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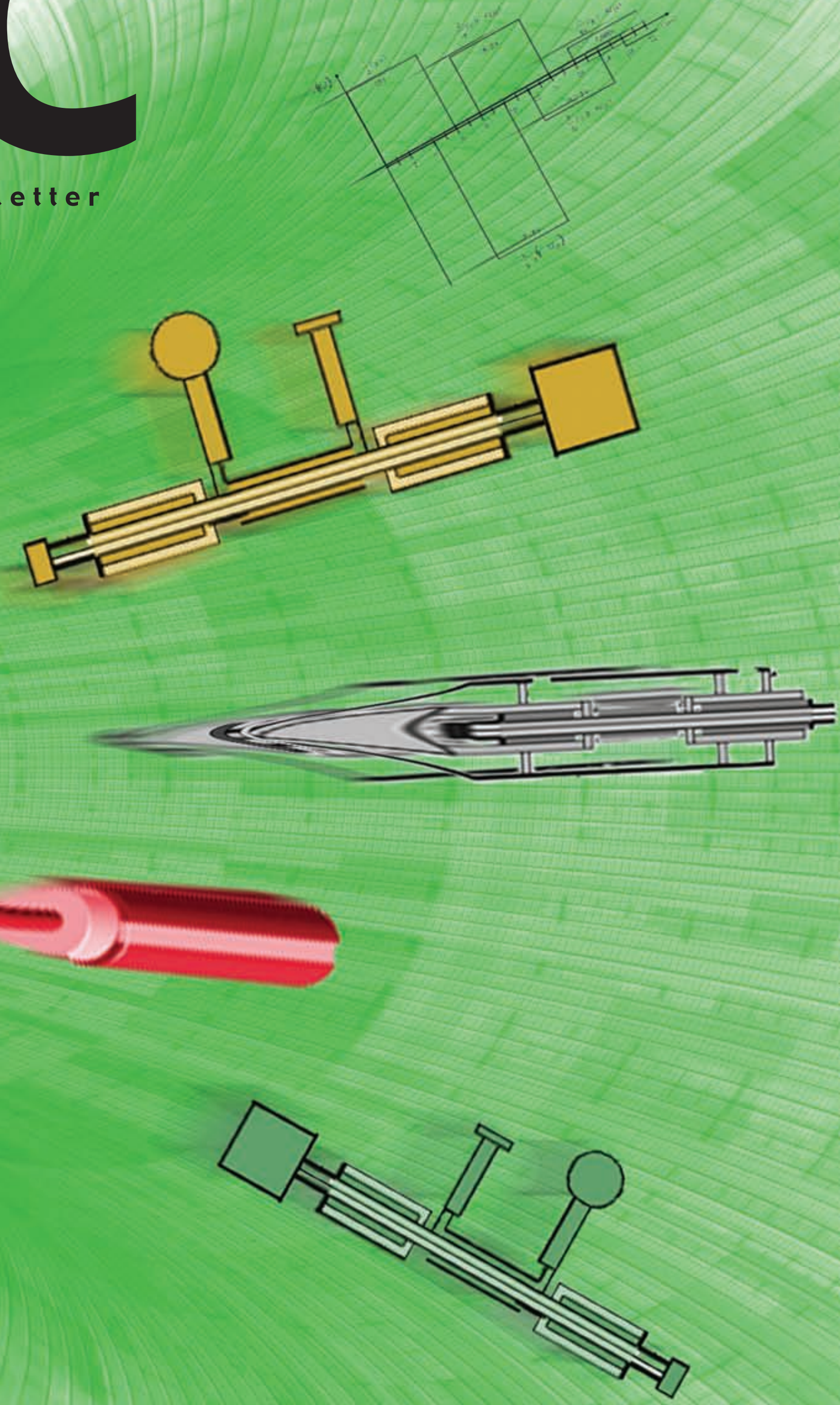
EMC

IEEE EMC Society Newsletter



Wave Tracing in Transmission Lines
by Clayton R. Paul

Transfer Impedance Measurements
by Bernard Démoulin and Lamine Koné

IEEE

Letter from the Editor

Newsletter Editor Janet O'Neil visits with EMC Society Board members, Professors Francesca Maradei and Vesna Roje (from left), at the Board's annual dinner held in Pittsburgh. For details on the Board meeting in Pittsburgh, see page 66.

New Technologies for the New Year!

In this issue, our EMC Society President, Francesca Maradei, talks about new technologies in our EMC community that are being addressed by special technical committees. These technologies include Smart Grid, Low Frequency EMC and Transportation System EMC. Smart Grid seems to have become a "buzz word" that everyone is increasingly talking about – and not only by engineers. Smart Grid will deliver electricity from suppliers to consumers by use of two-way digital technology to control power entering homes and buildings to save energy, reduce cost, and increase reliability and transparency. Low Frequency EMC addresses power quality in electric power systems associated with the increased use of electronics in renewables, electric vehicles, energy efficient technologies and Smart Grid applications. Transportation System EMC is concerned with the component and system design, testing and modeling of transportation systems, whether manned or unmanned.

There will also be a special issue this year of the *IEEE Transactions on EMC* addressing applications of nanotechnology in electromagnetic compatibility.

Read more about how the IEEE EMC Society is staying abreast of these emerging technologies by reading the President's Message on page 4. Then, consider getting involved! Details on who to contact are provided in this article.

Also in this issue we have two practical papers that should be of interest to the EMC community. These are featured on our cover image and you can find them starting on page 36. Industry expert Clayton Paul has contributed an excellent paper that provides a simple method

continued on page 19

FIELD OF INTEREST

The Field of Interest of the Electromagnetic Compatibility (EMC) Society involves engineering related to the electromagnetic environmental effects of systems to be compatible with itself and their intended operating environment. This includes: standards, measurement techniques and test procedures, instrumentation, equipment and systems characteristics, interference control techniques and components, education, computational analysis, and spectrum management, along with scientific, technical, industrial, professional or other activities that contribute to this field.

Newsletter Staff

IEEE EMC Society Newsletter Publication Schedule

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

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President's Message

Francesca Maradei, President, IEEE EMC Society

A Happy and Prosperous New Year to everyone! While I thought 2010 was a good year on balance, I am looking forward to a great year ahead and hope all of you have a wonderful 2011. The beginning of the second year of my presidency is a great time to review the Society accomplishments in 2010, and talk a little bit about the plans and initiatives for 2011.

EMC Society Accomplishments in 2010

The just concluded 2010 has been a vibrant and active year for our Society and we have been successful in our skills to look ahead and expand into new areas both technically and geographically.

As we look back on our initiatives and accomplishments over the last year, we can be proud of several things, including:

- Special technical committees addressing emerging technologies—Three new special committees that focus on emerging technologies have been established (more on this is coming later).
- Increased chapter development worldwide—We have welcomed two new chapters in South Africa and Nigeria, the first in Africa for our Society.
- Expanding EMC Symposia worldwide—The EMC Society Board Directors has approved holding two EMC Symposia in 2015, one International that will be held in Dresden (Germany), and one in Region 1–7.
- Increased Impact Factor (IF)—The EMC-Transactions has increased its IF from 1.083 to 1.294.
- Review of the EMC Transactions—Our periodical has successfully passed the traditional five year review by the IEEE.
- EMC Magazine—The IEEE has approved the transition of this Newsletter to an EMC Magazine that will be launched in January 2012.
- Procedure for technical co-sponsorship—A new approval process has been approved for providing EMC Society technical co-sponsorship to symposia (more details are provided in the following).
- Development and approval of the EMC Society Strategic Plan—After a three year effort, the EMC Society completed the development and approved the Strategic Plan (SP). (More on this will come in the next issue of the EMC Newsletter.)
- Creation of a Sections Coordinator position—The Section coordinator is responsible for: 1) being the liaison between Society Chapters and Sections, in improving relations, 2) coordinating Society local activities with Sections as well as local chapters, 3) supporting the formation of new chapters in Sections where there are no existing chapters and 4) supporting Society activities at Section events, including the Sections Congress event.

Special Technical Committees: Addressing Emerging Technologies

The ability of the EMC Society to look ahead and stay tuned with **new, emerging technologies** is of paramount importance to be abreast of the times.

As part of the IEEE-wide involvement in Smart Grid activities, the EMC Society established a *focus group on Smart Grid* and has dedicated to it significant resources and efforts. A **Special Technical Committee (SC1) on Smart Grid** has been established within the Technical Advisory Committee (TAC). This special committee is tasked with coordinating the EMC Society activity on providing EMC principles for organizations and associated documentation and specifications that address the efficient use of the AC power grid including the control of power entering a house or building. Such control may be from a meter at the point of power entry into these facilities to control incorporated into appliances and other electronic devices in these facilities. Such controllers may be sources of undesirable RF emissions and at the same time vulnerable to the RF environment, hence the need for EMC.

In addition, two further special committees reporting to the TAC were recently established:

SC2: Low Frequency EMC—This special committee is concerned with low-frequency EMC including Power Quality in electric power systems. The committee is focusing on application of fundamental EMC concepts also to low frequency conducted disturbances. EMC in power systems is expected to be increasingly important. This is due to increased use of electronics in renewables, electric vehicles, energy efficient technologies and Smart Grid applications.

SC3: Transportation System EMC—This committee is concerned with the component and system design, testing, and modeling/simulation of transportation systems. This includes both passenger carrying and non-passenger vehicles such as automobiles, trucks, trains/trams, and aircraft. Special emphasis is on the latest developments in high power and high voltage systems used for propulsion or control.

Whoever might be interested in joining the activities of these special committees is encouraged to contact one of the committee officers who can be found at http://ewh.ieee.org/soc/emcs/technical-committees.html.

Technically Co-Sponsored Symposia: A New Approval Process

Recognizing the importance of collaboration with other IEEE and non-IEEE entities in symposia activities, the EMC Society has created a **new formal process for granting Technical Co-Sponsorship** to other events. The revision of the approval process ended in 2010, and was intended to meet the new IEEE co-sponsorship policy that is requesting a much more tightly scrutinized process after several cases of hoaxed and computer-generated papers (occurring with other IEEE Societies).

This new process provides the balance between the desire to collaborate with other symposia and conferences (primarily, enhanced visibility and presence globally) and the need to ensure the quality of those events with whom the EMC Society is engaged. This process involves an evaluation by the Technical Advisory Committee (TAC) providing the technical point of view, and the entire Board of Directors (BoD) who approves (or disapproves) the request, while considering additional aspects as well.

Technical co-sponsorship is an arrangement whereby the IEEE EMC Society enters into an agreement with a technical event outside the EMC Society and, per IEEE policy, indicates **direct and substantial involvement by the EMC Society solely in the organization of the technical program**. The level of technical involvement will depend on the mutual desires of the EMC Society and the organizers of the event, but typically would include participation in the review and selection of some of the papers for the technical program.

Usually the EMC Society offers technical co-sponsorship on a case by case basis, e.g. if the conference is part of a series, every single event has to apply for the technical co-sponsorship.

The formal way toward a technical co-sponsorship is as follows:

- An organizer of a conference should submit the application together with the completed "Questionnaire for TCS Application" (available at http://ewh.ieee.org/soc/emcs/technicalsponsorship.html) to the Global Symposia Coordinator (GSC) of the EMC Society (email: GSC-EMC Society@ieee.org).
- The application is then evaluated by the EMC Society's Technical Advisory Committee (TAC) who has the responsibility for the technical programs of the Society. The level of involvement in the Symposium technical organization will be at the discretion of the TAC based upon inputs provided by the event requesting technical co-sponsorship.
- After TAC recommends approval, the GSC prepares the Memorandum of Understanding (MoU) in negotiation with the conference organizer.
- The application together with TAC recommendation is then brought to the attention of the EMC Society Board of Directors who will discuss the application and vote on approval.
- The EMC Society submits the MoU to IEEE HQ for review and final approval.

Technical co-sponsorship must be granted prior to the issuance of the call for papers by the event. This must happen in order to allow the event committee to use the IEEE and IEEE EMC Society logos in their call for papers and other advertising.

In order for this to occur, the request for technical co-sponsorship must be received by the EMC Society at least **five months** prior to the planned publication date of the call for papers. This required time allows for a review by the TAC, time to generate the MOU, time for voting by the EMC Society BoD, time for IEEE approval of the MOU, and time for both parties to sign the MOU so that the yes/no decision may be forwarded to the event committee two weeks prior to their planned publication date for the call for papers.

The TCS request form (available at http://ewh.ieee.org/soc/emcs/technicalsponsorship.html) must be completed in full to provide the TAC with the necessary information to evaluate the level of effort needed to support or deny support to the event. The Global Symposia Coordinator will provide guidance through the application process. Any questions should be sent to GSC-EMC Society@ieee.org.

At present, the EMC Society has the following list of co-sponsored conferences and technical meetings:

- ***SPI 2011 – 15th IEEE Workshop on Signal Propagation on Interconnects***, May 8–11, 2011, Naples, Italy
- ***2011 Asia Pacific EMC Symposium***, May 16–19, 2011, Jeju Island, Korea
- ***EMC Europe 2011***, September 26–30, 2011, York, UK
- ***EMC COMPO 2011***, November 6–9, 2011, Dubrovnik, Croatia
- ***IEEE COMCAS 2011***, November 7–9, 2011, Tel Aviv, Israel

Emerging Technologies: The IEEE Transactions on EMC Presents a Special Issue on Nano-EMC

As a result of increasing activity of the recently established technical committee TC-11 on Nanotechnology, the IEEE Transactions on EMC will publish a Special Issue on *"Applications of Nanotechnology in Electromagnetic Compatibility (nano-EMC)."* This Special Issue is intended to present recent research advances in nano-scale science and nanotechnology with applications of interest for the EMC community. The Special Issue is aimed to bridge the gap between nano-scale science and technology and EMC; to present new materials, devices and processes for EMC

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Chapter Chatter

Todd Robinson, Associate Editor

Into the Cold, By Mike Violette

The daffodils bend their faces skyward, but we remember winter…A thick sheet of sleet grips the ground and freezes wipers to windows. The winter has been brutish and, except for an occasional glimpse of Mother Sun, it is Yukon. Even when the snow stops falling there is no relief, the wind bending trees, rattling branches and the slick is thick and the wind can't knock the white stuff from the branches so it swoons mournfully through leaky windows. The dog won't stand outside long; but we all know that she's a city creature with a physique fit for couch, not a snow bank. This time of year harkens back to the last trip we made together to the Northern Territories in western Canada, flying in from DC, chasing the sun in the late afternoon to Seattle, jumping the border just north into Vancouver. There, we met with three local engineers—Tyler, Terry and Bill—who would accompany us north, and crowding our gear and persons into an eight seat puddle jumper out of Vancouver, we set down in a stiff cross wind onto the single runway at Prince George, an outpost town on the Trans-Canada/Yellowhead Highway. "The rental car will be parked at the terminal," the agent on the phone told me a few days before. "The keys are on the visor and the contract on the dash." OK. "Just fill it with gas when you're done and I'll send you a bill." Hmm. OK.We exited the gas-station-sized terminal, tended by a bored gate agent who was reading the local paper for the fourth time that day. In the lot, the cars all had electric plugs lolling out the front of their grills because if you don't plug in the crankcase heaters overnight, no battery and starter combination in the world will turn the frozen sludge smothering the crank.We unplugged the sedan and the reticent V8 turned over and we headed to the only hotel in town. Along the way, one of the veterans directed us to a quick pit stop: the local ABC retailer, where we loaded up on our own individual selections. "The nights are kinda long out here," Terry laughed, "and cold." "Ya, ya. And the men come out of woods in Spring to shower," Bill replied in a mock-Russian accent, and picked up his brown bag from the counter. "Let's go." West Coast Transmission, founded in 1949 by the late Frank McMahon, provided a few billion cubic feet of natural gas *per day* to the United States and the more populated East Coast cities of Canada. The pipeline, called the **big inch***, pushed the gaseous gold between remote pumping stations throughout the territory to hungry consumers south of the border. The stations were spaced at intervals of a few hours' drive. Our task was to make some measurements and take a look at a noise problem afflicting one of the stations. *The "big inch" referred to pipes that were 20 to 48 inches in diameter. In the larger branches, a man could crouch and walk a half a mile inside before he'd have to stretch. Along the big inch were two kinds of pumping stations featuring old technology and new, the first installed in the late 60s and the others, within the past few years. The first stop was at a large older station with pumps powered by V-12s, not your Jaguar sports-car variety, but freighter-sized boat engines adapted for the job and with cylinders large enough for a fit man. The machine's as big as a house. The newer stations were powered by jet turbines. If memory serves, the boat engines cranked out about 10,000 horsepower and the jet turbines roared 100,000 HP. The pump house with the V-12 had ten motors, all lined up in a row on a concrete deck. The room shook and the behemoths grumbled, thumping chest and rattling pelvis with enough motion to induce vertigo. To reach the spark plugs--two serving each piston--you needed to climb a ladder. Everything here was working fine. We made some measurements and shrugged our shoulders.The next pump station, powered by the turbine, was four hours away. We beat feet back to the hotel as the sun dove into the snowy plain, shot some pool and watched a few hours of national championship curling on the tube in the bar, a fascinating sport and the only one I know of that is played with a broom.The following morning we set out north of Prince George, driving through near-virgin forest and the only car on the road in either direction. Arriving at the earth-bound jet, whose insult was an ubersonic scream that pierced ear plugs and ear muffs, we set up our antennas and spectrum analyzer and mapped the space, collecting some data and performing quick checks of the control instrumentation: what the heck were we doing here? Outside, we packed up our gear and puzzled, "Where's the problem?" Tyler shouted over the whine of the machine, still cutting through at 80 dB although we were sitting in the car parked outside the building. "No problems here! This is just for reference. But we've got some noise at the *next* pump house. We've got the big V-12s there." He turned the car around in the parking lot and we headed away from the scream. "You'll see. The control feedback loop signals are bouncing all over the place. And we just installed new systems in both places." Back at the first stop everything worked fine. "Remember the lower quad-station?" Bill asked. "The first place…yesterday afternoon?" Yup. "Well, this next station is exactly the same: same layout, same engines, same control, same everything—or it's supposed to be." We drove while Bill and Terry chatted about the curling match. "You owe five loonies, Bill. Saskatoon's number one. Again." I'll pay ya in beer when we get back," Terry laughed. By mid-afternoon we arrived at the third location. Indeed, it was the same building, a large weather-beaten steel-paneled building that thrummed. "Let's go inside." Engine 3 was down and a technician was crouching down inside the crankcase. We looked over and he peered through the cylinder casing. Huge wrenches were laid out on the ground. I kicked

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one; it didn't move. Terry waved at the mechanic, who was wrestling with an enormous thrust-rod nut."Take a look over here," Terry motioned us to the wiring that fired the dual spark plugs that sprouted from the enormous heads. Not much different than a ginormous lawn mower engine. The wiring was tied to the natural gas supply lines that fed injectors on the heads—these babies ate what they were pumping. All was tied neatly back to an enormous distributor. Gray sensor cables were wrapped on the same array. We asked to see the sensor collection point. The shielded twisted pairs that carried sensor data were pulled neatly into the breakout box, same as the first place."Look at the shields," Norm said. We all looked down. There was the problem. "Two different guys wired these systems."What did Norm see?

Boston

A joint EMC and Power Electronics meeting was held on Tuesday, October 19, 2010 at EMC Corp in Hopkinton, MA. Nearly 20 members and guests attended the meeting. The speaker was Oliver Optiz of Wurth Electronics, Midcom Inc, a manufacturer of EMC and inductive components. The subject of the presentation was "Magnetics - Their Application in EMI and Power Electronics". The technical presentation covered new techniques for analyzing and solving radiated and conducted noise problems associated with today's complex board designs, as well as magnetic topics related to switch-mode power supplies. Specific topics covered were magnetic field basics, filtering and signals, insertion loss calculation, and filter topologies. For those who attended the presentation, Wurth Electronics provided a new design guide published by the company entitled, "Trilogy of Magnetics." The book can be reviewed via the following web link: http://www.web/online.com/web/emc/produkte_4/Neue_Trilogie.php

Oliver Optiz of Wurth Electronics with the Boston Chapter in October 2010.

Boston Chapter Chair Boris Schusterman (front left) presided at the October meeting.

Oliver Optiz of Wurth Electronics during his presentation to the Boston Chapter in October.

Chicago

Jerry Meyerhoff, Chapter Secretary, reports that the Chicago IEEE EMCS Chapter's Winter 2010 season started with its famous Oktoberfest event, wholly sponsored by ELITE Electronic Engineering in Downers Grove. Over 100 attendees enjoyed the hearty, traditional OktoberFest food and drink in the huge shielded room. Speaker Dr. William Radasky, IEEE Fellow and founder of Metatech, discussed High Power E-M Threats to the Power Distribution System. Dr. Radasky clearly and simply explained natural threats caused by solar emissions as well as man-made nuclear ionization. His analysis of the impact to the power grid and other electronic systems was compelling; particularly the photos of burned-out high voltage distribution power transformers and even insulators. It was comforting to learn that many of our traditional EMC analysis and mitigation techniques provide a good degree of protection if they are fully exercised.

Our November program was generously hosted at Shure Inc. in Niles, home to Programs Chair Tom Braxton and a new venue for us. Tom also invited the Audio Engineering Society Chicago Section and organized a complimentary pizza dinner sponsored by TEC-Rep.com which contributed to a great turnout of 85 people. Shure engineers Marty Reiling, Scott Brumm,

Chicago's OktoberFest Feast attracted 100 Chapter members to ELITE's shielded room.

Chicago Holiday Party event chair, Andrea Spellman (left), and member Louann Devine enjoy a joint turn at bocce bowling.

Roger Grinnip and Mike Moffit spoke on "Audio in an RF World" sharing their real-world experiences in designing solutions for wireless microphone EMC issues such as the infamous "GSM Buzz". In one case-study the microphone housing structure was resonant at the interfering source frequency; thus illustrating the importance of a systems-level design approach.

Our annual December Holiday party at "Pinstripes" was again organized by Programs Chair Andrea Spellman of Underwriters Laboratories and attracted over 30 participants. We enjoyed a spread of hearty flat-breads and veggies, Ray Klouda's famous Holiday Word Quiz and the popular bocce competition. Gift cards from a local electronic toy store were awarded to the top scoring bocce teams and the word game winners.

Treasurer Bob Hofmann organized our scholarship voting and happily announced a milestone, our 10th award winner, Cheng Zhang. He is a very qualified and deserving 4.0 EE Graduate Student at the Illinois Institute of Technology who is active in his IEEE Chapter and has industrial experience in RF design for cellular systems and particle accelerators.

We look forward to a busy 2011 led by our active board members, volunteers and commercial supporters.

Chicago's Tom Braxton (left) awards a speaker plaque to Bill Radasky at the OktoberFest.

In November, the Chicago Chapter held a joint meeting with AES at Shure Inc. with engineer Marty Reiling as speaker.

Chicago Chapter Chair Jack Black (center) checks Vickie Peter's Holiday Word Game entry at the Holiday Party.

Chicago Chapter Treasurer Bob Hofmann (left) awards the 10th scholarship to student Cheng Zhang.

Our monthly programs will include an added special February Engineering Week demonstration at IIT and our 13th annual May MiniSymposium organized again by Frank Krozel of EIA. Please check our website www.emcchicago.org for more information.

Croatia

Antonio Šarolić, Chapter Chair, reports that the IEEE EMC Croatia Chapter started the year 2010 with a new chair. Antonio Šarolić, PhD, Assistant Professor at the University of Split, picked up the chairman's gavel from Chapter founder and previous four-year chair, Ms. Vesna Roje.

Chapter activities in 2010 included a wide spectrum of events: technical, scientific, educational, public and social. Croatia's main yearly event, Symposium on Environmental Electromagnetic Compatibility, was held in September, in conjunction with the 18th International Conference on Software, Telecommunications and Computer Networks (SoftCOM 2010). The conference was held in Split and on the beautiful Adriatic island of Brač. The scientific and technical part of the Environmental EMC Symposium included 14 presented papers from various aspects of EMC, and four tutorials given by renowned experts: Elya Joffe (K.T.M. Project Engineering), Professor Frank Leferink (Thales Nederland), Dr. Sergey V. Tkachenko (Otto-von-Guericke University) and Professor Dragan Poljak (University of Split). The overall number of presented papers at the SoftCOM conference was over 110!

Evenings at the Symposium were spent in a more relaxed atmosphere enjoying the Adriatic in late summer: restaurants and wine tasting in the picturesque small town Bol on the island Brač (once famous

A focused audience at SoftCOM 2010 was evident by (in front row from left) Antonio Šarolić, Croatia Chapter Chair, Vesna Roje, and Dragan Poljak, all from the University of Split, Croatia. In the audience were Frank Leferink of Thales Nederland, Jacek Skrzypczynski from Wroclaw University of Technology, Elya Joffe of K.T.M. Project Engineering, and Sergey V. Tkachenko from Otto-von-Guericke University.

Zvonimir Šipuš (left), Head of the Department of Wireless Communications at the University of Zagreb, Croatia, and Antonio Šarolić, Croatia Chapter chair, from the University of Split, Croatia.

Elya Joffe giving a tutorial on "EMC Requirements Elicitation" at the Symposium on Environmental EMC, held in conjunction with SoftCOM 2010.

Frank Leferink giving a tutorial on "Reverberation Chambers" at the Symposium on Environmental EMC, held in conjunction with SoftCOM 2010.

as a small winemaking and fishermen city, now a tourist destination) and a social event with traditional dancing in the cellars of the emperor Diocletian's palace in Split, Croatia. The Chapter certainly looks forward to the 2011 SoftCOM conference that will also take place in Split and on one of the nearby Adriatic islands.

Earlier in the year, Chapter members took an active part at the Science Fair, a six-day public educational event, organizing educational presentations in the field of electromagnetics and radio communications. Posters and experiments were presented at the city center, trying to raise interest in engineering among the school children and general public. Throughout the year, some promotional activities were undertaken among students, seizing the fact that the Chapter Chair Antonio Šarolić also serves as the Student Branch Counselor of the IEEE SB Split. The benefits of IEEE and EMC Society membership were also promoted

A traditional dance at the cellars of the 1700 year old palace of the Roman emperor Diocletian, in Split, Croatia—the social event at SoftCOM 2010

during the Career Day at the University of Split.

Finally, in the last part of the year 2010, the Chapter welcomed the new feature of Distinguished Lecturer online seminars, which were used as an excellent basis for a pair of technical meetings. Greetings are extended from the Croatia Chapter to all EMC Society members. They are looking forward to see you at the EMC 2011 symposia!

France

The Chapter sponsored once again the French, "Colloque International et Exposition Sur la Compatibilité Électromagnétique" on April 7–9 in Limoges (France). This was the 15th edition of the Symposium and a great success with more than 100 presentations. The chairman of the IEEE France Section, Daniel Pasquet, offered an award for the two best student papers. The winners selected by the Scientific Committee were Fabien Adam and Denis Labrousse.

Germany

During November 10–11, 2010, the IEEE Germany EMC Chapter hosted the First Annual European Workshop on Intentional Electromagnetic Interference at the University of the Federal Armed Forces Hamburg. Over 40 EMC professionals and scientists gathered at this meeting to listen to and discuss 16 presentations in the fields of IEMI sources, modelling, coupling, and

Denis Labrousse is pictured receiving a symbolic cheque (which was materialized some time later) from André Berthon, chairman of the French Chapter, and the Chairman of the Symposium, Alain Reineix (from left to right).

Fabien Adam is shown receiving a symbolic cheque (which was materialized some time later) from André Berthon, chairman of the French Chapter, and the Chairman of the Symposium, Alain Reineix (from left to right).

German EMC Society Chapter members Stefan Dickmann and Markus Clemens listen with great interest to a presentation.

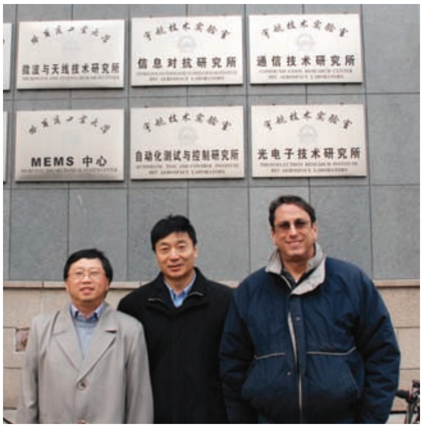
German EMC Society Chapter members listen while Stefan Potthast explains the susceptibility of generic IT-networks against IEMI attacks to the attendees of the First European Workshop on Intentional Electromagnetic Interference in Hamburg.

protection. Coffee breaks and dinner provided many opportunities to further exchange thoughts and opinions within an informal atmosphere. The workshop also was a benefit for the IEEE: Three attendees of the workshop enjoyed this IEEE event so much that, as a result, they signed up to become new IEEE members.

Harbin (China)

Two well-known IEEE EMC Society members, Professor Qiubo Ye and Mr. Mark Montrose, were invited to visit the IEEE Harbin EMC/MTT/AP joint Chapter from October 25 to November 1, 2010. Harbin is located in the Northeastern part of China. The chairman of the Harbin Chapter is Professor Qun Wu, who is with the department of Electronics and Communications Engineering, Harbin Institute of Technology (HIT). An English introduction about this university can be found in this link (http://en.hit.edu.cn/about/profile.htm). Professor Ye was an invited guest professor at HIT.

Mark Montrose is shown giving a presentation to the Harbin EMC Chapter in HIT.



Professor Ye, Professor Wu and Mr. Montrose (from left) outside a building in HIT National University Science Park which has many research centers, including the Microwave and Antenna Research Center headed by Professor Wu.

Mr. Montrose (left) and Professor Wu are shown in front of HIT's main building.

During the visit, Professor Ye gave several presentations on "Time Domain Behaviors of Ultra-Wideband Antennas" and "Numerical Methods for Electromagnetic Scattering by Large Structures." Professor Ye is currently a Project Leader and

Professor Ye answers a question from the audience following his presentation.

Professor Ye and Mr. Montrose are seen in the HIT Museum of Astronautics and Aerospace in front of an array of rocket models.

Research Scientist at Communications Research Centre and an Adjunct Professor of Carleton University, both located in Ottawa, the capital city of Canada. He is Chair of the IEEE EMC Society Standards Education and Training Committee (SETCom), Chair for the 2011 IASTED International Conference on Wireless Communications to be held in Vancouver from June 1–3, and General Chair for 2016 IEEE International Symposium on EMC to be held in Ottawa.

Mr. Montrose gave a series of presentations on "PCB EMC Compliance" and a number of EMC problems in the practical application of compliance. Mr. Mark Montrose is principle consultant of Montrose Compliance Services, Inc., a Senior Member of the IEEE and a current member of the Board of Directors of the IEEE as Division VI Director. He is also a long-term past Board member of the IEEE EMC Society plus champion and first president of the IEEE Product Safety Engineering Society. He has presented numerous papers based on sophisticated research related to printed circuit boards in the field of EMC at international EMC symposiums and colloquiums worldwide. Their presentations attracted sizable audiences including students and teachers in microwave and EMC and other research fields. After each of their presentations, there was a period of time for questions and answers. The presenters always answered questions in detail and made sure the answers were satisfactory. The audiences highly valued the opportunities to interact with these two world class experts. Both Professor Ye and Mr. Montrose were invited to tour the Microwave and Antenna Research Center headed by Professor Qun Wu in HIT and had nice discussions with Professor Wu's graduate students on research topics of interest. Professor Ye and Mr. Montrose, accompanied by Professor Wu, visited the HIT Museum of Astronautics and Aerospace which was recently established.

During their stay in Harbin, they had opportunities to tour the city and its attractions and were also treated to different Chinese cuisines. Mark said that every meal was thoroughly enjoyable. Mr. Montrose also had a good time traveling around Harbin. Accompanied by some students of Professor Wu, he travelled to Songhua River, Center Avenue, Sophia Church, Dragon Tower and other attractions in Harbin. Even though the weather was extremely cold, he enjoyed the beautiful scenery and took many pictures. Market places provided delicacies such as hot chestnuts (sold in Center Avenue) and Russian chocolate.

Oregon and SW Washington

Alee Langford, Chapter Vice-Chair, reports that the Oregon and SW Washington Chapter concluded the year with their annual Christmas social at Who Song and Larry's on the Columbia River. As the parade of Christmas ships sailed along, the attendees enjoyed Mexican food and laughter that was brought upon by all the wonderful white elephant gifts. The Chapter would like to thank all attendees, and members of the Chapter, for making 2010 such a great year.

Dave Britton (left) and Mark Briggs at the Oregon/SW Washington Chapter's Winter Social.

Ken and CeCe Westby enjoying themselves at the traditional Oregon/SW Washington Winter Social.

Sidney Chan of the Oregon/SW Washington Chapter was 'banking' on getting a great gift from the white elephant gift exchange.

As we welcome the New Year, plans are underway to confirm speakers for the monthly meetings. The first Chapter meeting will be February 16 with Bob Stern of Agilent. The topic is "Quality considerations in selecting a calibration supplier." The following month, we are pleased to announce that Bob Scully of NASA will be presenting on "EMI in Space." Meeting details and additional information can be found by visiting the Chapter website at http://ewh.ieee.org/r6/oregon/emc/

River Rock Valley (Illinois)

Jamal Shafii, Chapter Chair, reports that they held two EMC meetings in 2010, in March and October.

Zhong Chen of ETS-Lindgren was the speaker for March EMC meeting. The meeting was held at the Technology Center of Rock Valley College in Rockford. About 30 people attended the meeting. Zhong traveled from Austin, Texas for his presentation. He has chaired and spoken at the antennas and field probes workshops at the IEEE-EMC symposiums for the past several years.

Mr. Chen discussed two topics of importance for EMC testing: antennas and fields probes.

In addition to radiated emissions and immunity testing, EMC antennas are also used for site qualification testing and other applications such as exciting a reverberation chamber. Most EMC antennas are linearly polarized, such as log periodic, biconical antennas, and dipoles.

In most EMC applications, gain is interchangeable with directivity. Furthermore, gain also includes the mismatch factor between the antenna and its feed. VSWR, reflection coefficient, and return loss all describe the same physical phenomenon. Antenna factor (AF) is a function of antenna directivity, gain, VSWR and frequency. For a log periodic dipole antenna, the phase center of a log antenna moves from the back of the antenna boom to the front as frequencies go up. Thus, the measurement distance from the antenna to the device under test is unclear. It is often chosen at a fixed position as an approximation.

Unbalanced antennas have different responses depending upon which side is up when vertically polarized. This causes large measurement uncertainties. Baluns provide low impedance to differential current and high impedance to common mode current. For Biconical antennas, due to high VSWR at < 50 MHz, balun performance is important.

The speaker also discussed the calibration of different antennas, use of antennas for emission and immunity testing and site validation testing.

Field probes are broadband devices similar to RF power sensors. Isotropic probes consist of three orthogonal axes. Probes are designed to interact minimally with the environment.

The main components are: 1) Antenna elements which are resistively loaded, electrically short, and non-resonant, 2) Diode detector, and 3) C filtering where frequency information is lost.

For immunity measurements, we need to correctly size amplifiers for output power based on transmit antenna and test environment to confirm the spectral purity of the output signal. One needs to take modulation in mind as well and use the correct probe orientation in respect to the antenna to avoid resonance.

Zhong Chen of ETS-Lindgren presented at the March meeting of the River Rock Valley Chapter.

Many factors affect probe calibration and applications including signal purities, fixtures, isotropicity, linearity, and test setups. Care must be taken during each step.

Many thanks go to the EMC Society for covering speaker expenses through the Angel Program!

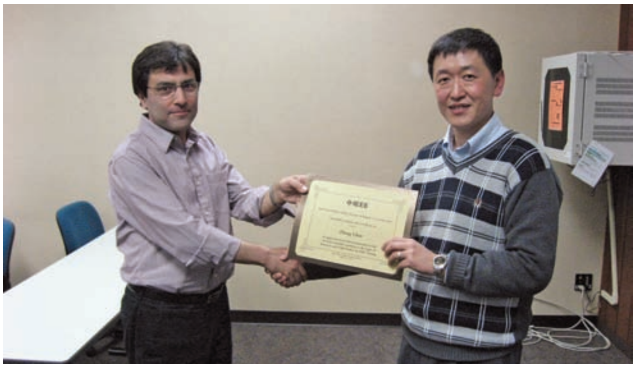
The speaker for the October EMC Chapter meeting was Professor Veysel Demir from the Department of Electrical Engineering in Northern Illinois University in Dekalb. The title of his presentation was, "Simulation of Electromagnetic Fields: The Finite Difference Time Domain (FDTD) Method and its Applications." The meeting was held in Rock Valley College in Rockford, Illinois. There were about 35 attendees.

