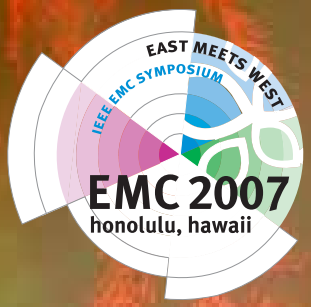

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SUPPLEMENT TO
EMC NEWSLETTER

EMC

2007 IEEE INTERNATIONAL SYMPOSIUM ON ELECTROMAGNETIC COMPATIBILITY

8-13 July 2007
Hawai'i Convention Center
Hilton Hawaiian Village Beach Resort & Spa
Honolulu, Hawaii

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WELCOME FROM THE CHAIR

Janet O'Neil, ETS-Lindgren
Chair, EMC 2007 Symposium Committee

ALOHA!
On behalf of the EMC 2007 symposium steering committee, we hope you will join us in Honolulu, Hawai'i, this July for the 2007 IEEE International Symposium on Electromagnetic Compatibility. The EMC Society Board of Directors approved this unique location years ago, as a special location was deemed necessary for a very special celebration: the 50th Anniversary of the formation of the EMC Society!

The location of Hawai'i also reflects this year's symposium theme of "East Meets West" as engineers from around the world will come from the East and the West to convene in the mid-Pacific for a week devoted to the study of EMC science. We've found the location to indeed be a central meeting point as the demographics of our technical paper authors is approximately 30% from Asia, 31% from the U.S. and 39% from Europe and the Middle East. This appears to be the first time we've seen such a balanced representation of symposium authors from around the world. That's exciting!

Our record number of technical papers, workshops, and tutorials submitted promise a record attendance. We are sure everyone will benefit from this increased attendance; there will be many great technical sessions to attend, and many potential customers in the exhibit hall. Surely the networking will be great in Hawai'i!

With the anniversary this year, the schedule for the symposium week was altered slightly. The workshops and tutorials will be held on Sunday and Monday. The technical papers and the exhibits will occur in the traditional Tuesday through Thursday timeframe. On Friday, we will conclude the symposium with the "official" 50th Anniversary Celebration luncheon and island tour. After all, one can't come to Hawai'i and spend the entire time in the big city of Honolulu. One needs to see the "real" Hawai'i of long ago, the endless fields of sugar cane and pineapples, the stunning sun-bleached beaches, and the incredibly lush landscape. For one day, you are invited to join the 50th Anniversary Committee for a special luncheon and tour. You can read more about this in the following pages.

We are also launching the Global EMC University at the symposium this year. This dedicated track is targeted to those people who are relatively new to EMC and includes a well-planned curriculum taught by world-renowned EMC experts. Nowhere else can one receive this level of EMC education from instructors all over the world in one place at one time. If you are new to EMC, this track is for you! Please register early if this interests you, as attendance is limited to ensure interaction with the instructors. CEUs are awarded to candidates who successfully complete the course.

In closing, I would like to thank the entire EMC 2007 steering committee for their excellent work on this symposium. Their names and areas of work on the committee are shown below. I tallied up the experience of this committee and was humbled when I realized we have on the committee five past EMC symposium chairs, five IEEE Fellows, four past-Presidents of the EMC Society, and several current EMC Society Board members. Every member of the committee has been involved in past EMC symposia or has organized regional events. Our committee members thus are not only experienced, but they are from many different countries and regions within the IEEE. I would be remiss if I did not also recognize and thank the Technical Committees of the EMC Society for their support of the symposium. This dedicated group reviewed close to 400 papers! Collectively, the members of the EMC 2007 steering committee and the Technical Committees have brought their time and talent to this symposium. You will reap the rewards of their dedication in Honolulu, Hawai'i, over July 8-13, 2007.

We hope to see you there.

Mahalo!

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SYMPOSIUM AT A GLANCE

The information below is current as of 30 April 2007; visit www.emc2007.org for updates.
Note: For 2007, the symposium week starts on SUNDAY and concludes on FRIDAY (except for NARTE Exams on Saturday, 14 July).

SATURDAY, 7 JULY 2007
8:00am to 5:00pm
Exhibitor Set Up

9:00am to 5:00pm
EMC Society Board of Directors Meeting

2:00pm to 6:00pm
Registration Open

SUNDAY, 8 JULY 2007
7:00am to 5:00pm
Registration Open

7:00am to 8:30am
EMCS Committee Meetings

7:30am to 8:15am
Speaker Breakfast

8:30am to 12:00pm
EMC Fundamentals Tutorial Part 1

8:30am to 12:00pm
Workshops and Tutorials

8:00am to 5:00pm
Exhibitor Set Up

10:00am to 10:30am
Morning Break

Lunch
12:00pm to 1:30pm

1:30pm to 5:30pm
EMC Fundamentals Tutorial Part 2 (Includes NARTE prep exam lecture)

1:30pm to 5:30pm
Workshops and Tutorials

3:00pm to 3:30pm
Afternoon Break

MONDAY, 9 JULY 2007
7:00am to 5:00pm
Registration Open

7:00am to 8:30am
EMCS Committee Meetings

7:30am to 8:15am
Speaker Breakfast

8:00am to 12:00pm
Global EMC University Track

8:30am to 12:00pm
Workshops and Tutorials

8:00am to 5:00pm
Exhibitor Set Up

9:00am to 4:00pm
IEEE EMC Chapter Retreat

10:00am to 10:30am
Morning Break

12:00pm to 1:30pm
Lunch

1:30pm to 5:00pm
Global EMC University Track continues

1:30pm to 5:30pm
Workshops and Tutorials

3:00pm to 3:30pm
Afternoon Break

5:30pm to 7:00pm
Special IEC Advisory Committee on EMC (ACEC) Tutorial on IEC EMC Standards

TUESDAY, 10 JULY 2007
7:00am to 5:00pm
Registration Open

7:00am to 8:30am
EMCS Committee Meetings

7:30am to 8:15am
Speaker Breakfast

8:00am to 12:00pm
Global EMC University Track

8:30am to 9:30am
Keynote Address by IEEE President Leah Jamieson

8:30am to 5:30pm
Exhibits Open

8:30am to 5:30pm
Demonstrations in Exhibit Hall

8:30am to 5:30pm
New Product Applications Presentations

9:30am to 12:00pm
Technical Program

10:00am to 10:30am
Morning Break

12:00pm to 1:30pm
Lunch

1:30pm to 5:30pm
Technical Program

3:00pm to 3:30pm
Afternoon Break

6:30pm to 8:30pm
IEEE EMC 2007
Welcome Reception
Rooftop Garden, Hilton Hawaiian Village

