagnetic fields. To generate those waves accurately, a new technique using a delay line instead of a balanced modulator is proposed. Experimental confirmation of basic properties are made for a prototype of orthogonal loop antennas.

Index terms: Radiated immunity test method, electromagnetic fields of rotation, double-sideband wave, orthogonal loop antennas

ABSORBED POWER AND RADIATION POWER IN TWO DIMENSIONAL LOSSY CYLINDRICAL MODEL

EMCABS: 09-3-98

Kazuyoshi Uchida, Takashi Nakamura, and Shinobu Tokumaru
EMC-Japan meeting at Science University of Tokyo, Tokyo
November 26, 1997, EMCJ97-81

Abstract: Portable telephones were spread remarkably in recent years, while biological effects upon human bodies by the electromagnetic wave were feared. In this paper, a portable telephone system having two antennas were proposed to reduce the SAR in the human body. As the simplest model of the portable telephone and human head mode., two dimensional lossy dielectric cylindrical human head model near with two line currents sources are analyzed. As an example, it was shown that total SAR decreases about ten percents in the case of one line source and peak SAR decreases about a quarter of the case with one line source.

Index terms: Cylindrical human head model, SAR, electromagnetic biological effect, portable telephone, lossy dielectric cylinder

CHARACTERISTIC COMPUTATION OF TEMPERATURE-RISE INSIDE REALISTIC HEAD MODEL FOR 1.5GHz MICROWAVE FAR-FIELD EXPOSURE

EMCABS: 10-3-98

Masaaki Yano, Jianqing Wang, and Osamu Fujiwara
EMC-Japan meeting at Toyohashi University of Technology, Aichi
December 15, 1997, EMCJ97-85

Abstract: This paper describes the temperature-rise distribution inside two different realistic head models simulating the adult and infant for 1.5 GHz microwave far-field exposure, which has the safety level (1 mW / cm2) specified in an uncontrolled environment. The FD-TD (finite-difference time-domain) method was used to analyze both the SAR (specific absorption rate) and the temperature-rise. The ambient temperature and the distribution of a non-uniform temperature inside the head before the microwave exposure were considered. As a result, we found that the peak temperature-rise is somewhat lower for the infant in comparison with the adult and the peak temperature-rises in the both models are around 0.07 degrees centigrade. We also found that for the infant the temperature-rise averaged in each tissue except the eyeball is larger and the averaged temperature-rise in the brain is nearly three times larger. The latter finding is based on the fact that a localized hot spot appears inside the infant.
Index terms: Microwave, localized SAR, biological effects, realistic head model, temperature-rise

BRAIN-EQUIVALENT SOLID PHANTOM AND ITS APPLICATION TO SAR ESTIMATION BY THERMOGRAPHIC METHOD

EMCABS: 11-3-98

Assiniboia Achene, At sushi Haze, and Koichi Ito
EMC-Japan meeting at Toyohashi University of Technology, Aichi
December 15, 1997, EMCJ97-86

Abstract: A lot of phantoms have been proposed as the human head model for experimental estimation of the interaction between the human head and electromagnetic fields around. In this paper, a solid phantom is introduced as the human head model realizing the same relative dielectric constant and conductivity as brain tissue. This brain-equivalent solid phantom makes it possible to accomplish highly reliable and precise estimation of specific absorption rate (SAR) in biological tissue. Brain-
equivalent solid phantom models of cubes and spheres are fabricated. Measurements are performed to estimate SAR in the human head modes exposed to microwave sources by using the thermographic method.

Index terms: Brain-equivalent solid phantom, SAR, thermographic method, infrared emission

THE INFLUENCE OF BUILDINGS ON MOBILE RADIO WAVES PROPAGATION IN AN URBAN AREA

EMCABS: 12-3-98

Paul Selormey, and Yasumitsu Miyazaki
EMC-Japan meeting at Toyohashi University of Technology, Aichi
December 15, 1997, EMCJ97-89

Abstract: Detailed characterization of radio propagation channel is a major requirement for successful design of mobile communication systems. In this paper , mobile radio channel characterization process based on the FDTD method is presented. The merits and demerits of the currently used methods, namely impulse-response method and ray-tracing methods are briefly discussed. The total field formulation of the FDTD method is discussed. The simulation model consists of a main street with six concrete buildings. The wave propagation patterns in the whole channel and the received signals at some line of sight and out of sight locations are presented.