Dr. Demir first discussed the basic formulation of FDTD from Maxwell's Equations. He then talked about modeling passive and active lumped elements in FDTD, near field to far field transformation, absorbing boundary condition

The October speaker, Veysel Demir (right), received a certificate of appreciation from Larry Wachowiak, Vice President of the IEEE River Rock Valley Section.

Pictured are attendees during the Q&A session at the March River Rock Valley Chapter meeting.

Attendees at the River Rock Valley Chapter meeting lingered following the presentation and asked many questions of the speaker.



Speaker Zhong Chen (right) receives a certificate of appreciation from River Rock Valley Chapter Chair, Jamal Shafii.

The October meeting of the River Rock Valley Chapter attracted many members and guests.

It was a full house at the October meeting of the River Rock Valley EMC Chapter.

The River Rock Valley EMC Chapter October speaker, Veysel Demir.

and scattering problems using FDTD. He illustrated some FDTD simulations such as scattering from dielectric spheres.

He then overviewed some ongoing applications of FDTD such as Earth/Ionosphere models in geophysics, wireless personal communications devices, phantom head validation, microwave detection of early stage breast cancer, and focusing plasmonic lens.

The full presentations can be found on our Section web site http://www.ieee.org/rrvs

Santa Clara Valley

On December 14, 2010, the Santa Clara Valley (SCV) EMC Chapter held a joint meeting with the SCV Product Safety and Engineering Society Chapter. Professor Ji Chen, ECE Dept., University of Houston, gave a presentation entitled, "EMC/EMI Issues in Biomedical Research."

The interactions between electromagnetic signals and biomedical systems lead to safety considerations for medical devices and patients. In his talk, Professor Chen presented some recent investigations on the EMC/EMI issues related to these scenarios. In particular, he discussed 1) safety evaluation for pregnant woman under walk-through metal detector, 2) thermal and temperature evaluation of pregnant woman models under MRI RF coil, 3) effects of implantable devices within human subject models under MRI coils, and 4) the interactions between vehicular mounted antenna and bystanders with implantable medical devices.

PHOTO BY JERRY RAMIE

Dr. Ji Chen of the University of Houston spoke to the Santa Clara Valley Chapter in December.

Dr. Ji Chen received the Bachelor's degree from Huazhong University of Science and Technology, Wuhan, Hubei, China, the Master's degree from McMaster University, Hamilton, ON, Canada, in 1994, and the Ph.D. degree from the University of Illinois at Urbana-Champaign in 1998, all in electrical engineering. He is currently an Associate Professor with the Department of Electrical and Computer Engineering, University of Houston, Houston, Texas. Prior to joining the University of Houston, from 1998 to 2001, he was a Staff Engineer with Motorola Personal Communication Research Laboratories, Chicago, Illinois. Dr. Chen has received the outstanding teaching award and the outstanding junior faculty research award from the College of Engineering at the University of Houston. He is also the recipient of an ORISE fellowship in 2007. His research group also received the best student paper award at the IEEE EMC Symposium in 2005 and the best paper award from the IEEE APEMC conference in 2008.

On January 11, Dr. William A. Radasky, President and Managing Engineer of Metatech Corporation, IEEE Fellow, P.E, spoke to the Santa Clara Valley Chapter regarding, "HEMP, IEMI and Severe Geomagnetic Storm Effects on Critical Infrastructures." Over the past 10 years there has been a growing awareness that the threat of high-altitude electromagnetic pulse (HEMP) from a nuclear detonation could be devastating to the commercial infrastructures of the United States, with special concern directed to the U.S. power grid. Interestingly, it has also been established that a severe geomagnetic storm from a solar event could also create significant damage to our power grid that could also take many years to repair. Finally, a new threat of intentional electromagnetic interference (IEMI) produced by electromagnetic weapons by criminals and terrorists raises a third specific electromagnetic threat.

PHOTO BY JERRY RAMIE

Dr. William Radasky spoke to the Santa Clara Valley Chapter in January.

Dr. Radasky's presentation briefly reviewed each of these threats and described their potential impact on the U.S. power grid. In addition, past work by the U.S. Congressional EMP Commission, the National Academy of Sciences and the International Electrotechnical Commission (IEC) was touched on. The talk closed with a brief summary of current actions being taken by the FERC, NERC and the U.S. Congress.

Dr. Radasky received his Ph.D. in Electrical Engineering from the University of California at Santa Barbara in 1981. He has worked on high power electromagnetics applications for more than 42 years. In 1984, he founded Metatech Corporation in California, which performs work for customers in government and industry. He has published over 400 reports, papers and articles dealing with electromagnetic environments, effects and protection during his career. He is Chairman of IEC SC 77C and IEEE EMC Society TC-5.

Dr. Radasky is very active in the field of EM standardization, and he received the Lord Kelvin Award from the IEC in 2004 for outstanding contributions to international standardization.

Singapore

Richard Gao Xianke, Chair of IEEE EMC Singapore Chapter, reports that Dr. Dominique Lesselier from CNRS France, delivered two technical talks to the Chapter entitled, "On Low-Frequency Electromagnetic Scattering by Simple Bodies in Conductive Medium, and Extensions to Subsurface Probing" and "MUSIC-Type Imaging From Asymptotic Formulations Within the Full Maxwell System and Additional Examples." The presentations were made at the National University of Singapore, on 28 October and 01 November 2010, respectively. A total of 24 attendees (seven were IEEE members), participated the seminars.

*Professor Zhizhang Chen, David from Dalhousie University Halifax, Canada, delivered a technical talk at the Institute of High Performance Computing of A*STAR, Singapore, on 30 November 2010.*

Participants listened attentively at Professor Madhavan Swaminathan's seminar on 15 December 2010.

Dr. Luk Arnaut from Imperial College, United Kingdom, delivered a series of four technical talks, "Electromagnetic Materials Modeling and Measurement," "Numerical and Stochastic Techniques for Modeling of Wave Propagation, Scattering and Radiation," and "Topics in Wireless Communication, Localization and Ranging." The talks were given at the Temasek Laboratories, NUS, and "Dynamic Random Fields & EM Reverberation Chamber with Applications to EMC Problems" at DSO, Science Park, respectively, during 22–24 November 2010. There were 71 participants for the four seminars (33 were IEEE members).

On 28 November 2010, the Singapore Chapter held a social event, "Chapter

Singapore Chapter committee members (from left to right), Dr. Junhong Deng, Dr. Richard Gao Xianke, Dr. Eng-Kee Chua, Dr. Chao-Fu Wang, and Mr. Keng Kok Khoo, gathered at Universal Studios.

Chapter members with their families participated the "Chapter's Family Day" at Universal Studios Singapore, Sentosa, on 28 November 2010.

*Professor Zhizhang Chen, David (right) appreciated a speaker gift of a tie with IEEE and EMC logos presented by Professor Er-Ping Li from IHPC A*STAR on behalf of the Singapore EMC Chapter.*

Family Day," for all Chapter members. The purpose was to provide a networking platform for all members thus enhance the relationship among members and to encourage members to spend their precious time with their families as an appreciation to the family's support. Further, the social event was held to celebrate the award of "Best Chapter for 2010" from the IEEE EMC Society. Thirteen Chapter members with 37 family guests joined the special social event which was held at Universal Studio Singapore, Sentosa. The thrilling, dazzling and fantastic attractions impressed all members, especially the kids, with an immersive entertainment experience.

On 29–30 November 2010, Professor Zhizhang Chen, David from Dalhousie University, Canada, delivered two technical talks entitled, "Method of Moments and Node-Based Meshless Method" and "Moving from Grid-based to Node-based Meshless Numerical Methods," respectively, with a total of 44 attendees, of which 19 were IEEE members.

On 6 December 2010, Professor Andreas Cangellaris from the University of Illinois at Urbana, USA, delivered an excellent talk entitled, "Electromagnetic Macromodeling – An Important Field Rich in Opportunities and Potential," at the Institute of High Performance Computing (IHPC) of A*STAR, Singapore. There were a total of 27 attendees (10 were IEEE members).

On 7 December 2010, Professor Qi-Jun Zhang from Carleton University, Canada, delivered a technical seminar, "Advances in Modeling and Optimization Techniques for High-Frequency Electronic Design," at Nanyang Technological University (NTU), Singapore. A total of 15 attendees (eight were IEEE members) participated the seminar.

On 10 December 2010, Professor Jun Fan from the Missouri University of Science and Technology, USA, delivered a technical talk entitled, "Source Reconstruction for IC Radiated Emissions from Measurements," at IHPC. There were a total of 12 attendees of which eight were IEEE members.

On 15 December 2010, Professor Swaminathan Madhavan from the Georgia Institute of Technology, USA, delivered a technical talk at IHPC as well, entitled "Multi-Physics and Multi-Scale Modeling of Structures for 3D Microsystems." A total of 13 people attended the presentation, six of which were IEEE members.

On 17 December 2010, Professor H. Nakano from Hosei University, Japan, gave a technical talk entitled, "Extremely Low-profile Spiral Antenna with PEC and EBG Reflectors," at NTU. There were a total of 24 attendees of which 15 were IEEE members. In conclusion, for the year of 2010, the Singapore Chapter organized a total of 37 distinguished lectures/technical seminars/workshops and three social events for Chapter members.

United Kingdom and Republic of Ireland

Paul Duxbury, Chairman, reports that during the EMCUK conference and exhibition on 12–13 October 2010, the Chapter once again ran a series of practical and computer based demonstration sessions akin to those at the International IEEE EMC Symposium. Well positioned in the exhibition hall, these informal table-top demonstrations showed a range of EMC concepts and principles, phenomena, effects, measurement methods, modeling approaches and simulation methods. As with previous years, there was a wide range of demonstrations including:

"The Principles of Operation and EMC Considerations for Railway Track Circuits" from Stuart Charles of E-Mead Consulting in which, with the aid of a model of a Depot Track Circuit, he showed the general methodology behind the EMC assessments that are undertaken to ensure that RSFs (Right Side Failures) and WSFs (Wrong Side Failures) are designed out of the system.

Alistair Duffy from De Montfort University, and a member of the IEEE EMC Society Board of Directors, gave a demonstration looking at IEEE STD 1597.1 on "Validation of Computational Electromagnetics Computer Modeling and Simulation" and how the Feature Selective Validation (FSV) method helps in quantifying comparative data to be used for validation.

Roy Ediss gave a few demonstrations over the two days including showing how analog and digital circuits behave in the presence of indirect electrostatic air discharge, and also showing how the near-field shielding ability of different materials varies depending on the properties of the material.

EMC

Letter from the Editor

continued from page 3

for rapidly sketching the terminal waveforms of a transmission line. We are grateful to Dr. Paul for his many outstanding papers contributed to the EMC Newsletter over the years. On page 42, you'll find the second paper of a series by Bernard Démoulin and Lamine Koné on the determination of the transfer impedance of cables and connectors, a topic that impacts many of our EMC members in their daily work. We have received many positive comments about the first paper in this series so we trust you will enjoy the second paper.

This is the last issue for Professor Canavero as our Technical Editor. I am sure you agree with me that his work as the Technical Editor has been excellent the past several years in providing high quality practical papers on interesting and diverse topics. Personally, I am very sorry to announce the end of his tenure as he was such a pleasure to work with over the years. I look forward to welcoming the new Technical Editor, Professor See Kye Yak of the Nanyang Technological University in Singapore, in our next issue. He comes highly recommended by Professor Canavero and will provide an avenue for the *EMC Newsletter* to the rapidly growing EMC community in Asia. I first worked with Professor See Kye Yak during the 2007 IEEE International Symposium on EMC. He was one of the speakers Clayton Paul invited to be on the program for the inaugural "Global EMC University" course held at our annual symposium. I enjoyed working with him then and look forward to renewing our friendship. You'll learn more about Professor See Kye Yak in the next issue of the *EMC Newsletter*. Please join me in thanking Professor Canavero for his tremendous support as Technical Editor for the *EMC Newsletter* and in welcoming Professor See Kye Yak.

You'll find many new contributions in this issue, such as the profile on the newly elected members to the IEEE EMC Society Board of Directors (page 59), the call for nominations to the IEEE EMC Society Board of Directors (page 62) as well as a review of the 2010 election process (page 58). You'll also find notice about changes to the EMC Society Constitution and Bylaws (page 77), big news from iNARTE (page 79) and information about the IEEE Technology Management Council (page 80). There's an interesting riddle in the introduction to Chapter Chatter (pages 6–7). If you can solve the riddle posed by Mike Violette, let us know!

In closing, we lost a giant member of our EMC community with the passing of Dr. Carl Baum. You can learn more about this legendary man on page 20. May he rest in peace. **EMC**

Completed Careers

Don Heirman, Associate Editor

Since the printing of the Fall 2010 issue of the EMC Newsletter, it saddens me to report that Carl Baum passed away. Many thanks to Bill Radasky who provided the following tribute to Carl.

I would like to continue to solicit your support in helping me receive the names of EMC Society members that have recently passed away. You can either forward them directly to your local Chapter chair, or if you don't know who that is, you can forward the names to me (d.heirman@ieee.org) or a member of the Completed Careers Committee directly, including Bruce Archambeault, Don Sweeney, and Andy Drozd. See page 3 of this Newsletter or the EMC Society website (www.emcs.org) for contact information of these committee members.

Thank you in advance for your assistance as we honor EMC Society members who have completed their careers.

Carl Edward Baum

In Memoriam of Carl Edward Baum (1940–2010)

His ideas kept flowing like a mighty river.

Carl Baum, mentor to many, took his last breath peacefully on December 2, 2010 in Albuquerque, NM. Carl was born in Binghamton, New York, on February 6, 1940. He received his B.S. (with honors), M.S., and Ph.D. degrees in electrical engineering from the California Institute of Technology, Pasadena, CA in 1962, 1963, and 1969, respectively. Following his B.S., he received his commission in the Air Force and was stationed at the Air Force Weapons Laboratory at Kirtland AFB, Albuquerque, NM. He served from 1963 until 1971 as an officer, and then accepted a civilian position and retired as a Senior Scientist in 2005. Since his retirement from USAF, he was a Distinguished Professor in the Department of ECE at the University of New Mexico.

During his military career, he was awarded the Air Force Research and Development Award and the Air Force Nomination to Ten Outstanding Young Men of America. In a career that spanned five decades, this remarkably creative engineer introduced innumerable new concepts in mathematics, electromagnetic theory and system design, many of which remain the standards of excellence today. From his earliest designs in EMP sensors and simulators to the latest developments in high-power microwave and ultra-wideband antenna and system design, Dr. Carl Baum's research has remained ever on the forefront of technology. His advances in EM theory have left an indelible mark and a lasting legacy on the technical world and have led to much of what we do today in EMP, HPM, and Target ID.

His scientific contributions were prodigious. He has written innumerable technical notes, articles, books, and presentations and was the editor of the Note Series that has published state-of-the-art research results for the past 45 years. He received the Richard R. Stoddart award of the IEEE EMC Society (1984), the Harry Diamond Memorial Award (1987), the AFSC Harold Brown Award (1990), and the Air Force Basic Research Award (Honorable Mention) in 1999. In addition, he has received five Best Paper Awards from the AMEREM/EUROEM Awards Committee, and he and his research team were honored as an AFOSR Star Team for 2000-2002 and received the first annual R. Earl Good Award from AFRL (2004) for their work in target identification. He was named an IEEE Fellow in 1984, an EMP Fellow in 1986, and the first Air Force Research Laboratory Fellow in 1996, but the honors that meant the most to him came in July of 2004 when he was bestowed with an Honorary Doctorate of Engineering by the Otto von Guericke University in Magdeburg, Germany during EUROEM 2004 and received a special honor from his colleagues in Russia for his lifetime of achievements. He received the IEEE John Kraus Antenna Award (2006) and also the Electromagnetics Award from the IEEE (2007). He was a member of Commissions A, B, & E of the U.S. National Committee of the International Union of Radio Science (URSI) and established the SUMMA Foundation which sponsors various electromagnetics-related activities including scientific conferences, publications, short courses, fellowships, and awards. He has led EMP short courses and HPE workshops around the globe. Dr. Baum was an active organizer of scientific conferences and workshops that brought together researchers from all over the United States and the world to share the latest in electromagnetic research.

When not putting his new ideas in mathematics and electromagnetics (EM) into new technical notes or organizing

continued on page 23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Quick, easy, permanent retrofit with EESeal® FilterSeals
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EMC Personality Profile

Bill Duff, Associate Editor

Ray Adams

Ray's son Joe is shown with his daughter Gabby on the ski slopes of Colorado.

Introducing Ray Adams

The EMC Personality for this issue of the IEEE EMC Newsletter is Ray Adams. Ray attended the College of New Jersey from 1977 to May 1981 and received a Bachelor of Science Degree in Electronic Engineering Technology. Ray was particularly interested in the RF/microwave classes taught by Dr. Allen Katz, the advisor for the local student chapter of the IEEE. Dr. Katz blended theory with practice and he was instrumental in getting Ray to join IEEE. Ray took additional courses in Electronic Engineering and Engineering Mathematics at California State University Fullerton and the University of California Los Angeles Extension.

Ray is the Chairman of the 2011 IEEE International Symposium on EMC. Chairing an EMC Symposium is a major responsibility and we all owe Ray hearty thanks for taking on this monumental task. I can appreciate what Ray is experiencing because I chaired the 2000 IEEE International Symposium on EMC in Washington, DC.

The Symposium is the highlight of the year for the EMC community. This year, the Symposium will be held on August 14 through August 19 at the Long Beach, California Convention Center. Dr. Bruce Archambeault, Chairman of the EMC Society Technical Advisory Committee (TAC) reports that the committee has organized an excellent Technical Program this year. Some of the highlights are:

- Henry Ott will teach the fundamentals of EMC based on his award winning book *Electromagnetic Compatibility Engineering*;
- The Global EMC University will be in its 5th year; and
- A Special Session on Signal Integrity is being organized by Dr. Howard Johnson.

The host hotel is adjacent to the convention center making it convenient for attendees and exhibitors. There are plenty of restaurants and attractions within walking distance from the convention center and there is also a free "Passport" bus service. You should plan to attend. I am sure you will find that it is a very worthwhile activity.

In addition to chairing the symposium, Ray is an EMC Systems Engineer with the Boeing Space and Intelligence Systems in El Segundo, California. Ray joined Boeing in November 2007. He performed analyses and derived unit and system level EMC requirements for scientific and communications satellites. He developed test methods for EMC qualification and developmental testing. He also mentored several mid-level to entry level EMC engineers and performed troubleshooting to resolve out of specification conditions.

From August 2004 to November 2007, Ray was a Senior Project Manager for Fischer Custom Communications. While he was at Fischer, he designed EMC test accessories for MIL-STD-461, CISPR and IEC test methods. He performed SPICE analyses to support design and trouble shooting efforts and provided engineering support to customers. Ray also authored product application notes and equipment manuals and presented training to Fischer lab technicians.

Prior to joining Fischer, Ray was an EMC Engineer for Hughes Space and Communications (Boeing Satellite Systems), a Senior Section Manager for TRW

Ray's family includes (from left) son Joe, wife Sylvia and daughters Nicole and Sarah.

Space and Defense, and a Senior Electronic Engineer for General Dynamics.

His assignments included designing, overseeing the installation and managing the operation a 14,000 square foot EMC Test Facility. As a result of Ray's efforts, the cost per unit of EMC qualification was reduced by 50% and made the lab competitive with outside test laboratories. Ray also performed high power microwave tests on various tactical missiles and weapon systems.

Ray is an active member of the IEEE EMC Society. He has been the Chairman of the Los Angeles IEEE EMC Chapter since 1993, and as mentioned earlier, he is chairing the 2011 IEEE International Symposium on EMC. He is also a member of the IEEE Microwave Theory and Techniques Society.

In addition to his interests in RF/microwave antennas, systems and measurement technology, Ray spends his spare time road cycling, snow skiing and scuba diving.

Ray and his wife Sylvia have three children: Joseph, Nicole and Sarah as well as four grandchildren: Noble, Jewels, Gabrielle and Robert.

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Completed Careers

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meetings, Dr. Baum enjoyed playing the piano and creating his own musical compositions, many of which have been heard at the biennial AMEREM and EUROEM conferences. His compositions can also be heard at one of the many churches in Albuquerque that host the annual concerts of the Albuquerque Symphony Orchestra and Chorus, and even at his own church where he used to be the choir director. Twenty-three of these compositions have been recorded.

Carl is survived by his two nephews and sister-in-law, George, Spencer, and Martha Baum of Albuquerque.

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Please Let Us Know

I would like to continue to solicit your support in helping me receive the names of EMC Society members that have recently passed away. You can either forward them directly to your local Chapter chair, or if you don't know who that is, you can forward the names to me (d.heirman@ieee.org) or any other committee member which can be found on the EMC Society web page (www.emcs.org) and by clicking on the "Committees" button in the left column. Thank you in advance for your assistance as we honor EMC Society members who have completed their careers.

A Message from the EMC Society Technical Advisory Committee Chair

By Bruce Archambeault

The Technical Program for the 2011 IEEE International Symposium on EMC in Long Beach, California will have something for everyone — from the novice EMC engineer to the advanced practitioner. The technical papers have enjoyed a reputation for extremely high quality in the past years, and EMC 2011 will be no different!

In fact, I am excited and pleased to announce that the EMC 2011 Symposium will have guest speakers who are the top leaders in their respective fields. This is a unique opportunity to see these technical giants in person!

- Henry Ott will teach the fundamentals of EMC based on his award-winning book, *Electromagnetic Compatibility Engineering*

- Dr. Howard Johnson will organize a special session on Signal Integrity

Technical papers will cover a wide range of topics including EMC Measurements, EMI Control, Computational Electromagnetics, Signal Integrity, High Power Electromagnetics, EMC Management, Electromagnetic Environments, as well as the newest technical topic areas for the EMC Society: Nanotechnology, Engineered Materials, and Smart Grid.

Remember, for the latest research in EMC – visit us in Long Beach!

Long Beach Convention Center

The Long Beach Convention & Entertainment Center is a spectacular multi-purpose complex - one of the few waterfront facilities nationwide - featuring more than 400,000 square feet of flexible exhibit and meeting space, two theaters, an arena and 34 meeting rooms. The glass concourse and lobby offer expansive views of the scenic harbor and downtown skyline.

Located in the heart of downtown Long Beach, the Center is within walking distance to first-class accommodations, shopping, dining, attractions, sightseeing along picturesque bays and 5 1/2 miles of sandy beach.

Harmonizing WAVES for EMC

EMC Society History

Daniel D. Hoolihan, Associate Editor,
Chair of the EMC Society History Committee

The first article in the History Section is the EMC Society Newsletter Review from 50, 25, and 10 years ago. This is an article that appears in every EMC Newsletter; in this issue we look at the Institute of Radio Engineers Professional Group on Radio Frequency Interference Newsletter – Number 15 – March – 1961, the IEEE Electromagnetic Compatibility Society Newsletter – Issue No. 128 – Winter – 1986, and the IEEE EMC Society Newsletter – Issue No. 188 – Winter – 2001.

The second article is a new attempt for us to highlight some important information from the early days of our Society—in the middle of the 1950s. During that time period the first attempts to organize "Interference Experts" were beginning in the United States, primarily on the East Coast with some activity on the West Coast in California. Rexford Daniels was an Interference Expert who began editing and publishing an informal Newsletter called the "Quasies and Peaks." He proceeded to publish 18 issues from March of 1955 until March of 1958. The Newsletters ranged in length from four pages to 12 pages and were full of industry news and articles. He usually wrote an editorial for each Newsletter.

We will reprint all 18 issues of "Quasies and Peaks" over the next 18 publications of the Newsletter; assuming the Editor-in-Chief agrees with that plan!

We will start with the March 1955 issue in this instant publication and go consecutively from there.

We are happy to report some very positive feedback on an article published in the Winter – 2010 (Issue No. 224) of the EMC Newsletter. Several readers remarked positively on The Saturday Evening Post reprint of "RFI: Invisible Killer." The subtitle of the reprint was "Does Radio Frequency Interference—today's electronic clutter of the air-waves—cause those mysterious plane crashes, missile failures and communications blackouts?" The article was written by Richard Haitch.

As explained in the preface to the article in the Newsletter, we had to find Mr. Haitch to secure his permission to reprint the article. We did find him and we then sent him a copy of the Newsletter in which we republished his article. True to form, Mr. Haitch, the professional writer and distinguished gentleman he is, responded with the following hand-written note:

"6/23/2010—Dear Mr. Hoolihan—Thank you for the copy of your magazine containing a reprint of an article I wrote in 1961 (!!). You have now proved conclusively that there is life after death.

Your tenacious detective work in reaching me by phone is impressive.

Best Wishes, Richard Haitch

Keep those cards and letters and e-mails coming! **EMC**

EMC Society Newsletter Review – 50–25–10 Years Ago

March – 1961 – Institute of Radio Engineers (IRE) Professional Group on Radio Frequency Interference (PGFI) Newsletter – Number 15 – (NOTE - The IRE PGRFI was the engineering organization that evolved into the present-day IEEE EMC Society)

The first article on the cover page of this Newsletter was titled "The RFI Program for the IRE Convention on Radio Frequency Interference at the Waldorf-Astoria on March 20, 1961." The "RFI" Program included the following presentations:

"Radiation Characteristics of Antennas at Other than Design Frequencies," by J. C. Pullara and J. P. Jones, Melpar, Inc., Falls Church, Virginia.

"The Relationship between Broadband Interference Measurements (dBMC) and Pulsed-CW Signals," by L. R. Pangburn, General Electric Company, Utica, New York.

"Shielding Enclosure Performance Utilizing New Techniques," by R. B. Schulz, Armour Research Foundation of Illinois Institute of Technology, Chicago, Illinois, and D. P. Kanellakos, Stanford University, Stanford, California.

"Graphical-Numerical Prediction of Tuned RF Amplifier Output Spectrum," by William (Bill) G. Duff, Jansky & Bailey, Inc., Washington, D.C.

"Radar Mutual Interference Problem," by C. Gager, A. Ruvin, and C. Fowler, Airborne Instruments Lab., Deer Park, Long Island, New York.

The cover page of the Newsletter also announced the formation of a San Francisco Chapter of the PGRFI. The Chairman was Peter Spence of Filtron, the Vice-Chair was Robert Lathrop of Cook Engineering, and the Secretary-Treasurer was Richard Davis of Lockheed MSD.

A third article in the Newsletter was titled "RF Interference Measurement Techniques Panel Discussion at New York Section Meeting." It said, "The monthly meeting of the New York Section held on November 2, 1960 at the Engineering Societies Building Auditorium was devoted to a panel discussion on 'Measurement Techniques in Radio Frequency Interference.' The panel members were Mr. J. F. Chappell of the U. S. Army Signal Research and Development Laboratories; Mr. Samuel (Sam) J. Burruano of the Filtron Co.; and Mr. A. R. Kall of Ark

Electronics Co. with Mr. B. Rosen of Polarad Electronics Corp as the moderator.

Mr. Kall led off the panel presentation with a summary of the interference measurement requirements contained in the military specifications emphasizing the problem areas such as reproducing near-field measurements, giving limits in terms of received microvolts or microvolts per meter, requirements for impedance stabilization networks, the measurement of broadband interference and the elusive impulse bandwidth figure, and the use of sine wave or impulse calibration of interference meters.

Mr. Chappell then spoke on competition for the RF spectrum and how it is complicated by unintentional radiation. He then gave a short history of the developments that led up to the present RF interference instrumentation from the Signal Corps viewpoint. This covered the reasons why they use peak measuring instruments with impulsive calibration to measure broadband interference in terms of microvolts per unit bandwidth and the use of antenna injection methods for radiated measurements. He concluded with a discussion of the Spectrum Signature requirement of MIL-STD-449 and the uses that will be made of this information.

Mr. Burruano then discussed some of the problem areas in the military specifications including the difference between the limits of 1,000 mc using a dipole antenna or a horn antenna and the new limits in effect and the difficulties in obtaining meaningful measurements above 1,000 mc.

Another article mentioned that "Electronic Industries" magazine in the December 1960 issue on page 40 reported the following interference event:

"RFI-Oddity - An airline at Chicago reported interference to its air-to-ground radio communication. The Allegna and Chillicothe monitoring stations of FCC 'fixed' the area of its source and local investigators traced it to a Michigan piano factory. There, a radio frequency heater was doing a good job of drying wood glue, but it was also putting out a hefty radio emission that could be heard hundreds of miles away."

The Editor of the Newsletter was Rexford Daniels, Monument Street, Concord, Massachusetts.

Twenty-Five Years Ago – Issue No. 128 – Winter – 1986 – IEEE Electromagnetic Compatibility Society Newsletter

Two cover stories highlighted this Newsletter issue. The first was the "Results of the Board of Directors Election Ballot" and the second was "1986 IEEE Conference & Exhibition on EMC."

The newly elected Board of Directors members included Richard T. Ford, H.R. (Bob) Hofmann, Mel Johnson, L. Gilda Haskins, Risaburo Sato, and James S. Hill. Their three-year term of office started on January 1, 1986.

The 1986 IEEE Conference and Exhibition on EMC was held on February 6, 1986 at the Grand Hotel, One Hotel Way, Anaheim, California. The theme of the conference was "Electromagnetics Today - EMC, FCC, EMP, ESD, Tempest and Fiber Optics." The conference had both a commercial and military electronics orientation. More than forty exhibitors were expected for the exhibition on EMC. Larry Caney, from Eaton Corporation, was the Chairman of the EMC Show.

Mr. Herb Mertel reported on Standards Activities in the Newsletter. He addressed a specific issue in his article, "United States and International Line Impedance Stabilization Networks (LISNs)." He discussed the CISPR LISN characteristics, LISN characteristics for the frequency range from 150 kHz to 30 MHz, LISN characteristics for the frequency range of 10 KHz to 30 MHz, and AC supply voltages (115 Volts AC versus 220 Volts AC).

Emerson Pugh, an IEEE Director, wrote an article on "Division 4 - Electromagnetics and Radiation - Key Developments of the Last Hundred Years." In commemoration of the IEEE Centennial, he met with presidents of the IEEE Societies in the Division of Electromagnetics and Radiation. He then reported on each President's thoughts and ideas on the efforts of the Societies since the founding of the IEEE in 1884.

Gene Knowles, the 1984 President of the EMC Society, said the following: "I consider Marconi to be the first EMC engineer. Four years after Marconi successfully demonstrated radio communication, he filed Patent No. 7777, which permitted more than one station to operate without interference. Since then, technology and systems have grown and become more sophisticated, Armstrong's super heterodyne receiver permitted more devices in a finite spectrum, and the advent of radar and pulse equipment in the 1940s and 1950s expanded the use of the spectrum and greatly increased the need for electromagnetic compatibility. The field was technically active, but professionally unorganized until 1957 when the IRE granted a charter to the New Professional Group on Radio Interference; the group later became the IEEE EMC Society. In the IEEE Centennial Year, the membership passed 2,500, and the first International Symposium was held in Tokyo, Japan. Now, 85 years after patent 7777, electromagnetic compatibility has become an internationally recognized discipline."

The EMC Personality Profile featured Julius P. Knapp of the FCC. William G. (Bill) Duff was the EMC Personality Profile Editor.

The Editor of the Newsletter was Robert (Bob) D. Goldblum.

Ten Years Ago – Issue No. 188 – Winter – 2001 – IEEE EMC Society Newsletter

The cover of this Newsletter had two articles on it; the first was the President's Message from Joe Butler, the President of the EMC Society, and the second article was a "COMAR Report" article.

Joe's message reported on the latest activities of the EMC Society Board of Directors including the election of Todd Hubing as the President-Elect. He mentioned that he had traveled to Paris to attend a Region 8 Division I and IV Chapter Coordination Meeting. He also gave a brief report on the IEEE Technical Activities Board (TAB) meeting held in November of 2000.

The COMAR Report was filed by Dan Hoolihan, the COMAR representative from the EMC Society. COMAR is a technical committee under the umbrella of the Engineering in Medicine and Biology Society of the IEEE. Two Technical Information Statements by COMAR were reviewed; one was on Magnetic Resonance Imaging (MRI) exposures and the second was on Cellphone Protective Devices which included a discussion of hands-free devices and shielding devices.

The Chapter Chatter Editor was Todd Hubing; his review of Chapter activities included a song about his friend, teacher, role model and mentor, Tom Van Doren. Todd said that "If there's one thing I've learned during my brief song-writing career, it's that people seem to appreciate my songs more when I don't sing them." (Associate Editor's Note – Having heard Todd sing some of his songs while accompanying himself on the guitar, I think he is being too humble – he actually sings quite well). Instead of repeating the words of "The Tom Van Doren Song" here, I recommend you just ask Todd to sing the song for you the next time you see him.

The Personality Profile was done on Larry Cohen. The Associate Editor for Personality Profile was Bill Duff.

The Editor of the Newsletter was Janet O'Neil. **EMC**

Quasies and Peaks – The Precursor to the EMC Society Newsletter

Before the Professional Group on Radio Frequency Interference (PGRFI) was formed in 1957, there existed a Newsletter that tied the Interference Experts together through the power of the printed word. The Institute of Radio Engineers (IRE) was where the Professional Group on Radio Frequency Interference (PGRFI) was first formed and that Group became the genesis of the IEEE EMC Society.

Rexford (Rex) Daniels was the Editor of this self-published Newsletter that started in March of 1955 and existed for several years. Rex was one of the Founders of the EMC Society and the first Editor of the Newsletter for the PGRFI; he served in that role until 1969. Rex Daniels was highlighted in the History Section of the EMC Society Newsletter in Issue No. 209 (Spring 2006). He was also honored in the EMC Society Newsletter Issue No. 133 in the Spring of 1987 when his obituary was featured on the front cover.

Specifically, Mr. Daniels was responsible for publishing 18 issues of *Quasies and Peaks*: (1) March – 1955, (2) April – 1955, (3) May – 1955, (4) June – 1955, (5) July-August – 1955, (6) September – 1955, (7) October – November – 1955, (8) December – 1955, (9) January – February – 1956, (10) March-April – 1956, (11) May – June – 1956, (12) July – August – 1956, (13) September – October – 1956, (14) November – 1956 – February 1957, (15) March – April – 1957, (16) May – June – 1957, (17) July-August – 1957, and (18) September – October – November – 1957 – March 1958.

In 1990–1991, Chet Smith was the Historian for the EMC Society; he put the *Quasies and Peaks* Newsletter on microfilm as well as the first 148 issues of the EMC Society's Newsletter. The Associate Editor has managed to reconvert the microfilm images to paper in order to read the Q & P Newsletter.

For purposes of historical preservation, we are going to try and reproduce the issues of the *Quasies and Peaks* newsletter in this section of the Newsletter. Since there are a number of issues and some are quite long, it will take a series of issues of the EMC Newsletter to do this.

So, this issue we will start with the March, 1955 *Quasies & Peaks* publication.

Quasies and Peaks – March – 1955 Interference Testing and Research Laboratory, Inc.; 150 Causeway Street, Boston 14 Massachusetts

EDITORIAL

THIS CAN BE PREVENTED

The following sequence of quotations, we believe, point up one of the glaring deficiencies facing the public and industry in trying to understand the importance of interference reduction, namely; the serious lack of authoritative information on which the public, the press, and general business can intelligently evaluate technical statements relative to the problem. Until such time as a real attempt is made by either the government, or by technical societies, to present the facts to the public, similar confusion can be expected.

Our interest in this matter was occasioned by several manufacturers asking us for further explanation and clarification of a news item which appeared in the Wall Street Journal, February 10, 1955, as follows:

"Interference Control" is the latest industrial problem raised by the automation era. Enemy "jamming" of complex electronic systems important to both defense industries and civilian production, could mean disaster in time of emergency, say Defense Department officials. They're studying the possibilities of radio interference with power generators, X-ray machines, office accounting equipment and "electronic brains."

As the news item in the Journal did not seem to jive with known facts, as we understood them, we thought we owed it to those – who had taken the trouble to inquire – to find out the facts. For the benefit of others who may have found themselves in the same situation, we are pleased to present the original sources.

The News item in the Journal was taken from the Armour Foundation "Industrial Research Newsletter," Vol. 5, Number 4, January 1955, which read as follows *"Jamming of complex electronic systems, upon which most of America's post-war weapons depend, by radio interference, could mean disaster in time of emergency, John W. Klotz, secretary of the advisory panel on electronics to the Assistant*

Secretary of research and development, Department of Defense, stated in a recent radio interference reduction conference at Armour Research Foundation. Other fields in which interference control is important are power generators, X-ray machines, lighting fixtures, office accounting equipment and even hand tools."