WEDNESDAY, 11 JULY 2007
7:00am to 5:00pm
Registration Open

7:00am to 8:30am
EMCS Committee Meetings

7:30am to 8:15am
Speaker Breakfast

8:00am to 12:00pm
Global EMC University Track

8:30am to 12:00pm
Technical Program

8:30am to 5:30pm
Exhibits Open

8:30am to 5:30pm
Demonstrations in Exhibit Hall

8:30am to 5:30pm
New Product Applications Presentations

10:00am to 10:30am
Morning Break

12:00pm to 1:30pm
Lunch

1:30pm to 5:30pm
Technical Program

3:00pm to 3:30pm
Afternoon Break

6:30pm to 10:30pm
IEEE EMC 2007 Gala Event:
Traditional Hawaiian Luau
at the World Famous Royal Hawaiian Hotel

THURSDAY, 12 JULY 2007
7:00am to 11:00am
Registration Open

7:00am to 8:30am
EMCS Committee Meetings

7:30am to 8:15am
Speaker Breakfast

8:00am to 12:00pm
Global EMC University Track

8:30am to 12:00pm
Technical Program

8:30am to 1:00pm
Exhibits Open

8:30am to 1:00pm
Demonstrations in Exhibit Hall

8:30am to 1:00pm
New Product Applications Presentations

10:00am to 10:30am
Morning Break

1:00pm to 2:30pm
Awards Luncheon

1:00pm to 11:59pm
Exhibitor Tear Down

2:45pm to 5:30pm
Technical Program

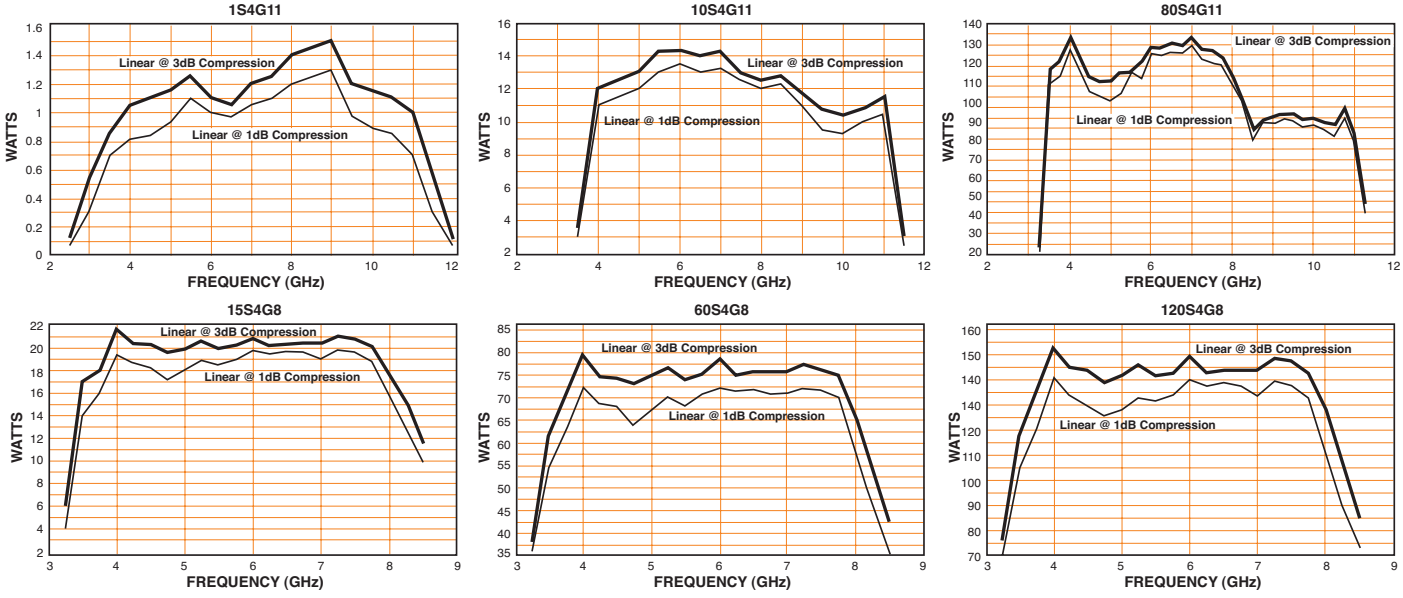
3:45pm to 4:00pm
Afternoon Break

FRIDAY, 13 JULY 2007
8:00am to 12:00pm
Exhibitor Tear Down

9:30am to 4:00pm
EMC Society 50th Anniversary Celebration
Luncheon & Island Tour

SATURDAY, 14 JULY 2007
8:00am to 5:00pm
NARTE Exams
Hilton Hawaiian Village Hotel

Why Meet The Standards When You Can Exceed Them.



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With wireless devices multiplying so rapidly, it's no wonder that the microwave spectrum is getting more and more crowded. That's why an increasing number of new and proposed EMC standards are pushing test limits higher in frequency and field strength.

Even these new standards don't take all potential threats into account. Nor do EMC standards allow for the possibility of transmitters operating in close proximity, which can produce RF fields far greater than those mandated in the standards.

So it's becoming more critical to test beyond the specs. Better to prevent equipment problems now then to try and fix them later.

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PLENARY SESSION

Tuesday, 10 July 2007
8:30am - 9:30am
Hawai'i Convention Center

The 2007 IEEE International Symposium on EMC steering committee is pleased to announce that IEEE President Leah Jamieson will be the keynote speaker to officially open the technical sessions of the EMC Society's 50th Anniversary Symposium. Ms. Jamieson will also present the prestigious 2007 IEEE Electromagnetics Award to Carl Baum, the 2007 IEEE Undergraduate Teaching Award to Clayton R. Paul, and this year's Fellow Awards. To conclude the plenary session, in recognition of the 50th Anniversary of the EMC Society and its rich historical legacy, invited speaker Tapan Sarkar will give a presentation on James Clerk Maxwell and his numerous contributions to EMC science. This talk, based on a book co-written by him on the history of wireless technology, will discuss Maxwell from a historical perspective focusing on some of his works that many are not familiar with beyond his classical electromagnetic equations.

SYMPOSIUM KEYNOTE ADDRESS

"Engineering in the Changing World"

Leah Jamieson, 2007 IEEE President

Abstract
Global and technological trends are driving change both in the engineering profession and in engineering education. What grand challenges and technological trends will shape engineering endeavors over the next 20 years? What attributes will define success in 21st century careers? How do we prepare students for careers where traits such as innovation and flexibility are as crucial as math, science, and engineering fundamentals? What role might professional societies play in this changing landscape? What unexpected opportunities might result from the broadening of engineering beyond its traditional scope? We need nothing short of a revolution in how we think about 21st century education and careers.

Biography
Leah H. Jamieson received the S.B. degree in mathematics from MIT and the Ph.D. degree from the Department of Electrical Engineering and Computer Science, Princeton University. In 1976 she joined the faculty at Purdue University, West Lafayette, Indiana, USA, where she is the Ransburg Distinguished Professor of Electrical and Computer Engineering and John A. Edwardson Dean of Engineering.