Index terms: FDTD method, propagation characteristics, wave scattering, mobile radio waves

EMC Standards Activities
continued from page 14

Shielding Test Fixtures for Frequencies from 1 Hz to 10 GHz — PAR approved in March

We would like to thank Dale Sventanoff from Lindgren RF Enclosures, Dr.Jose Perini (retired) and Hugh Denny (retired) for their chairing and making happen Standards 299, 1128, and 1302, respectively. They will receive a much deserved certificate of appreciation at our Denver symposium awards banquet.

Finally, there is a particular IEEE Standards Collection on Electromagnetic Compatibility—1996. This collection was compiled by Ed Bronaugh and Don Heirman of the EMCS Standards Committee. It is published by the IEEE Standards Office and contains 32 EMC-related standards including most of the above standards (the remaining non-included EMCS standards will be included in the 1999 edition of the Collection) as well as those EMC-related standards from ANSI ASC C63, Antenna and Propagation Society, Industrial Applications Society, Communications Society, and Power Engineering Society.

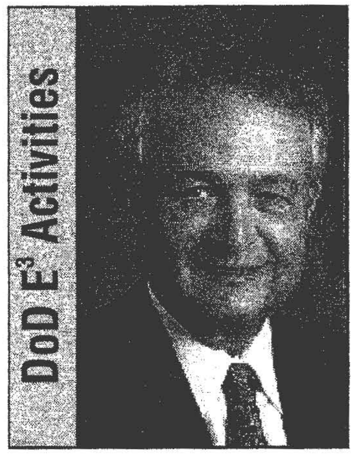
For ordering information for this "must have" collection, email to:

customer.service@ieee.org

and ask for document SHSH94329-NZU at the IEEE member price of $250.00.

Finally, in the future we plan to highlight various standards activity as well as the SAC activity in the Newsletter. Stay tuned for the latest. If you are interested in joining a working group (all of the above standards and committees are in need of volunteers to maintain and write their product), email to Don Heirman on d.heirman@worldnet.att.net. He will see to it that the appropriate working group chair for the standards operation or the representative for the SAC gets your name to further your contact and participation.

Don Heirman
VP for Standards and
Chairman of the Standards Committee



BOB GOLDBLUM
ASSOCIATE EDITOR

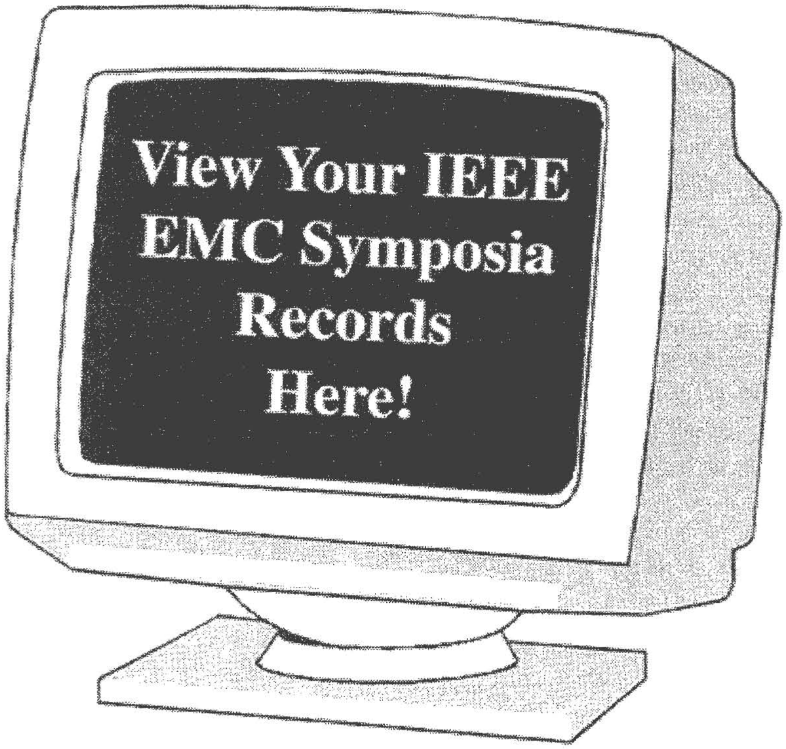
The DoD continues to be quite active in E^3 events. As I prepare this article, I am also preparing to attend the various one-day Service meetings and the 4-day DoD E^3 Program Review being conducted during the week of April 6 in Orlando, FL. Over 200 DoD and contract support personnel will be attending this annual meeting. Details of the meeting will be provided in my next article.