We are indebted to Mr. Klotz for extracts, relative to this news item, from his original address before the Symposium on Radio Interference Reduction at the Armour Conference, as follows:

"Looking at the total weapon development program collectively, the interference control problem has become a significant part of our defense effort. The PROBLEMS of interference, which we have accepted in the past as matters of momentary inconvenience or annoyance to the operator, will in the long run spell the difference between success and failure of our complex weapons systems. More than that - in many instances - the safety of the operator himself or the success of the mission will be involved.

It is also noteworthy that the interference control program extends beyond the association with the development and installation of the equipments for weapons control. Just by way of suggestion, I would mention power generators, X-ray machines, lighting fixtures, office accounting and computing equipment, hand tools - as examples of other important fields where the importance of interference control cannot be minimized. One electrical device generating unwanted interference can "jam" or reduce the utility of a communication circuit as effectively as the most strategically located enemy counter-measures jammer."

It is understandable how the reporter on the Wall Street Journal, with little or no knowledge of the subject of interference, could have tried to dramatize the Armour release. It is disconcerting, however, to see that this subject - which is of such importance to business and banking management - should continue to be presented in an inaccurate manner. This situation again confirms the immediate need for informed publicity on this vital problem. **THIS CAN BE PREVENTED**.

Leonard Thomas Paper

We are pleased to include, with this issue of Quasies and Peaks, a copy of a paper presented at the Fourth Conference on High Frequency Measurements, sponsored by the AIEE, IRE, URSI and the National Bureau of Standards, Washington, DC on 17 January 1955, titled "Radio Interference Measurement Techniques" by Leonard W. Thomas, Head, Radio Interference Section, Support Branch, Electronic Design and Development Division, Bureau of Ships, Navy Department.

List of Standards Organizations in 42 Countries

The American Standards Association, 70 East 55th Street, New York 17, NY has prepared a list of Standards Organizations, including names of Directors and addresses, in 42 countries throughout the world.

IRE Symposium on Spurious Radiation, List of Speakers

The list of speakers at the Spurious Radiation Symposium, to be held March 24th at the annual convention of the Institute of Radio Engineers, is as follows:

- Ralph Brown, Chairman
- A. V. Loughren, Hazeltine Electronics Corp. on Industry
- W. R. G. Baker, General Electric Company on Management
- George E. Sterling and E. M. Webster on FCC

Armed Services Reliable Electron Tubes

Electronic Design, February 1955 issue, reprints a list of reliable electron tubes included in military specification MIL-E-1B, as recently tabulated in the Information Bulletin of the Armed Services Electro-Standards Agency (ASEA).

New AC-DC Relay Meets MIL-I-6181

Hi-G, Inc., Bradley Field, Windsor Locks, Connecticut announces a new compact magnetic circuit design which permits four germanium diodes to fit inside the standard relay can of its AC-DC relay. Reduced interference noise is claimed to meet MIL-I-6181.

New Small Motor Radio Noise Filter

A miniature molded radio noise filter has been designed by the Potter Company of Chicago, to fit a small motor and gear assembly. It is a continuous-duty, dual-section filter, measuring 1 3/16 inches OD by 3/4 inch long, and serves as an integral part of the motor instead of as an external accessory. It exceeds Air Force specifications as applied to small motors, and meets metalized paper size with paper and foil reliability.

Electrolytically Deposited Copper Sheet for Interference Reduction

Henry E. Boegelli, development engineer, The American Brass Company, Waterbury 20, Connecticut, discussed the use of electrolytically deposited copper sheet in an article titled TVI ELIMINATION, the May 1954 issue of Plant Engineering, for the purpose of interference reduction.

The American Sisalkraft Corporation, 101 Park Avenue, New York 17, New York makes Copper Armored Sisalkraft in three weights - 1, 2, and 3 oz. per square foot. Different weights have been found satisfactory for different frequencies. Further details may be obtained by writing to 101 Park Avenue, NY 17.

A New Method for Measuring the Impedance of Stabilization Networks

The U. S. Naval Air Development Center, Johnsville, PA in Report No. EL-41016.59, prepared by C. S. Vasaka, describes a quick method for measuring the impedance of stabilization network AN/USA-2. Extracts from the report are as follows:

Problem

A. Several requests have been made by contractors to devise a practical method of measuring the impedance magnitude of the input of the Line Stabilization Network AN/US-2 used with Specification MIL-I-6181B. The main difficulty expressed was that impedance bridges are not readily available in all of the contractor's laboratories, also that it is not necessary to know R, L, and C separately.

Factual Data

B. The practical test setup of measuring impedance as outlined in this report was developed by AEEL. It gives an accuracy of about 5% and requires only a signal generator and a receiver used as a detector, both of which are readily available by contractors performing radio interference tests. It does not require an impedance bridge.

Conclusions and Recommendations

G. The test method described is satisfactory for use as a practical method to determine if the impedance Zn of the stabilization network AN/US-2 meets the requirements of Figure No. 12 of Specification MIL-I-6181B.

H. Within the limitations listed above, the test method described for measuring impedance magnitude can be used in many applications instead of the standard method requiring the use of an impedance bridge.

I. It is recommended that the test method described be accepted for use by contractors in the measurement of the impedance of the Stabilization Network AN/US-2 of Specification MIL-I-6181B.

Note: A copy of this report may be obtained by writing to NADC - attention Mr. C. S. Vasaka.

New Service Manual for Take-down Cell-type Screen Rooms

NADC Report No. EL-54122, dated 2 December 1955, titled "Service Manual for NADC-AEEL Take-down Cell-type Screen Room" is available to contractors and others through a request to NADC and showing interest involved.

BuDocks Develops Interference Trouble-shooting Meter

The Bureau of Yards and Docks, Code D-218, has developed a trouble-shooting meter for use in the frequency range from 500 kc to 210 mc, with sensitivities of the order of 10 uv to 1/10 volt. The meter was originally developed for checking ignition but can be used for purposes of detecting interference in electronic equipment, electric motors, hand tools, etc.

New Booklet on Electronic Weatherstripping and RF Gaskets

The Metal Textile Corporation, Roselle, N. J. is bringing out a new booklet titled "Suppressing Radio Interference with METEX Electrical Weatherstrip and RF Gaskets." It will be first distributed at the IRE show in New York.

New Method Developed to Bond Metals to Fiberglass

The American Fiberlast Company, Augusta, Maine, manufacturers of fiberglass boats, has developed a method of bonding metals to fiberglass. They are interested in knowing of any applications of value to the electronics industry, such as printed circuits, metal coated tubing, etc.

Motorola Reports on Tubular Capacitor Improvements

Motorola, Inc., in the November - December 1954 issue of the Motorola Service News, reports on tests made on three classes of paper tubular capacitors; Class (A) Conventional Paper Case; (B) Molded Phenolic Case; and (C) Ceramic Case. Among the advantages of Class (C) capacitors are:

1) Greater service life expectancy
2) Lower insulation resistance change versus humidity
3) Excellent shelf life
4) Improved marking readability
5) Reduction of End-Seal Pop-outs

Bibliography

Trouble Shooting in Advance by Proper Wiring Design by Gerald Weiss of the W. L. Maxson Corp, an article in Control Engineering, September 1954.

Discoidal versus Tubular Feed-Through Capacitors by Heinz M. Schlicke in the Proceedings of the IRE, February 1955.

Threshold Signals - Radiation Laboratory Series, Massachusetts Institute of Technology, Vol. 24, McGraw-Hill Book Company, N. Y.

Who's Who in Interference Reduction

George Rees, formerly with the Electronic Division of the Naval Gun Factory, Washington, D.C., is now assistant to R. L. Haskins, Code 965E, BuShips.

Robert McCabe, 1781 Bide-a-Wee Park, Columbus 5, Ohio. Radio Noise Measurement and Elimination, Field Intensity Surveys.

New Rochelle Tool Corp., 320 Main Street, New Rochelle, NY. Phone NE 2-5555. Certification of induction and dielectric heating equipment in accordance with FCC rulings.

EMC

Book Review

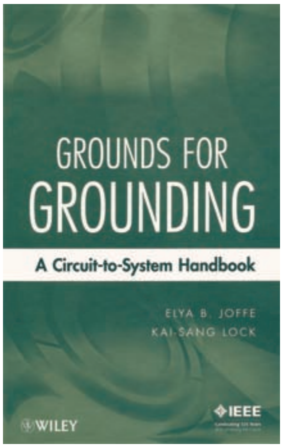
Antonio Orlandi, Associate Editor

Title: Grounds for Grounding
Author: E.B. Joffe and K.S. Lock
Publisher: John Wiley, 2010
ISBN: 978-0-471-66008-8

The topic of "grounding" in Electromagnetic Compatibility (EMC) is one of the most controversial in this engineering discipline.

The famous EMC saying, "Ground is a place for potatoes and carrots to grow," [1] gives a taste of the easiness with which this concept can be (or, much better, it is) misunderstood by today's engineers.

On June 4, 1999 I attended a seminar given by the main author of the book, Elya Joffe, at the University of Rome "La Sapienza" on the topic of grounding principles. The rigorous logic with which the concepts were given and the explanation of their physical foundations left an important mark on my technical background. Reading this book, I've found again these important characteristics of the knowledge sharing.



In this book of more than 1,000 pages, the authors demonstrate that grounding theory is not intuitive, but the design of any grounding system is founded on solid science. Achieving a functional grounding philosophy often results from battles of wits, perseverance – and the resolution of conflicts in between – intuition, engineering experience, and judgment.

A key objective of this book is to dispel the mystery associated with grounding. This is accomplished in the 10 chapters by providing a methodical approach for the design of grounding systems, from circuits through systems and up to platforms and facilities. The book, in my opinion, meets the above challenge by putting grounding into the proper perspective. It outlines a physical foundation for explaining the concept of grounding, founded on electromagnetic field theory, while providing insight into practical aspects of grounding system implementation, particularly as related to its interdisciplinary nature, extending from circuits to facilities. It is clearly demonstrated that grounding systems in facilities, systems, or circuits do, in fact, follow a consistent scheme.

The book begins in Chapter 1 by introducing the reader to the fundamental concepts pertaining to grounding, starting with a discussion of Maxwell's equations, particularly as they apply to the topic of grounding. Essential terms and concepts relating to real-world electrical circuit behavior are reviewed in Chapter 2.

Chapter 3 presents the basics of grounding, beginning with a discussion of the term "ground" and the different objectives of grounding.

Chapter 4 is one of the chapters I like the most. In an excellent logical sequence it provides an in-depth review of the fundamentals of grounding design. The key issue emphasized in this chapter is that the term "ground" actually relates to the concept of current return path, a key notion throughout the book. Chapter 4 discusses in detail the fundamental topologies of grounding systems and provides a novel yet practical systematic approach for planning grounding systems. The concept of "ground loops" is developed and solutions are presented. The implementation of the fundamental grounding architectures in large-scale systems and installation are further examined. Chapter 4 ends with grounding-related case studies.

Chapter 5 explains the principles of bonding. The approaches of achieving low-impedance connections between metallic surfaces and structures as a fundamental objective for meeting the desired grounding objectives are portrayed.

Chapter 6 describes in detail safety-related grounding concerns. Rationale for electrical safety grounding requirements is provided and safety grounding design principles in power distribution and lightning protection systems are presented.

Chapter 7 covers grounding in wiring and cable systems. One of the most controversial and misunderstood aspects of system grounding design stems from the question of cable shield termination ("grounding"). In this Chapter I've found, for the first time, a clear distinction between signal grounding and shield termination.

Chapter 8 provides the foundation for understanding the essential necessity of adequate grounding of EMI terminal protection devices (e.g., EMI filters and transient-suppressing devices) performance. The effect of acceptable versus objectionable grounding of such protective devices is clearly demonstrated.

In Chapter 9 (of some 250 pages) the application of grounding in printed circuit boards (PCBs) is discussed in depth, particularly as related to power conditioning and signal return paths. The question of grounding in mixed analog/digital circuits is also addressed. Novel and emerging techniques, associated with (AC) grounding structures, such as "high impedance surfaces" (HIS), also known as "electromagnetic band-gap" (EBG) are also introduced.

Chapter 10 leads the reader to the facility and platform levels. The design of integrated grounding systems in facilities is described. The complexity of and approaches to the integration of multiple subsystems into a larger system as related to grounding system design are discussed. It also expands the concept of grounding architecture design to the unique cases of mobile platforms, for example, tactical C^{3}I (command, control, communication, and intelligence) shelters, aircraft, space systems and ships.

The several appendices in the book are one of the key points of this book. They provide extensive supporting information and supplemental data, which will be of great use for the reader.

Appendix A provides a glossary of grounding-related terms and definitions, with references to their sources, particularly when derived from official international standards and codes. When several definitions exist for a term, they are all included, with reference to the context of their applicability. Appendix B lists commonly used acronyms employed throughout the book for easy reference by the reader. Appendix C presents commonly used symbols associated with variables referred to throughout the book. Appendix D presents a list of many grounding-related standards, specifications, and codes with their scope. Appendix E demonstrates the equivalence between Ohm's Law and Fermat's "Least Time" Principle, which is useful for understanding the reason why current selects a particular return path. Finally, Appendix F provides an overview of S-parameters and their application for the evaluation of grounding performance, particularly on printed circuit boards, extensively used in Chapter 9.

I am certain that this book, founded on fundamental physical principles on the one hand and on real-world, practical experience on the other, provides an excellent resource for achieving successful, cost-effective, and timely state-of-the-art designs of electronic and electrical equipment, systems and networks. This book will not completely replace experience and experiment, but it will greatly shorten the path to a successful design.

[1] B. Archambeault, PCB Design for Real-World EMI Control, Kluwer Academic Publisher, 2002, USA.

EMC

Other Noteworthy Books

In response for my call for books to review in the last issue of the EMC Newsletter, I received information about a book published in Polish. While the Book Review column focus on books published in English, I'd to share information on other noteworthy books published in other languages. An example of one is shown below. If you know of other noteworthy books published in languages other than English, please let me know via email at antonio.orlandi@univaq.it. Thank you!

The Author: JAN SROKA
Title (translated): Measurement Uncertainty in EMC Testing, Radio-frequency Emission
Publisher: Warsaw Institute of Technology
ISBN: 9788372078377

Dr. Jan Sroka is with the EMC-Testcenter Zurich AG in Switzerland. For more information, he may be reached at jan.sroka@hotmail.com.

WANTED: EMC Books to Review!

Dear IEEE EMC Society Members,

The "Book Review" columns that are published in the EMC Newsletter are a great treasure for all of us. They give us the possibility to be informed of the existence and contents of published books that are of interest in the wide range of topics covered by our common technical and scientific interest: Electromagnetic Compatibility.

The large number of books published on EMC related topics per year makes it impossible for a mortal Associate Editor to be acquainted of all of them. Because of this, I wish to ask you for your help.

Please contact me if you:

- Have read a technical book that you consider worthy to be shared with members of our community
- Have noticed a book that could be of interest to the IEEE EMC Society members
- Are an author of a technical book on EMC related issues

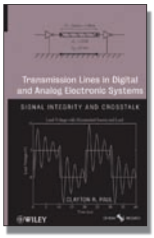
Please indicate the author(s), the book title, the publisher, the ISBN and a brief description and/or your comments on why you feel the book should be considered for review in the EMC Newsletter.

This will help me very much in considering books for review and hopefully increase the number of book reviews made available to our community.

Thank you in advance for your help and time!

Antonio Orlandi
Book Review Associate Editor
antonio.orlandi@univaq.it

DISCOVER ELECTRICAL AND COMPUTER ENGINEERING TEXTBOOKS
BY WILEY AND WILEY-IEEE PRESS AUTHOR: CLAYTON R. PAUL

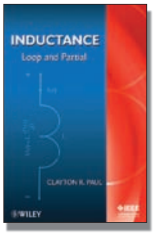


Transmission Lines in Digital and Analog Electronic Systems
Signal Integrity and Crosstalk

Clayton R. Paul

9780470592304 • Cloth • 298pp • $99.95 • Aug 2010
Wiley

A complete but concise description of all the skills required to analyze modern high-speed digital and high-frequency analog electronic systems are given. Waves, time delay, phase shift, wavelength and electrical dimensions, as well as the Fourier series and bandwidth of digital signals are covered. Time-and frequency-domain methods for the solution of lossy and lossless two-conductor and multiconductor (MTL) transmission lines are discussed. A CD is included that contains the PSPICE computer program (along with a brief PSPICE tutorial) and numerous MATLAB and MTL codes to assist the reader in understanding the reader..

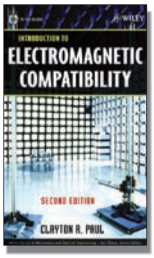


Inductance
Loop and Partial

Clayton R. Paul

9780470461884 • Cloth • 379pp • $115.00 • Nov 2009
Wiley-IEEE Press

The basic circuit components are the resistor, the capacitor and the inductor. Of these three elements, inductance is the least understood element. Students have considerable difficulty understanding this concept as well as the computation of the inductance value. Without the ability to compute the value of an inductance, the analysis cannot be completed.

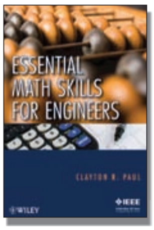


Introduction to Electromagnetic Compatibility, 2nd Edition

Clayton R. Paul

9780471755005 • Cloth • 983pp • $145.00 • Dec 2005
Wiley-Interscience

Fundamental principles of electromagnetic compatibility (EMC). All "digital" electronic devices today emit unwanted electromagnetic fields that may cause interference. These emissions are regulated by governmental agencies and the devices must comply with these or else the device cannot be sold in any country in the world. Hence the product must be designed to limit these emissions or the product will be useless. Numerous worked-out example problems and review problems are given after each important concept. An abundance of end-of-chapter problems with answers are also given. A CD containing the PSPICE program (along with a brief PSPICE tutorial) and various transmission line programs is included.

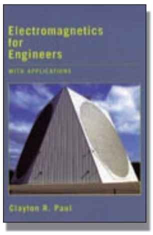


Essential Math Skills for Engineers

Clayton R. Paul

9780470405024 • Paper • 211pp • $52.95 • Mar 2009
Wiley-IEEE Press

Electrical and computer engineers require a complete and working knowledge of certain mathematical skills. This book discusses these and only these concepts in order to focus the reader on these fundamental skills.

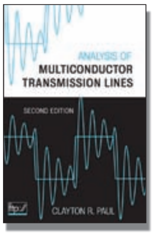


Electromagnetics for Engineers
With Applications to Digital Systems and Electromagnetic Interference

Clayton R. Paul

9780471271802 • Cloth • 403pp • $185.95 • Aug 2003
Wiley

Fundamental principles of electromagnetics with emphasis on practical engineering applications. Vector algebra, static (DC) fields, Maxwell's equations simplified, uniform plane waves, transmission lines and fundamentals of antennas. Numerous worked-out example problems and review problems are given after each important concept. An abundance of end-of-chapter problems with answers are also given. Each chapter concludes with numerous examples of the practical applications of the theory.

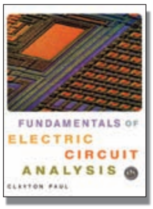


Analysis of Multiconductor Transmission Lines, 2nd Edition

Clayton R. Paul

9780470131541 • Cloth • 783pp • $180.00 • Oct 2007
Wiley-IEEE Press

A complete discussion of the methods for analyzing two-conductor and multiconductor transmission lines. All aspects of the analysis methods are covered both analytical and numerical. Numerous worked-out example problems and review problems are given after each important concept. An abundance of end-of-chapter problems with answers are also given. The PSPICE code and various transmission line programs can be downloaded from a Wiley FTP site (along with a brief PSPICE tutorial).



Fundamentals of Electric Circuit Analysis

Clayton R. Paul

9780471371953 • Paper • 501pp • $128.95 • May 2000
Wiley

A complete and concise description of all analysis skills for lumped electric circuits: KVL and KCL, DC circuits, AC (phasor) circuits and complex algebra, time domain circuits and the Laplace transform, is given. This book contains all the basic analysis skills that all electrical and computer engineers must master to become successful. Numerous worked-out example problems and Quick Review problems are given after each important concept. An abundance of end-of-chapter problems with answers are also given.

Textbooks for undergraduate and early graduate electrical and computer engineering students as well as industrial practitioners.

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President's Message

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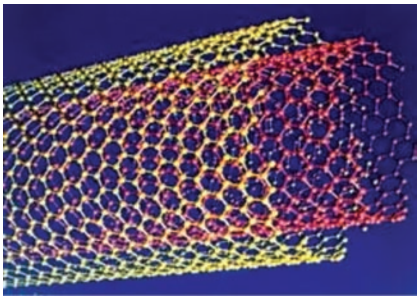
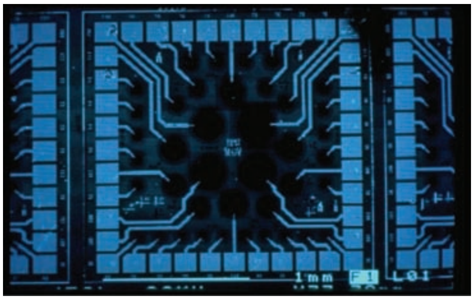

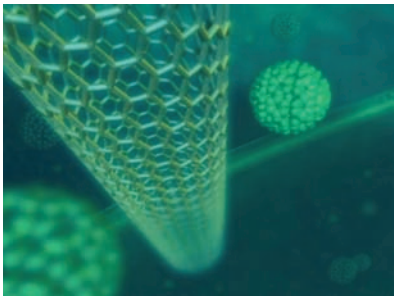

The IEEE Transactions on EMC will present a special issue in 2011 on nanotechnology related to EMC.

applications exploiting the power of nanotechnology; and to investigate EMC issues related to the integration of nano-components in micro and macro electrical and electronic systems.

Suggested topics to be covered in this issue include: electromagnetic modeling and characterization of nano-structured materials, devices and systems for EMC; nano-structured materials for EMC applications, such as EM shielding, EM energy absorption, antistatics, surge suppression and protection, novel devices; electrical and EM properties of nano-composites for EMC; nano-interconnects for next generation ICs; signal integrity in nano-components and nano-devices; nano-structured sensors for EMC; MEMS-based technology for smart antennas arrays and frequency-selective surfaces for EMC; nanometrology for EMC.

Papers must be submitted by May 1, 2011. For more info, please look at the call of papers available on page 55 of this Newsletter.

Breaking News

EMC Society Standards Travel Grant Now Available!

At the November EMC Society Board of Director's meeting, the Board unanimously approved the implementation of a special grant that was received from a donor. The Grant is to partially help those EMC Society members to actively participate in EMC Society standards development and attend regular meetings of the EMC Society Standards Development Committee (SDCom), the Standards Advisory and Coordination Committee (SACCom) and the Standards Education Committee (SETCom).

The EMC Society appreciates the opportunity for advancing the standards activity of the Society via the implementation of the travel grant. The EMC Society will administer the Grant by providing proper oversight of delegated duties to a Standards Travel Grant Committee. Details of the Standards Travel Grant are available in the Standards Column later on in this issue. For any additional info as well as for getting the travel grant request form, please contact the VP for Standards, Don Heirman (d.heirman@ieee.org).

Board of Directors Meetings

The next EMC Society Board of Directors (BoD) meeting is scheduled on March 28–30, in Fort Lauderdale. I remind you that all meetings of the EMC Society BoD are open. Any members who want to attend will be most welcome. The schedule of the BoD meeting is posted on the website at http://www.ewh.ieee.org/soc/emcs/conferences.html, and in the calendar section of the Newsletter.

Call for Volunteers

The success of our Society is possible thanks to the many fine volunteers who have contributed unselfishly of their time and talent. As the Society evolves, and new initiatives emerge, we are always in need of volunteers. Please, give serious consideration to becoming involved in our broad and challenging goals and objectives. The full list of committees can be found on our website at http://www.ewh.ieee.org/soc/emcs/directors.html.

I look forward to working with all of you who join the volunteers of the Society, helping achieve the set of our goals for the benefit of us all. For making a suggestion, comment, or just for dropping a friendly note, please do not hesitate to e-mail me at: fr.maradei@ieee.org. **EMC**

2011 Asia-Pacific EMC Symposium

May 16-19, 2011, Jeju Island, Korea

APEMC
Korea 2011
May 16-19

The 2011 Asia-Pacific Symposium & Exhibition on Electromagnetic Compatibility (2011 APEMC) will be held in Jeju, Korea, from May 16 to 19, 2011. We are delighted to announce this meeting. Please consider the possibility of your participation and also encourage your team members to join us in beautiful Jeju Island, Korea.

Continuing the success of the Symposium on Asia Pacific Electromagnetic Compatibility, co-hosted by the KIEES and the IEEE EMC Society, and co-sponsored by KCC, RRA, and the EMC Center of RAPA, the authors are cordially invited to submit their high-quality papers representing their original results in all areas of EMC in electrical and electronic engineering.
Proposals for tutorials/workshops/special sessions are highly encouraged.

The symposium will cover the entire scope of electromagnetic compatibility.

Topics of interest include, but are not limited to :

- Sources of Electromagnetic Interference
- EMC Management
- EMC Measurement Techniques
- Lighting & Power System EMC
- Grounding
- System-Level EMC and PCB EMC
- Transportation and Automotive EMC
- Antenna and Propagation Issues
- Electronic Packaging and Integration EMC
- Power Integrity and Signal Integrity
- Computational Electromagnetics
- Nanotechnology in EMC
- Semiconductor EMC
- Communication EMC
- EMC Material
- Bio-Medical Electromagnetics
- Electromagnetic Field Dosimetry
- Propagation Through Biological Media
- Biological Effects of Electromagnetic Fields
- Electromagnetic Modeling of the Human Body
- Electromagnetic Interference with Medical Devices
- Advanced Numerical Modeling
- Regulatory Activities and Safety Trends
- Any other relevant topics

Submissions will be opened for :

- Regular papers (oral and poster) including student papers for the best student paper contest
- Invited papers
- Special sessions, workshops, and tutorials
- Exhibitions and demonstrations

Please visit http://www.apemc2011.org and submit your paper taking care of the following schedule :

- Proposals for special/invited sessions and topical meetings, workshops and tutorials : August 22, 2010
- Preliminary paper submissions : November 14, 2010 (4 pages in PDF format only)
- Notification of acceptance : January 31, 2011
- Final paper submission : March 4, 2011

Please forward the information on this preliminary call to all those potentially interested in submitting their contributions. We are looking forward to seeing you in Jeju Island, Korea.

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Practical Papers, Articles and Application Notes

Flavio Canavero, Technical Editor

Dear Readers,

This is my farewell message. I will miss this quarterly appointment with you, by means of the papers that I was regularly offering for your reading and meditation. However, I know that the incoming Technical Editor (Professor Kye Yak See from Nanyang Technical University, Singapore), with his enthusiastic leadership and competence, will bring to your attention a new wave of interesting and challenging papers. This is what we need for keeping the freshness and success of our Newsletter.

In ending my term, I wish to express my sincere thanks to the Board of Directors of the EMC Society for their confidence in my work, and in particular to the Newsletter Editor, Janet O'Neil, for her invaluable support during these years; I really enjoyed working with her. During my turn, I was very lucky to find a large number of experienced contributors who gifted the Newsletter with very informative papers. I wish to thank these authors for the time and zeal they put into the preparation of their contributions. I also would like to mention the anonymous reviewers, who worked behind the scenes; their very enlightening comments frequently helped the authors to focus and polish their papers.

In the current issue, I bring to you two outstanding contributions. The first article is entitled "A Simpler Alternative to Wave Tracing in Solving Transmission Lines" and is authored by Professor Clayton R. Paul, who presents a practical and simple method for rapidly sketching the terminal waveforms of a transmission line. Professor Paul's intent is to suggest a clever technique avoiding the cumbersomeness of tracing all the individual waves propagating along the line and adding their effects at the terminals (please think of how you would do using the "lattice" or Bergeron method). This paper provides general equations for the terminal voltage and current waveforms in terms of symbols, so that the result is applicable for all problems and does not have to be rederived for every line. Also, the validity of this technique is not limited by specific source waveforms.

The second article is entitled "Shielded Cable Transfer Impedance Measurements; High Frequency Range 100 MHz–1 GHz" by Bernard Démoulin and Lamine Koné, with the TELICE Lab of Lille University of Science and Technology, in Lille, France. This is a second contribution of a series on the determination of the transfer impedance of cables and connectors, and brings us the highly competent view of one of the labs that mainly contributed to the IEC Standard on transfer impedance characterization of cables. Professor Démoulin, recently retired, has graciously agreed to share with us the significant experience he cumulated in the former Laboratory for Radiopropagation and Electronics (now TELICE), where testing procedures for cable shielding effectiveness were developed.

EDITOR'S NOTE: It is with mixed emotions that I edit this column. I have enjoyed working with Professor Canavero for several years on the EMC Newsletter. His tremendous work, and that of his colleague before him, Professor Bob Olsen of Washington State University, was critical to the IEEE approval of the transition of the EMC Newsletter to a magazine in 2012. Professor Canavero's dedication to this column and his professionalism in dealing with the numerous authors and reviewers over the years will always be appreciated. I look forward to working with Professor Kye Yak See and welcome him in our next issue as the new Technical Editor.

A Simpler Alternative to Wave Tracing in Solving Transmission Lines

Clayton R. Paul,
Mercer University, Macon, GA (USA), paul_cr@Mercer.edu

Abstract—A simple method for rapidly sketching the terminal voltage and current waveforms of a lossless, two-conductor transmission line is given. The resulting simple equations for the terminal voltages and currents of the line are given in terms of symbols and do not have to be rederived for every problem. The method easily accommodates source waveforms having arbitrary wave shapes.

Index Terms—transmission lines, time-domain solution, wave tracing

I. The Basic Transmisssion-Line Problem

The basic transmission line considered is shown in Fig. 1 and consists of two parallel conductors having uniform cross sections along their total length $\mathcal{L}$ that are directed along and parallel to the z axis. A source represented with a Thevenin equivalent representation consists of an open-circuit voltage waveform, $V_S(t)$, and a source resistance R_S. The line is terminated with a load consisting of a resistance R_L. The line parameters such as length, spacing of the two conductors, and all

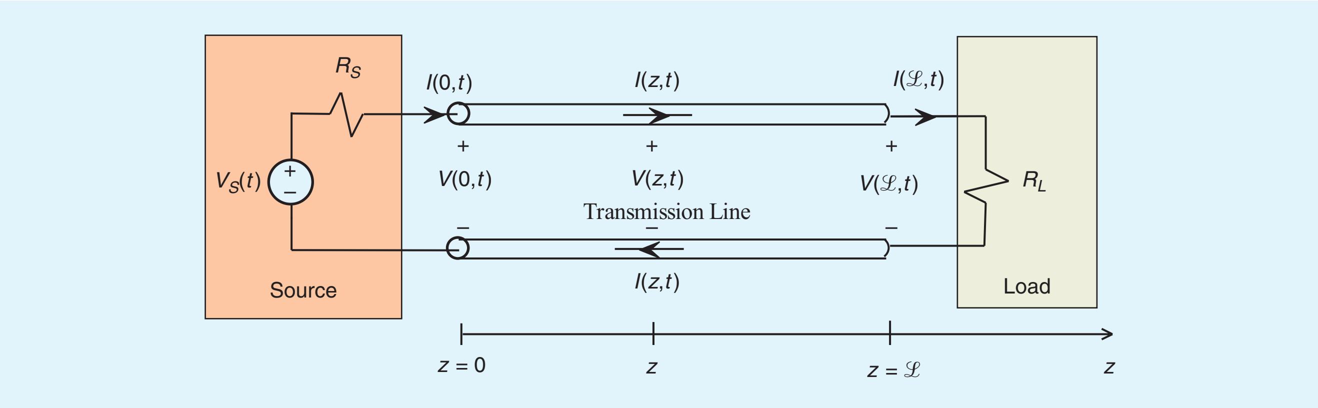

Fig. 1. The general configuration of the two-conductor, transmission lines to be studied.

conductor dimensions are assumed known. The terminal impedances R_S and R_L as well as the waveform of the open-circuit voltage source, $V_S(t)$, are also assumed known. The line voltage and current are functions of position along the line, z, and time, t, as $V(z, t)$ and $I(z, t)$. The task here is to produce the solution waveforms of the terminal voltages and currents: $V(0, t)$, $V(\mathcal{L}, t)$, $I(0, t)$, and $I(\mathcal{L}, t)$. This is the primary task in determining the *signal integrity* of a digital system.

Waves of voltage and current propagate along the conductors where they are reflected at the terminals. In order to sketch the terminal solution waveforms, we can trace the individual waves as they are reflected at the terminals and then sum in time all the waves present as illustrated in reference [1]. In this paper we will derive general equations for the terminal voltage and current waveforms in terms of symbols rather than numerical values for a specific problem so that the resulting equations apply for all problems and do not have to be rederived for a specific problem. The results are predetermined for any source waveform, $V_S(t)$ and don't require any further wave tracing or other derivations for a new problem. Replacing $V_S(t)$ with a different waveform but retaining the other problem parameters doesn't change the process.

II. The Transmisssion-Line Equations

The line voltages and currents, $V(z, t)$ and $I(z, t)$, are governed by the *transmission-line* equations [1]:

$$\frac{\partial V(z,t)}{\partial z} = -l\frac{\partial I(z,t)}{\partial t} \tag{1a}$$

$$\frac{\partial I(z,t)}{\partial z} = -c\frac{\partial V(z,t)}{\partial t} \tag{1b}$$

which are a set of *coupled*, partial differential equations. All cross-sectional dimensions of the line are contained in its per-unit-length inductance, l, and its per-unit-length capacitance, c. The electric and magnetic fields along the line lie in the x-y plane transverse to the axis of propagation, the z axis. Hence the field structure is referred to as the Transverse Electro Magnetic (TEM) mode of propagation. The velocity of propagation of the TEM waves along the line is

$$v = \frac{1}{\sqrt{lc}} \quad \frac{\text{m}}{\text{s}} \tag{2}$$

So we can obtain one parameter from the other:

$$l = \frac{1}{cv^2} \quad \frac{\text{H}}{\text{m}} \tag{3a}$$

$$c = \frac{1}{lv^2} \quad \frac{\text{F}}{\text{m}} \tag{3b}$$

The general solution of the transmission line equations is

$$V(z,t) = V^+\left(t - \frac{z}{v}\right) + V^-\left(t + \frac{z}{v}\right) \tag{4a}$$

$$I(z,t) = \frac{1}{Z_C}V^+\left(t - \frac{z}{v}\right) - \frac{1}{Z_C}V^-\left(t + \frac{z}{v}\right) \tag{4b}$$

where Z_C is the *characteristic impedance of the line*:

$$Z_C = \sqrt{\frac{l}{c}} \;\; \Omega = vl = \frac{1}{vc} \tag{5}$$

The V^+ and V^- are, as yet, undetermined *functions* but depend on z, t, and v only as $t + (z/v)$ and $t - (z/v)$. These functions are determined by the source and load: $V_S(t)$, R_S, and R_L. Also note that there is an important negative sign in the solution for the current. The V^+ represent forward-traveling waves traveling in the $+z$ direction, whereas the V^- represent backward-traveling waves traveling in the $-z$ direction. So in general we have waves of voltage and current (or equivalently waves of electric and magnetic fields) traveling back and forth down the line. We see that the voltage and current waves are in general being reflected at the source and at the load, and the combination of these waves determine the total voltage and current solution waveforms at the source and the load ends of the line.

III. Reflections At the Line Terminations

The time required to transit the line from one end to the other is the *one-way time delay* on the line:

$$T_D = \frac{\mathcal{L}}{v} \tag{6}$$

At the load end of the line, $z = \mathcal{L}$, the voltages and currents are denoted as

$$V(\mathcal{L},t) = V^+(t - T_D) + V^-(t + T_D) \tag{7a}$$

$$I(\mathcal{L},t) = \frac{1}{Z_C}V^+(t - T_D) - \frac{1}{Z_C}V^-(t + T_D) \tag{7b}$$

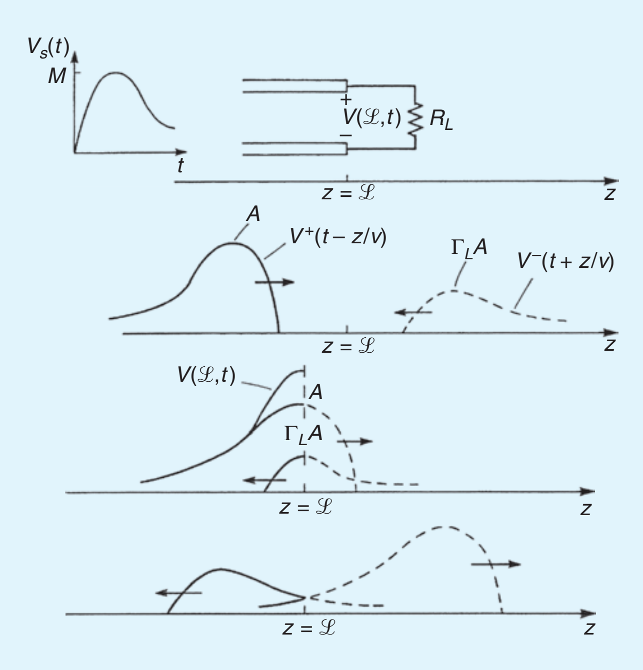

Fig. 2. Illustration of reflection at a mismatched load.