Jamieson is co-founder and past director of the Engineering Projects in Community Service (EPICS), an engineering design program that operates in a service-learning context. Initiated at Purdue in 1995, EPICS programs have been created at sixteen additional universities and one high school. EPICS co-founders were awarded the U.S. National Academy of Engineering's 2005 Bernard M. Gordon Prize for Innovation in Engineering and Technology Education. EPICS was featured in the PBS documentary Communities Building Community, produced by WFYI Indianapolis in 2003.

Jamieson's research interests include speech analysis and recognition; the design and analysis of parallel processing algorithms; and the application of parallel processing to the areas of digital speech, image, and signal processing. She has authored over 160 journal and conference papers and has co-edited books in these areas. She has been an IEEE Signal Processing Society Distinguished Lecturer and an IEEE Computer Society Distinguished Visitor.

Jamieson has been an active volunteer in the 365,000-member Institute of Electrical and Electronics Engineers (IEEE) for many years and was recently elected to be the 2007 IEEE President. She was awarded an IEEE Third Millennium Medal (2000) and the IEEE Signal Processing Society's 2003 Meritorious Service Award. Jamieson is a Fellow of the IEEE and a member of the U.S. National Academy of Engineering.

"WHO WAS JAMES CLERK MAXWELL AND WHAT IS/WAS HIS ELECTROMAGNETIC THEORY?"

Tapan Sarkar of Syracuse University

According to Dr. Sarkar, Maxwell can be considered as one of the world's greatest scientists even if he had never worked on electricity and magnetism. His influence is everywhere, which surprisingly is quite unknown to most scientists and engineers. The talk will describe some of that research including for example, the ophthalmoscope and the Maxwell's yellow spot test for macular degeneration, the three colors used in color television, as inventor of the concept of ensemble averaging and the developer of the concept of entropy which was expounded by Leo Szilard and others as information theory. He took the first color photograph, laid the basic foundation on the choice of three primary colors in characterizing any color, and developed accessories for colorblind people, which are still used today. He developed general laws of optical instruments and even developed a theory on the composition of Saturn's rings. He created a standard for electrical resistance. He also wrote the first paper on negative feedback that was the cornerstone of Norbert Wiener's work on cybernetics. Additionally, he improved the system of dimensional analysis which led him to predict that light was electromagnetic in nature and surprisingly the method of solving the loop currents as the ratio of determinants, to name a few. He developed a coherent set of units of measurement of electricity and magnetism, which became misleadingly known as the Gaussian system. Even though Maxwell has influenced development in many areas of the physical sciences and had started a revolution in the way physicists look at the world, he is not very well known for these accomplishments, unfortunately, outside some selected scientific communities. The reasons for that will also be described.

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DO WE HAVE A TECHNICAL PROGRAM FOR YOU AT EMC 2007!

Don Heirman, Don HEIRMAN Consultants
Todd Hubing, Clemson University
Technical Program Co-chairs

Over 300 (yes 300!) papers were submitted for this year's symposium in Hawai'i. That's more than double the number submitted for last year's symposium and by far the largest number submitted for any EMC symposium that we could recall. As indicated in the advance program on the EMC 2007 web site, just under 250 papers were accepted - another record. But records don't mean as much as the quality of the accepted papers, which this year was noticeably higher than previous years. Your Society technical committees went out of their way to ensure that papers were of the highest caliber. One technique that was employed to make this happen was to institute a system that allowed the authors to get the reviewers' comments for improvements, make the necessary changes, and resubmit for a second round of reviews. Those papers that were resubmitted for the second round were usually significantly improved and met the high standard of quality required to be included in the technical program.

This year, many of the papers are associated with "technical area tracks" to allow an attendee the opportunity to follow a specific technical area throughout the week. The technical tracks that have been identified for this program are:

- Automotive EMC
- EM Modeling Techniques
- New EMC Measurement Technologies
- Printed Circuit Board Design
- PCB and System Modeling
- Signal Integrity
- System EMC Test
- System EMC Design.

In addition to the wealth of technical paper submissions, we had over two dozen proposals for workshops and tutorials, again a record number. Twenty workshops/tutorials will be offered on Sunday and Monday of the symposium week, covering such topics as:

- EMC and EM Modeling Fundamentals
- Test Site Validation Above 1 GHz
- Advanced EMC Materials and Designs
- Power and Signal Integrity
- EMC and Wireless Devices
- Managing Regulatory Access to the Asia-Pacific Markets

A very special workshop given by the IEC Advisory Committee on EMC (ACEC) focusing on "a conversation with ACEC" on their work and the work of IEC TC77 (immunity focus) and IEC/CISPR (emission focus).

The ACEC workshop will be held on Monday evening where there will not be any parallel workshop/tutorial activity so that many who are not familiar with the international EMC standardization program can come and hear what that is all about.

Since this is also the 50th anniversary of the Society, we have set aside a special session that will focus on historical papers, including the following topics:

- System Level Electromagnetic Environment Simulations
- Military Aircraft EMC in the United Kingdom
- EMC Absorbers Through the Years and Their Impact on New Site Validation Techniques
- The History of Integrated Circuit EMC
- 50 Years of EMC at Georgia Institute of Technology

Another exciting area is our invited speaker special sessions. This year is especially important since special session papers were peer reviewed in the same manner as the open call for papers. So key technical experts will present the cream of the crop of special session papers. Here is a partial list of special session topics:

- Power Integrity/Signal Integrity for Next Generation Systems
- Industry Standard Cables and Shielding Performance
- Emerging EMC Technologies in Japan
- Automotive EMC
- EMC/EM Effects in Waveform Diversity Applications
- Advanced EMC Measurements

A new addition to the technical program this year is the Global EMC University. The objective of this special track is to provide a comprehensive discussion of the basic concepts and skills that are used in the EMC profession. Clayton Paul and Flavio Canavero are in charge of this event, which is open to a limited number of attendees who sign up ahead of the symposium. More information on the Global EMC University and the rest of the technical program can be found in the following pages and on the conference website at http://www.emc2007.org.

In summary this is a "can't miss" symposium, not only for the outstanding technical program, but to also celebrate a half-century of our EMC Society. We are looking forward to seeing you in Hawai'i!

Carl Baum, recipient of the 2007 IEEE Electromagnetics Award, will present a special lecture on Wednesday, July 11, from 12:30 - 1:30 pm at the Hawai'i Convention Center titled: Low- and High-Frequency Solutions of the Telegrapher Equations for Nonuniform Multiconductor Transmission Lines. All symposium registrants are invited to attend.