The NATO Special Working Group (SWG) on Maritime Electromagnetic Environmental Effects (SWG-10) will be participating in the 14th International Wroclaw Symposium and Exhibition on EMC scheduled for June 23-25, 1998. U.S. members of the SWG-10 will be presenting technical papers on Spectrum Management programs. A separate technical session has been set aside for the NATO segment. This is part of the overall Partners for Peace program which NATO is pursuing as Poland, Hungary, and the Czech Republic join the North Atlantic Treaty Organization.

In a recent reorganization, the Joint Spectrum Center (JSC) has been moved under the Defense Information Systems Agency (DISA). This has resulted in the establishment of an Office of Spectrum Assessments and Management (OSAM) in DISA which is headed by Mr. Frank Holderness. More information will be forthcoming on this new spectrum office as it becomes available.

Naval Air Systems Command (NAVAIR) is sponsoring an E^3 and Lightning Conference in San Diego, CA on May 18-21, 1998. For a complete program, contact Ms. "Mike" Jakubec at 757-499-9632.

MIL-HDBK-237B has finally been approved and is published. This handbook provides the program management guidelines for E^3. As a handbook, its use is not mandatory. However, it is expected to receive wide circulation and application. Copies may be obtained from the Defense Printing Service, 700 Robbins Ave., Philadelphia, PA 19111, Tel. 215-697-2179.



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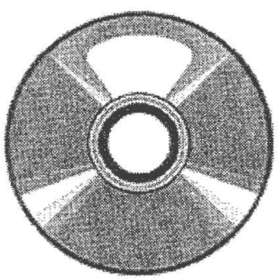

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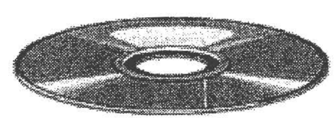

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Calendar

EMC Related Conferences & Symposia

1998

June 9-11
Sponsored by the Electronic Representatives Association (ERA) and the IEEE with the cooperation of the EMC Society
IEEE NEPCON EAST/ ELECTRO '98
Bayside Exposition Center
Boston, MA
For information about attending or exhibiting, call 1.800.467.5656 or fax 203.840.9656

June 14-19
11TH INTERNATIONAL CONFERENCE ON HIGH-POWER ELECTROMAGNETICS: EUROEM '98
Tel Aviv, Israel
The Secretariat Euroem '98
Tel: 972.3.5140000
Fax: 972.3.5140077
e-mail: euroem98@kenes.com

June 15-19
Organized by the Naval Surface Warfare Center, Dahlgren Division, at their facilities in Dahlgren, VA
REVERBERATION CHAMBER TESTING THEORY/EXPERIMENT SHORT COURSE
Mike Hatfield
540.653.3451

June 23-25
Organized by The Association of Polish Electrical Engineers, The Wroclaw Technical University, and The Institute of Telecommunications
14th INTERNATIONAL WROCLAW SYMPOSIUM AND EXHIBITION ON ELECTROMAGNETIC COMPATIBILITY
Wroclaw, Poland
Mr. W. Moron
Tel: +4871.728812
Fax: +4871.729375
E-mail: emc@ il.wroc.pl
www.emc98.wroc.pl

June 29 - July 1
Sponsored by the US EMC Standards Corporation in cooperation with the American National Standards Institute, Accredited Standards Committee C63 - Electromagnetic Compatibility (ANSI ASC C63)
ANSI ASC C63.4 WORKSHOP ON THE MEASUREMENT OF RADIO-NOISE EMISSIONS AND EMC MEASUREMENT UNCERTAINTY WORKSHOP
Includes Vendor Exhibition on EMC Products and Services on June 29
Sponsored by the Oregon Chapter of the EMC Society
Portland, OR
The 5th Avenue Suites Hotel (NEW location)
Exhibits: Jerry Page, 503.648.0275, jpage@nwemc.com
Registration: Janet O'Neil, 425.868.2558