If the load is *matched*, i.e., $R_L = Z_C$, then we will only have a forward-traveling (incoming) wave at the load and there will be no reflected wave at the load. But for some general load that is not matched, $R_L \neq Z_C$, we must have an incident (forward-traveling) wave and a reflected (backward-traveling) wave at the load in order to satisfy Ohm's law. Define the *voltage reflection coefficient at the load* as the ratio of the reflected and incident voltage waves:

$$\Gamma_L = \frac{V^-(t + T_D)}{V^+(t - T_D)} \tag{8}$$

If we know the load reflection coefficient, Γ_L, we can determine the reflected voltage wave knowing the incident voltage wave. The *total* voltage and current at the load can then be written in terms of the load reflection coefficient as

$$\begin{aligned} V(\mathscr{L}, t) &= V^+(t - T_D)\,[1 + \Gamma_L] \\ I(\mathscr{L}, t) &= \frac{1}{Z_C} V^+(t - T_D)\,[1 - \Gamma_L] \end{aligned} \tag{9}$$

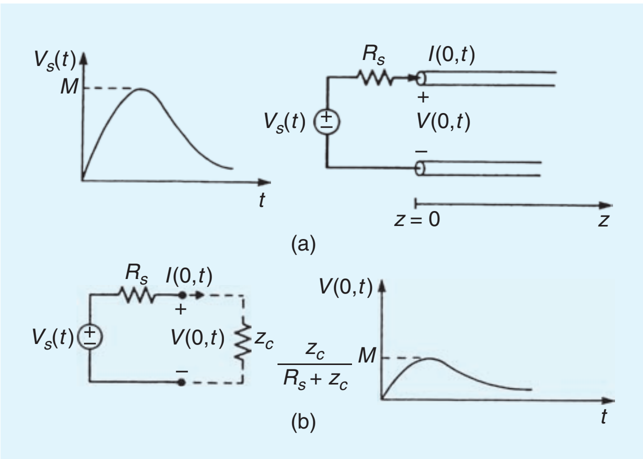

Fig. 3. Illustration of the input impedance to the line for $0 \le t < 2T_D$.

Taking the ratio of these two relations gives

$$\frac{V(\mathscr{L}, t)}{I(\mathscr{L}, t)} = R_L = Z_C \left[\frac{1 + \Gamma_L}{1 - \Gamma_L}\right] \tag{10}$$

Solving this gives the *voltage reflection coefficient at the load* as

$$\Gamma_L = \frac{R_L - Z_C}{R_L + Z_C} \tag{11}$$

Observe that since there is a minus sign in the current relation, the current reflection coefficient is the negative of the voltage reflection coefficient:

$$\Gamma_L|_{\text{current}} = -\Gamma_L|_{\text{voltage}} \tag{12}$$

The process of reflection at the load is like a mirror: the reflected wave is coming out of the mirror and the incident wave is going in as illustrated in Fig. 2. *The total voltage is the sum of the incident and reflected waves.*

The voltage or current wave that was reflected at the load travels back to the source in another time delay of T_D where it is reflected with a voltage reflection coefficient at the source of

$$\Gamma_S = \frac{R_S - Z_C}{R_S + Z_C} \tag{13}$$

and sent back to the load. The current reflection coefficient at the source is, again, the negative of the voltage reflection coefficient at the source:

$$\Gamma_S|_{\text{current}} = -\Gamma_S|_{\text{voltage}} \tag{14}$$

Finally we obtain the initially sent out wave. We reason that when the source voltage is initially applied, an initial forward-traveling wave is sent out towards the load. This initial wave will take a time delay of T_D to get to the load. Any reflections of this initial wave at a mismatched load will require another one-way time delay of T_D to get back to the source. Hence no reflected wave will have arrived at the source over the time interval $0 < t < 2T_D$. So the total voltage at the source is just the initially sent out forward traveling wave and hence the ratio of the total voltage to total current at the source end of the line, $z = 0$, will just be

$$\frac{V(0, t)}{I(0, t)} = \frac{V^+(t - 0)}{\frac{1}{Z_C} V^+(t - 0)} = Z_C \qquad 0 < t < 2T_D \tag{15}$$

So the input impedance to the line initially appears to be Z_C. Hence we can calculate the initially sent out voltage and current waves from

$$V_{\text{init}} = \frac{Z_C}{R_S + Z_C} V_S(t) \tag{16}$$

$$I_{\text{init}} = \frac{V_S(t)}{R_S + Z_C} \tag{17}$$

as illustrated in Fig. 3.

IV. Closed-Form General Solutions of the Terminal Voltages and Currents

We can trace the incident and reflected waves giving closed-form solutions for the terminal waveforms in terms of symbols

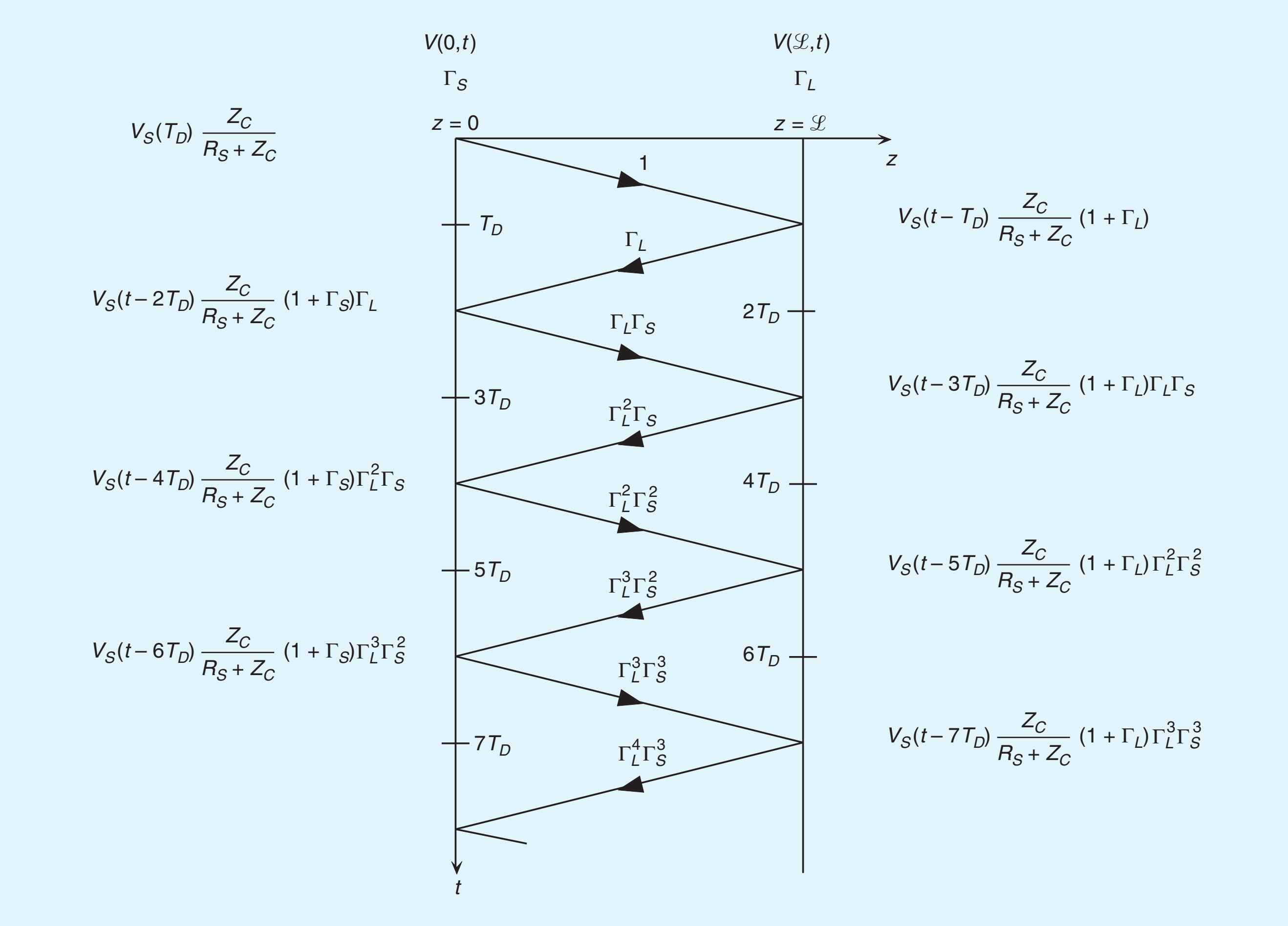

Fig. 4. The lattice diagram.

which do NOT have to be repeated for every different problem. To obtain these solutions we will use a form of a "lattice diagram" shown below in Fig. 4 that is *normalized* for a unity wave that is launched initially. Time is recorded on the vertical axis in increments of the one-way time delay T_D, and positions along the line are recorded on the horizontal axis. At a time point on the vertical axis where an incident and a reflected wave are present, the incident wave is multiplied by the reflection coefficient and the two waves are added.

The following TOTAL solutions have identical FORMS for ALL problems. For the terminal voltages these are

$$V(0,t) = \frac{Z_C}{R_S + Z_C} V_S(t) + \frac{Z_C}{R_S + Z_C}(1 + \Gamma_S)\, \Gamma_L [V_S(t - 2T_D) + (\Gamma_S\Gamma_L) V_S(t - 4T_D) + (\Gamma_S\Gamma_L)^2 V_S(t - 6T_D) + \cdots] \tag{18a}$$

and

$$V(\mathcal{L},t) = \frac{Z_C}{R_S + Z_C}(1 + \Gamma_L)\, [V_S(t - T_D) + (\Gamma_S\Gamma_L) V_S(t - 3T_D) + (\Gamma_S\Gamma_L)^2 V_S(t - 5T_D) + (\Gamma_S\Gamma_L)^3 V_S(t - 7T_D) + \cdots] \tag{18b}$$

The terminal current solutions are similarly obtained from the voltage solutions but with the reflection coefficients for currents being the negative for those for the voltages as shown in (12) and (14) and the initially sent out wave is given by (17). Hence the symbolic solutions for the total terminal currents are

$$I(0,t) = \frac{1}{R_S + Z_C} V_S(t) + \frac{1}{R_S + Z_C}(1 - \Gamma_S)(-\Gamma_L)[V_S(t - 2T_D) + (\Gamma_S\Gamma_L) V_S(t - 4T_D) + (\Gamma_S\Gamma_L)^2 V_S(t - 6T_D) + \cdots] \tag{19a}$$

and

$$I(\mathcal{L},t) = \frac{1}{R_S + Z_C}(1 - \Gamma_L)\, [V_S(t - T_D) + (\Gamma_S\Gamma_L) V_S(t - 3T_D) + (\Gamma_S\Gamma_L)^2 V_S(t - 5T_D) + (\Gamma_S\Gamma_L)^3 V_S(t - 7T_D) + \cdots] \tag{19b}$$

where Γ_S and Γ_L in the current expressions are the voltage reflection coefficients but their signs reversed.

Observe in these expressions that the total voltages and currents at the input and the output to the transmission line are combinations of the source waveform, $V_S(t)$, that are delayed by two time delays. Also note that the magnitudes of the source and load reflection coefficients are less than or equal to unity:

$$|\Gamma_S| \leq 1 \tag{20a}$$

$$|\Gamma_L| \leq 1 \tag{20b}$$

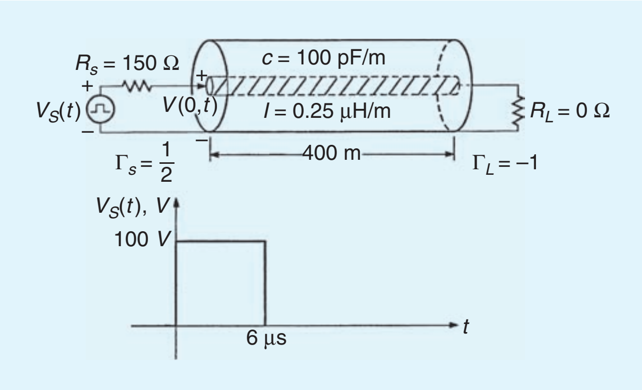

Fig. 5. An example.

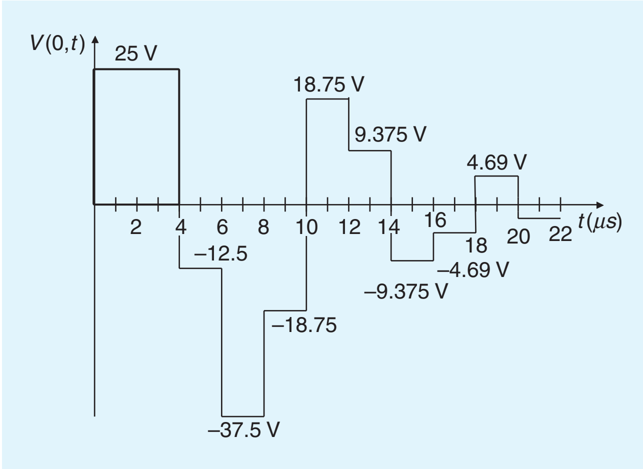

Fig. 7.

Observe that the total terminal voltage waveforms, $V(0, t)$ and $V(\mathcal{L}, t)$, in (18) and total terminal current waveforms, $I(0, t)$ and $I(\mathcal{L}, t)$, in (19) are sums of delayed replicas of $V_S(t)$ multiplied by products of the source and load reflection coefficients, $(\Gamma_S \Gamma_L)^n$, which are also progressively less than unity. Hence if the source resistor is less than the characteristic impedance, $R_S < Z_C$, and the load resistor is greater than the load resistor, $R_L > Z_C$, or vice-versa, the source and load reflection coefficients are of *opposite sign*. Hence a resulting terminal voltage will have a portion added to it and subtracted from it resulting in *oscillations*. On the other hand if the source resistor and the load resistor are both less than the characteristic impedance, $R_S < Z_C$, $R_L < Z_C$, or are both greater than the characteristic impedance, $R_S > Z_C$, $R_L > Z_C$, the source and load reflection coefficients are of the *same sign* and the terminal voltage will steadily build up to its steady-state value. These observations apply also to the terminal currents.

The voltage results in (18) are multiplied by a factor representing the voltage division at the source that was used to determine the initially sent out voltage: $Z_C/(R_S + Z_C)$. Similarly the current results in (19) are multiplied by $1/(R_S + Z_C)$. Finally, each result is multiplied by a constant: $(1 + \Gamma_S)\,\Gamma_L$ for $V(0, t)$ and $(1 + \Gamma_L)$ for $V(\mathcal{L}, t)$ and $(1 - \Gamma_S)\,(-\Gamma_L)$ for $I(0, t)$ and $(1 - \Gamma_L)$ for $I(\mathcal{L}, t)$ where these current coefficients result from negating the voltage reflection coefficients to give the corresponding current reflection coefficients. Once these coefficients are determined, the component waveforms are plotted in terms of the delayed source waveform $V_S(t)$. Once this is completed, these waveforms are summed to give the total waveforms $V(0, t)$, $V(\mathcal{L}, t)$, $I(0, t)$, and $I(\mathcal{L}, t)$ and the analysis is complete.

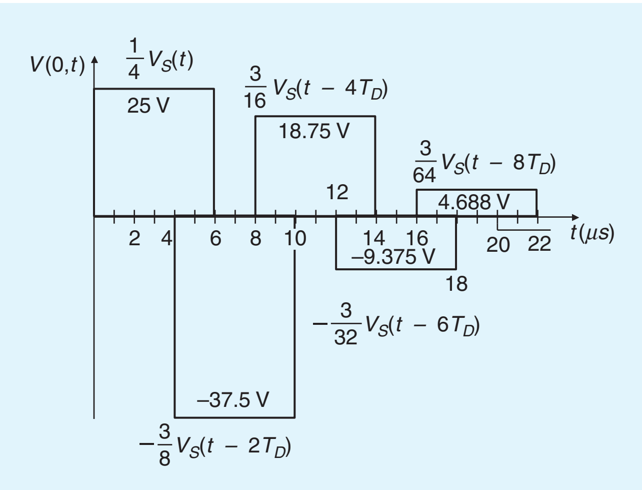

Fig. 6.

V. Examples

Sketch the voltage at the input, $V(0, t)$, and the current at the output, $I(\mathcal{L}, t)$ of the line versus time for the problem in Fig. 5.

This problem illustrates the case where the source voltage waveform, $V_S(t)$, is a pulse of amplitude of 100 V and 6 μs duration that is several one-way time delays of the line, $T_D = \mathcal{L}/v = 2\ \mu$s, in duration. Hence the incident and reflected pulses from opposite terminations overlap in time and combine to give very complicated total wave shapes at those terminations. First perform the initial computations:

$$Z_C = \sqrt{\frac{l}{c}} = \sqrt{\frac{0.25 \times 10^{-6}}{100 \times 10^{-12}}} = 50 \quad \Omega$$

$$v = \frac{1}{\sqrt{lc}} = \frac{1}{\sqrt{(0.25 \times 10^{-6})(100 \times 10^{-12})}} = 200 \quad \frac{\text{m}}{\mu\,\text{s}}$$

$$T_D = \frac{\mathcal{L}}{v} = 2\ \mu\,\text{s}$$

Perform the initial computations for the voltage:

$$V_{\text{init}} = \frac{Z_C}{R_S + Z_C} V_S(t) = \frac{50}{150 + 50} 100 = 25\ \text{V}$$

$$\Gamma_S = \frac{R_S - Z_C}{R_S + Z_C} = \frac{150 - 50}{150 + 50} = \frac{1}{2}$$

$$\Gamma_L = \frac{R_L - Z_C}{R_L + Z_C} = \frac{0 - 50}{0 + 50} = -1$$

For this example we compute the factors $Z_C/(R_S + Z_C) = 1/4$, $(1 + \Gamma_S)\,\Gamma_L = -3/2$ for $V(0, t)$ and $(1 + \Gamma_L) = 0$ for $V(\mathcal{L}, t)$. For the plot of $V(0, t)$ the series expression in (18a) becomes

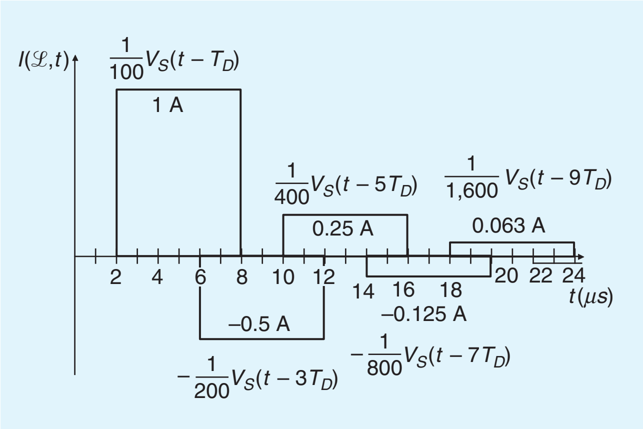

Fig. 8.

$$
\begin{aligned}
V(0,t) &= \frac{1}{4}V_S(t) - \frac{3}{8}\Big[V_S(t-2T_D) - \frac{1}{2}V_S(t-4T_D) \\
&\qquad + \frac{1}{4}V_S(t-6T_D) - \frac{1}{8}V_S(t-8T_D) + \cdots\Big] \\
&= \frac{1}{4}V_S(t) - \frac{3}{8}V_S(t-2T_D) + \frac{3}{16}V_S(t-4T_D) \\
&\qquad - \frac{3}{32}V_S(t-6T_D) + \frac{3}{64}V_S(t-8T_D) + \cdots
\end{aligned}
$$

which is shown in Fig. 6:

Adding the pulses gives the solution for $V(0,t)$ shown in Fig. 7.

The series solution for voltages in (18) can be easily modified for currents as in (19) by (1) negating the voltage reflection coefficients to give the current reflection coefficients AND (2) using

$$
I_{\text{init}} = \frac{1}{R_S + Z_C}V_S(t) \tag{21}
$$

as shown in (19). For the plot of current the coefficients are $1/(R_S + Z_C) = 1/200$, $(1 + -\Gamma_S)\,(-\Gamma_L) = 1/2$, for $I(0,t)$ and $(1 + -\Gamma_L) = 2$ for $I(\mathcal{L},t)$. The series expression for $I(\mathcal{L},t)$ in (19b) becomes

$$
\begin{aligned}
I(\mathcal{L},t) &= \frac{1}{200}2\Big[V_S(t-T_D) - \frac{1}{2}V_S(t-3T_D) \\
&\qquad + \frac{1}{4}V_S(t-5T_D) - \frac{1}{8}V_S(t-7T_D) + \cdots\Big] \\
&= \frac{1}{100}V_S(t-T_D) - \frac{1}{200}V_S(t-3T_D) \\
&\qquad + \frac{1}{400}V_S(t-5T_D) - \frac{1}{800}V_S(t-7T_D) + \cdots
\end{aligned}
$$

Figure 8 shows this summation in terms of the source pulse, $V_S(t)$.

Adding the pulses gives the solution for $I(\mathcal{L},t)$ shown in Fig. 9.

As another example and one in which $V_S(t)$ is complicated, suppose $V_S(t)$ is again a pulse of 100 V and duration of 6 μs but steadily ramps from 0 V at $t = 0$ s to 100 V at $t = 6$ μs at which time it goes to zero as shown in Fig. 10.

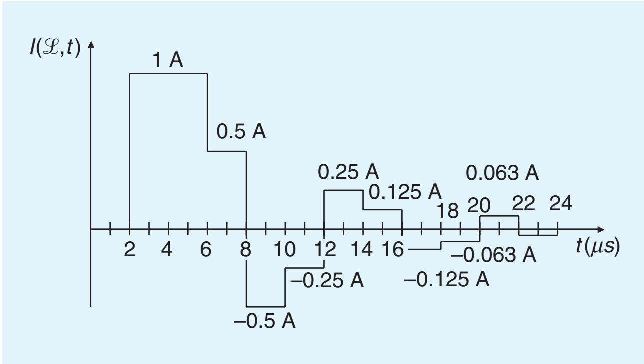

Fig. 9

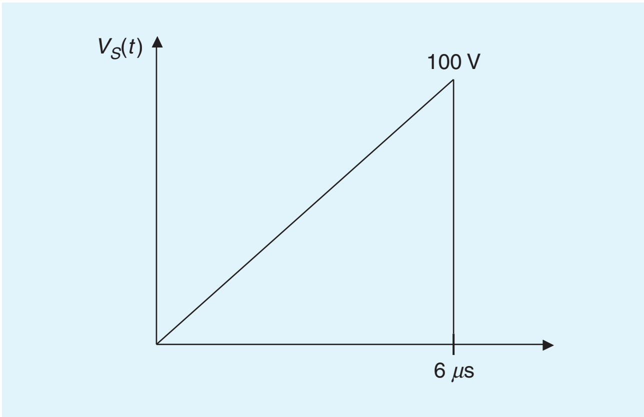

Fig. 10.

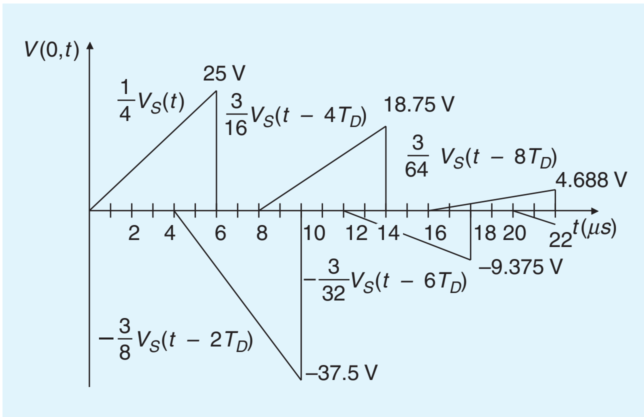

Fig. 11.

Since none of the parameters except the waveform for $V_S(t)$ has been changed, the equation for $V(0,t)$ is *unchanged*:

$$
\begin{aligned}
V(0,t) &= \frac{1}{4}V_S(t) - \frac{3}{8}\Big[V_S(t-2T_D) - \frac{1}{2}V_S(t-4T_D) \\
&\qquad + \frac{1}{4}V_S(t-6T_D) - \frac{1}{8}V_S(t-8T_D) + \cdots\Big] \\
&= \frac{1}{4}V_S(t) - \frac{3}{8}V_S(t-2T_D) + \frac{3}{16}V_S(t-4T_D) \\
&\qquad - \frac{3}{32}V_S(t-6T_D) + \frac{3}{64}V_S(t-8T_D) + \cdots
\end{aligned}
$$

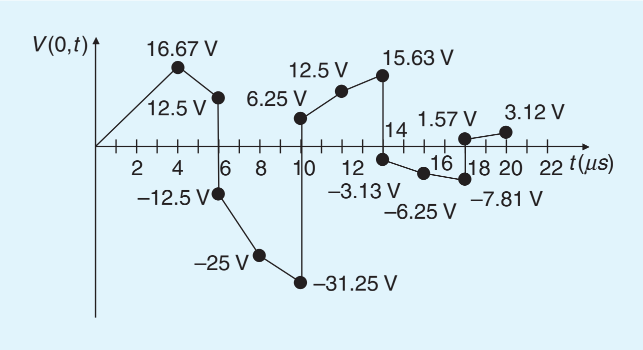

Fig. 12.

Plotting the individual components is shown in Fig. 11.

Adding the pulses gives the solution for $V(0, t)$ shown in Fig. 12.

All of the results of the above examples were validated using the PSPICE circuit analysis computer program. Use of the *exact lossless transmission line* model in PSPICE for more complicated *lossless* transmission-line problems is highly recommended [1].

VI. References

[1] C.R. Paul, "Transmission Lines in Digital and Analog Electronic Systems: Signal Integrity and Crosstalk," John Wiley, Hoboken, NJ, 2010.

Biography

Clayton R. Paul received the B.S. degree, from The Citadel, Charleston, SC, in 1963, the M.S. degree, from Georgia Institute of Technology, Atlanta, GA, in 1964, and the Ph.D. degree, from Purdue University, Lafayette, IN, in 1970, all in Electrical Engineering. He is an Emeritus Professor of Electrical Engineering at the University of Kentucky where he was a member of the faculty in the Department of Electrical Engineering for 27 years retiring in 1998. Since 1998 he has been the Sam Nunn Eminent Professor of Aerospace Systems Engineering and a Professor of Electrical and Computer Engineering in the Department of Electrical and Computer Engineering at Mercer University in Macon, GA. He has published numerous papers on the results of his research in the Electromagnetic Compatibility (EMC) of electronic systems and given numerous invited presentations. He has also published 18 textbooks and Chapters in 4 handbooks. Dr. Paul is a Life Fellow of the Institute of Electrical and Electronics Engineers (IEEE) and is an Honorary Life Member of the IEEE EMC Society. He was awarded the IEEE Electromagnetics Award in 2005 and the IEEE Undergraduate Teaching Award in 2007.

Shielded Cable Transfer Impedance Measurements High frequency range 100 MHz–1 GHz

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Introduction

In our previous paper [1] we described the setup for the measurement of the transfer impedance of shielded coaxial cables. We demonstrated that the conventional triaxial setup does not allow to reach frequencies higher than 100 MHz, mainly due to the onset of propagation phenomena. In fact, for a cable sample of 1 m in length, the maximum frequency attainable by means of a measurement of the near-end crosstalk voltage does not exceed 30 MHz. On the other hand, if we measure the far-end crosstalk voltage, the maximum attainable frequency can grow up to 100 MHz. However, the technology of the transfer impedance bench setup must be modified, in order to be able to explore the bandwidth between 100 MHz and 1 GHz.

It is a known fact that the accuracy produced by a purely computational compensation of propagation phenomena is not acceptable; hence, a more rational approach to the reduction of the propagation effects is the reduction of the physical length of the sample under test. The rule of proportionality with wavelength teaches us that we need to reduce the dimension by a factor of 10 (i.e., adopt samples of 10 cm), in order to reliably measure up to 1 GHz, without being affected by propagation. On the other hand, at higher frequencies, mismatches of the perturbation line tend to amplify, especially at the line extremities where the signal source and the matched load are connected. The consequence of such defects is to produce an uncertain estimate of the perturbation current, which–in turn–results in a non-negligible error of the transfer impedance estimate. All the above reasons call for an adjustment of the technology of the transfer impedance bench setup to the extension of the frequency range [2], [3].

The first Section of this article concerns the description of two transfer impedance setups, whose configurations have been devised in particular for reducing the mismatch defects for cable samples of 10 cm in length. We first describe the wire injection method, the construction principle of which resides in a perturbation line made by a thin ribbon conductor glued on the cable insulating jacket. Then we introduce the shield discontinuity method, by which the sample under test represents the inner conductor of a coaxial cavity terminated by a short circuit. The second Section deals with the calibration of the above setups by means of samples made by a coaxial homogeneous tube with one or more apertures. We will compute the transfer inductance of these samples with the aim of determining their transfer impedance in the frequency range 100 MHz–1 GHz. The third Section presents measurement results obtained for a calibration sample with one aperture, and for a 10-cm long cable with a braided shield.

Improvement of the Measurement Setups for High Frequency Range

Ignoring propagation phenomena, the transfer impedance is generally directly proportional to the ratio between the measured voltage V_{cM} at the end of the sample under test and the current I_m, injected into the cable shield with length L_0, i.e.,

$$Z_{tM} = \frac{2}{L_0}\frac{V_{cM}}{I_m} \tag{1}$$

Since, as we mentioned, several imperfections introduced by the injection current measurement are due to propagation phenomena, we can easily correct them using expressions found in [1] which include the contribution of the propagation phenomena. Theoretically, the transfer impedance Z_t can be obtained by means of the following expression, if the near-end crosstalk voltage is used in (1),

$$Z_t = \frac{Z_{tM}}{F_0(\omega, L_0)} \tag{2}$$

while an alternate expression for the transfer impedance Z_t is needed, if far-end crosstalk voltage measurements are employed:

$$Z_t = \frac{Z_{tM}}{F_{L_0}(\omega, L_0)} \tag{3}$$

In practice, these corrections are only usable for frequencies situated below the first zero of the denominator functions in (2) and (3). The functions $F_0(\omega, L_0)$ and $F_{L0}(\omega, L_0)$ as appearing at denominators in equations (2) and (3) are developed in [1], these fall to zero at the following frequencies f_n and f_p :

$$F_0(\omega_n, L_0) = 0 \quad \rightarrow \quad f_n = \frac{n}{\left(\frac{1}{v_1} + \frac{1}{v_2}\right)L_0} \tag{4}$$

$$F_{L_0}(\omega_p, L_0) = 0 \quad \rightarrow \quad f_p = \frac{p}{\left|\frac{1}{v_1} - \frac{1}{v_2}\right|L_0} \tag{5}$$

We can notice in these formulas that the parameters v_1 and v_2 correspond to the speeds of the currents and voltages in the disturbing line and the coaxial cable respectively.

As an example, let us consider a triaxial setup, the length of which is $L_0 = 1$ m and the propagation velocities compared to the speed of light are $v_1 = 0.8\,c$, and $v_2 = 0.6\,c$. The first ($n = 1$) near-end voltage zero appears at $f_1 = 102$ MHz, and the first ($p = 1$) far-end voltage zero at $f_1 = 720$ MHz. Since the measured voltage "minimum" is not exactly a "zero" (as predicted by (4) and (5)), the correction in proximity of these frequencies will be affected by a significant error.

This method is therefore not really usable in this example for frequencies lower than 50 MHz; however, the limit of this correction can be extended to 300 MHz if we use far-end voltage.

To obtain measurements usable up to 1 GHz, it is essential to reduce the dimensions L_0 of the sample, in order to avoid high-frequency propagation phenomena. Thus, a 10-cm test sample brings the near-end voltage limit to 500 MHz, and to 3 GHz for far-end voltage. However, it should be mentioned that the previously-described triaxial setup is not recommended for samples of small dimensions. Moreover, leakage localized at sample cable terminations leads to additional errors (some specific arrangements involved by use of sample with 10 cm small dimension was necessary for reaching reliable measurements). The following is dedicated to the description of measurement setups with the so called wire injection and shield discontinuity methods, that are more suitable for high frequencies than classical triaxial arrangements.

Measurement Setup with Wire Injection Method

Fig. 1 shows the longitudinal section of an impedance measurements bench based on the wire injection method.

The perturbing line consists of a conductor of length L_0 tied to the external insulating sheath of the cable under test. Fig. 2 represents a transverse section localized in the median part of the measurement device. The width of the self-sticky metallic

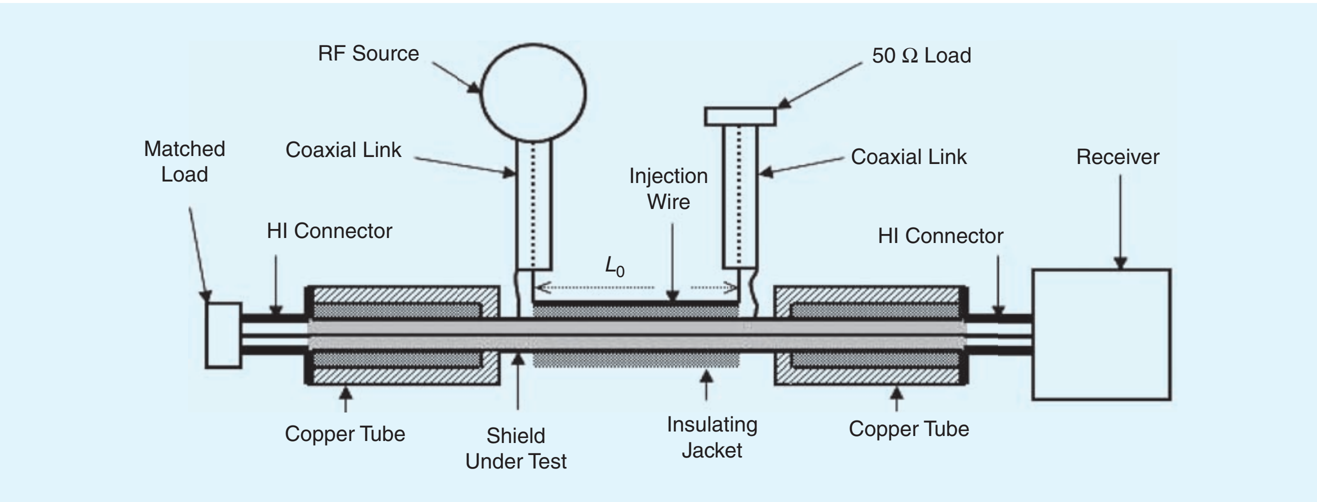

Fig. 1. Description of the wire injection setup.

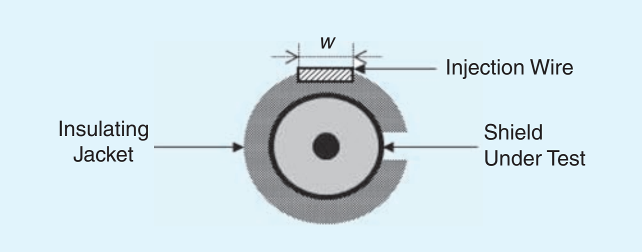

Fig. 2. View of the cross section of the cable under test showing the location of the injection wire.

strap is determined so that the characteristic impedance of the relevant transmission line is 50 Ω. A high-frequency source is connected to this input line through a coaxial cable of characteristic impedance 50 Ω.

A second coaxial connection, symmetrical to the previous one, connects the line extremity with the 50 Ω matched impedance.

Like in the classic triaxial setup, the injection wire connected with the source voltage produces an electromagnetic radiation in proximity of the measurements bench. It is therefore essential to protect the passive terminations of the sample with additional shielding. This involves homogeneous copper (or tin) pipes providing a uniform electric contact with the shield periphery, situated at the ends of the perturbed zone. Far-end voltage is measured by means of a spectrum analyser connected to the end of the cable under test, opposite to the injection point; the other end of the cable is terminated on a matched load.