EMC 2007 TECHNICAL PAPER ABSTRACTS

10-12 July 2007

The information is current as of 30 April 2007, visit www.emc2007.org for updates.
Note: N/A after an author name indicates "no affiliation;" information was not provided by author.

SPECIAL SESSION: HISTORY

Establishing EMC Education: The Ten-Year Contribution of the University Grant Program

Thomas Jerse, The Citadel; and Mark Steffka, University of Michigan-Dearborn

The University Grant Program was first funded by the IEEE EMC Society in 1997. Over the past 10 years it has provided seed money for the establishment of eight courses in the basic principles of electromagnetic compatibility at academic institutions on two continents. All past recipients were surveyed, and the collected data was used to assess the impact and exceptional return on investment of the program. Brief descriptions of some of the experiments developed are also included.

A Historical Perspective of System-Level TDFD EME Simulation

Rodney Perala, Electro Magnetic Applications, Inc.

Computational electromagnetics (CEM) and particularly the time-domain finite-difference method (TDFD), began to be used for system-level simulations of electromagnetic effects (EME) in the 1970s. From that time until now, there have been dramatic advances resulting in large capability growth with simultaneous reductions in computing cost. The net result is that the TDFD method can form the core of a powerful simulation capability, useful for virtual EME system-level verification and demonstration.

EMC Absorbers Through the Years with Respect to the New Site Validation Procedure in the Frequency Range from 1 to 18 GHz — A Practical Approach

Friedrich-Wilhelm Trautnitz, Albatross Projects GmbH

This paper describes the development of EMC absorbers and EMC chambers until today. The first anechoic chamber in Europe was built in the mid sixties. Due to the fact that absorber chambers were not necessary in the early sixties, EMC measurements were easily possible on open area test sites (OATS). This project was for many years the only EMC chamber in Europe. The market for EMC chambers increased with increasing radio services because of ambient noise. In the mid eighties the market for EMC chambers again awoke. The technical requirement for EMC chambers was to fulfill the VDE 0871. At the end of the eighties VDE founded a special committee discussing the requirements of alternate test sites. The volume method for validating test sites first was integrated in ANSI C 63.4 – 1988. In Cenelec – the European committee – a working group was also founded for establishing an EN standard for alternate test sites. The result was the EN 50147-1 (shielding) and -2 (NSA site validation). The volume method was integrated in CISPR 16 in the mid nineties. Meanwhile the volume method for NSA measurement of alternate test sites is well established. The technical development of EMC absorbers will be described discussing pyramidal foam absorbers, hollow pyramidal foam absorbers, and hybrid absorbers – a combination of several absorbers (ferrite and foam absorber). New inventions like pyramidal foil absorbers will also be discussed. The new site validation (site VSWR) procedure from 1 to 18 GHz is shown.

Fifty Years of EMC Research at Georgia Tech

Hugh Denny, Georgia Tech Research Institute

Research studies in electromagnetic compatibility (EMC) have been underway at GTRI since 1953. Investigations have ranged from studies of the nonlinear properties of solid state junctions to the development of control methods for widely dispersed systems. Highlights of accomplishments and contributions during this half-century plus are presented.

EMC of Integrated Circuits: A Historical Review

Etienne Sicard, Institut National des Sciences Appliquées (INSA) of Toulouse

This paper provides a non exhaustive review of the research work conducted in the field of integrated circuit electromagnetic compatibility over the past 40+ years.

Military Aircraft Electromagnetic Compatibility: Release to Service Testing in the United Kingdom, Past, Present and Future

Timothy J. Duggan, Systems Evaluation Services, QinetiQ

Release to Service (RTS) Electromagnetic Compatibility (EMC) testing of military aircraft in the United Kingdom (UK), can be traced back as far as 1932 concerning the effect of engine interference on an aircraft's communication systems. However, it was interference seen to aircraft weapons and electrical systems during operations from aircraft carriers in the 1960s that resulted in the significant expansion of the EMC assessment and test capabilities by QinetiQ (and its predecessor organizations) at Boscombe Down, Farnborough, and by aircraft prime contractors. This paper describes the evolution of EMC test methods and facilities used to assess UK military aircraft from the 1960s to the present and into the future, taking into account the advances in avionics technology and the associated challenges in assessing their suitability for RTS.

EMC MEASUREMENTS I

Development and Application of a High-Resolution Thin-Film Probe

Kuifeng Hu, University of Missouri-Rolla

A high-resolution thin film probe was developed and compared to a conventional single loop probe, and showed a 250 µm spatial improvement measured at a height of 250 µm over 118 µm differential traces. A 180 degree hybrid junction was used in the measurement circuit to separate the electric and magnetic coupling from the probe. A network analyzer with narrow band filtering was used to detect the weak signal from the probe and further determine the phase. The developed thin-film probe was successfully used to detect the package pin current with phase information at clock frequency harmonics.

The Design of an Electro-optical Modulator Used in EMC Measurements

Yinan Geng; Rong Zeng; Jinliang He; Shuiming Chen; and Bo Zhang, — Department of Electrical Engineering, Tsinghua University

The electro-optical modulator based on Pockels effect implements the transition from electrical signal to optical signal. This makes using optical fiber in EMC measurements come true. This paper describes the principle of modulators based on Pockels effect, designs the modulator with high precision, calculates the electric field in the modulator, discusses the parameters of the modulator, and gives the equivalent electrical circuit.

The Development of Integrated Electro-optic Sensor for Intensive Electric Field Measurement

Rong Zeng; Weiyuan Chen; Jinliang He; Puxua Zhu; Xiaolin Li; and Qi Wang, — Department of Electrical Engineering, Tsinghua University

In order to meet the special demands of impulse electric field measurement simultaneously, such as intensive signal, fine insulation, transient, wide frequency band, and small size, three kinds of optical electric integrated electric field sensor were designed and fabricated. The output/input character and frequency response of the sensors were examined carefully. It can be found that the measurable amplitude of two traditionally designed sensors is less than 80 kV/m, which is not suitable for intensive electric field measurement. But a novel sensor designed here is suitable for insulated, intensive (about 300kV/m) electric field measurement. And the application of which, in the lightning impulse experiment upon air gap, ensures that the sensor can be expected to be in widespread use in transient intensive electric field measurement investigations.

Basis for a Wireless Network for EMC Measurements in Electric Substations

W. H. Siew, University of Strathclyde; Karl Liu, N/A; Bukar Musa, N/A; Yu Wang, N/A; and Faheem Mir, N/A

Switching operations of power equipment, such as disconnect switch and circuit breakers in high voltage substations, produce high frequency transient currents which propagates along the busbars. The busbars then act as antennae, producing transient electromagnetic fields in the switchyards. In electromagnetic compatibility (EMC) considerations, the resulting fields are important sources of electromagnetic interference (EMI); moreover, highly sophisticated, new technology equipments are being introduced into the substations environment for measurement, control, protection, and communication purposes. These equipments are located close to the switching equipments in the switchyards, hence to establish the EMC of the equipment it is desirable to quantify this high voltage environment. This paper describes a new digital wireless measurement system which is based on Bluetooth technology that can be used in power stations or other similar harsh environments. It comprises a Remote Acquisition Unit (RAU), a Wireless Data Communication Network (WDCN) and a PC-based Control Platform. The performance and capability of the system is assessed against another measurement system based on fiber optics technology and found to be more portable, easier to install, and cheaper than the latter. The limitations of the wireless system are considered and ways of addressing them in further research are discussed.