June 29
Sponsored by the Washington DC/Northern Virginia Chapter of the IEEE EMC Society
EMC HARMONIZATION CONFERENCE
The Ritz-Carlton Hotel
McLean, VA
Leo Makowski, 703.494.1900
E-mail: haefely_trench_usa@compuserve.com

July 20
Sponsored by the SAE (Society of Automotive Engineers)
One Day Exhibition and Tutorial with Henry Ott on "The Ten Most Common EMC Design Problems & Their Solutions" PLUS "EMC Diagnostic Techniques"
The Novi Hilton, Novi, MI
Jennifer Bett
Tel: 724-772-8527
E-mail: bett@sae.org

August 3-5
Sponsored by The Canadian Radiation Society and AK Electromagnetique Inc.
FIRST INTERNATIONAL SYMPOSIUM ON POWER LINE TO MICROWAVE RADIATION
Montreal, Quebec, Canada
Dr. David Smith
Tel: 514.620.3717
Fax: 514.267.1144
E-Mail: kumar@colba.net

August 21 - 22
Sponsored by the US EMC Standards Corporation in cooperation with the American National Standards Institute, Accredited Standards Committee C63 - Electromagnetic Compatibility (ANSI ASC C63)
C63.4 WORKSHOP ON THE MEASUREMENT OF RADIO-NOISE EMISSIONS
Denver, CO (in conjunction with IEEE EMC Symposium)
Adams Mark Hotel
Janet O'Neil, 425.868.2558

September 14-18
Organized by the Faculty of Engineering University of Rome "La Sapienza" Rome, Italy
EMC '98 ROMA: INTERNATIONAL SYMPOSIUM ON ELECTROMAGNETIC COMPATIBILITY
Daniela Fioramonti
Tel: +39.2.777901
Fax: +39.2.798817
E-Mail: conferencesaei@aei.it

Week of October 5
MODE-STIRRED, ANECHOIC CHAMBER, AND OATS USERS MEETING
Air Force Research Lab, Rome, NY
Raymond W. Tucker, Jr.
315.330.3884
E-mail: tuckerr@rl.af.mil

IEEE Administrative Meetings 1998
(For information on all meetings, contact Janet O'Neil, 425.868.2558)

August 23
EMC Society Board of Directors
Adams Mark Hotel
Denver, CO

September 18
EMC Society Board of Directors
Rome, Italy

November 14
EMC Society Board of Directors
New Brunswick, NJ

EMCS Cooperating Symposia
U.K.: Biannually, even years, in September
Zurich: Biannually, odd years, in February
Wroclaw: Biannually, even years, in June

IEEE EMCS Symposia Schedule

1998 Denver, CO
August 24-28
Adam's Mark Hotel
Barry Wallen
303.682.6600

1999 Tokyo, Japan
May 17-21
S. Nitta
E-Mail: nitta@cc.tuat.ac.jp

1999 Seattle, WA
August 2-6
Westin Hotel
Bill Gjertson
425.393.2557
E-mail: w.gjertson@ieee.org

2000 Washington, DC
August 21-25
Washington Hilton
Bill Duff
703.914.8450

2001 Montreal, Canada
Montreal Convention Center
Christian Dube
514.653.6674

2002 Minneapolis/St. Paul
Hyatt Regency, Minneapolis
Dan Hoolihan
612.638.0250
E-Mail: dhoulihan@tuvps.com

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

An Institutional Listing recognizes contributions to support the publication of the IEEE EMC SOCIETY NEWSLETTER and the IEEE TRANSACTIONS ON ELECTROMAGNETIC COMPATIBILITY. Minimum rates are $500.00 for four consecutive issues of each publication during one calendar year (each publication is distributed quarterly). The above Instittutional Listings represent those contracted for 1998. Institutional Listings for 1999 will be solicited in December 1998. No agency fee is granted for soliciting such contributions. For inquiries related to institutional listings, please contact Janet O'Neil, Editor, phone 425.868.2558, e-mail j.n.oneil@ieee.org.