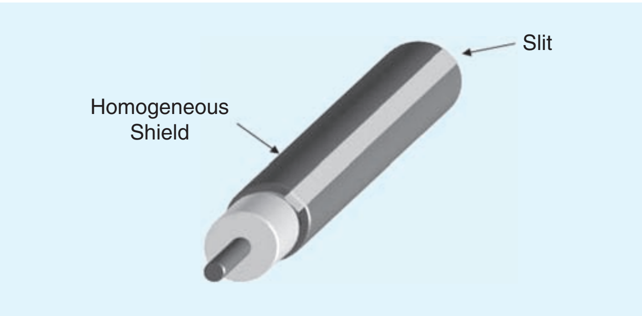

Fig. 3. Cable shield configuration with a slit.

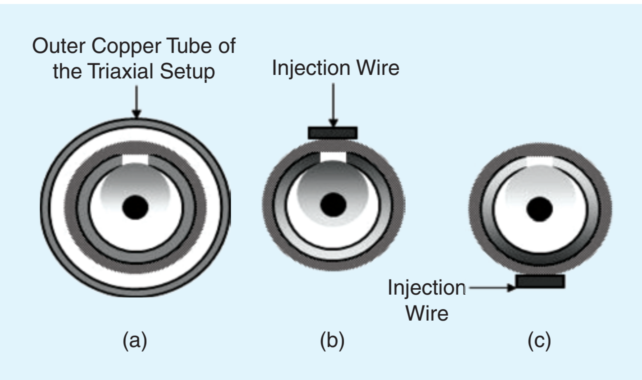

Fig. 4. Various conditions of the magnetic field leakage depending of the current density distribution throughout the cable shield cross section. (a) Current density with uniform distribution. (b) Current density increased near the location of the shield slit. (c) Current density increased at the opposite side of the shield slit.

This measurement technique allows for the continuous exploration of frequencies from about 1 kHz to 1 or 2 GHz. As pointed out above, the sensitivity of this method is limited by the wire radiation, and in order to reach transfer impedance values below 100 $\mu\Omega$/m we need to adopt the special precautions described in reference [1].

Contrary to the triaxial setup, the current distribution in the transverse section of the shield under test is not exactly uniform. Therefore, the measured transfer impedance will depend on the angular position of the wire. This phenomenon is particularly visible when the shield structure departs from a perfectly cylindrical shape. For instance, Fig. 3 shows a homogeneous shield with a defective coverage, constituted by a slit placed on the cylinder generatrix.

Fig. 4 shows the current density throughout the cross section of the sample either for: (**a**) a uniform distribution in the triaxial setup, or for (**b**) a nonuniform variation realized by means of the injection wire placed in front of the slit, or (**c**) opposed to it. The shadowed circles under the slit indicate the relative intensity of the magnetic field leakage, which, of course, reaches its maximum in the disposition (**b**) and has its minimum in disposition (**c**). Consequently, we appreciate that the test performed with the triaxial setup reproduces a global transfer impedance, that can be found in this second method by means of an average of the measurements realized placing the coupling wire at four test points of the cross-section separated by 90 degrees.

Triaxial Setup with Shield Discontinuity Method

This technique uses resonance properties of a triaxial setup constituted by a short-circuited perturbing line; Fig. 5 shows a longitudinal cross-section of such setup.

The sample cable is placed inside metallic pipes which create the central conductor of a coaxial cavity; such pipes also have a complementary shielding function. In fact, the sample is interrupted in the middle for a short distance L_0 that represents a "discontinuity". With this procedure, we partially expose the shielded cable under test to the perturbing current produced by a high-frequency source connected at the cavity input. The equivalent circuit shown in Fig. 6 helps in describing the measurement setup working principle.

The perturbing line, short-circuited at one end, is therefore powered by the high frequency voltage source E_0 with internal impedance Z_0, generating a current distribution $I_1(z)$ and a voltage distribution $V_1(z)$. The hatched region indicates the part of the shield really exposed to the perturbing current indicated in

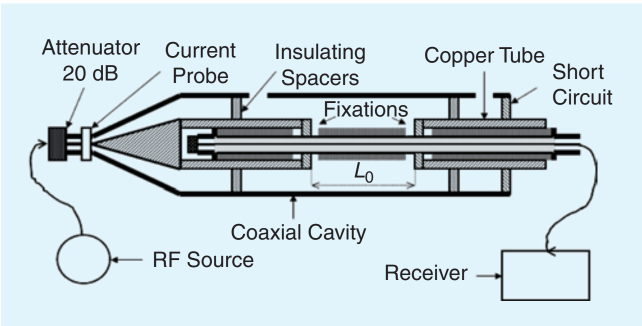

Fig. 5. Description of the setup named shield discontinuity method.

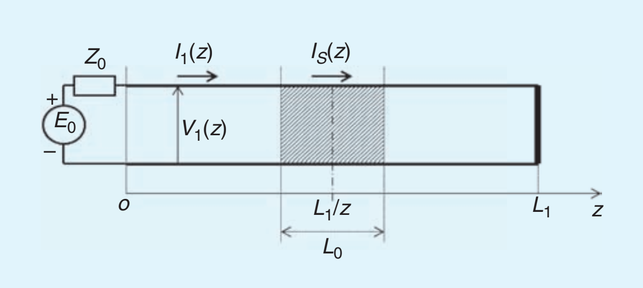

Fig. 6. Transmission line arrangement for the computation of the current $I_S(z)$ at the shield discontinuity.

this point by $I_S(z)$. The discontinuity is preferably placed in the median part of the line (i.e., at $z = L_1/2$), where the parameter L_1 represents the cavity longitudinal dimension.

The transverse dimension of the perturbing line is chosen to produce a characteristic impedance Z_{c1} close to 50 Ω, and the spacers have a slight influence on the electromagnetic field configuration. We assume that the propagation constant γ_1 in the cavity is close to the value in air, that is:

$$\gamma_1 = jk \cong j\frac{\omega}{c} \tag{6}$$

An additional simplification assumes that the geometrical transition at the discontinuity does not modify the local characteristic impedance. Under the above hypotheses, a simple analytical expression for $I_1(z)$ is derived:

$$I_1(z) = I_0\cos[k(L_1 - z)] \tag{7}$$

where the amplitude I_0 becomes

$$I_0 = \frac{E_0}{Z_0\cos(kL_1) + jZ_{c1}\sin(kL_1)} \tag{8}$$

The measurement principle exploits the current behaviour $I_S(z)$ observed at the cavity resonance. The following numerical example should clarify these phenomena. A coaxial cavity has a longitudinal dimension $L_1 = 70$ cm and a characteristic impedance $Z_{c1} = 50$ Ω; the propagation velocity of the TEM mode is $v_1 = c$. The source can be connected to the line in two different configurations:

1) Matched source (without attenuator) with voltage amplitude $E_0 = 10$ V and impedance $Z_0 = Z_{c1} = 50$ Ω
2) Sources with a 20 dB attenuator and voltage amplitude $E_0 = 1$ V and impedance $Z_0 = Z_{c1} = 5$ Ω

Fig. 7 shows the current computed in the median part of the cavity $I_1(L_1/2)$ as a function of frequency. The thin line represents the simulation obtained with the matched source, while the thick line refers to the current with the insertion of a 20 dB attenuator between matched source and cavity input.

This theoretical result suggests that the current graph can be subdivided into three different regions. The low frequencies region spreads from 10 kHz to 30 MHz; here, the transfer impedance can be directly determined by the ratio between the voltage collected at the end of the sample and the current measured at the cavity input. The middle frequencies region covers in this example the range between 30 MHz and 150 MHz: here, the correct evaluation of the transfer impedance needs a mathematical correction. The high frequencies region, situated between 150 MHz and 3 GHz, allows the direct measurement of

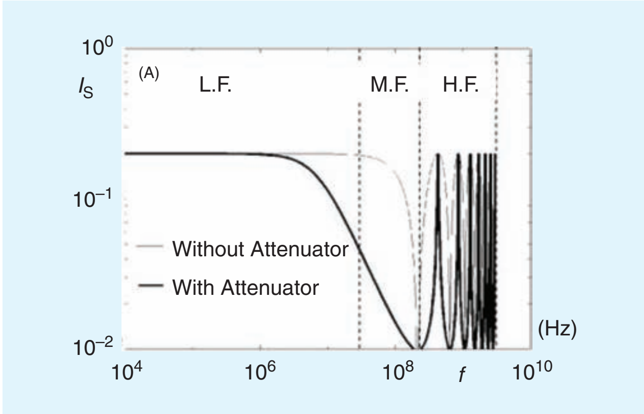

Fig. 7. Variations vs the frequency of the current $I_S(z)$ with and without attenuator inserted between the RF Source and the input port of the setup.

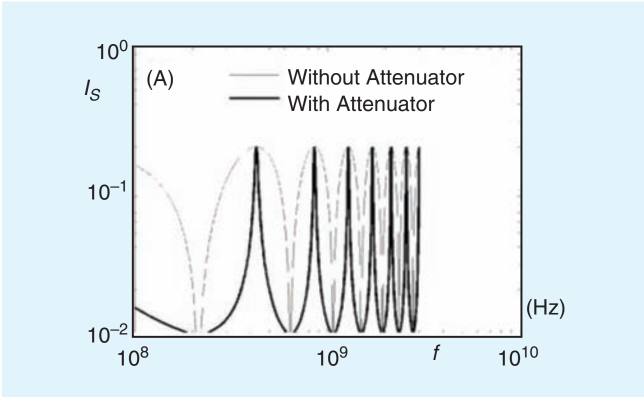

Fig. 8. Zoom about the resonances occurring on the current $I_S(z)$ at the shield discontinuity, these are lesser damped when the attenuator is inserted.

the transfer impedance: this is done at the particular frequencies imposed by longitudinal cavity resonances, i.e. for the specific frequencies f_n given by the following condition:

$$\cos\left(k\frac{L_1}{2}\right) = \pm 1 \quad \rightarrow \quad f_n = n\frac{c}{L_1} \tag{9}$$

For the example considered above, such frequencies assume the values of 428 MHz, 857 MHz, 1.3 GHz, 1.7 GHz, 2 GHz, 2.5 GHz, etc. Considering the cavity transverse dimensions (usually in the range of 7–8 cm), the exploitation of frequencies above 3 GHz is not advisable, due to the errors introduced by the excitation of TE and TM modes in the cavity.

A zoom of Fig. 8 between 100 MHz and 3 GHz shows details about resonance selectivity.

We can see that a matched source produces broad resonances because of the high damping of the circuit. We can reduce this phenomenon by reducing the source output impedance through the interposition of an attenuator, that also helps protecting the radio frequency generator from the overload produced by the wide range of impedance variations at the cavity input.

It can be shown that in the high frequencies region, the transfer impedance can be evaluated by the voltage-current ratio at the resonances, i.e.

$$|Z_t| \cong \frac{2}{L_0}\left|\frac{V_2(L_0)}{I_1(L_1/2)}\right|_{f=f_n} \tag{10}$$

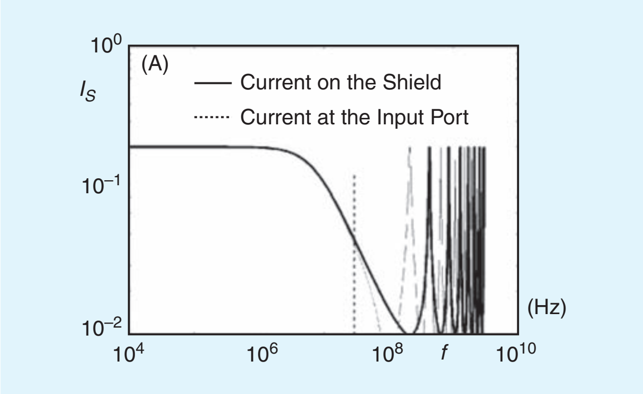

Fig. 9. The resonances are shifted in respect of the location of the current along the inner conductor of the coaxial cavity.

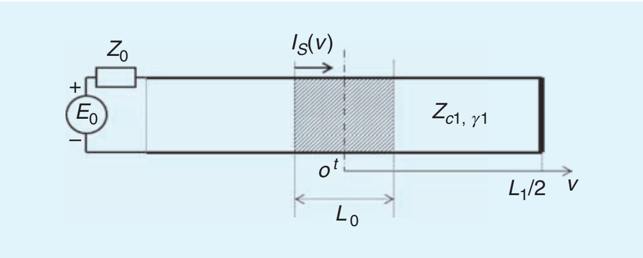

Fig. 10. Transmission line arrangement for the computation of the voltage at the end of the shielded cable under test.

Current $I_1(L_1/2)$ cannot be evaluated in the central part of the sample; hence, its indirect evaluation can be realized by means of a current sensor placed at the cavity input. For the previous example, the curves of Fig. 9 compare the currents computed at the median point and at the input of the sample.

For low frequencies between 10 kHz and 30 MHz, the two current values are identical, and a similar observation applies for resonance peaks at high frequencies. However, at intermediate frequencies between 30 MHz and 100 MHz, significant differences are observed and predictions require the application of a correction factor.

To evaluate the voltage $V_2(L_1)$, we can use the longitudinal coordinates shift shown in Fig. 10.

The new coordinate v is defined as

$$v = z - \frac{L_1 - L_0}{2} \tag{11}$$

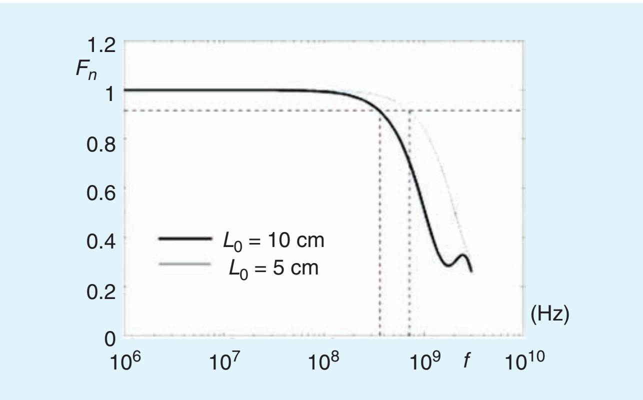

Fig. 11. Change in shape of the function $F_n(\omega, L_0)$ with the length L_0 of the shield Discontinuity.

At resonance frequencies, the shield current $I_{Bn}(v)$ takes the expression:

$$I_{Sn}(v) = I_{0n}\cos(k_n v) \tag{12}$$

where the current amplitude is virtually independent of the resonance order, i.e.

$$I_{0n} = \frac{E_0}{Z_0} \tag{13}$$

The voltage generated at the sample end in presence of resonances is then expressed by the following integral:

$$V_2(L_1) = (-1)^n \frac{1}{2} Z_t I_{0n} e^{-\gamma_2 L_1/2} \int_{-L_0/2}^{L_0/2} ch(\gamma_1 v)\, e^{-\gamma_2 v} dv \tag{14}$$

This integral produces a correction function $F_n(\omega_n, L_0)$ to be applied to the voltage determined at low frequencies:

$$V_2(L_1) = (-1)^n \frac{1}{2} Z_t I_{0n} L_0 F_n(\omega_n, L_0) \tag{15}$$

where the factor $F_n(\omega_n, L_0)$ takes the following analytical form:

$$F_n(\omega_n, L_0) = \frac{1}{2} \frac{sh\left[(\gamma_1 + \gamma_2)\frac{L_0}{2}\right]}{(\gamma_1 + \gamma_2)\frac{L_0}{2}} e^{-\gamma_2 L_1/2} + \frac{1}{2} \frac{sh\left[(\gamma_1 - \gamma_2)\frac{L_0}{2}\right]}{(\gamma_1 - \gamma_2)\frac{L_0}{2}} e^{-\gamma_2 L_1/2} \tag{16}$$

Using the previous numerical example, correction curves can be generated according to (16). The coaxial cavity is characterized by a length L_1 = 70 cm and a characteristic impedance Z_{c1} = 50 Ω; the TEM-mode propagation velocity on the perturbing line is $v_1 = c$ and inside the sample cable it amounts to $v_2 = 0.6c$. The curves of Fig. 11 show simulations results for two discontinuities with different dimensions, as follows: L_0 = 10 cm (the corresponding line is the thicker one) and L_0 = 5 cm (thinner line).

The intercepts of the curves in Fig. 11 with the 0.9 and 0.5 levels identify those frequencies for which the error introduced by propagation phenomena represents 10% or 50% of the low-frequency impedance value, respectively, as summarized in the following table.

The above errors can be compensated during the measurement by means of the calculation of function (16).

Since tubular shields placed on both parts of the discontinuity generally exceed the sample diameter, we can adjust the inaccuracy produced by the characteristic impedance transition by means of other expressions not given here.

L_0 = 10 cm	ε = 10%	→	f = 400 MHz
	ε = 50%	→	f = 1 GHz
L_0 = 5 cm	ε = 10%	→	f = 700 MHz
	ε = 50%	→	f = 2 GHz

Contrary to the coupling-wire setup previously described, the discontinuity method adopts a closed coaxial structure confining the electromagnetic energy around the sample under test. This configuration reduces the risk of parasitic coupling and allows a sensitivity improvement, attaining a level of $\mu\Omega$/m for frequencies up to hundreds of MHz. This measurement method is recommended for the qualification of high-immunity cables or shielded connectors.

Above 3 GHz, the methods discussed above generate significant errors due to the appearance oh higher-order propagation modes in the setup. An alternative approach consists in replacing the measurement of the transfer impedance with the determination of the shielding attenuation performed in a stirred-mode reverberation chamber.

Calibration Method for High Frequency Range

In our previous paper [1] we showed that the calibration of the measurement setup for the transfer impedance of shielded cables requires a specific sample made of a homogenous metal conductor in a form of a tube. In fact, the transfer impedance of such sample can be determined by the Schelkunoff's formula [1] which may be also found in the first term of equation (17) of this paper. The comparison of the measured value of the transfer impedance with the computed result was used in our previous work to point out to some imperfections of the measurement setup, in particular the effect of field leakage in the contact zone between the sample and the rest of the setup. Also, exploiting the fact that the transfer impedance of a homogeneous metallic tube monotonically decreases with the increasing frequency, we showed that the calibration sample allows to determine the measurements sensitivity, defined as the minimum measurable threshold, usually given by a multiple or submultiple of $\mu\Omega$/m.

Knowing that the transfer impedance of a copper tube, whose thickness is on the order of a tenth of a millimeter, attains values below 1 $\mu\Omega$/m at frequencies above 70 MHz, we cannot expect to use this sample to calibrate a measurement setup in the frequency range 100 MHz–1 GHz. In fact, the increase of frequency has the inevitable consequence of increasing the amplitude of induced voltages due to leakage, and the sensitivity in this frequency range surpasses the threshold of 1 $\mu\Omega$/m, attaining values towards 10 or 100 $\mu\Omega$/m. The use of homogeneous shields of thickness lower than 100 μm would allow to reach an acceptable threshold also in the frequency range 100 MHz–1 GHz, but experience has demonstrated that it becomes rather difficult to realise tight contacts at the sample extremities, thus making the calibration results too influenced by field leakage.

For the above reasons, at frequencies above 100 MHz, we adopt samples having their transfer impedance determined by the electromagnetic coupling produced by a small circular aperture. Fig.12 provides construction details of the this sample, which is represented by a piece of coaxial cable, whose longitudinal dimension is determined according to the previously defined criteria. The sample requires a homogenous copper shield of thickness E, whose suggested order of magnitude will be specified later on. The magnetic coupling is produced by a small circular aperture of diameter d through the shield surface [6].

The transfer impedance of such sample takes the following expression :

$$Z_t = R_0 \frac{(1+j)\dfrac{E}{\delta}}{sh\left[(1+j)\dfrac{E}{\delta}\right]} + j\,L_t\omega \qquad (17)$$

The first term of (17) represents the coupling due to the diffusion of the electric field tangential to the surface of the copper shield; in fact, this term contains the shield thickness E, its per-unit-length resistance R_0 and the skin depth δ. The second term $L_t\omega$ expresses the voltage induced by the electromagnetic coupling through the circular aperture; it contains the angular frequency ω of the sinusoidal perturbing current injected along the shield and the transfer inductance of the aperture L_t. We must realize that, in the frequency range between 100 MHz and 1 GHz, a hole of diameter d on the order of a millimeter and a copper tube of thickness E larger than 100 μm, give rise to a term $L_t\omega$ that is largely dominant in eq. (17), i.e.,

$$d \geq 1\text{mm} \ \text{ and } \ E \geq 100\ \mu\text{m} \ \rightarrow \ Z_t \cong j\,L_t\omega \qquad (18)$$

Consequently, the measured transfer impedance of this sample with a hole is proportional to the frequency; hence, the graph of the amplitude of Z_t is a straight line whose slope is determined by the value of L_t. Therefore, the superposition of the theoretical straight line depending on L_t and the measured transfer impedance allows us to evidence possible discrepancies, revealing calibration defects of the measurements setup.

The coupled line theory help us to show that the sample transfer inductance L_t depends on the diameter D of the shield, as follows:

$$L_t = \frac{\mu_0\,\alpha_m}{\pi^2 D^2} \qquad (19)$$

where $\mu_0 = 4\pi 10^{-7}$ H/m is the magnetic permeability of vacuum and α_m is the coefficient of magnetic polarizability of the aperture [5], which, for a small circular hole, can be analytically determined by means of the plane-wave diffraction theory:

$$d \ll D \ \text{ and } \ E \ll d \ \rightarrow \ \alpha_m = \frac{d^3}{6} \qquad (20)$$

It should be pointed out that the validity of the above (19) and (20) requires that the hole diameter d is much larger than the thickness E but much smaller than the shield diameter D.

By means of several samples with apertures of decreasing diameters, we can observe that the coefficient α_m–proportional to d^3–generates voltages of decreasing amplitudes at the end of the samples. This procedure allows us to evaluate the sensitivity of the test setup up to very high frequencies. Should the aperture

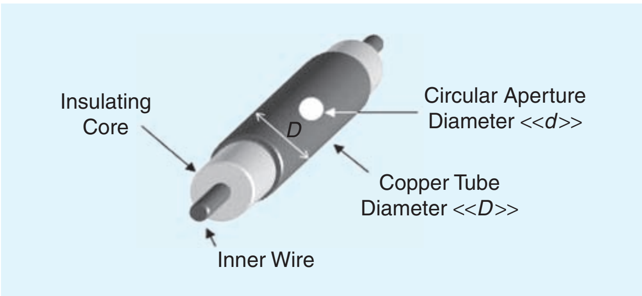

Fig. 12. Calibration sample with small circular aperture: description of the main geometrical parameters.

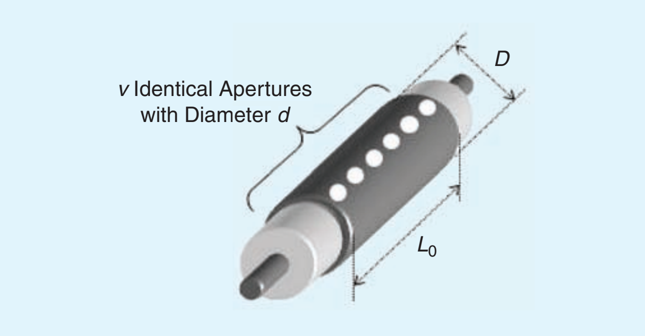

Fig. 13. Calibration sample with v similar uniformly spaced circular apertures.

diameter be comparable or smaller than the shield thickness, the literature provides a correction coefficient for the polarizability computation [7].

In order to appreciate the influence of propagation phenomena on the measurement accuracy, we adopt a sample with a series of regularly-spaced apertures along the generatrix of the copper tube, as illustrated in Fig. 13. The transfer inductance then becomes:

$$L_t = \frac{\nu}{L_0} \frac{\mu_0 \, \alpha_m}{\pi^2 D^2} \tag{21}$$

where the parameter v indicates the number of identical apertures of diameter d and L_0 is the length of the generatrix along which the holes are uniformly aligned. It should be noted that the transfer inductance of (21) has dimensions of H/m, contrary to the case of a single aperture, for which L_t given by (19) is expressed in H.

Examples of Transfer Impedance Measurements Carried out within 100 MHz to 1 GHz

This Section presents results of measurements conducted on a calibration sample and on coaxial cables with braided shields. The calibration sample is made of a copper tube (diameter D of 10 mm, and thickness of 0.1 mm) with a hole (diameter d of 5 mm). The braided cables are of commercial types KX 15 and KX 4. Comparisons of measurements made on different setups

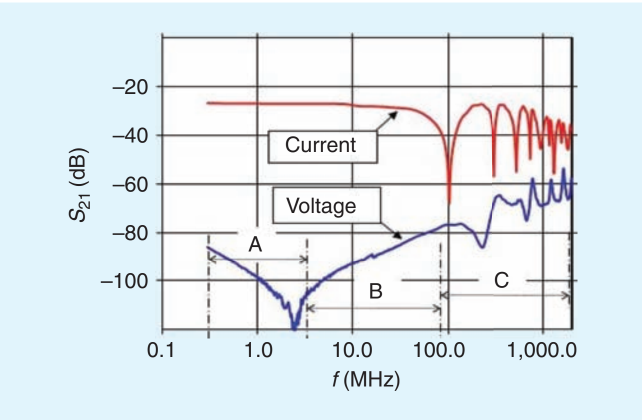

Fig. 14. Test performed on the calibration sample with one small circular aperture. The upper red curve shows the S_{21} vs the frequency when the input of the network analyzer is connected at the current probe. The blue curve below shows S_{21} when the N.A. input is collecting the near end voltage.

(one with shield discontinuity, one of classical triaxial type, and one with wire injection method) are proposed in the following.

Measurements of a Sample with an Aperture

The curves of Fig. 14, referring to a setup with shield discontinuity, show the behaviour of the current measured at the setup input and of the voltage collected at the output, as described in Sect. II. The sample under test is a calibration sample with an aperture.

The results of Fig. 14 are shown between 300 kHz and 2 GHz, but the measurement method is exploitable below 100 MHz, where we observe a reduction of sensitivity due to the reduced dimensions of the sample under test. The vertical scale represents the values of S_{21} (in dB) as given by the network analyzer, of which one port is connected to the input of the measurement bench and the second port is linked either to the current probe installed at the input of the measurement bench or at its output where the sample is short circuited.

The red trace on the upper part of the graph shows the behaviour of S_{21} as obtained with the output port of the network analyzer connected to the current probe. The comparison with Fig. 7 indicates a satisfying agreement with the thin line obtained by simulation of the sample. This condition explains the discrepancies of the positions of maxima and minima of the current. In fact, the first minimum of the experimental curve–actually located at the frequency of 100 MHz–perfectly coincides with the first resonance of the 70-cm long cavity.

The blue trace shows the behaviour of the voltage measured at the end of the sample. The change of this curve with frequency suggests a subdivision of the graph into three separates zones.

Zone **A**, situated between 300 kHz and 30 MHz, is characterized by a monotonic decrease of the curve with frequency: this means that coupling through the sample is dominated by the diffusion of the electric field in the copper thickness of 0.1 mm. Referring to (17), it means that the strength of the second term on the right-hand side, i.e. the transfer reactance, is negligible with respect to the first term. Zone **B**, situated between 30 MHz and 100 MHz, shows a monotonic increase of voltage with frequency: in this case, coupling is clearly dominated by the small aperture and the transfer impedance mainly depends on the second term of (17). In zone **C**, situated between 100 MHz and 2 GHz, the voltage undergoes amplitude fluctuations more and more correlated to propagation phenomena as the frequency grows above 100 MHz. It is ought to be remarked that the resonances evidenced by amplitude maxima are correlated to maxima of the induction current circulating on the sample located in the central part of the cavity.

The transfer impedance above 100 MHz is precisely determined at voltage maxima. The curves of Fig. 15 allow us to compare the transfer impedance measured by means of the discontinuity setup with the straight line derived from (17). It must be noted that–above 100 MHz–the red curve showing the measurement results is obtained by a linear interpolation of transfer impedances determined for each individual voltage resonance. The green curve, limited to the interval 1 MHz–1 GHz, is the result of the transfer reactance calculation, according to (18), (19) and (20): the excellent agreement with the measurement curve is evident.

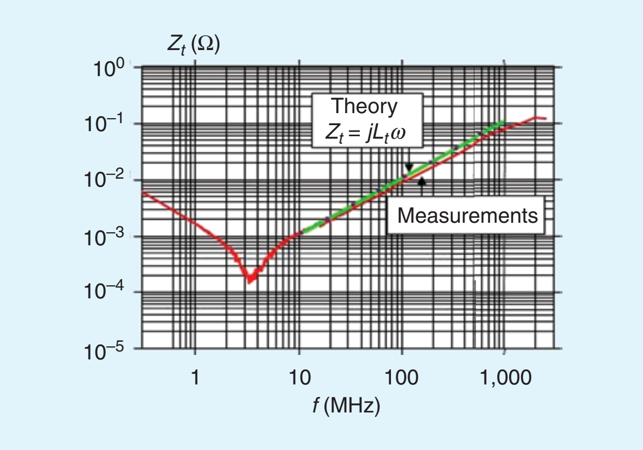

Fig. 15. Transfer impedance of the calibration sample with one aperture deduced from the test carried out with the shield discontinuity method.

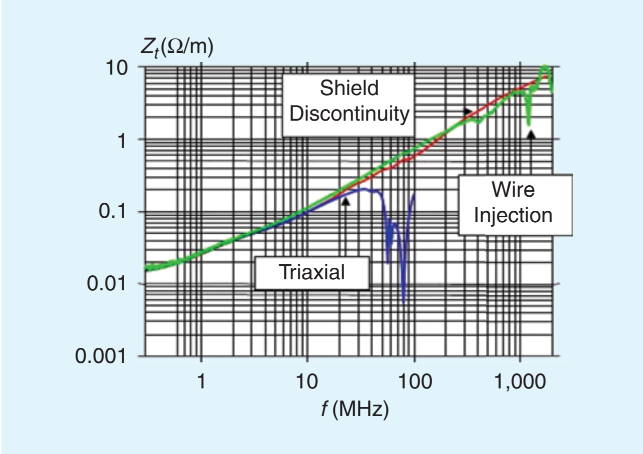

Fig. 16. Transfer impedance of the KX15 single braided cable tested successively with the triaxial, wire injection and shield discontinuity methods.

Comparison of Measurements for Three Setups

The objective here is to collect on a single plot (Fig. 16) the curves of the transfer impedances obtained for a classical triaxial setup, the wire injection setup described above in Section II, and the shield discontinuity setup. The triaxial setup was made according to the description of Fig. 4 of our previous paper [1]. The cable used for this comparison is a single braided coaxial one (type KX 15 (RG 58)), and the test length of 10 cm, as already indicated.

The blue line of Fig. 16 represents the transfer impedance obtained by near-end crosstalk voltage measured on a 1-m long cable sample by means of the classical triaxial setup. This curve is undistinguishable from the results of the other methods up to a frequency of approximately 20 MHz. From 20 to 100 MHz, this curve presents significant fluctuations that can be correlated to the de contribution of both propagation phenomena and setup radiation. The physical origin of such discrepancies has been thoroughly discussed in our previous paper [1].

The green line of Fig. 16 represents the transfer impedance obtained by the method of the wire injection. The quasi-monotonic behaviour of this curve up to approximately 1 GHz proves that the technique is well-adapted for the suppression of propagation artefacts. It should be noted that the measurement refers to the far-end crosstalk voltage, but the amplitude fluctuations between 1 and 2 GHz should be related to the setup radiation and to the mismatch of the injection line, both appearing at high frequencies. In fact, we should mention that the evaluation of the perturbation current for the injection-line method is made by taking the ratio of the power injected on the perturbation line, assuming that the value of its input impedance is very close to 50 Ω. However, this impedance is not rigorously invariant, since it depends on the constancy of the characteristic impedance, especially at the transition to the line made of a ribbon conductor glued to the insulation jacket of the cable under test. Also, the section under test is transitioned at its input and output to 50-Ω coaxial cables connected to the UHF source and to the load of the injection line, respectively. Such transitions locally introduce parasitic impedances whose influence can appear in the GHz range.

The red curve is the result of the measurement obtained by means of the shield discontinuity technique. With reference to the plot of Fig. 14, it appears that the impedance curve is known continuously between 300 kHz and 100 MHz, but at higher frequencies–from 100 MHz and 2 GHz–the value of Z_t is only known for those points where the voltage measured on the test sample presents amplitude maxima. The graph of Fig. 16 confirms that, above 100 MHz, the red curve is a linear interpolation of resonance points.

Braided Shield Behaviour for a Large Frequency Range

In general, transfer impedance of cables with a shield made of a single braid can be modelled by means of the following expression:

$$Z_t = R_0 + j\,L_t\,\omega \qquad (22)$$

where the quantity R_0 represents the per-unit-length braid resistance and L_t is the transfer inductance due to magnetic leakage occurring at the junction of the braids composing the carrier conductors. For regular cables, the order of magnitude of these parameters is $R_0 \approx 10$ mΩ/m and $L_t \approx 0.5$ nH/m. However, some cables depart from the model expressed by (22), as in the case of cable type KX 4 (RG 213), whose transfer impedance measured by the shield discontinuity technique is reproduced in Fig. 17.

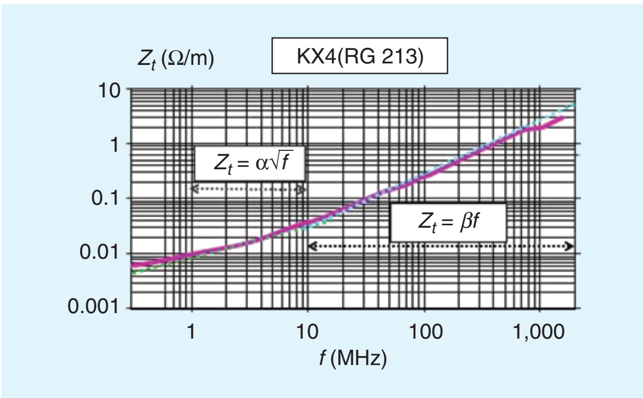

Fig. 17. Typical behaviour of the transfer impedance measured on a single braided cable shield with pitch angle lesser than 45°.

The vertical logarithmic scale of Fig. 17 represents the magnitude of the transfer impedance, and two dotted straight lines are added to the measurement curve (in magenta color). A careful analysis of the graph indicates that, for frequencies between 1 MHz and 10 MHz, the curve agrees with a straight line in logarithmic coordinates, meaning that the transfer impedance is proportional to the square root of frequency. On the contrary, from 10 MHz to 2 GHz, the measured curve is best fitted by a straight line with a slope having a double value of the previous one, meaning a direct proportionality with frequency. Knowing that the shield of RG 213 cables presents a pitch angle smaller than 30°, we can argue that the mechanisms of electromagnetic coupling in this case are rather different from those activated by small apertures, as for the case of the calibration sample reported in Fig. 12. Phase measurements of the transfer impedance show that the transfer impedance model best suited for braids of RG 213 type agrees rather well with the following expression:

$$Z_t = R_0 + k\sqrt{\omega}\, e^{-j\frac{3\pi}{4}} - j\, L_t\omega \tag{23}$$

where R_0 is the per-unit-length braid resistance, k is a real coefficient depending on the braid parameters and has positive values if the pitch angle with respect to the cable axis is smaller than 45°. In (23), the first two terms are complemented with the transfer impedance of the braid, but–contrary to the model of small apertures described above–the term L_t appears with a negative sign, indicating that the asymptotic phase behaviour tends towards $-\pi/2$ for very high frequencies. These phenomena reveal specific coupling mechanisms described in research work published in previous work about twenty years ago [8], [10].

Conclusion

Although the transfer impedance measurement setups discussed in this paper are specifically designed for the frequency range between 100 MHz and 1 GHz, the measurement principle they implement allows also to explore frequencies below 100 MHz. In fact, the minimum frequency of the measurement bandwidth is set by the HF signal generator and receiver available to the user.

The specificity of setups made for the 100 MHz–1 GHz bandwidth resides in the length reduction (approx 10 cm) of the sample of the shielded cable under test. This means a loss of sensitivity on the order of 20 dB with respect to a classical measurement performed by means of a triaxial setup on a 1-m long cable sample. The sensitivity loss is particularly noticeable for frequencies below 100 MHz, where the transfer impedance of cables for high immunity can be on the order of $\mu\Omega$/m, and in some cases attain even lower values. The consequence is, that for such very good shields, it may be required to compare the measured data obtained by means of the high-frequency setup with the classical tests performed in the triaxial configuration.

It should also be mentioned that measurement setups based on the injection line or on the shield discontinuity, as described in the present paper, are not unique for the frequency bandwidth 100 MHz–1 GHz; different techniques have also been proposed in the literature [9], [11]. However, the injection line and the coaxial discontinuity are likely to be of simpler use.