On the Selection of Telecommunication Port Impedance Stabilization Networks (ISNs)

David Arnett, Hewlett Packard Company; and Edward Blankenship, Hewlett Packard Company

When measuring telecommunication port conducted disturbances on 10BaseT or 100BaseT Ethernet, test labs will find different test results based on whether they select an ISN for two differential pairs or for four differential pairs. This paper discusses the reason why test data from the two ISN designs will sometimes agree and sometimes diverge.

Electromagnetic Compatibility Lack in Measuring Devices and Quick Passive Detection Method

Marian Soinski; Roman Rygal; and Wojciech Pluta, — Czestochowa University of Technology; and Piotr Kepski, Research & Development Office

Strong stationary magnetic fields from permanent magnet, or strong electromagnetic fields from many different sources, when used in a wrong way, can change a proper behavior in already optimized technical equipment. For example, many electronic electrical energy meters do not correctly count the consumption of electrical energy, or low-voltage current transformers do not indicate proper levels of output signal. This is evidence of a lack of electromagnetic compatibility (EMC). To prevent the described situation from happening, some actions have to be taken. This paper outlines the problem and proposes a possible solution to the phenomenon of illegal use of the described lack of EMC.

EMC TEST FACILITIES AND ANTENNAS

A Critique on Traceability in Site Validation Measurements

Zhong Chen, ETS-Lindgren; and Achim Enders, Technical University at Braunschweig

Site validation measurement procedures are specified in ANSI C63.4 and ANSI C63.5 in the U.S., and CISPR 16 internationally. The metrics for site performance for both standards is the site attenuation deviation or normalized site attenuation deviation. However, the (normalized) site attenuation deviations measured according to these standards for the same site-under-test are non-unique, leading to ambiguities in the reference for traceability. Because the antennas used for site attenuation measurements are not specified, the variety of allowed antennas have a non-negligible effect on site-attenuation deviations. The main variable antenna characteristics which directly influence the apparent site response are different antenna balun impedances, different near-field coupling effects for different antenna elements, and different far-field radiation patterns. Results are presented for these influencing factors to show that several dB variations in site attenuation deviations can be obtained for the same site. Consequently, standards development organizations are suggested to (re-)consider specifying and adopting some type(s) of reference antenna(s).

Extracting Useful Information from Radiated Emission Test Site NSA and VNSA Data Sets

Ed Blankenship; David Arnett; and Gary Town; Hewlett-Packard Company; Derick Skouby; and Henry Benitez, — ElectroMagnetic Investigations, LLC

This paper explores historical and technical details of the radiated emission site attenuation techniques. We give an example of additional information beyond pass/fail that can be gleaned from the results. Our research demonstrates two ways to investigate test site anomalies, using variations on the standard site attenuation method.

Verification of an EMC Facility Retro-Fit using Time-Domain and Field Uniformity Measurements

Dennis Camell, National Institute of Standards and Technology (NIST); Michael Taylor, Hach Co.; Robert Johnk, NIST; and Ben Davis, NIST

This paper summarizes a joint NIST-Industry measurement effort. Time-domain and field uniformity measurements are used to verify a retro-fit of RF absorber in an EMC Compliance Chamber from 30 MHz to 6 GHz. Time gating and dense frequency packing of inser-

tion data was used to compare before and after measurements of the chamber surfaces. A free space reference provided improved data fidelity. After the update a standard IEC 61000-4-3(A1) test volume uniformity assessment was performed. These results show that the RF absorber retro-fit resulted in improved radiated emissions and immunity performance.

Rod Antenna Interaction Inside a Shielded Chamber

Dennis Swanson, Lockheed Martin MS2

This paper investigates the interaction of a rod antenna with the test setup in which it is installed. Historically, the rod antenna has been widely used for radiated emissions testing. Anecdotal rumors exist to hint that there can be considerable variation in measurements taken with a rod antenna. To investigate these alleged variations, simulation software was used to model rod antenna test setups. The software calculated the coupled voltage received by the rod antenna from a simulated wire harness. Calculations were compiled as a function of the shield room size and the size of the test bench. Simulations also included comparisons to outdoor test sites. The results of this analysis should be considered when revising standards that employ the use of a rod antenna (e.g. CISPR 25, MIL-STD-461E, etc.).

Free Space Antenna Factors Through the Use of Time-Domain Signal Processing

Dennis Camell; Robert Johnk; David Novotny; and Chriss Grosvenor, — National Institute of Standards and Technology (NIST)

This paper demonstrates the usefulness of time domain processing to determine free-space antenna factors (FSAF) for EMC antennas. Procedures are explained and data is provided from 30 MHz to 9 GHz. We investigate time gating of dense frequency packed insertion loss data obtained with an ultra-wideband measurement system. These results show the advantage of time-domain gating to provide reliable results for free space antenna factors of EMC antennas.

EMC MANAGEMENT

The Role of EMC Standards in Product Quality

Wayne A. Hunter, Agilent Technologies, Inc.

This paper provides the reader with a representation of how the most common international EMC standards created by the IEC for commercial electronic equipment are created, why it is important to use standards, and how these standards can actually increase the quality of the product. The paper attempts to also provide the reader with a background for the electromagnetic conditions the standards attempt to simulate. It attempts to provide the reader with some reference to what is mandatory, what is optional, and suggested levels for a product based upon the intended operating environment. The paper will mainly reference international standards created by the IEC and CISPR for simplicity. Since national or local standards may be different, the paper is a good guidance, but not a substitute for the application of due diligence.

A Hierarchical Model for Prescribing EMC Design Targets to the Components of a System

Hirayr Kudyan, Alcatel-Lucent

Components of a system (i.e., units, shelves, or modules) cannot meaningfully be tested for system-level emissions compliance by themselves. The lack of EMC design objectives for emissions at the sub-system level makes it ambiguous for component designers to

decide whether a given component design is EMC sufficient. The purpose of this paper is to discuss and present a qualitative scheme for defining practical EMC design targets for the components of a system for production purposes. This is a preliminary step in attempting to address this need, using a combination of common sense, stand-alone component level emissions testing strategy, and periodic design reviews of components during their design cycle.