As far as frequencies above 1 GHz are concerned, it is clear that the devices based on the principle of coupled transmission line reach their validity limits. In fact, as soon as the wavelength approaches the transverse dimension of the metallic tube employed by the shield discontinuity setup, we reach the limit of validity of TEM propagation, and higher order modes appear, and give rise to systematic measurement errors with growing amplitude with frequency. For the injection-line method at frequencies above the GHz, the increase of common-mode current produces additional systematic errors. In both cases, the experience has taught us that the compensation of errors via mathematical or technological tricks is inefficient. Thus, we turned toward the use of shielding effectiveness measurements via electromagnetic field illumination, and we demonstrated that the adoption of mode-stirred reverberation chambers brings interesting insights and allows for the conversion of shielding attenuation measurements into the conventional transfer impedance characteristic.

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Biography

Bernard Démoulin *was born in 1946. He received his Ph.D. in 1981 and until 2008, was head of the EMC group at the IEMN-TELICE Laboratory. He is presently professor emeritus at the University of Lille, France. His domain of expertise is mainly related to the effect of electromagnetic coupling through cables, transfer impedance measurement and the study of Mode Stirred Reverberation Chambers. He is a senior member of the French society of electrical engineers (SEE) and an URSI correspondent member.*

Lamine Koné *was born in 1956; he received his Ph.D. degree in 1989. Since 1990, he has been working as engineer in the IEMN-TELICE laboratory at the University of Lille, France. His domain of expertise deals with EMC measurements, especially concerning the transfer impedance on shielded cables or connectors and tests carried out in mode-stirred reverberation chambers.* **EMC**

EMC Standards Activity

Don Heirman, Associate Editor

International EMC Advisory Committee Meets in the US

In early December, the Advisory Committee on EMC (ACEC) of the International Electrotechnical Commission (IEC) met over a three day period at ETS-Lindgren's facility in Cedar Park, Texas. The committee has 20 members (15 were in attendance) representing IEC technical committees that deal with EMC issues and standards. Diethard Moehr of Siemens chairs the committee with Dr. Remy Baillif (IEC Central Office Technical Officer) as secretary.

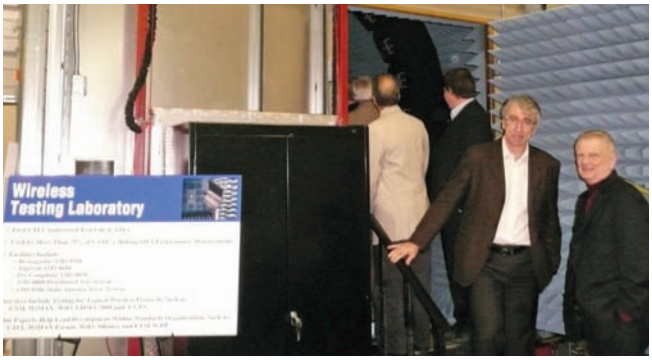
The members represent various technical committees, including those shown below, and appointed experts by the IEC Standardization Management Board.

TC77	Electromagnetic Compatibility
SC77A	Low Frequency Phenomena
SC77B	High Frequency Phenomena
SC77C	High Power Transient Phenomena
CISPR	International Special Committee on Radio Interference
CIS/A	Radio Interference Measurements and Statistical Methods
CIS/H	Limits for the Protection of Radio Services
CIS/I	EMC of Information Technology Equipment, Multimedia Equipment and Receivers
TC22	Power Electronic Systems and Equipment
TC46	Cables, Wires, Wave-guides, RF Connectors, RF and Microwave Passive Components and Accessories
TC61	Safety of Household and Similar Electrical Appliances
TC62	Electrical Equipment in Medical Practice
SC62A	Common Aspects of Electrical Equipment used in Medical Practice
TC65	Industrial-Process Measurement, Control and Automation

Prior to the start of the meeting, there was a tour of the ETS-Lindgren facilities showing several chambers used for a variety of tests including those for wireless, acoustics, and EMC measurements. A highlight of the tour was seeing the basic manufacturing process to fabricate what they provide including antennas, TEM devices, and RF filters as well as test chambers. It was interesting to see their open area test site

PHOTOS BY JANET O'NEIL

A tour of the ETS-Lindgren facility was held prior to the start of the ACEC meeting. Inspecting the wireless test chambers are (from left) Robert Sitzmann of Siemens AG, Masamitsu Tokuda of the University of Tokyo, Noboru Shibuya of Takushoku University, Emmanuel De Jaeger of Laborelec, Diethard Moehr of Siemens, Jacques Delaballe of Schneider Electric, Bernd Gehrke of BSH Bosch und Siemens Hausgeräte, and Ajay Garg of Hydro One Networks.



Herve Rochereau (left) and Don Heirman view ETS-Lindgren's wireless testing laboratory.

Don Heirman of Don HEIRMAN Consultants, Beniamino Gorini of Alcatel-Lucent Italia, Herve Rochereau of EDF - R&D, Bernd Jaekel of Siemens AG, Remy Baillif of the IEC Central Office, and Martin Wright of British Telecom (from left) are shown inside the three meter semi-anechoic chamber used for product development.

with the largest conductive ground plane in the US where antennas are calibrated and new design performance is checked.

The meeting agenda covered many important topics that come to the attention of ACEC where in many cases, after review of the presentations, ACEC advises the presenters on how to handle EMC matters. On occasion the advice is reported to the Standardization Board via a report that is drafted after each ACEC meeting.

In any case, many subjects are reviewed at this meeting after the usual administrative activity of discussing member assignments to follow organizations that have EMC activity not only in the IEC but in other organizations such as the IEEE EMC Society Standards Development Committee.

Next, the minutes of the last meeting were reviewed to ensure that any open action items are covered in the remainder of the agenda. Other organizations that ACEC invites to present their activity are shown below, along with other groups that are present at the meeting:

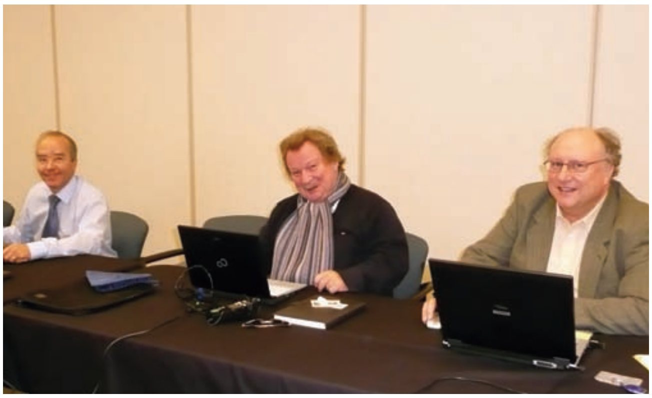
- International Organization for Standardization (ISO)
- International Telecommunication Union (ITU)-Radio Communications and Telecom Sectors
- European Committee for Electrotechnical Standardization (CENELEC)
- European Telecommunications Standards Institute (ETSI)

At this meeting, for example, Dr. Jaeger presented an update on the work of the International Council on Large Electric Systems (CIGRE) and the International Forum on International Electricity Distribution (CIRED). In particular, the EMC and EMF activities of CIGRE Study Committee C4 (C4.2) were presented. As with most international committees, there are issues with power quality associated with the Smart Grid, especially above 2.5 kHz. CIGRE is also working on related issues with the use of power line communications. Dr. Jaeger then indicated that an update of their guide on "EMC in Power Plants and Substations" is expected in 2011.

Next on the agenda were reports from product committees on their EMC activity/issues. From the list of Technical Committees/Subcommittees noted above, and additional committees, below are those that were reported on at this meeting:

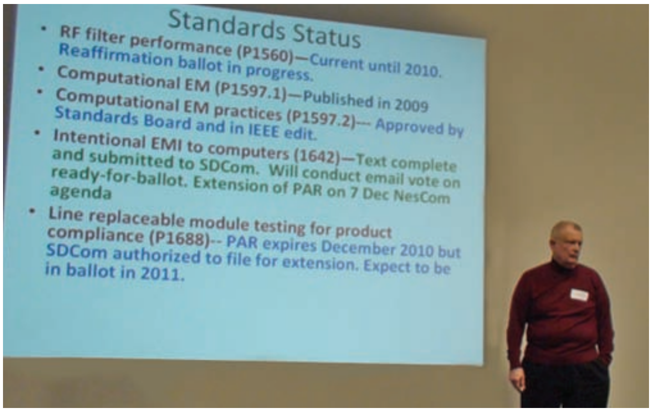
- TC13 –Electrical Energy Measurement, Tariff, and Load Control (metering) - concern was raised on meters working with currents of up to 200 Amps or more not reading correctly due to excessive harmonics on the power grid

Don Heirman, Martin Wright, Remy Baillif, Beniamino Gorini, Bernd Jaekel and Herve Rochereau (from left) learned about testing wireless devices with multiple antennas.



Remy Baillif (ACEC secretary), Diethard Moehr (chairman) and Robert Sitzmann (TC62) are shown (from left) preparing for the start of the ACEC meeting.

Noboru Shibuya (left) and Masamitsu Tokuda traveled from Japan to Cedar Park, Texas for the ACEC meeting held at ETS-Lindgren.



Don Heirman is shown presenting a review of IEEE EMC Society standards activity that is of interest to ACEC.

- TC22
- TC46
- TC61
- SC62A
- TC65/SC65A
- TC69—Electric Road Vehicles and Electric Industrial Trucks
- TC106—Methods for the Assessment of Electric, Magnetic, and Electromagnetic Fields Associated with Human Exposure

Note that the presentation by the author on TC106 was to bring together a liaison relationship with ACEC. The suggested interactions were in both directions as stated by the chairman of TC106—Ron Petersen. Here are a few of the actions suggested:

TC106 Action:

- Review any EMC documents that ACEC has access to and determine if human exposure is introduced
- Ask ACEC to comment on measurement techniques to assess RF environment levels
- Provide help in the application of Guide 107

ACEC Actions:

- Review TC106 documents that describe radiated emission measurements
- Provide insight on how to handle RF emissions from antenna arrays
- Review TC106 standards that describe RF measurement instrumentation and use of measurement uncertainty

The idea is that ACEC can guide the exchange to its member technical committees as appropriate to expert opinions and reviews. It was then agreed that Don Heirman as a member of ACEC will be the liaison with TC106 (TC106 had made this appointment at their meeting at the IEC General Meeting in Seattle last October).

Speaking of Guide 107 (EMC–Guide to the drafting of EMC publications), the Standardization Management Board (SMB) earlier in the year made such guides mandatory and hence any publication with a focus on EMC matters shall follow the Guide. The committee decided to look again at the Guide which is maintained by ACEC to ensure that mandatory and suggested areas in the Guide are clearly differentiated. *This Guide should be of interest to our own EMC Society standards activity. When it is updated, there will be a chance to review some of its basic requirements perhaps at an EMC Society Standards Development Committee meeting.*

Next, a review of the ACEC activity in providing tutorials and workshops including the increased support of the IEC Central Office was discussed. At the IEC General Meeting in Seattle, a two hour tutorial was held describing primarily the EMC standards activity of CISPR and TC77. This may form the kernel of expanding it to a full day or two in the future. To see the slides from a previous tutorial use: http://www.iec.ch/zone/emc/on_pres.htm

The next part of the agenda was to hear from CISPR and TC77 members present on the activities of their respective committees. In general, these were status reports by the chairmen of the parent committee and their Subcommittee

Enjoying the ETS-Lindgren hosted reception at a local restaurant were Remy Baillif, Herve Rochereau, Janet O'Neil, Bill Radasky of Metatech, Zhong Chen and Don Heirman (from left). Janet and Zhong are with ETS-Lindgren.

(From left) Martin Wright is encouraged to try a famous Texan beer, Shiner Bock, by his ACEC colleagues Robert Sitzmann and Emmanuel De Jaeger.

Don Heirman thanked all for coming to Cedar Park, Texas for the ACEC meeting and ETS-Lindgren for hosting the meeting and the dinner at a wonderful barbecue restaurant.

chairmen who were present. There is not enough room in this column to review the dozens of slides that were presented. But if there is any particular interest in the activities of these committees, you can contact the secretary of CISPR who is Stephen Colclough at s.colclough@samsung.com and the secretary of TC77 who is Diethard Moehr at diethard.moehr@siemens.com who will I am sure direct you to the appropriate person to answer your questions.

At each meeting the committee reviews the EMC Zone on the IEC web site to see if there are any changes needing to done or to check documents there. It is found by http://www.iec.ch/zone/emc/

The ACEC secretary has indicated that there will be a "new look" on the web site so even if you may have visited it in the past, it may be worthwhile to see the changes.

ACEC also assigns members to review standards of IEC Product Technical Committees that have EMC in their work. At this meeting, the secretary reported the following documents were reviewed:

- New work item proposal for SC45B (Radiation Protection Instrumentation)
- Committee draft document for TC72 (Automatic Controls for Household Use)
- Committee draft for vote document for SC17B (Low-voltage Switchgear and Controlgear)
- Committee draft for vote documents for TC29 (Electroacoustics)
- Committee draft document for TC85 (Measuring Equipment for Electrical and Electromagnetic Quantities)

So you can see the breadth of the IEC technical committees that have documents involving EMC application or use and hence are candidates for ACEC review. The reviews themselves look at the application of Guide 107 and any other clauses that contain emission or immunity aspects to make suggestions for improvement or provide confirmation that the EMC discussions/requirements are acceptable.

Two other agenda topics brought about considerable discussion. The first topic was a Swedish proposal for a strategy to increase the coordination of standardization of power quality and EMC. This proposal was submitted to the SMB which asked for National Committee (NC) responses. Seven responded as well as the officers of SC77A which handles low frequency phenomena (from power frequency up to 2000 Hz) which includes power line harmonics and voltage fluctuation horizontal standards for products to meet if required. While there was some support for the Swedish proposal for a special committee, there were several NCs that indicated that ACEC should review the matter. Hence, the SMB decided to submit the Swedish proposal to the ACEC for consideration and a report before they took any further action. At the ACEC meeting in Texas, there continued the discussion with the result that there was already good coordination with the needs for power quality and EMC simultaneous application. It was further decided that no special committee or working group would be needed to address the matter. The report back to the SMB is in preparation. Any significant reaction to the ACEC report will be covered in a subsequent Newsletter column.

"Should there be limits between 2 kHz and 150 kHz?" was the topic discussed next. Herve Rochereau, secretary of SC77A, presented a paper urging the consideration of limits in this frequency range to control voltage components on the power line from modern electronic equipment. His recommendation was to have product committees as well as EMC specific committees, such as TC77 and CISPR, to review their existing standards with the view to closing the limit "gap" between 2 kHz and 150 kHz where no present limits exist. ACEC agreed to support the request.

The last item on the agenda was to indicate any issues that ACEC can review with respect to Smart Grid (SG). There is an SMB Strategic Group 3 on Smart Grid which advises the SMB on fast-moving ideas and technologies likely to form the basis for new international standards or IEC TCs in the area of Smart Grid technologies. Both TC77 and CISPR have indicated the usefulness of their standards for SG application. That was noted at the meeting as ACEC continues to monitor how it can help in moving forward the application of EMC principles to achieve the interoperability of the SG system(s).

With a discussion of meetings for 2011, the meeting adjourned. If there are any questions, please contact Don Heirman, d.heirman@ieee.org.

EMC

CALL FOR PAPERS
IEEE Transactions on Electromagnetic Compatibility

Special Issue on
Applications of Nanotechnology in Electromagnetic Compatibility (nano-EMC)

PAPERS DUE: May 1, 2011

In the past few years, there has been an exploding interest in nanoscale science and technology. Nanotechnology is functional engineering on an extremely small scale that can be used to develop innovative materials and devices, and implants for numerous industrial applications. It involves the control of materials with a nanoscale fine structure, and with the manipulation of tiny objects at the dimension of molecules and atoms. The potential benefits of nanotechnology are revolutionary. Nanotechnology is truly multidisciplinary: research at the nanoscale frontier is unified by the need to share knowledge, tools and techniques, and expertise on atomic and molecular interactions. Nanotechnology is currently exploited in electronics, optoelectronics, photonics, sensors, material science, medicine and biology, but its application in EMC is still not very wide.

This Special Issue is intended to present recent research advances in nanoscale science and nanotechnology with applications of interest for the EMC community. The Special Issue is aimed to bridge the gap between nanoscale science and technology and EMC; to present new materials, devices and processes for EMC applications exploiting the powerful of nanotechnology; to investigate EMC issues related to the integration of nanocomponents in micro and macro electrical and electronic systems.

Suggested topics to be covered in this Issue include:

- Electromagnetic modeling and characterization of nanostructured materials, devices and systems for EMC;
- Nanostructured materials for EMC applications, like EM shielding, EM energy absorption, antistatics, surge suppression and protection, novel devices;
- Electrical and EM properties of nanocomposites for EMC;
- Nanointerconnects for next generation ICs;
- Signal integrity in nanocomponents and nanodevices;
- Nanostructured sensors for EMC;
- MEMS-based technology for smart antennas arrays and frequency-selective surfaces for EMC;
- Nanometrology for EMC.

Please submit your manuscript on-line to the IEEE TEMC Manuscript Central at the web site http://mc.manuscriptcentral.com\tems-ieee, making it clear that it is for this Special Issue, before **May 1, 2011**. All manuscripts should conform to IEEE Transactions on EMC Guidelines (see "Information for Authors"). Papers should not exceed 8 pages in length, due to editorial limitations. The publication of the Special Issue is scheduled for **November 2011**.

Guest Editors:

M. D'Amore, Research Center on Nanotechnology Applied to Engineering, Sapienza University of Rome, Rome, Italy (marcello.damore@uniroma1.it) – **M. S. Sarto,** Research Center on Nanotechnology Applied to Engineering, Sapienza University of Rome, Rome, Italy (mariasabrina.sarto@uniroma1.it) - **G. W. Hanson,** College of Engineering and Applied Science, Department of Electrical Engineering and Computer Science, the University of Wisconsin, Milwaukee, USA (george@uwm.edu) - **A. Naeemi,** Microelectronics Research Center, School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, Georgia, USA (azad@ece.gatech.edu) – **T. B. Kang,** Nanyang Technological University Singapore, School of Electrical & Electronic Engineering, Singapore (ebktay@ntu.edu.sg).

EMC Europe 2011

26-30 September, York

International Steering Committee Board of Chairmen:

J L ter Haseborg, Chairman (Germany)

H Garbe, Vice-Chairman (Germany)

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J Catrysse (Belgium)

A P J van Deursen (The Netherlands)

M Feliziani (Italy)

F Silva (Spain)

N Uzunoglu (Greece)

T W Wieckowski (Poland)

Local Organising Committee:

A C Marvin, Chairman

C Christopoulos, Vice-Chairman

J F Dawson

L Dawson

C Marshman

D W P Thomas

A Nothofer

S Greedy

Important Dates:

17 January 2011:
Preliminary Paper Submission.

1 March 2011:
Proposals for Workshops, Tutorials and Special Sessions.

1 March 2011:
Experimental and Practical Demonstrations.

8 April 2011:
Notification of Acceptance

9 May 2011:
Submission of Final Paper

The Conference:

EMC Europe is the pre-eminent EMC Conference in Europe and will be held at the University of York in the UK in 2011. We wish to invite and encourage all those working in electromagnetic compatibility to participate in this prestigious event in 2011.

EMC research and conferences in Europe have a long tradition. From the series of independent EMC conferences based in Wroclaw, Zurich and Rome running every second year, has now emerged EMC Europe which will be organised every year in a European city to provide an international forum for the exchange of technical information on EMC. The 2010 EMC Europe Conference was in Wroclaw and in 2011 it will be at York.

Technical Scope:

Authors are invited to submit original contributions on all aspects of EMC. Only full papers 4-6 pages in length, in IEEE, format, will be considered by the deadlines shown below. In addition, Workshop, Tutorial and other Special sessions will be organised to provide up-to-date practical help to those new to the subject or requiring an update, as well as to address in more depth topical subjects. Normal preliminary paper submission should be done electronically through the EMC Europe 2011 website (www.emceurope2011.york.ac.uk).

Proposals for Workshops, Tutorials and Special sessions will be coordinated by Dr D W P Thomas and the experimental and other practical presentations by Dr Angela Nothofer. There will be a technical exhibition held in parallel with the conference coordinated by Mr Chris Marshman. Sponsorship opportunities will also be available. Conference registration will be done at www.emceurope2011.york.ac.uk where further details will become available in due course.

All queries to: conference@emceurope2011.york.ac.uk

The Organisers aim at making this a technically rewarding conference and your stay in the historic city of York a very pleasant one.

A C Marvin, University of York
C Christopoulos, University of Nottingham

http://www.emceurope2011.york.ac.uk

EMC EUROPE 2011
YORK, UK

The Venue

In the last century King George V said that "The History of York is the History of England". York was founded in AD70 by the Romans as Eboracum and became their capital city in the Northern part of England. It retained this status through medieval times as England's second city and the seat of government for the North.

Constantine was declared Roman Emperor in York in 306AD. After the fall of Rome in 410AD, Eboracum became the Anglo-Saxon trading city of Eorforwic, then the Anglo-Danish city of Jorvik, finally emerging with its modern name York in later medieval times. Evidence of all these phases of its life is still visible today. Today York is dominated by its 13th century cathedral York Minster, the largest gothic cathedral North of the Alps, and by its 13th century city walls and castle. The inner street plan is still that of the 10th century Anglo-Danish city.

The University of York is a surprisingly recent foundation dating back only to 1963. The Electronics Department at the University along with colleagues from the University of Nottingham are pleased to be hosting EMC Europe 2011 in this fascinating city.

York is within easy reach of five national parks, the Yorkshire Dales, the North Yorkshire Moors, The Peak District, The Lake District and the Northumbria National Park with Hadrian's Wall.

Scotland is less than three hours away by train.

York is well served by air with direct rail connection to Manchester airport served by flights from all over the world. Regional airports, Newcastle, Leeds/Bradford, Doncaster/Sheffield, Humberside and East Midlands (Nottingham) are also in easy reach. The most convenient intercontinental hub is Amsterdam Schiphol with connections to all the regional airports around York. It is less than two hours to London by rail with connections via Eurostar trains to Paris and Brussels. The port of Hull is one hour away by road with direct ferry connections to Rotterdam and Zeebrugge.

York has many hotels and guest houses. We have also reserved accommodation at the University with single rooms en-suite with breakfast available for only £38.50 per night (€46 or $58 at current exchange rates).

http://en.wikipedia.org/wiki/York
http://www.visityork.org/

Reflections on 2010 BoD Elections

Elya B. Joffe, EMC Society, Immediate Past President and N&A Committee Chair

Introduction
As chair of the Nominations and Appointments (N&A) Committee of the EMC Society, I would like to congratulate the newly elected/re-elected members of the BoD, commencing their 3-year term on January 1, 2011. I would also like to thank all candidates for willing to volunteer their time and efforts in service to the Society as members of the BoD, and wish to encourage those candidates who were not elected this time to consider "running" again in the future.

2010 BoD Elections, Results and Reflections
The following is a brief summary of the process and results of the elections.

Solicitation of Candidates
The N&A Committee made unprecedented efforts in soliciting candidates:
- Four e-Notice blasts to all EMC Society members
- Four ListServe blasts to all Chapter Chairs
- Direct solicitations by BoD members and N&A Committee members
- Home page announcements
- Direct solicitation to unsuccessful candidates in past years
  Nominations were accepted until and on May 31, 2010.

Result of Solicitation
As a result of the solicitation, we had eight candidates for the BoD; this is in conflict with our Bylaws, as it is stated as follows: *"4.5 On or before 15 July, the Chairman of the Nominating Committee shall mail or email to IEEE Headquarters the slate of at least nine nominees for election to the six offices to be filled on the Board of Directors."*

After consultation with the IEEE HQ, it was found that the BoD could approve the slate of eight candidates, which was officially done.

Result of Elections
The newly elected members (please see their brief biographies at the end of this article) are:
- Chuck Bunting (New to the BoD)
- Ryuji Koga (New to the BoD)
- Kermit O. Phipps (New to the BoD)
- Robert (Bob) Davis (Re-elected to the BoD)
- Todd Hubing (Past Board member)
- Donald L. Sweeney (Past Board member)

Congratulations to the newly elected/re-elected BoD members!

Reflections on Recent Elections Process
These elections were the first to be carried out under the newly approved policy. Accordingly, for the first time, structured common candidate election material was provided to the voting members, with the categories being:
- Personal Biography
- IEEE EMC Society Activities
- IEEE EMC Society Accomplishments and Recognitions/Awards
- Candidate Statement
- Color Photo

In particular, as a result, ALL candidates provided, for the first time, Candidate Statements, for consideration by the members of the Society.

Elections Results
The following is a brief statistical summary of the elections results:

- Total paper ballots returned 54 (1.4%)
- Total web ballots returned 704 (18.5%)
- Total ballots received 758 (19.9%)
- Total ballots cards mailed 3,798 (100%)

It can easily be observed that the return rate was 20% – the highest we have had, at least in recent years, and higher than the IEEE average (10% to 15%). I am sure much thanks are due to the hard work of the N&A Committee. Yet – this is less than desirable… Please consider casting your vote next time. Every vote makes a difference.

Candidate's Statistics
Out of the eight candidates:
- Four are brand new
- Three are ex-BoD members
- Two (25%) were from Regions other than 1-6
- One of the candidates elected to the BoD was also a candidate (but not elected) in the elections held in 2009

Out of the elected candidates, three of the six candidates (50%) are brand new to the BoD:
- Chuck Bunting
- Ryuji Koga
- Kermit O. Phipps

Of these three candidates, one resides outside Regions 1–6 (Ryuji Koga).

Closing Action: Thank you, Members of the 2010 Nominations and Appointments (N&A) Committee!

The results of the recent BoD elections (and officer elections held at the Board's November 2010 meeting) reflect the outcome of the efforts of the N&A Committee Members.

Membership in the N&A Committee is a 1-year commitment, and is by invitation of the Committee Chair. Per the EMC Society Bylaws: "The Nominating Committee shall consist of a chairperson and four or more members of the Society. At least two-thirds of the voting members of the Nomination Committee shall be elected or appointed by the governing body upon which not more than half of the committee membership may be current members of the Board of Directors."

Accordingly, I formed a six member N&A Committee, the membership of which was comprised of the following by my invitation:

BoD Members

- Henry Benitez (long time BoD Member)
- Mike Oliver (Newly-elected - 2009 - BoD Member)

Non-BoD and Non-US Members

- Gustavo Fano (Argentina)
- Joungho Kim (Korea)
- Paul Duxbury (UK)
- Tzong-Lin Wu (Taiwan)

As the work of the 2010 N&A Committee has been completed, I disbanded the committee at the close of the November 2010 Board meeting and have formed a new N&A Committee in 2011 in support of the 2011 BoD elections.

Thank you to all the N&A committee members and volunteers for a job well done! **EMC**

Introducing Members Newly Elected to the EMC Society Board of Directors

The following members began a three-year term on the Board effective January 1, 2011. Abbreviated biographies of these members are provided below.

CHUCK BUNTING received the A.A.S. degree in electronics technology from the Tidewater Community College, Virginia Beach, VA, in 1985, the B.S. (honors) degree in engineering technology from the Old Dominion University, Norfolk, in 1989, and the M.S. and Ph.D. degrees in electrical engineering from the Virginia Polytechnic Institute and State University, Blacksburg, in 1992 and 1994, respectively. From 1981 to 1989, he was with the Naval Aviation Depot, Norfolk, first as an apprentice, then an electronics mechanic, and later an electronics measurement equipment mechanic. From 1991 to 1994, he held a Bradley Fellowship and a DuPont Fellowship. From 1994 to 2001, he was an Assistant/Associate Professor at the Old Dominion University, where he worked closely with NASA Langley Research Center on electromagnetic field penetration in aircraft structures and reverberation chamber simulation using finite element techniques. Since 2001, he has been an Associate Professor at Oklahoma State University, Stillwater. His research interests include fundamental variational principles and computational electromagnetics, statistical electromagnetics, electromagnetic characterization and application of reverberation chambers, and the analysis of optical and microwave structures using numerical methods including finite element techniques. He is past chair of TC9 (Computational Electromagnetics) and currently chair of Global EMC University as well as a newly elected at-large member of the IEEE EMC Board of Directors. Chuck is an also an instructor (and coordinator) for the Reverberation Chamber Short Course held annually at Oklahoma State University (see http://rc-course.okstate.edu/ for more information). This course presents a week long theoretical and hands-on application of reverberation chambers for EMC measurements.

ROBERT DAVIS (S'72-M'73-M'80-SM'10) has over 30 years experience working as an Electromagnetic Environmental Effects (E3) Engineer on Department of Defense related programs and the Space Shuttle program. My employer for the last 20 years has been Lockheed Corporation, where I have worked on ground based radar, submarine, surface Ship and under water UUV programs. The other companies I worked for include Hamilton Standard Corp., American Electronic Laboratories and the Electromagnetic Compatibility Analysis Center (currently the Joint Spectrum Center). I have been active in the GEIA G46 EMC Subcommittee for the last 8–10 years, where I have served as the Chairman for the last 6 years.

IEEE EMCS Activities: VP for Member Services 2009-2010; Member of the Board of Directors 2008–2010; Chairman for the Completed Careers Committee; Associate Editor of the *EMCS Newsletter*, heading up the *Completed Careers* section, publishing articles in the Newsletter for the *Completed Careers* section; Secretary 2010 EMC Symposium.

IEEE/EMCS Accomplishments and Recognitions/ Awards: Active member of the Board of Directors; established the Completed Careers Committee, to honor those members that had significantly contributed to the society and had recently passed away. As VP for Member Services, I worked closely with the BoD and other members of the Executive Committee in establishing a new Graduate of the Last Decade (GOLD) Representative and Sister Society Coordinator positions. Member of the 2010 EMC Symposium leadership committee, serving in the role of Secretary; documenting meeting minutes, maintaining the actions item list and establishing a repository of all committee correspondence and documents.

Statement: I have been a member of the IEEE EMC Society for over 30 years. I am active in the TC-4 subcommittee. I am presently serving my first term on the Board of Directors and have been an active member of the BoD. In fact, shortly after becoming a member of the BoD I became chairman of the newly established Completed Careers Committee; which honors those members of the EMC Society that had significantly contributed to the society and recently passed away. I am also serving my first term as VP for Member Services; a position that has afforded me the opportunity to use my leadership experience; being responsible for several subcommittees. I enjoy the time I spend supporting the EMC Society and look forward to serving the Society for another 3 years on the Board.

TODD HUBING (S'82-M'82-SM'93-F'06) is the Michelin Professor of Vehicle Electronics at Clemson University. He holds a BSEE from MIT, an MSEE from Purdue, and a Ph.D. from North Carolina State University. He began his career as an EMC engineer for IBM, where he did EMC testing and troubleshooting on a variety of computer and network products. In 1989, he became a faculty member at the University of Missouri-Rolla (UMR) where he worked with other faculty and students to analyze and develop solutions for a wide range of EMC problems affecting the electronics industry. Since moving to Clemson in 2006, he has continued his work in electromagnetic compatibility and computational electromagnetic modeling. Dr. Hubing is an IEEE Fellow and a Fellow of the Applied Computational Electromagnetics Society.

IEEE EMCS Activities: IEEE EMC Society Board of Directors (1995–2005, 2007–); Vice President for Communication Services (2009–2010); Fellow Evaluation Committee Chair (2009–); Technical Program Co-Chair for the 2010 Asia-Pacific Symposium & Exhibition on Electromagnetic Compatibility (APEMC Beijing 2010), Beijing, China, April 2010;Technical Program Co-Chair for the 2007 IEEE International Symposium on Electromagnetic Compatibility, Honolulu, Hawaii, USA, July 2007; IEEE EMC Society Richard B. Schulz Best Transactions Paper Award – 2007; Journal of the Applied Computational Electromagnetics Society Best Paper Award – 2003 and 2006; Honorary Life Member of the IEEE EMC Society – 2004.

Statement: Todd was first elected to the IEEE EMC Society Board in 1995. What he lacked in experience, he more than made up for with enthusiasm. He was passionate about EMC and he was excited about new opportunities spurred by the proliferation of consumer electronics and advances in electromagnetic modeling techniques. He was also enthusiastic about the role that the EMC Society could play in promoting advances in this field. He took on new challenges, pushed for change, and despite occasional resistance from gray-haired curmudgeons on the Board; he managed to make significant contributions. Now, 15 years later, Todd is one of the gray-haired curmudgeons on the Board. Nevertheless, he has not lost his passion for EMC or his dedication to the mission of the society. He is running on the platform that every productive Board needs a few curmudgeons in order to maintain historical perspective and avoid reinventing the wheel.

RYUJI KOGA (M'79) was born in Tokyo on 1 January 1945. He received B.E., M.E. and D.E. degrees from Kyoto University in 1967, 1969, and 1975, respectively. He was employed at Atomic Energy Institute of Kyoto University. In 1976 he moved to Okayama University and focused on electronics. He experienced the adverse effects of EMI from digital system attached to the extremely sensitive analog system for laser sensing. Since then, he has been engaged in the study of EMC. His research group has expertise knowledge in controlling noise in PCB, and the modeling of EM behavior of PCB, cable and chassis. He was the chairperson of Technical Committee of IEICE, Japan (EMCJ). He was also the chair of IEEE EMCS Japan Chapter, and the chair of URSI-E Committee, Japan.

IEEE/EMCS Activities: He is a member of IEEE EMCS and has been the Chair of EMCS Japan Chapter in the term of 2008-2009, as well as the vice chair, in 2006-2007. He invited four lecturers from abroad including three IEEE EMCS Distinguished Lecturers. He contributed to organizing a special session in IEEE EMC Symposium 2007, Hawaii. He presided at the 2009 EMC Symposium/Kyoto cosponsored by IEEE EMCS, which was his first experience to have a deep contact with EMCS through legal negotiation. The IEICE technical committee on EMCJ of IEICE has held 10 technical meetings every year since 1976, which were cosponsored by IEEE EMCS, and he presided over the committee since 2003 to 2006 as the chair and the vice chair contacting with IEEE EMCS Japan-Chapter. He has been, since 2004, the vice president of CEEM held in China every three years, technically cosponsored by EMCS.

Statement: Prof. Ryuji Koga had been a great success as the President of International Symposium of EMC Kyoto '09. Also, he was the Chair of IEEE EMCS Japan Chapter 2008 to 2009 and he had founded and cooperated with many international conferences in Region 10 such as CEEM, APEMC, PPEMC and etc. with China, Korea, Taiwan, and Japan. And he was also one of the most active members of EMCJ of ICIEC, and one of the top research professors of Okayama University until his retirement in this March. One of his strong points is his proficiency in the Chinese language. He served as the director and the liaison officer of Changchun Office of Okayama University in China until his retirement.

KERMIT O. PHIPPS (AM'97-M'01-SM'09), is a Project Engineer/Scientist at the Electric Power Research Institute (EPRI), and is a NARTE Certified EMC engineer. He has served in the US Air Force as an electronic warfare specialist. In his 18 year tenure at EPRI, his research and testing focuses on grounding, lightning protection, electromagnetic compatibility (EMC), development of EMC test instrumentation, and characterization of various electromagnetic environments. He has conducted numerous power quality and EMC training sessions and field investigations. Mr. Phipps is the author of test plans, protocols, book chapters, and research papers presented at international power quality and EMC conferences. He is a member of the IEEE EMCS Standards Development Committee, current Secretary of the EMCS Technical Advisory Committee, Secretary for P299.1 and past chair of Technical Committee 4 and has completed work as the chairman of IEEE 1560 "Standard for Methods of Measurement of Radio Frequency Power Line Interference Filters."

IEEE/EMCS Activities: For more than 13 years, I have been a member of the IEEE. During the last 10 years, I have served the EMC Society's Technical Committee 4 as Secretary, vice-chair and chair. I am currently TAC Secretary, and member of the SDCom. I am currently the Secretary for P299.1 and led an eight year effort as chair of P1560, now IEEE 1560. I have given presentations for several years for the Education Committee for Standards Development. I have presented three EMCS conference papers, chaired sessions, and performed two education workshop demonstrations on filtering and shielding. I have attended and participated in every EMC symposium since 1998.

IEEE/EMCS Accomplishments and Recognitions/ Awards: My single most creditable accomplishment was leading the eight year effort of developing IEEE 1560 from beginning to completion. I have no EMCS awards, however, my greatest personal satisfaction more than anything is the fact I have gained the recognition and respect of my fellow senior EMCS members. This was recognizable by the attendance and support during a presentation I gave on shielding effectiveness in 2008, in the face of much controversy surrounding the issue. The message of the paper was to bring about clarity of near field and far field measurements and the differences seen in shielding effectiveness numbers. By so doing, I have demonstrated I am willing to take risks by addressing controversial issues within the community and where science needs to be preserved.