Uncertainty Analysis and Novel Test Procedures Performed with a Real-Time Time-Domain EMI Measurement System

Stephan Braun; and Peter Russer, — Institute for High Frequency Engineering (TU-Munich)

Time-domain EMI measurement systems allow for the reduction of the measurement time by several orders of magnitude. In this paper novel test procedures for radiated emission measurements based on a real-time time-domain EMI measurement system are presented. Those test procedures take advantage of the parallel calculation of the spectrum at several thousand frequency bins. By a full maximization procedure, fully automated measurements can be performed. By an enhanced pre- and final scan, a test procedure is presented that reduces test time by at least one order of magnitude. The proposed test reduces the critical parameters that have to be selected by the operator. Measurements have been performed in the frequency range 30 MHz to 1 GHz and compared with the results obtained by an EMI receiver. The long term stability of the emission of a brush motor is investigated. A measurement uncertainty analysis is based on a reliable statistic of about 200,000 quasipeak values. The standard deviation as well as the histogram of the probability density function is calculated and evaluated.

SIGNAL INTEGRITY I

Noise Isolation Modeling and Experimental Validation of Power Distribution Network in Chip-Package

Hyunjeong Park; Joungho Kim; and Changwook Yoon, — Korea Advanced Institute of Science and Technology (KAIST)

This paper models a chip and package power distribution network in the simplified SPICE-level. The model is successfully validated by experiment using a Vector Network Analyzer. By using the SPICE-level model, the noise isolation between the noise current source at the chip and power distribution network at the package is analyzed from 1 MHz to 3 GHz. The contribution of each part in the power distribution network is also analyzed by experiments. The transfer impedances are simulated and measured between the chip and package power distribution network varying with the wire-bond and the on package decoupling capacitor, case by case.

Improvements of Time-Domain Transmission Waveform in Serpentine Delay Line with Guard Traces

Guang-Hwa Shiue; Chia-Ying Chao; Wei-Da Guo; and Ruey-Beei Wu, — National Taiwan University

As the signal frequency goes higher, the crosstalk noise has become the major signal integrity concern for the design of various delay lines. Since the guard trace is increasingly adopted to alleviate the mutual coupling effect in modern highspeed digital systems, this paper qualitatively investigates its effects on the time-domain transmission (TDT) waveform and eye diagram of the serpentine delay line. Based on HSPICE simulation, it is demonstrated that the utilization of the guard traces can reduce the original TDT crosstalk level by more than 50%, thereby greatly improving the eye opening and jitter. Finally, the time-domain measurement is also performed to validate the proposed analyses.

Multimodal Analysis of Guard Traces

Pablo Rodriguez-Cepeda; Miquel Ribó; Francisco-Javier Pajares; Joan-Ramon Regué; Albert-Miquel Sánchez; and Antonio Pérez, — Enginyeria La Salle - Universitat Ramon Llull

In this paper a new multimodal model, useful to analyze the behavior of two signal lines separated by a guard trace, is presented. A multimodal point of view allows a simple interpretation of the phenomena involved in the coupling and transmission of signals propagating through the three traces. Three guard trace configurations are analyzed using the model and measured in order to test the adequacy of the multimodal approach. The results show a good agreement between the measurements and the model, thereby validating it.

Stripline Simulation Model with Tapered Cross Section and Conductor Surface Profile

Antonio Ciccomancini, CST of America

This paper investigates the sensitivity of on wafer interconnect to the Si CMOS process parameters. In particular the tapered (trapezoid) etching and the conductor surface profile (Rrms) of copper foils are numerically analyzed in order to quantify their effect on the electrical performance of a stripline structure. Line impedance, insertion loss, and time signal attenuation are evaluated by means of three dimensional (3-D) electromagnetic (EM) simulations. The Hammerstad and Jensen analytical model is implemented and results are compared with those coming from the full 3-D EM simulation model. Good agreement in the frequency range 0 to 50 GHz is observed.

An Improved Cavity Model for the Analysis of the Voltage Bounce in Power-Bus Structures

Giulio Antonini, University of L'Aquila; Mauro Lai, Intel Corporation; and Todd Bermensolo, Intel Corporation

This paper presents an improved cavity model for the analysis of transient voltage bounces in power / ground structures. Firstly, accurate models from DC to the maximum frequency of interest are adopted to describe conductor and dielectric losses; and secondly, the Vector Fitting technique is used to generate a rational model which is converted in a state-space macromodel, well suited for transient analysis. The numerical results demonstrate the high efficiency and good accuracy of the proposed method.

Power and Signal Integrity and Electromagnetic Emission: The Balancing Act of Decoupling, Planes and Tracks

Frank Leferink, Thales Nederland

The noise voltage in the reference or ground of a printed circuit board is often the cause of unwanted radiated emission. Power supply planes attribute to the noise voltage. By replacing the power supply planes with tracks, the noise voltage in the reference or ground can be considerably reduced, which leads to a dramatic reduction of the radiated electromagnetic fields. This has been shown using transmission line equations for a general two-conductor line. Simulation and measurements results confirm the beneficial effect of removing power planes. A reduction of 50 dB in radiated electromagnetic field strength was obtained. The question was raised whether (or not) the signal integrity is negatively influenced by using power tracks instead of planes. Several printed circuit boards have been built and measured, showing that signal integrity remains while reduction of radiated emission is achieved.

SIGNAL INTEGRITY II

Signal Integrity Analysis of a 1.5 Gbit/s LVDS Video Link

Volker Zwillich, University of Ulm; Michael Wollitzer, Rosenberger Hochfrequenztechnik GmbH&Co; Thomas Wirschem, National Semiconductor; Wolfgang Menzel, University of Ulm; and Helmut Leier, DaimlerChrysler AG

Future applications in luxury class cars may require digital video transmission with data rates as high as 1.5Gbit/s. The signal integrity of an LVDS Serializer/Deserializer video link was investigated in this work from the viewpoint of the car manufacturer. Physically consistent simulation models for the driver, receiver, connectors, and cables were developed which are valid up to 3GHz. Simulated and measured eye diagrams are compared and evaluated to obtain the maximum cable length as a function of data rate. Finally, the effect of pre-emphasis on the maximum cable length for various data rates was investigated.

Implementation of On-Chip and On-Package Reactive Equalizer to Minimize Inter-symbol Interference (ISI) and Jitter from Frequency Dependent Attenuation

Seungyoung Ahn, Samsung Electronics; Jongtae Chun, Samsung Electronics; and Joungho Kim, Korea Advanced Institute of Science and Technology (KAIST)

In this paper, we propose an on-chip and on-package reactive equalizer scheme to minimize the inter-symbol interference (ISI) and jitter. The suggested reactive equalizers are designed and optimized in the frequency domain for 3 Gbps signaling on the transmission line with frequency dependent loss and parasitic capacitance. The suggested reactive equalizer is implemented using 0.18 μm CMOS process, and the verification of the improvements in signal quality is performed by simulation and measurement of time domain reflection and eye diagram.

Signal Integrity of Carbon Nanotube Bundles

Maria Sabrina Sarto; Marcello D'Amore; and Alessio Tamburrano, — University of Rome "La Sapienza"

Simulation models are proposed to predict the transmission performances and the signal integrity of single-wall carbon nanotube (SWCNT) bundles in the frequency and time domains. The multiconductor transmission line approach is used for the computation of the common mode responses of bundles made by a different number of conductive nanotubes in the frequency range up to 103 GHz. The eye-diagram is the tool to verify the time-domain characteristics of the bundle excited by a digital voltage source with a capacity of 5 Gbit/s. A reduced order model is developed for the analysis of the cross-talk between SWCNT bundles inside the same rope.

Concurrent Analysis of Signal-Power Integrity and EMC for High-Speed Signaling Systems

Woong Hwan Ryu; Edward Chan; Mauro Lai; and Myoung Joon Choi, — Intel Corporation

A robust co-analysis approach for signal integrity, power integrity, and electromagnetic compatibility is successfully established and demonstrated through the investigation of power referenced address and control signal transmission in a double data rate (DDR) memory system. Metrics to look at the entire signaling system including SSO and signal-to-plane coupling in various referencing schemes are discussed. Finally a general radiated emission reduction from 3 to 10 dB has been achieved in an entire power referenced DDR memory system.

Causality Enforcement In Transient Simulation of HDMI Interconnects With Magnitude Equalization

Eakhwan Song, Korea Advanced Institute of Science and Technology (KAIST); Jeonghyeon Cho, KAIST; Dong Gun Kam, Silicon Image; and Joungho Kim, KAIST

An intuitive causality enforcement method is presented for the successful transient simulation of High definition Multimedia Interface (HDMI) interconnects including an equalizer, the magnitude of which is mathematically defined for compliance testing of the interconnects. Non-causal results of the simulation come from the absence of the phase of the equalizer and can be corrected by enforcing a proper phase of the equalizer. Since the magnitude-only equalizer is a non-physical device that has no delay, the phase part can be synthesized by the discrete Hilbert transform (DHT) with zero-delay assumption. The proposed procedure is validated with transient simulation.

Singular Value Based Model Order Reduction for Interconnect ARX Modelling

Ljubica Radic-Weissenfeld; Christopher Wiegand; Christian Hedayat; and Werner John, — Fraunhofer Institute of Reliability and Microintegration, Advanced System Engineering (FhG IZM ASE), Paderborn, Germany

This paper presents the abstract modelling of packages and high density interconnections, in order to build a model knowing very little information. The approach is based on combining black box modelling and order reduction. The package is divided into single block models that are defined from arbitrary input and output signals. Using black box modelling, numerically effective simulations of the buffer and interconnection is possible. A balanced form of the high order model of interconnection can be easily reduced. The dominant states essential for order reduction are recognized in a product of singular values issued from the observability and controllability Gramians. In this way, a preferred signal integrity analysis can be achieved using an electrical circuit simulator.

SIGNAL INTEGRITY III

Causal Modeling and Extraction of Dielectric Constant and Loss Tangent for Thin Dielectrics

Arif Engin; Abdemanaf Tambawala; and Madhavan Swaminathan, — Georgia Institute of Technology; Pranabes Pramanik; and Kazuhiro Yamazaki, — Oak-Mitsui Technologies

New dielectric materials are being used for reducing electromagnetic interference (EMI) and improving signal integrity (SI). Examples include using high dielectric constant materials for decoupling and thin dielectrics for managing return currents. As the frequency of the signals being propagated through such materials increases, the frequency dependent material properties become very important. We present a method to extract the frequency-dependent dielectric constant and loss tangent of such materials using rectangular power/ground planes. We have also developed a rapid plane solver for fast extraction of material properties and a causal modeling methodology based on the vector fitting algorithm.

Signal and Power Integrity Co-Simulation for Multi-Layered System on Package Modules

Krishna Bharath; Arif Engin; and Madhavan Swaminathan, — Georgia Institute of Technology; Kazuhide Uriu; and Toru Yamada, — Matsushita Electric Industrial Co.

The coupling of simultaneous switching noise (SSN) in a mixed signal system on package modules is a critical signal and power integrity (SI/PI) problem. In the presence of split planes and apertures, SSN

coupling occurs both horizontally as well as vertically across layers. Thus, to catch SI and PI problems at an early stage of design requires fast signal and power co-simulation methodologies. In this paper, we outline the multi-layer finite-difference method and how the accuracy of the technique can be enhanced with models for fringe and gap effects. We then briefly describe a method for integrating the signal distribution network with the power distribution network to enable co-simulation. The method is then applied to a mixed signal board containing split planes, and numerical results are compared to full-wave simulations.

Nonlinear Identification of Complex Systems Using Radial Basis Function Networks and Model Order Reduction

Werner John; Christopher Wiegand; Ljubica Radic-Weissenfeld; Christian Hedayat; and Ulrich Hilleringmann, — Fraunhofer Institute of Reliability and Microintegration, Advanced System Engineering (FhG IZM ASE), Paderborn, Germany

As wiring density increases with integration and miniaturization of packages (SIP) and PCB, the ability to simulate precisely the signal integrity (SI) behaviour of complex systems becomes decisive, while the simulation time increases dramatically. Therefore it is essential that the design of such complex systems is supported by accurate simulation models. This paper proposes a methodology for the identification and the fast simulation of non-linear complex HDI/HDP systems and integrated circuits by means of radial basis function (RBF) nets. For this purpose a specific modelling technique is presented with a complete flow that leads to the development of a black box model (BBM). This approach is then combined with the model order reduced (MOR) attempt and allows accelerated simulation of a whole transmission line-buffer set.

Transmission Line Model for the Gapped Power Bus Structure

Joe Trinkle; and Antonio Cantoni, — The Universtity of Western Australia

A transmission line model is developed for the computation of the transfer impedance between gapped supply zones. The model is shown to be accurate to high frequencies by validation with full wave simulation.

Fast Macromodel-based Signal Integrity Assessment for RF and Mixed-Signal Modules

Pietro Brenner, Infineon Technologies AG, Germany; Flavio Canavero, Politecnico di Torino; and Stefano Grivet-Talocia, Politecnico di Torino

This paper presents a macromodel-based approach for fast signal integrity assessment for highly integrated Radio Frequency (RF) and Mixed-Signal System on Chip (SoC) applications. In particular, we introduce a complexity reduction process that enables the signal integrity verification via analog circuit simulations, and we apply the methodology to complex radio transceiver chips in order to characterize the influence of parasitic elements on the signal processing performance of the system. Some preliminary tests show that the proposed methodology leads to significant simulation speed-up factors with respect to standard approaches for the specific application herewith considered.