Statement: I have more than 25 years of experience that includes technical military service and civilian research. For the last 18 years, I have worked at the Electric Power Research Institute (EPRI) and currently hold the position of Project Engineer/Scientist. My goal is simple in seeking a position on the EMC Society's Board of Directors: "To promote EMC technology and the contribution it can make to society." It is important to regenerate membership growth in the EMC Society and its technical committees. The EMC Society is currently losing critical talent and requires new talent for the next generation of EMI control challenges. Thank you for taking the time and considering me as a candidate for a position on the EMC Society's Board of Directors.

DONALD L. SWEENEY (M'80-SM'00-LM'11). Senior EMC Engineer (NARTE Certificate Numbers EMC-001209-NE & EMC-001210-NT) and president of D.L.S. Electronic Systems, Inc. He is a graduate of the Department of Electrical Engineering, University of Illinois at Urbana and has over 40 years experience in the electrical engineering field. Most of his time has been devoted to solving problems in electromagnetic engineering and closely related disciplines. He has worked for Extel Corporation, Teletype Corporation, Gates Radio, and Collins Radio prior to forming D.L.S. Electronic Systems, Inc.; a Wheeling, Illinois based company. He specializes in EMC, RFI and EMI consulting and testing. Don has taught at Oakton College and the University of Wisconsin (at both the Madison and Milwaukee Campuses), and consults nation-wide on electromagnetic compatibility. His company offers a class on EMC design developed over 30 years and he has taught these to more than 2,500 engineers. He has served as a special consultant to Lawrence Livermore National Laboratory and the Nuclear Regulatory Commission. He is the founding chairman of the U.S. Council of EMC Laboratories and a NARTE certified EMC Engineer. He is a senior life member of the IEEE, past Chicago area Chairman of the IEEE EMC Society, and has served more than 12 years on the Board of Directors of the IEEE EMC Society. He has served on the IEEE EMC Standards Development Committee (SDCom) for more than 15 years, has been the Angel to the Chicago EMC Chapter, and is a member of the committee on P1688 Module Electromagnetic Interference (EMI) Testing and P299 Shielding. As part of the work on P299, he received a plaque stating "IEEE-SA Standards acknowledges with appreciation Don Sweeney for contribution to the development of this (P299) standard, published 28 February 2007." Because of this work, he was contacted by the Department of Defense of Canada and asked to rewrite two of their standards for the specifying and construction of shield rooms. As a member of the Board, he believes he presents an independent viewpoint. As a small business owner, he is concerned about cost. He has been a member of the IEEE for over 30 years. He believes he owes much of his own professional EMC development over those years to the EMC Society and feels serving on the BoD is a way to give back. He believes he brings to the BoD a small business perspective along with a desire to help our Society assist its members in growing in the discipline of EMC. **EMC**

Call for EMC Society Board of Directors Nominations

Candidate nominations are now being accepted for the 2011 IEEE Annual Elections ballot for Director-at-Large positions on the IEEE EMC Society Board of Directors for a three year term, beginning January 1, 2012. In accordance with the bylaws, nominations may be made by the Nominations and Appointments (N&A) Committee or by petition by individual voting members.

To be eligible for consideration as a candidate by the N&A Committee, a nomination supported by signatures of **at least fifteen (15) EMC Society higher-grade members** (i.e., excluding those of students and affiliates) in good standing (i.e., dues paid), excluding the candidate, must be submitted, accompanied by a **BoD Candidate Nomination Form.**

Note: Individual voting members may also propose, by petition, names to be added to the EMC Society annual election ballot for positions of Director at-Large to be elected by the voting members of the EMC Society for the coming term. Such petitions shall carry a minimum of 82 names of Society higher-grade members in good standing.

A secure on line petition web site will be set up for each eligible candidate (a hyperlink to all the nominee sites will be on the EMCS web site, www.emcs.org). Nominees may alternatively submit paper-form petitions. Only signatures submitted electronically or original signatures on paper-form petitions shall be accepted. Facsimiles, or other copies of the original signature, shall not be accepted.

Candidates who plan to run should contact as soon as possible the N&A Committee Chair (e-mail: eb.joffe@ieee.org) and provide their full name, IEEE number and Grade and their preferred manner for petition submission.

Nominees should possess professional stature and significant technical skills in electromagnetic compatibility. They must have adequate financial support outside the Society and have the approval of their organizations or employers to actively participate in the Board meetings and contribute to its activities. Duties include attendance at three (3) of four (4) Board meetings per year and participation on committees, both of which require telephone, fax, mail and e-mail communications.

Nominees must be full, higher grade members of the IEEE and members of the EMC Society of good standing. Elected Directors must serve a three-year term commencing January 1, 2012. Attendance at the last meeting of the 2011 year is also desirable. No member can serve more than two (2) consecutive three-year terms, including partial terms.

Nominations shall be submitted to the N&A Committee. All candidates willing to run and serve are required to submit to the N&A Committee, in addition to the petition, the **BoD Candidate Nomination Form** including the following elections material for inclusion in the ballot:

- **Personal biography – Technical and Professional Experience**, not to exceed 125 words in length, intended to round out the profile of the Nominee's experience outside the IEEE and EMCS activities.
- **Factual summary of IEEE/EMCS Activities**, not to exceed 150 words in length, intended to summarize the candidate's current and past service to the IEEE and the EMC Society.
- **A candidate photograph** taken within two years of 1 August 2011. A digital photograph can be submitted electronically in either TIF or high-quality JPEG format. The photo should be the original digital file, 300 dots per inch (dpi) resolution.
- **Statement of candidacy**, not to exceed 150 words in length

A Microsoft Word template for the petition and BoD Candidate Nomination Forms is available on line at the EMCS web site www.emcs.org.

Please submit the elections material, including the nomination form with digital photograph to the
Nominations and Appointments Committee Chair:
Elya B. Joffe

e-mail: eb.joffe@ieee.org, or ebj@netvision.net.il
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Qualifying nominations and all supporting documentation shall be provided to the N&A Committee **with a date-tag of no later than May 30, 2011**.

For answers to any questions, please contact Mr. Joffe or any member of the Board of Directors.

Design Tips

Bruce Archambeault, Associate Editor,
Phd IEEE Fellow, IBM Distinguished Engineer bruce.arch@ieee.org

Welcome to Design Tips! In a past issue, we discussed how easy it is to create common mode noise on differential signals with small amounts of skew, rise/fall time mismatch, etc. In this issue, we will discuss how easy it is to create common mode noise from asymmetries with ground-reference vias on PCBs! At first glance, it might seem that a ground-reference via would not have any impact on a differential pair of vias on a PCB. However, this is not necessarily true! This common mode noise created by asymmetry can then create a significant amount of EMI problems.

Please send me your most useful design tip for consideration in this section. Ideas should not be limited by anything other than your imagination! Please send these submissions to bruce.arch@ieee.org. I'll look forward to receiving many "Design Tips!" Please also let me know if you have any comments or suggestions for this section, or comments on the Design Tips articles.

Via Asymmetry Causes Common Mode Conversion from Differential Mode Signals

By Bruce Archambeault, PhD, IEEE Fellow, IBM Distinguished Engineer, bruce.arch@ieee.org
Sam Connor, IBM Senior Technical Staff Member, sconnor@ieee.org

From an EMC perspective, the differential currents generate insignificant EMI emissions. If external, unshielded cables have only differential currents, very little emissions will be generated. However, if common mode currents exist on these same unshielded cables, the common mode currents are equivalent to the single ended signal currents and can cause significant EMI emissions.

A previous Design Tips article showed how quickly common mode noise is created when there is skew between the two differential signals, or rise/fall time mismatch, etc. Any asymmetry in the path of the differential signal can cause significant common mode conversion of the original differential mode signal. This Design Tip will show how asymmetrical ground-reference vias placed near to differential signal vias will cause a significant increase in the common mode conversion.

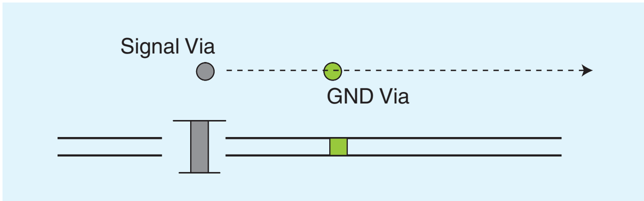


Fig. 1. Single-ended signal via with nearby ground-reference via.

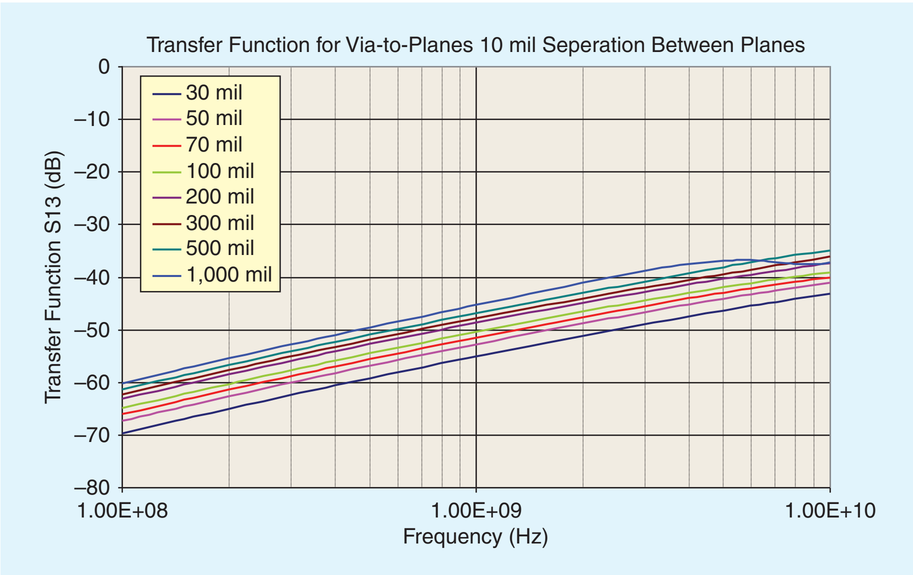


Fig. 2. Effect of distance between signal via and ground-reference via.

Single-Ended Signal Via

First, let's look at what happens when a single-ended signal passes through a via and changes reference planes. We'll assume that both planes are considered ground-reference and have many vias connecting the two planes together. We'll create

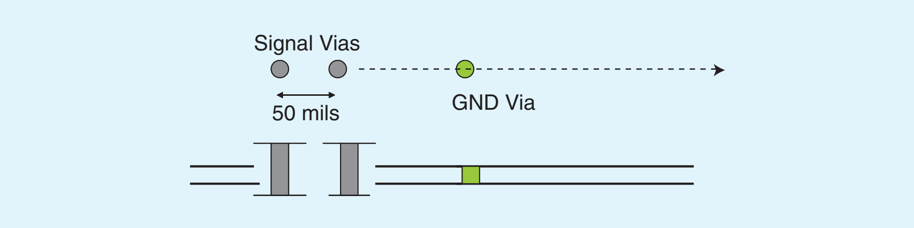


Fig. 3. Differential vias with nearby ground-reference via.

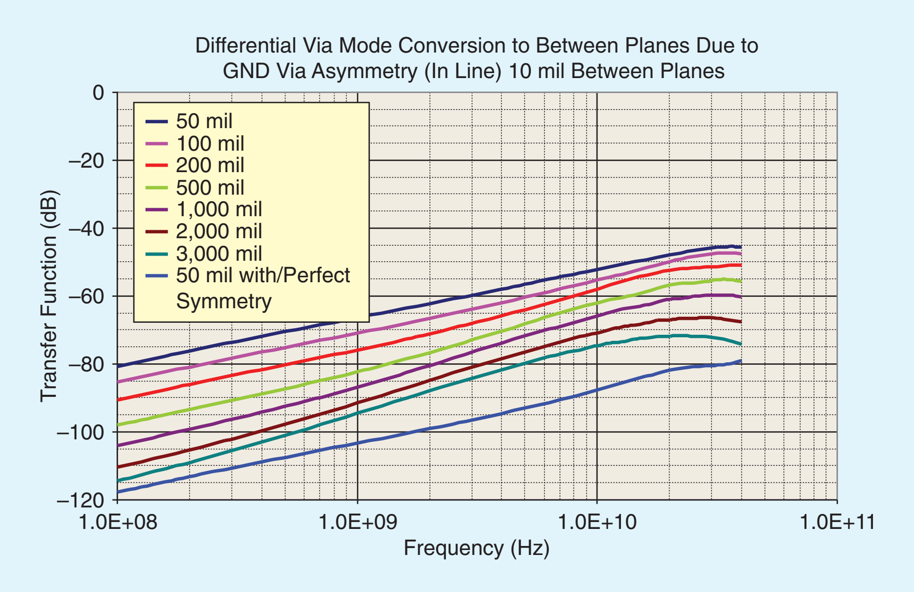


Fig. 4. Noise coupled between planes due to ground-reference via asymmetry.

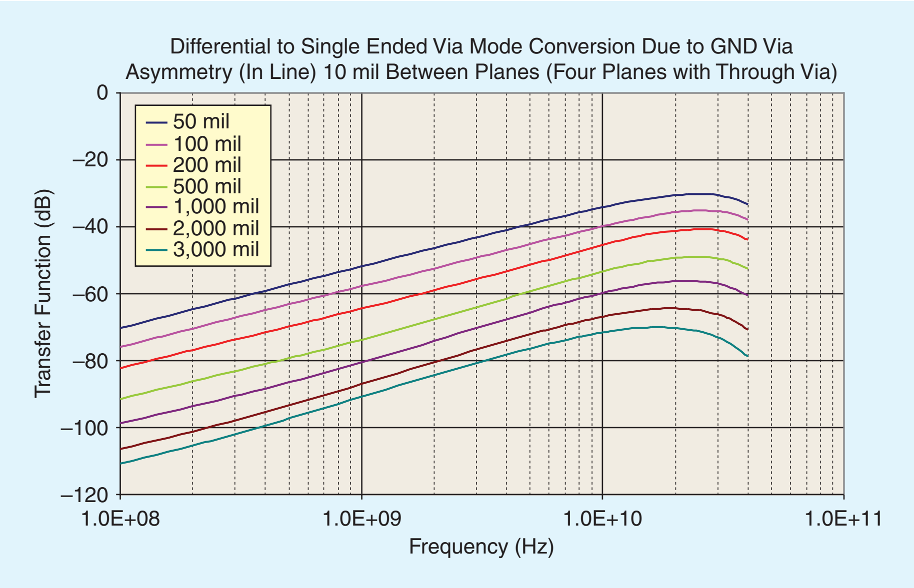


Fig. 5. Common mode noise conversion due to ground-reference via asymmetry (single plane pair transition).

a signal via that passes through the two planes and noise will be coupled from the signal via to between the two planes. This noise can then propagate and couple onto other vias or I/O connectors and escape the shielded enclosure. Figure 1 shows a simple geometry where the nearest ground-reference via is moved from very close to the signal via to further away. Figure 2 shows how the location of the ground-reference via can affect the amount of noise coupled to between the planes. When the ground-reference via is close to the signal via, the amount of noise coupled is lowest.

Differential Vias

If we now take the case of a pair of vias with differential signals with no common mode noise on these vias, there will be little noise coupled to between the planes as long as there is no nearby asymmetry. We'll now place a ground-reference via nearby to one side of the differential pair, as shown in Figure 3, and we'll move it further from the differential via pair. Figure 4 shows the transfer function of the noise coupled to between the planes from the intentional differential signals. Note that as the ground-reference via comes closer to the differential via pair (and increases the asymmetry), the amount of noise coupled to between the planes increases!

We can also observe how much common mode noise is created on the differential signal vias. This common mode noise could be conducted along the differential signal path until it arrives at an I/O connector and exits the shielded enclosure. If the I/O cable is unshielded or poorly shielded (as with many high speed differential cables) the amount of EMI emissions will increase significantly.

Figure 5 shows the common mode conversion for a single plane pair transition. In typical PCBs, there may be many plane pairs as the signal travels from the top to the bottom of the PCB. Figure 6 shows the common mode conversion as the vias travel through 10 plane pairs.

Consider a 2 Gb/s differential signal travelling through the

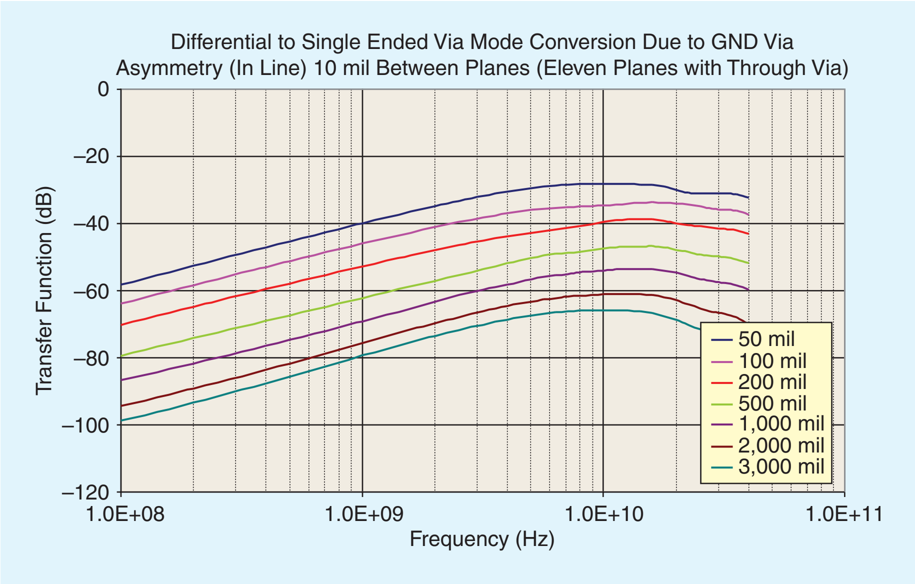


Fig. 6. Common mode noise conversion due to ground-reference via asymmetry (ten plane pair transition).

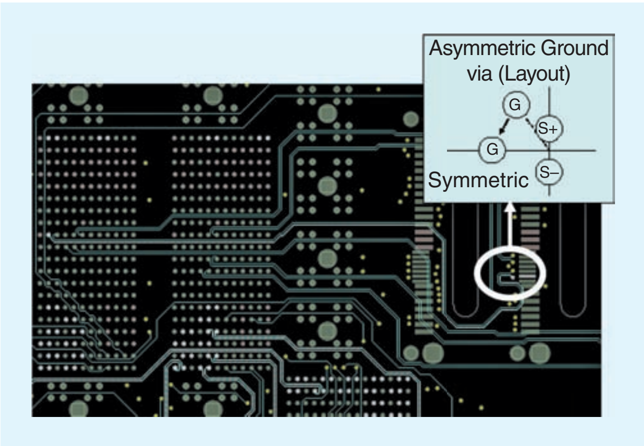


Fig. 7. Real world pcb geometry with asymmetrical ground-reference via.

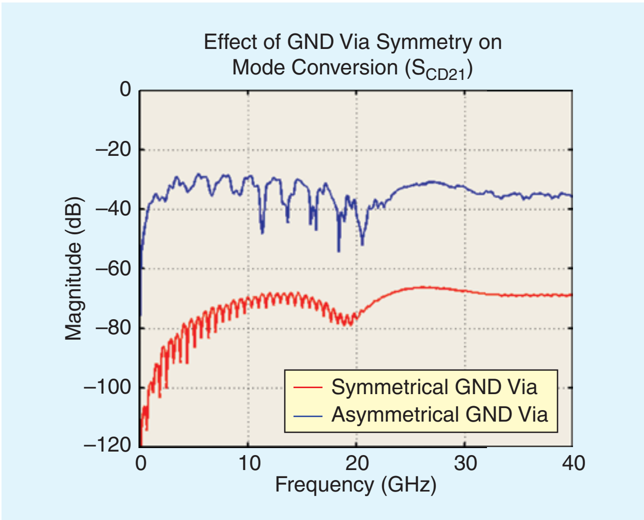


Fig. 8. Comparison of mode conversion (S_{cd21}) with GND return via symmetry and asymmetry.

asymmetrical differential vias with a ground-reference via only 50 mils from one of the differential vias. From Figure 6 we see the fundamental frequency of 1 GHz will have a common mode conversion of −40 dB. This means if the intentional differential signal is one volt, then the common mode noise will be 10 mV. If we use the rule-of-thumb that above 1 GHz an external cable must have no more than 1 mV of noise in order to meet Class A emissions requirements, then the common mode noise is 20 dB too much, and will require at least 20 dB of shielding to meet the limits.

From the differential signal's common mode conversion point of view, it would seem that we want the ground-reference via to be far away from the differential via pair. However, this would only help reduce the amount of common mode created by the asymmetrical ground-reference via. Any other common mode noise on the differential signal pair created because of other issues, such as skew, rise/fall time mismatch, etc. will need to have a close ground-reference via so that the other common mode noise will not be coupled to between the planes. Clearly the best option is to use a nearby ground-reference via (or more than one) to ensure symmetry!

Another example is taken from a real-world PCB. A screen shot of the PCB layout is shown in Figure 7. The insert shows the initial asymmetrical placement of the ground-reference via, and the new location where the symmetry is enforced. Figure 8 shows the impact of moving the ground-reference via to a symmetrical location. More than 40 dB reduction in the common mode conversion was realized!

Summary

Common mode noise will be created by a variety of causes. Via placement and symmetry of nearby ground-reference vias is another source of significant common mode noise for differential signals. It is important to closely control the symmetry of ground-reference vias near to differential pair vias. **EMC**

EMC Society Board of Directors Meeting

The Westin Hotel, Pittsburgh, Pennsylvania
November 13–14, 2010

The President's Opening Remarks

President Maradei called the meeting to order at 9:00 am. A round of introductions was made. Board members present included B. Archambeault, H. Benitez, C. Brench, C. Bunting, L. Cohen, R. Davis, A. Duffy, R. Ford, F. Heather, D. Heirman, D. Hoolihan, T. Hubing, E. Joffe, R. Jost, J. LaSalle, F. Maradei, A. Marvin, J. Norgard, M. Oliver, J. O'Neil, G. Pettit, V. Roje, D. Sweeney, K. Williams, P. Wilson, and T. Yoshino. Absent was Board member R. Scully. Guests present included M. Montrose (via telecom for BoD officer elections) and M. Handley (present for convention center tour).

Ms. Maradei reviewed Board meeting protocol, the IEEE code of ethics, and upcoming activities. She welcomed the new Board members present and thanked them for their interest in the Board activities. She congratulated Elya Joffe upon his election as President-elect of the Product Safety Engineering Society (PSES). She reported on the passing of Roger Sudbury, IEEE Division IV Director. Ms. Maradei reviewed the activity of the Excom meeting held the previous evening. The meeting addressed administrative points including the agenda review, motions to be presented, etc. All items discussed are included on the meeting agenda.

Regarding Global Outreach activity, Ms. Maradei noted she attended the EMC Europe 2010 conference in Wroclaw in September as well as presented at the Polish EMC Chapter meeting while in Poland. This was the last EMC symposium and marked the 20th time the symposium has been held in Wroclaw. This conference is now absorbed by the EMC Europe conference. She will attend a regional event in Buenos Aires in April 2011 and the APEMC 2011 conference in Korea in May. She presented at the Pittsburgh Chapter meeting in November and potentially will present at the new Nigeria Chapter this fall.

Ms. Maradei then presented an update on the IEEE Technical Management Committee (TMC). A workshop will be organized by the EMC Society at the next TMC conference. Kimball Williams and Elya Joffe will manage this workshop. They are looking for a volunteer to assist them.

Ms. Maradei reviewed the approved e-motion made since the last Board meeting granting EMC Society technical cooperation for the SPI 2011 conference.

Consent Agenda

The agenda was presented for review. The consent agenda included approval of: The November 2010 meeting agenda, the July 2010 Board meeting minutes and the independent contractors for the EMC Society: Warren Kesselman, Shannon Archambeault, Janet O'Neil and Kye Yak See. There has been

PHOTOS BY JANET O'NEIL

The newly elected officers of the IEEE EMC Society for 2011–2012 include (front row from left) Janet O'Neil of ETS-Lindgren, Ghery Pettit of Intel, Francesca Maradei of the University of Rome "La Sapienza", (back row from left) John LaSalle of Northrop Grumman, Don Heirman of Don HEIRMAN Consultants, Bob Davis of Lockheed Martin, Bruce Archambeault of IBM, and Perry Wilson of the National Institute of Science and Technology (NIST).

The EMC Society Board of Directors met for two days in Pittsburgh, Pennsylvania. Members are shown preparing for the meeting to start with a full agenda of topics to discuss.

no increase in contractor fees from 2010 to 2011. The Board approved the consent agenda. The approved July 2010 Board minutes will be posted to the EMC Society website.

Treasurer's Report

John LaSalle presented a report on EMC Society finances. The Society is tracking toward the budgeted net of $18,400. Committee expenditures (Cost Center 1900) are operating toward an approved budget of $255.4k (deficit). Travel expenses were reviewed with the major expenses being the Distinguished Lecturer (DL) program and the Board AdCom operations. Under miscellaneous activity, Angel funds approved included a payment to Dr. Jamal Shafii, Rock River Valley, North Central Illinois; Wong Tsz Ching and Patrick Wong, Hong Kong Chapter; Frank Sabath, Germany Chapter, and Boris Shusterman of the New England Chapter. Mr. LaSalle discussed the second pass budget for 2011 in detail and concluded his report with a summary statement of the budget as of September 2010.

Past President's Report

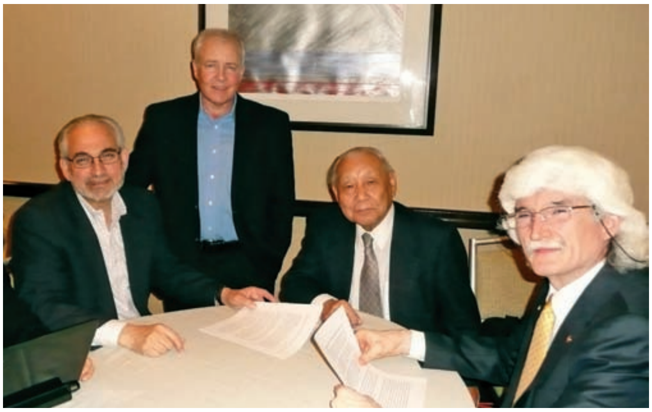
Elya Joffe presented his report. He discussed the recent elections to the Board of Directors and the voting process. Approximately 20% of the ballots were returned. This is a very good number. The newly elected Board members for a three year term beginning January 1, 2011 include Donald Sweeney, Bob Davis, Todd Hubing, Ryuji Koga, Chuck Bunting, and Kermit Phipps.

Discussion ensued about the EMC Society Field of Interest. Dick Ford had some comments. In the interest of time it was suggested that the Field of Interest discussion be moved to New Business.

On the Constitution and Bylaws, Mr. Joffe noted there were several motions made by the Board which impacted these documents. The motions are included in his report. In accordance with policy, these will be announced to the membership via publication in the EMC Newsletter.

Mr. Joffe then discussed the election of officers to the Board of Directors for 2011–2012. The list of candidates for each

Todd Hubing of Clemson University, Vice President for Communications, presented a report on the current scope of the IEEE Transactions on EMC and suggested revisions.



The Board of Directors devoted time to addressing milestones for its Long Range Plan while in Pittsburgh. (From left) Bob Davis, Larry Cohen of the Naval Research Lab, Takeo Yoshino, Emeritus Professor of the University of Electro-Communications, and Elya Joffe of KTM Project Engineering participated in the planning session.

Mont Handley (left), National Sales Director of the Visit Pittsburgh Convention and Visitors Bureau, and Mike Oliver of MAJR Products, Chair of the 2012 IEEE International Symposium on EMC in Pittsburgh, Pennsylvania, conducted a tour of the convention center during the Board meeting.

Art in the David L. Lawrence Convention Center reflected the city of Pittsburgh's long association with the Heinz family, purveyors of fine condiments.

office was presented. Today the candidates will present their campaign statements; tomorrow the votes will be cast. He showed the order of the voting for November 14. He noted that all existing and new Board members are able to vote in the elections ONLY; newly elected Board members cannot vote on other motions presented during the meeting as their term does not start until January 1, 2011. Mr. Joffe next reviewed the officer election process. The candidates for each office were presented. Each candidate spoke to the Board about their respective interest in the position and future plans should they be elected. Janet O'Neil and John LaSalle were re-elected as secretary and treasurer, respectively, by acclamation.

The David L. Lawrence Convention Center, site of the 2012 IEEE International Symposium on EMC.

Conference Services

Ghery Pettit presented his report for Vice-President of Conferences. He presented the dates for the upcoming symposiums and briefly reviewed the individual reports submitted by EMC 2011 (Long Beach), EMC 2013 (Denver) and EMC 2014 (Raleigh).

Mr. Pettit relayed the report of Frank Sabbath. This shows the conferences that have been approved/not approved for EMCS technical co-sponsorship (TCS).

He then presented a review of the TCS applications and efforts underway to standardize the MoU process. A timeline is assigned to each part of the process so there are no delays in the approval process. A mechanism will be added to the process to allow the Board to review the requests for technical co-sponsorship prior to voting. A procedure will also be added to show that the Board can overrule TAC's recommendation to approve/disapprove the co-sponsorship. The Board approved the application process for EMC Society technical co-sponsorship. The Board also approved technical co-sponsorship for EMC Europe 2011 in York, UK, from September 26–30, 2011; EMC COMPO 2011, in Dubrovnik from November 6–9, 2011; the Asia Pacific EMC conference in May 2012 (APEMC 2012) – conditional upon the society receiving 10% of the net surplus from the conference and that 50% of the members of the technical program committee be from the EMC Society; and long term technical co-sponsorship of EMC Europe for 2012 and beyond.

Mr. Pettit then provided an update on the 2012 IEEE International Symposium on EMC in Pittsburgh, Pennsylvania. Mike Oliver is the chair for this symposium. Mr. Oliver noted that there will be a tour of the David L. Lawrence Convention Center later in the meeting. He introduced Mont Handley, National Sales Director of the Visit Pittsburgh Convention and Visitors Bureau, who will lead the tour.

Mr. Pettit's report concluded with information from Janet O'Neil as Exhibitor Liaison and Regional Conference

The David L. Lawrence Convention Center sits on the banks of the Allegheny River in the heart of downtown Pittsburgh. Shown enjoying the fresh air during a break in the tour are (from left) Todd Hubing, Francesca Maradei, Janet O'Neil and John LaSalle.

The November meeting of the Board of Directors included a dinner to thank the outgoing Board members and welcome the incoming Board members. (From left) Andy Marvin from the University of York, Bonnie Brench and Randy Jost of Utah State University enjoyed the reception held before dinner.

Coordinator. There are several tabletop shows planned by the EMC Chapters in 2011, including a new one for the joint AP/EMC Chapter in Buenos Aires (Region 9) on April 1. This is the first time a regional IEEE EMC event will be held in Buenos Aires, Argentina.

Communication Services

Todd Hubing, Vice-President for Communication Services, presented his report. As a result of the TAB Periodicals Review, Dr. Hubing advised the IEEE EMC Transactions scope of work had not been updated since 1957. Various Board members had suggestions for revisions to the text. President Maradei will also be forming a committee to participate in the IEEE's review of EMC Society publications early next year.

Newsletter Editor Janet O'Neil reported the Fall 2010 issue is in process. The standard symposium and regular feature articles have been provided. Financially, the Summer 2010 issue of 88 pages cost $17,565 for the printing and mailing of 4,625 copies. There were nine advertisers in the issue (down from 18 in the last issue) that generated $11,293.50 in billed ad revenue, of which the EMC Society received a net of $6,211. These financial figures for the Summer 2010 issue are included in her report which shows all three issues produced to date

(From left) John LaSalle, Todd Hubing, Chuck Bunting of Oklahoma State University, Alistair Duffy of De Montfort University, and Colin Brench also enjoyed the reception.

Bruce Archambeault (left) visited with Dan Hoolihan of Hoolihan EMC Consulting during the reception. Apparently, Dan did not agree with a comment made by Bruce or the intrusion of the photographer!

(From left) Victoria and Mike Oliver are shown with Dianne Paris and Larry Cohen at the reception.

in 2010. Note the Summer issue is traditionally a "light" issue with less content and less ads than the other issues of the year. Ms. O'Neil advised Flavio Canavero will retire as the Newsletter's Technical Editor at the end of 2010. He heartily recommends Professor Kye Yak See of the Nanyang Technical University in Singapore to replace him as the Technical Editor. Ms. O'Neil has worked with Professor See for many years and appreciates the intelligence and diplomacy he can bring to this position. He is also quite active in the IEEE EMC Society in Asia – which is gaining more prominence in the EMC community. On the Newsletter to Magazine transition, IEEE has approved the Phase I proposal presented at the TAB meetings in Montreal in June 2010. IEEE has also "conditionally approved" Phase II of the proposal in mid October at its FinCom meetings. A formal presentation from the EMC Society is planned for November 18, 2010 at the IEEE TAB meeting in New Brunswick, NJ. Financial details are being reviewed to take into account composition being handled by the IEEE or by an outside contractor as well as the level of IEEE editorial services required. To move forward on this proposal, the EMC Society has an initial investment to make in the first year of magazine publication (2012) which at this time is a not to exceed amount of $40K. The expenses include the cost to be on *Xplore* as well as a "transition fee" to take composition outside IEEE that will be charged the first three years of publication. For more information, please communicate with Todd Hubing and/or Janet O'Neil.

Heyno Garbe's report as Editor-in-Chief of the Transactions on EMC is included in the VP Communications Report. He advised the submission rate of 326 papers appears to have leveled off. The page count for 2011 was therefore set at 1,100 pages, including a special issue. There is no backlog of papers to be published; in fact, this is no longer a problem since the approved papers are published when ready directly to IEEE Xplore "Early Access." Professor Garbe's report includes charts showing data on paper submissions and production statistics. The Associate Editor lunch held in Fort Lauderdale during the EMC 2010 symposium was very well received. This was a best practice mentioned at the Society's publications review by TAB. Professor Garbe plans to hold a lunch for the Associate Editors during the EMC 2011 symposium.

Mr. Hubing concluded his report by advising updates continue to be made to the IEEE EMCS web site on a regular basis. No major format changes are planned until 2011.

Member Services

Bob Davis, Vice-President for Member Services, presented his report. He noted he has two motions from Member Services to present at this meeting. Rationale for these motions was included in his report. The Board approved a change in the amount of the President's Memorial Award from $2K to $4K for the original award and from $1K to $2K for the possible follow on award. The Board also approved the creation and administration of a new "Standards Travel Grant". Mr. Davis then reviewed the budget for Member Services and costs for the DL program, awards, etc.

Regarding membership, Mr. Davis advised 24 members have been elevated from member to senior member this year to date. Current membership is at 4,031 (with affiliates) a slight increase since this time last year. IEEE membership is up 2.3% and EMC Society membership is up 4.1% since this time last year. The issues with the database, which was affecting the Completed Careers Committee from identifying if deceased individuals were IEEE EMCS members, has been resolved. The committee is working on a membership booth and a brochure. The new e-membership offering will be promoted at the IEEE EMC Society events in Argentina and Brazil next year.

Bruce Archambeault next reported on Awards. All Award Certificates/Plaques have been sent to those who were not at the Fort Lauderdale symposium to receive them in person. The call for awards to be presented at the EMC 2011 symposium is in process.

Don Heirman reported on the "Completed Careers" committee (CCC) activity. Bill Rhodes and Professor Amemiya were honored in the Summer 2010 EMC Newsletter. The CCC continues to process the EMC Society major contributors that have passed away. They are looking for new CCC members that can be active.

Bruce Archambeault reported on the DL program. The DLs for 2010–2011 include Dr. Giulio Antonini, Mark Steffka and Dr. Omar Ramahi. The DLs for 2011–2012 include

Henry Benitez of ElectroMagnetic Investigations, Fred Heather, and Don Sweeney (from left) represent the west coast, east coast and central US-based members of the EMC Society Board of Directors.

Following dinner, outgoing Board members from 2008-2010 present - including (from left) Colin Brench, Randy Jost, Bob Davis, and Fred Heather of the Navy Pax River - were recognized for their service to the EMC Society by President Francesca Maradei (center).

Jerry Ramie, Jerry Meyerhoff, Professor Wen-Yan Yin and Chuck Bunting. The report includes a price per meeting attendee for a DL lecture, the number of lectures given to date per DL, etc. Regarding the Respected Speakers Bureau (RSB), Mr. Archambeault noted two RSB talks have been presented since the last Board meeting. The current speaker list includes Colin Brench, Alistair Duffy, Jim Drewniak, Tzong-Lin Wu, Cheung-Wei Lam, Eric Bogatin, Werner Schaefer, David Pommerenke, Bruce Archambeault, Elya B. Joffe, Jun Fan and Chris Holloway.

Frank Sabath then provided a detailed report for Region 8. Currently there are 1,248 active members (33 less than his last report); 119 members are in arrears (e.g. a member who has not paid the membership fee) and there are 124 inactive members. A distribution of active members in Region 8 is shown in his report. Within 17 sections there are 12 EMC Chapters and six joint EMC Chapters. An analysis of active member distribution shows that six sections (Denmark, Greece, Iran, Nigeria, Serbia and Montenegro) have enough active members to form an EMC Chapter.

Takeo Yoshino reported on Region 10 activity. Since the last Board meeting, the largest show in China, EMC Shanghai, was held in early November. An EMCS membership booth was not set up since it is a commercial show.

Chapter Coordinator Sergio Pignari reports there are now 73 Chapters; no Chapters are on the IEEE "watch list". New Chapters under construction include Syracuse, NY; Waterloo, Canada; and West Michigan. The top regions for Chapters includes Regions 1-6 with 33 Chapters, Region 8 with 20 Chapters, and Region 10 with 13 Chapters. A Chapter Chair training session with dinner was held on Monday, July 26 during the Fort Lauderdale EMC symposium – 25 people attended.

Chuck Bunting reported as the Sister Society Coordinator. He wrote an article on this activity for the EMC Newsletter, Fall 2010. Target "sister" societies include the Institute of Electrical, Information and Communication Engineers (IEICE) of Japan, the Society of EMC Engineers in India and the Chinese Institute of Electronics (CIE) in China.

Kimball Williams presented a detailed report on PACE. This is included in the VP Member Services report.

Bob Davis closed his report by advising Henry Benitez will attend the IEEE Sections Congress in August 2011 in San Francisco, CA.

Standards Services

John Norgard, Vice-President for Standards, presented his report. He noted on Smart Grid that the standards committee will organize a smart grid workshop at EMC 2011. Don Heirman presented an update on current standards activity. He noted work continues on aggressive schedules and activities are being pursued with other Societies. There is a potential Board position paper for standard 1775. There will be closer interaction with SACCom in following standards activity in non-EMCS standards developed. Finally, SDCom will join EMC Society efforts in focusing on Smart Grid contributions.

Suspension of Meeting

Ms. Maradei suspended the meeting at 5:00 pm. The meeting continued on Sunday morning, November 14 at 8:30 am.

Continuation of Meeting on Sunday, November 14, 2010

Note all members present for the November 13 meeting were also present on November 14 with the exception of Don Sweeney, who did not attend due to illness.

Officer Elections

Elections were held for the Board officer positions, including the five Vice-President and President-elect positions. Candidates were voted upon by secret ballot. As a result of the ballot counts:

- Ghery Pettit was elected President-elect
- Bruce Archambeault was elected VP Conferences
- Perry Wilson was elected VP Communications
- Bob Davis was elected VP Member Services
- Bob Scully was elected VP Technical Services
- Don Heirman was elected VP Standards

Newly elected Board members for 2011–2013 present - including (from left) Don Sweeney of DLS Electronic Systems, Todd Hubing, Bob Davis and Chuck Bunting – were welcomed by President Maradei (center). Mr. Davis was re-elected to the Board.

Following the Board of Directors meeting in Pittsburgh, President Maradei travelled to New Brunswick, New Jersey to attend the IEEE Technical Activities Board (TAB) meetings. While at the meeting, Ms. Maradei was instrumental in securing TAB's approval of the EMC Society's transition from a newsletter to magazine in 2012.

Strategic Planning Update

Ms. Maradei reviewed the work the Board has done to date on the strategic planning document. The Board approved the strategic planning document finalized at the November 12, 2010 Board strategic planning meeting. The Board also approved the impact of the approved motions on the strategic plan.

New Business

The following items were discussed under New Business:

Scope of the *IEEE Transactions on EMC* – Todd Hubing advised he had received several comments from Board members on the version presented at yesterday's meeting. He updated the scope accordingly. The Board approved the scope of *IEEE Transactions on EMC* as presented.

Field of Interest (FOI) Review – Dick Ford would like to set up an FOI review committee to develop a new FOI. Anyone interested in joining the committee should contact Mr. Ford. Elya Joffe volunteered to join this committee. Ms. Maradei noted that the IEEE has a 60 word limit on a Society's FOI statement.

Boston Globe – Dick Ford would like to address the Boston Globe article and their misusage of the EMC Society name on a topic related to cell phone usage. Ms. Maradei agreed to address this with the publication working with Mr. Ford.

Outgoing Board Letter – Randy Jost asked that the Board consider writing a letter to the employer of an outgoing board member thanking them for their employee's service to the Board.

Technical Services

John Norgard presented a report in the absence of Bob Scully, Vice President for Technical Services. The Board approved creating an EMC Society award for excellence in continuing EMC engineering education as outlined in the report. Bruce Archambeault, Technical Advisory Committee (TAC) Chair, reported on the activities of his committee. He reviewed the schedule of meetings for the coming year. They will use the same software for EMC 2011 as they have for the past few symposiums. There has been a change in the leadership of several TCs with the chair stepping down, resulting in the vice chair now acting as chair. Randy Jost reported briefly for the Education and Student Activities committee (ESAC). Mr. Heirman noted that the student branches need to be made aware of the importance of emphasizing their relationship to IEEE in the signage at their respective universities. Kimball Williams, the EMC Society Liaison to the Society on Social Implications of Technology (SSIT), presented a report on the history and current activity of the SSIT.

Summary of Financial Impact of Approved Motions

Elya Joffe advised that the total financial impact of the approved motions made during the meeting is $38,100.

Action Item Review

Secretary O'Neil reviewed the action items discussed during the meeting. An updated, consolidated list of action items will be sent to the Board following the meeting.

Adjournment

Ms. Maradei closed the meeting with thanks to everyone for attending, imploring everyone to address their action items and address the five year review.

With no further business, the meeting adjourned at 11:30 am.

Submitted by:

Janet O'Neil
Secretary, EMC Society Board of Directors

EMCABS

EMC Abstracts

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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, you can order it from NTIS or DTIC. Recently it became clear that EMCABs were more timely than publications which were being listed in data files. Therefore, additional information will be included, when available, to assist in obtaining desired articles or papers. Examples are: IEEE, SAE, ISBN, and Library of Congress identification numbers.

As the EMC Society becomes more international, we will be adding additional worldwide abstractors who will be reviewing articles and papers in many languages. We will continue to set up these informal cooperation networks to assist members in getting the information or contacting the author(s). We are particularly interested in symposium proceedings which have not been available for review in the past. Thank you for any assistance you can give to expand the EMCS knowledge base. **EMC**

EMCABS: 01-02-2011

LONG-TERM POWER QUALITY MONITORING IN DISTRIBUTION NETWORKS

+ Pavel Santarius, + Petr Krejci, + Radovan Hajovsky and ++ Radim Cumpelik
+ VSB-Technical University of Ostrava, Czech Republic
++ CEZ– a.s., Czech Republic

Proceedings of XX International Conference on Electromagnetic Disturbances, Kaunas University of Technology, Lithuania, September 22–24, 2010, pp. 13–16.

Abstract: In the power company CEZ in the North Moravia Region (the Czech Republic) the monitoring of a number of selected parameters of the quality of electrical energy (harmonics, flicker and unbalance) is being carried out in cooperation with research laboratories of the Faculty of Electrical Engineering and Computer Science, VSB- Technical University of Ostrava. The monitoring is being carried out in a complex manner in 59 feeding points 400 V, always within one week intervals, and at the same time on all voltage levels (HV, MV and LV). In the paper, the results of the complex monitoring during 12 years are summarized together with the comparison of the changes of parameters after three years. In addition, the results of annual continual monitoring for one selected locality on an MV level are presented in the paper.

Index terms: Power quality, harmonics, flicker, unbalance.

EMCABS: 02-02-2011

INVESTIGATION OF EVALUATING METHOD OF INFLUENCES BY DISTURBANCES ON DIGITAL TV USING ACTUAL BROADCASTING SIGNAL

Nobuo Kuwabara and Shohei Yanagi
Department of Electrical Engineering and Electronics, Kyushu Institute of Technology, Japan

Proceedings of XX International Conference on Electromagnetic Disturbances, Kaunas University of Technology, Lithuania, September 22–24, 2010, pp. 29–32.

Abstract: Influence by the disturbances from the electrical equipment was investigated by using the actual broadcasting signal. The disturbances from the equipment were measured by an oscilloscope and were generated by the arbitrarily waveform generator The TV signal and the disturbances level were evaluated by a quasi peak value, an amplitude probability distribution and an average power. The influences on received images were evaluated by mean opinion score (MOS). The relation between MOS and these signal levels were investigated concerning the actual digital TV signal and the analog TV signal. The results suggested that the evaluation by the average power was appropriate because the method could reduce the influence on the kind of disturbance.

Index terms: Analog TV, digital TV, disturbances, APD, quasi peak, average power, mean opinion score.

EMCABS: 03-02-2011

FORCASTING AND FINDING ELECTROMAGNETIC SHIP'S SIGNATURES

+ Krzysztof Dymarkowski, + Rafal Namiotko, ++ Grzegorz Pettke and ++ Edward Szmit
+ OBR Centrum Techniki Morskiej S.A., Poland, ++ Polski Rejestr Statkow S.A., Poland

Proceedings of XX International Conference on Electromagnetic Disturbances, Kaunas University of Technology, Lithuania, September 22–24, 2010, pp. 33–36.

Abstract: The paper presents a matrix model of platform/ship structure and the topological approach for the assessment of electromagnetic field signature. The model is developed on the basis of an assumption taking into account the sources of electromagnetic emissions, the ship's structure discontinuity, including manholes, cable passes, casings, etc. An analysis of the electromagnetic emission paths out of the ship's hull is also included.

Index terms: Ship's electromagnetic field signature, electromagnetic emission, naval ship, electromagnetic topology.

EMCABS: 04-02-2011

SHIELDING EFFECTIVENESS OF GRADIENT LIQUID-CONTAINING COMPOSITE MATERIALS

Natallia Nasonova, Tatiana Pulko, Galina Pukhir, Vjacheslav Kizimenko and Leonid Lynkov
Belarusian State University of Informatics and Radioelectronics, Belarus

Proceedings of XX International Conference on Electromagnetic Disturbances, Kaunas University of Technology, Lithuania, September 22–24, 2010, pp. 57–60.

Abstract: In order to reduce the reflectivity of metal objects, radio absorbing materials are commonly used. Using the CST Microwave Studio 2010 we model the frequency characteristics of electromagnetic radiation reflection through an RCS calculation in the SHF range. We show that by applying the dielectric layers on a metal surface, its RCS decreases as a result of dissipation of the electromagnetic energy. The highest efficiency of RCS decreasing on the metal plate is ensured by a three-layered structure comprising a low-loss dielectric layer as the first matching layer, a high-loss dielectric layer as the second matching layer and a metal plate. Results of real RCS decrease by a developed double-layered composite liquid-containing structure are given.

Index terms: Liquid dielectrics, radar cross-section, electromagnetic radiation, modeling.

EMCABS: 05-02-2011

MONITORING SYSTEM CONSIDERING TIME VARYING ELECTROMAGNETIC FIELDS IN MAGNETIC FUSION TEST FACILITIES

+ Tatsuhiko Uda, + Masahiro Tanaka, ++ Shizuhiko Deji, +++ Yoshitsugu Kamimura, ++++ Jianqing Wang and ++++ Osamu Fujiwara
+ National Institute for Fusion Science, ++ Kobe Co-Medical College, +++ Utsunomiya University, ++++ Nagoya Institute of Technology, Japan

Proceedings of XX International Conference on Electromagnetic Disturbances, Kaunas University of Technology, Lithuania, September 22–24, 2010, pp. 67–70.

Abstract: To consider occupational safety management from static magnetic field to high frequencies of electromagnetic fields, the electric and magnetic fields had been measured around a magnetic fusion plasma test facility of a Large Helical Device (LHD). The LHD uses a superconductive coils system and high-power radio frequency wave devices for auxiliary plasma heating. Although usual leakage of the electric and magnetic fields were less than the regulation level, it shows time-dependently and statistical variation according to plasma shots and experimental condition. To establish the continuous monitoring system desired in such a facility, the authors used some instruments, including the convenient personal monitors, to confirm their sensitivity had been examined and clarified their applicability.

Index terms: Magnetic fusion plasma, electromagnetic fields measurement, safety management.

EMCABS: 06-02-2011

INVESTIGATION OF COMPACT FLUORESCENT LAMPS ELECTROMAGNETIC RADIATION

Konstantinas Otas, Alfonsas Vaskys and Paulius Vaskys
Kaunas University of Technology, Lithuania

Proceedings of XX International Conference on Electromagnetic Disturbances, Kaunas University of Technology, Lithuania, September 22–24, 2010, pp. 95–98.

Abstract: EU decided to phase out the sale of incandescent light bulbs in the coming years in favor of much more efficient compact fluorescent lamps (CFLs). The CFLs for replacing 100 W incandescent lamps (ILs) and most widely found on the Lithuania market were selected for experimental investigation in this work. Lamp current, power, power factor, light output and UV radiation of 27 CFLs of different brands were investigated. UV radiation evaluation of tested lamps was carried out.

Index terms: Compact fluorescent lamp, CFL, lamp current, lamp power, lamp luminous flux, UV radiation.

EMCABS: 07-02-2011

ESTIMATION OF GAP BREAKDOWN FIELD FOR AIR DISCHARGES OF ESD-GUN WITH LOW CHARGE VOLTAGES

+ Ikuko Mori and ++ Osamu Fujiwara
+ Suzuka National College of Technology, ++ Nagoya Institute of Technology, Japan

Proceedings of XX International Conference on Electromagnetic Disturbances, Kaunas University of Technology, Lithuania, September 22–24, 2010, pp. 111–114.

Abstract: To grasp the characteristics of air discharge of ESD-guns with low charge voltages, the gap breakdown field is estimated using a discharge circuit approach with the maximum current rising slope and peak current. At the same time, because the rise time below several hundred volts reaches the measurement limit of the oscilloscope, real discharge current waveforms are reconstructed using complex frequency response of the second order low pass filter of the oscilloscope and then gap breakdown field in this case is also estimated. As a result, the gap breakdown field can be estimated approximately 2.6×10^7 V/m

Osamu Fujiwara (far left) of the Nagoya Institute of Technology is shown at the XX International Conference on Electromagnetic Disturbances, held at the Kaunas University of Technology in Lithuania from September 22–24, 2010. Joining him for a City Tour from the hotel "Park Inn Kaunas" were (from right) Kazimieras Vytautas Maceika, Head Professor of Department of Aviation Technologies Vilnius Gediminas Technical University; Tatsuhiko Uda, Professor of National Institute for Fusion Science, Japan; Rama Rinkeviciene, Dean of Electronics Faculty, Professor of Automation Department, Vilnius Gediminas Technical University; and Ikuko Mori, Assistant Professor of Suzuka National College of Technology, Japan.

below charge voltage of 600 V and those obtained from reconstructed waveforms gives higher values and below 400 V they are estimated to be 3×10^7 V/m.

Index terms: Electrostatic discharge (ESD), ESD-gun, air discharge, low charge voltage, circuit approach, gap breakdown field.

EMCABS: 08-02-2011

CURRENT-POTENTIAL MEASURING METHOD FOR ESTIMATION OF THREAT RELATED TO LIGHTNING STRIKE TO A RADIO BASE STATION

Renata Markowska, Jaroslaw Wiater and Andrzej Sowa
Bialystok University of Technology, Poland

Proceedings of XX International Conference on Electromagnetic Disturbances, Kaunas University of Technology, Lithuania, September 22–24, 2010, pp. 141–146.

Abstract: The paper presents a methodology and provides an example showing results of on-site measurements of surge current flows and potentials in a radio base station. The basic idea of the method is to simulate a lightning strike to the base station tower using a surge generator and to measure surge current flows and potentials with respect to remote ground at various elements of the station. The aim of the experiment was to provide complex information on the performance of a radio base station affected by surge currents. This information may be used in further theoretical analysis of lightning threats for testing and verification of numerical models and/or for analysis of various lightning protection measures.

Index terms: Direct lightning strike, communication tower, onsite simulation of lightning strike, measurements, surge current flow, ground potential rise.

EMCABS: 09-02-2011

SEPARATION DISTANCES IN LIGHTNING PROTECTION OF ANTENNAS

Andrzej W. Sowa
Bialystok University of Technology, Poland

Proceedings of XX International Conference on Electromagnetic Disturbances, Kaunas University of Technology, Lithuania, September 22–24, 2010, pp. 151–154.

Abstract: An antenna mast on the roof of a structure should be protected against direct lighting strike. To achieve such protection, it should lay within the protective spaces and have a minimum separation distance between mast and element of air-termination system required. In this paper, the study of separation distances for different wave shapes of lighting surge voltage is presented.

Index terms: Lighting protection, antennas, separation distances.

EMCABS: 10-02-2011

INVESTIGATION OF THE VOLTAGE INFLUENCE ON PARTIAL DISCHARGE CHARACTERISTIC PARAMETERS IN SOLID INSULATION

+ Povilas Valatka and ++ Gediminas Dauksys
+ Department of Electric Power Systems, Kaunas University of Technology

++ Department of Electric Power Systems, Kaunas University of Technology, Kaunas Technical College, Lithuania
Proceedings of XX International Conference on Electromagnetic Disturbances, Kaunas University of Technology, Lithuania, September 22–24, 2010, pp. 155–158.
Abstract: The solid insulations of electrical equipment are perpetually affected by various duration of over voltages and over currents. Depending on its duration, the over voltage event can be transient- a voltage spike, or permanent, leading to a power surge. Electric stress of insulation depends on its thickness and amplitude of applied voltage. The damaged solid insulation may also influence characteristic parameters of partial discharges. The characteristic parameters of solid insulation quality should be permanently evaluated. The paper discusses the voltage influence on partial discharge characteristic parameters in the solid insulation. Partial discharge values of different sizes and shapes of solid insulation defects under different voltage influences are evaluated.
Index terms: Partial discharge, partial discharge characteristics, overvoltage, dielectric, solid insulation.

EMCABS: 11-02-2011

INFLUENCE OF SLOTTED ENCLOSURE RADIATION PATTERN ON MESUREMENTS OF SHIELDING EFFECTIVENESS IN GTEM CELL

Andrzej Rusiecki
Bialystok Technical University, Faculty of Electrical Engineering, Poland
Proceedings of XX International Conference on Electromagnetic Disturbances, Kaunas University of Technology, Lithuania, September 22–24, 2010, pp. 169–172.
Abstract: Influence of the radiation pattern of slotted enclosure on results of shielding effectiveness (SE) measurements in a GTEM cell is presented. The measurement results are compared to the calculated Far-Field (FFLD) emission of the enclosure. The effect of the spatial radiation pattern on the SE calculations has been taken into account using a Poynting vector integration. Differences in measured SE for different equipment setups in GTEM cell are presented.
Index terms: Shielding effectiveness, slotted enclosure, GTEM, far-field, Poynting vector integration.

EMCABS: 12-02-2011

EXPERIMENTAL RESEARCH OF PULSE PROCESSES IN THE OBJECT GROUNDING SYSTEM

+, ++ Nerijus Bagdanavicius, + Anatolijus Drabatiukas, + Sarunas Kilius and ++ Alfonsas Morkvenas
+ Kaunas Technical College, Lithuania
++ Kaunas University of Technology, Lithuania
Proceedings of XX International Conference on Electromagnetic Disturbances, Kaunas University of Technology, Lithuania, September 22–24, 2010, pp. 173–178.
Abstract: The suitable grounding of sensitive electronic equipment cases in the building objects is one of the measures to reduce the effect of the disturbances which arise due to the lightning impact or various commutations in the power supply network. The data registration and analysis is essential when characterizing such disturbances. Registration demonstrates the real statistical parameters in the particular objects. In this work, the influence of the object grounding system on the disturbances induced by the lightning discharge is evaluated.
Index terms: Surge, surge registration, test pulse, electromagnetic pulse, grounding system.

EMC

Bylaws Changes

Publication of Amendments to EMC Society Constitution and Bylaws

Elya Joffe, Immediate Past President of the IEEE EMC Society

INTRODUCTION

From time to time, amendments to the Constitution and Bylaws (C&BL) of the EMC Society are required in order to maintain their relevance and to align them with the organizational structure of the Board of Directors (BoD).

Note: The current (June, 2010) version of the Constitution and Bylaws (C&BL) of the EMC Society can be found at the EMC Society web site at http://www.emcs.org/pdf/EMC Society_C&B_August_08_Rev4.pdf.

Quoted from Article X (Amendments) of the EMC Society Constitution:

"Article X – Amendments

Section 1. Amendments to this Constitution may be initiated by petition submitted by at least 1% members of the Society, or by the Board of Directors. Such petition or Board approved amendment(s) shall be submitted to the IEEE Technical Activities Board, and to the Executive Committee of the IEEE for approval. ***After approval, the proposed amendment shall be published in the Society Newsletter, or otherwise publicized by direct mailing to the membership, with notice that it goes into effect unless ten percent of the Society members object within 30 days.*** *If such objections are received, a copy of the proposed amendment shall be mailed with a ballot to all members of the Society at least 30 days before the date appointed for return of the ballots. The ballot must carry a statement of the time limit for their return to the IEEE office. When a mail vote of the Society membership is required, approval of the amendment by at least two-thirds of the ballots returned shall be necessary for its enactment.*

"Section 2. Amendments may be adopted by a two-thirds vote of the Board of Directors present in a meeting assembled, provided that notice of the proposed amendment has been sent to each member of the Board of Directors at least 15 days prior to such meeting; or an amendment may be adopted by a two-thirds mail or email vote of the members of the Board of Directors provided a 30-day period is provided for such responses. ***In either event, the proposed amendment shall be published in the Society's Newsletter or other appropriate publication.*** *No amendment shall take effect until it has been published and has been mailed to the Managing Director, Technical Activities of the IEEE, who must then obtain approval of the IEEE Executive Committee."*

As chair of the Constitution and Bylaws (C&BL) Committee of the EMC Society, it is my pleasure to bring forth to you, the members of the Society, the following amendments to Revision 4 of the C&BL, which have been approved by at least 2/3 of the BoD and have likewise been approved by the IEEE Executive Committee. They are therefore now publicized in the Newsletter for the members review. Please note that **newly added** text is underlined, while **deleted** text is ~~[struck through and in square parentheses]~~.

If objections by no more than 10 percent (10%) of the Society members to the proposed amendments are received within 30 days of the date of publication of the amendments in the Newsletter, the amendments listed herein shall come into effect.

Comments or objections may be sent to: **Elya B. Joffe, C&BL Committee Chair, e-mail: <eb.joffe@ieee.org>**

AMENDMENTS TO EMC SOCIETY CONSTITUTION, 10 JUNE 2010 REVISION 4

Amendment to Article II - Field of Interest

The following amendments constitute grammatical corrections only.

Section 1. The Field of Interest of the Society involves engineering related to the electromagnetic environmental effects of systems to be compatible with ~~[themselves]~~ itself and their intended operational ~~[operating]~~ environment. This includes: standards, measurement techniques and test procedures, instrumentation, equipment and systems characteristics, interference control techniques and components, education, computational analysis, and spectrum management, along with scientific, technical, industrial, professional or other activities that contribute to this field.

AMENDMENTS TO EMC SOCIETY BYLAWS, 10 JUNE 2010 REVISION

Amendment to Section 10: Technical Committees

The following amendments align the Technical Committees Structure with the existing TC structure.

10.5 Committees: The Technical Committees may include, but are not limited to, the following areas of interest.

EMC Management - TC1
EMC Measurements - TC2
EM Environments – TC3
EM Interference Control – TC4
High Power Electromagnetics – TC5
Spectrum Management – TC6
~~[Non-Sinusoidal Fields – TC7]~~
~~[EM Product Safety – TC8]~~
Computational Electromagnetics – TC9
Signal Integrity – TC10
Nanotechnology – TC11

Amendment to Section 12: Standing Committees

The following amendments align the Board's Standing Committees Structure with the existing Standing Committees structure.

12.2 Typical Standing Committees: The Standing Committees may include, but are not limited to, the following:

a) Administrative Committees
   1) Planning

b) Technical Service Committees
   1) Education and Student Activities
   [~~2) Standards~~]
   2) Technical Advisory
   3) Representative Advisory

[~~c) Professional Services Committees~~]
   [~~1) Public Relations~~]
   [~~2) Survey~~]
   [~~3) Inter-Society Relations~~]
   [~~4) PACE~~]
   [~~5) International~~]

c) Member Services Committees
   1) Awards
   2) Chapters
   3) Membership
   4) Fellow Evaluation
   5) Fellow Search
   6) Constitution and Bylaws
   7) Nominations and Appointments
   8) Distinguished Lecturer
   [~~9) Internet~~]
   9) Survey
   10) PACE
   11) Sister Societies
   12) Photographer

d) Communications Services Committees
   1) Newsletter
   2) Symposium
   3) Transactions
   4) History
   [~~5) Chapter Publicity~~]
   5) IEEE Press Liaison
   6) Public Relations

e) Standards Committees
   1) Standards Development
   2) Standards Education and Training
   3) Standards Advisory and Coordination

f) Conferences and Symposia Committees
   1) International Symposia
   2) Global Symposia
   3) Financial Assistance Program

Amendment, adding Section 16: GOLD (Graduates of Last Decade) Coordinator Position

The following amendment creates a new Section 16 to the bylaws, whereby the position of a GOLD (Graduate of the Last Decade) Representative) on the BoD is created.

Section 16: GOLD Coordinator Appointment and Participation

A GOLD (Graduate of the Last Decade) Representative [Defined in IEEE Member & Geographic Activities Manual, Section 4.7] shall be appointed by the President with a majority approval vote of the Board of Directors at the last Board meeting of the year prior to the commencement of his/her term as the ruling President effective 1 January. The term of this appointment shall be for three (3) years beginning 1 January (consistent with the term limits for elected BoD Members-at-Large), extendable for a maximum of one (1) additional term contingent on the appointee meeting the requirements of GOLD status during his/her term of service on the Board. The VP of Member Services shall be responsible for seeking and nominating or recommending to the President qualified EMC-S volunteers who are willing to serve as a GOLD Coordinator. The GOLD Representative, if not an Elected Member of the Board of Directors (Director-at-Large), shall have the status of an Ex-Officio (non-voting) member during his or her tenure in that office. The GOLD Coordinator shall not be counted as part of the quorum.

The charter of activities for the GOLD Coordinator shall include, but not be limited to:

- **Bringing motions to the floor at BoD meetings and having all discussion privileges in matters before the BoD, except that no vote shall be cast. The GOLD Coordinator shall not be included in a quorum count.**
- **Serving on or chairing standing and ad hoc committees.**
- **Leading committees or teams focusing on engaging young volunteers at the student branch and chapter levels to participate in EMC-S activities.**
- **Undertaking Board special projects and problem solving studies.**
- **Implementing ideas and organizing conferences.**
- **Editing and contributing to newsletters.** **EMC**

iNARTE and RABQSA Vote to Affiliate

Brian Lawrence, Executive Director, iNARTE

On March 21, 2011, the iNARTE Board of Directors voted unanimously in favor of an Affiliation Agreement with RABQSA International. A few days earlier, the Board of RABQSA had approved the same motion. Both organizations offer personal credentialing through a variety of Certification Programs that are either accredited to, or in accordance with, ISO 17024.

NARTE was established by industry leaders in 1982 in response to the FCC's deregulation and encouragement of industry certified personnel. As an objective third party certification body, NARTE developed an evaluation process for Telecommunications Engineers based not only on examination, but real world skills and work experience.

Early in 1987, it was determined that a similar credential certification process for EMC engineers and technicians was needed to help improve the quality of direct technical support to the Naval Air Systems Command (NAVAIR) and to the U.S. fleet. In addition to improving the technical quality of support, certification, as a recognized standard, provides a demonstrable benchmark to differentiate qualified EMC/EMI personnel. More recently, iNARTE has developed similar certification programs for engineers and technicians working in ESD control and Product Safety engineering.

In 2007, the NARTE name changed to iNARTE to recognize a growing international membership.

RABQSA was created in 2004 by the merging of the personnel certification activities of the US based Registrar Accreditation Board (RAB) and the Australian based Quality Society of Australasia (QSA). At the time of this merger, RAB activities were controlled by the American Society for Quality (ASQ). In 2005, RAB's accreditation programs for management systems certification bodies became the responsibility of the ANSI-ASQ National Accreditation Board (ANAB). The auditor certification and auditor training provider programs of RAB became the responsibility of RABQSA International.

ASQ is the sole voting member of RABQSA, and RABQSA will become the sole voting member of iNARTE as a result of this latest affiliation. ASQ was established in 1946. Headquartered in Milwaukee, Wisconsin, ASQ is a global community of experts and the leading authority on quality in all fields, organizations, and industries with over 85,000 members worldwide. ASQ supports membership services and business operations through ASQ Global, ASQ China, and ASQ Mexico; with ASQ WorldPartners® around the globe; and through its work with ANAB and RABQSA.

The RABQSA organization has principal offices in Sydney, Australia, in the ASQ Building, Milwaukee, Wisconsin, and in Seoul, Korea. They design, develop, and deliver personnel and training certification services for various industries, and work through more than a dozen regional offices in Asia, Europe and South America.

The activities of iNARTE and RABQSA do not compete but are entirely complimentary, in that iNARTE has developed programs for certification of the hands on engineering communities, whereas RABQSA schemes are directed at assessors, auditors and inspectors. iNARTE programs are almost entirely "Qualification Based"; RABQSA schemes are, for the most part, "Competency Based".

(From left) iNARTE's Brian Lawrence and Kathy Lawrence are shown with the RABQSA organization's Frank Phillips, (Director of Business Development), Adam Maxwell, (Director of Operations), and Peter Holtmann, (President and CEO).

This affiliation raises the profile of iNARTE in the global community. Becoming part of the ASQ, ANSI, ANAB, RABQSA family, exposes iNARTE to the upper echelon of international regulatory organizations and industry associations and is expected to provide new opportunities for significant growth.

The affiliation will be a seamless process for iNARTE members. Existing iNARTE certification programs will continue to be administered as before and the status of iNARTE members will not change. The new EMC Design Engineer certification program remains on track for launch at the 2011IEEE International Symposium on EMC in Long Beach, where we will be offering the first certification examination in this new discipline, and taking applications from experienced design engineers for grandfathering into the program.

Valuable links: **http://www.narte.org,**
http://www.rabqsa.com/ **EMC**

Save the Date!

The following iNARTE events will take place during the 2011 IEEE International Symposium on EMC in Long Beach, California:

August 15, 2011
iNARTE Exam Prep Workshop

August 19, 2011
iNARTE Exam

For more information: www.narte.org

The IEEE Technology Management Council

The IEEE EMC Society: One of Fourteen Founding Member Societies

Michael Condry

The EMC Society is one of fourteen founding Member Societies of the IEEE Technology Management Council (TMC) and has a voting representative on its Board of Governors: Kimball Williams, past EMC Society president. The TMC provides an opportunity to network with leaders from the other Member Societies in their common pursuit of the mission and goals of the TMC, and to explore additional ways for the Member Societies to interact with each other and discover programs to help sponsor society membership.

All engineering disciplines, including EMC, need to understand and work with management requirements in order to operate within the business environment. This includes managers, engineers and industry researchers. As a council, TMC focuses on the elements of technology management using the specific needs of industry in the supporting societies. In this manner, the mission and goals of the TMC can enhance the experience, knowledge, and skill sets of EMC members who now also are, by virtue of the EMC Society being a TMC Member Society, members of their local TMC Chapter.

Opportunities to network will exist at societal conferences as well. Anyone with an interest in the management of technology, management principles in general, or who is a technical professional responsible for technology management, or is striving to become a manager, should have an interest in the offerings of the TMC. Corporate individual contributors will also benefit from tutorials on how to best survive in industry where employee responsibilities will require contributions to planning, budget and reviews in addition to the expected engineering design and development for products and research.

EMC Society members may want to subscribe to the TMC publications. The *Transactions on Engineering Management* is research-oriented, and the popular *Engineering Management Review (EMR)* is a compilation of papers reprinted from the most respected engineering and technology management journals in the world, as selected by its editorial board. The EMR is targeted more for the practicing professional. TMC has conferences that are attracting business needs of its Society Members and is developing tutorials and distinguished speakers that can be used within society conferences.

Information about the TMC can be found at http://www.ieeetmc.org/.

Editor's Note: Many thanks to Kimball Williams, past president of the IEEE EMC Society and member of the TMC Board of Governors, for sending this article to the EMC Newsletter.

EMC

Calendar

EMC Related Conferences & Symposia

2011

May 8–11
SPI 2011 – 15th IEEE Workshop on Signal Propagation on Interconnects
Conference Center Federico II
Naples, Italy
www.spi2011.unina.it

May 16–19
Asia Pacific EMC Symposium
Jeju Island, Korea
www.apemc2011.org
(See ad page 35)

August 12–13
ANSI C63® Workshops
Held in conjunction with the 2011 IEEE International Symposium on EMC
Northwest EMC
Irvine, California
Janet O'Neil
425.868.2558
www.c63.org

September 15–17
SoftCOM 2011
The 19th International Conference on Software, Telecommunications and Computer Networks
Split, Croatia
www.fesb.hr/SOFTCOM

September 26–30
EMC Europe 2011
University of York
York, United Kingdom
www.emceurope.org/2011
(See ad pages 56-57)

October 16–21
AMTA 2011
The 33rd Annual Meeting of the Antenna Measurement Techniques Association (AMTA)
The Inverness Hotel and Conference Center
Englewood, Colorado
www.amta2011.org

November 1–4
APL 2011
7th Asia-Pacific International Conference on Lightning
Chengdu, China
www.apl2011.org

November 6–9
EMC Compo 2011
8th International Workshop on Electromagnetic Compatibility of Integrated Circuits: "EMC-Aware Design from IC to System Level"
Center for Advanced Academic Studies
Dubrovnik, Croatia
www.emccompo2011.org

November 7–9
COMCAS 2011 – The International IEEE Conference on Microwaves, Communications, Antennas and Electronic Systems
Hilton Hotel
Tel Aviv, Israel
www.comcas.org

November 9–11
The 10th EMC Society of Australia Symposium
Perth, WA – Australia
www.emcsa2011perth.org

EMC Annual Symposia Schedule

2011	**August 14–19, Long Beach, California** Ray Adams, 310.303.3300 (See ad pages 24–25)
2012	**August 6–10, Pittsburgh, Pennsylvania** Mike Oliver, 814.763.3211
2013	**August 5–9, Denver, Colorado** Danny Odum, 303.693.1778
2014	**August 3–7, Raleigh, North Carolina** Bruce Archambeault, 919.486.0120
2015	**August 17–21, Dresden, Germany** Hans Georg Krauthäuser, +49 (0)351.463.33357 hans_georg.krauthaeuser@tu-dresden.de
2016	**July 25–29, Ottawa, Canada** Qiubo Ye, 613.998.2769

IEEE EMC Board of Directors and Standards Committee Meetings

Please note the Standards committee meetings of the IEEE EMC Society are held the day prior to the EMC Board meetings listed below. All Standards committee meetings are open to anyone with an interest in EMC standards. To attend a Standards committee meeting at one of the locations below, contact Don Heirman at d.heirman@ieee.org. Board meetings are also open to those interested in the administration of the EMC Society. For information on the Board meetings, contact Janet O'Neil, 425.868.2558, j.n.oneil@ieee.org. Your involvement is welcome!

August 14 and 18, 2011
Long Beach, California

Mid – November 2011 (exact dates to be determined)
US East Coast Location

EMC Chapter Colloquium and Exhibition "Table-Top Shows"

2011

May 10
Chicago, Illinois
"Essential EMC Measurement Tools" and "Shielding of Electronic Products, Enclosures and Cables"
Lee Hill, Silent
Itasca Country Club
Itasca, Illinois
Frank Krozel, Electronic Instruments
Phone: 630.924.1600
Email: frank@electronicinstrument.com
www.emcchicago.org

May 18
Detroit, Michigan
"EMC Measurement"
Colin Brench, Amphenol TCS
Werner Schaefer, Cisco Systems
Canton Summit on the Park
Scott Lytle, Yazaki North America
Phone: 734.983.6012
Email: scott@emcsociety.org
www.emcsociety.org

May 19
Santa Clara, California
"A Practical Guide to Measuring and Modeling PDN Components"
Dr. Eric Bogatin, Bogatin Enterprises, LLC
Biltmore Hotel Santa Clara
Caroline Chan, Lockheed
Email: caroline.chan@lmco.com
http://ewh.ieee.org/r6/scv/emc/

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