Determination of Propagation of Fast Induced Transient Impulses on PCB-Level

Werner John; and Mohamed Taki, — Fraunhofer Institute of Reliability and Microintegration, Advanced System Engineering (FhG IZM ASE), Paderborn, Germany

In this contribution, an extended approach to determine the flow of induced transient noise injected into a system of interconnects will be presented. It is now possible to create subcircuits for detailed analysis and use more than one noise source. Dominant and critical signal traces that transfer significant noise, form multiple noise sources that couple with digital device input ports and are determined in the frequency domain using advanced graph searching algorithms. The time domain simulation of the whole signal paths, including device drivers and receivers, is performed using a hybrid analysis in HSpice environment. The approach is applied to an interconnect system driven by two sensitive inverter gates. The scattering parameters and the waveform of the propagating impulses considering dominant signal paths show good agreement with the total system response.

SPECIAL SESSION: POWER INTEGRITY / SIGNAL INTEGRITY FOR NEXT GENERATION SYSTEMS

Broadband Noise Suppression Using a Hybrid Photonic Crystal Power/Ground Plane Substrate

Tzong-Lin Wu, National Taiwan University; Yi-Che Chen, National Taiwan University; Ting-Kuang Wang, National Taiwan University; Alex Lu, N/A; and Lexus Lan, N/A

A novel hybrid photonic crystal power/ground layer (H-PCPL) concept is proposed with broadband power noise isolation (or suppression) performance. Two different hybrid approaches are investigated; one is fixed radius but varied pitch for the high-DK disc, and the other one is varied radius and pitch for the disc. It is found the first approach can enhance the bandwidth of the noise rejection but can not obtain a continuous and wide stopband because there is an absolute passband between two gaps. However, the second approach can obtain a continuous and wide stopband by mixing two radius of the disc. Gap map of the photonic crystal lattice is employed to synthesize the stopband profile in both approaches. As an example, a wide stopband ranging from 2.8 GHz to 7.9 GHz can be achieved based on two kinds of radius, 2 mm and 1.45 mm, under the same disc pitch 10 mm, the effective series inductance of the capacitors.

Load Current Funneling Examination for Power Distribution in High Performance Multi-core Silicon Devices

Joseph T. DiBene, II, Intel Corporation

Powering silicon devices today are challenging due to the increasing concentration of current into the load at the silicon. As multi-core processing becomes more available, larger numbers of computational units are placed on a single piece of silicon allowing more processing and higher bandwidth in our computer systems. However, as the devices become smaller, the current density also increases which raises some fundamental questions on the impacts at the interconnect level and the performance of the power distribution network in general. This paper discusses the issue of current funneling into high density devices particularly around the advent of multi-core processing and discusses some of the issues and effects one may see as the technology moves forward into the future.

Power Delivery for High Performance Processor Packages, Part I

David Hockanson, Sun Microsystems, Inc.; and Joseph T.Dibene II, Intel Corporation

The continued reduction in processor core voltage, increases in current required, and chip density and size place more pressure on effectively controlling the impedance of a CPU power distribution system. Voltage fluctuations across the die limit functionality and speed. The core-power path from the die to the voltage regulator is discussed herein. The path is separated into segments, and a one-dimensional circuit model is created to aid in the discussion.

Multi-Gigabit I/O Link Circuit Design Challenges and Techniques

Joe Wu, Intel Corporation; and Joseph T. DiBene, II, Intel Corporation

This paper describes the major challenges in designing multi-Gigabit I/O link CMOS circuits. Techniques to overcome the challenges are presented, including transceiver design, discrete and continuous time equalization, termination control, and clocking circuits.

Integrated Circuit Architecture Impacts on Application Signal Integrity

Ross Carlton, Freescale

Increasing operational and data frequencies of integrated circuits is making system design more costly and challenging as designers cope with signal integrity impacts. An understanding of the architecture and design of integrated circuit input/output circuits and packaging technology can prevent undesired performance degradation and maximize reliability. This presentation will discuss a few of the aspects of IC and package design that impact signal integrity.

Early Time Charge Replenishment of the Power Delivery Network in Multi-Layer PCBs

Giuseppe Selli, University of Missouri-Rolla; Matteo Cocchini, University of Missouri-Rolla; James Knighten, NCR Corporation; Bruce Archambeault, IBM Corporation; Jun Fan, NCR Corporation; Samuel Connor, IBM Corporation; Antonio Orlandi, University of L'Aquila; and James Drewniak, University of Missouri-Rolla

The investigation of decoupling issues has been extensively treated in the literature in both the frequency and the time domain. The two domains describe from different perspectives the same physical phenomenon, being related by a Fourier transform. In this paper, well known decoupling issues usually addressed in the frequency domain are discussed in the time domain. Moreover, some modeling issues related to the cavity model approach are discussed and, in particular, the circuit extraction feature associated with this methodology is utilized throughout the paper to carry out the time domain simulations within a SPICE based tool. The depletion of charges stored between the power bus is investigated in the time domain as a function of the plane thickness, SMT decoupling closeness, and interconnect inductance values.

SPECIAL SESSION: ELECTRONIC PACKAGING EMC AND SIGNAL INTEGRITY

Noise Isolation in LTCC-based X/Ku-band Transceiver SiP Using a Double-Stacked Electromagnetic Bandgap Structure

Jongbae Park, Korea Advanced Institute of Science and Technology (KAIST); Junchul Kim, N/A; Albert Chee W. Lu, N/A; Yujeong Shim, KAIST; and Joungho Kim, KAIST

We experimentally investigate the isolation effect of the noise coupling in an X/Ku-band transceiver SiP fabricated on a low-temperature co-fired-ceramic (LTCC) multilayer substrate, using a double-stacked electromagnetic bandgap (DS-EBG) structure. The fabricated transceiver SiP is composed of a Ku-band transmitter and X/Ku-band receiver. To prevent the simultaneous switching noise coupling from digital circuits, a DS-EBG structure was designed and implemented to the transceiver SiP. The effect of the DS-EBG, which gives a 30 dB stopband over X/Ku-band ranges, was demonstrated through frequency and time domain measurements.

Design of UWB Transceiver SiP for Short Range Communication

Changwook Yoon, Korea Advanced Institute of Science and Technology (KAIST); Hyunjeong Park, KAIST; Junwoo Lee, Hynix Semiconductor Inc.; Youngjin Park, Korea Electrotechnology Research Institute; and Joungho Kim, KAIST

Since a UWB system uses a wide frequency range from 3.1 GHz to 5.1 GHz, package parasitic effects have been a hot issue which affects system malfunction. To prevent such malfunctions, SiP technology is adjusted considering not only a circuit performance but various design issues in a package from viewpoints of signal integrity and power integrity. Furthermore, a UWB band-pass filter is embedded into a package to reduce the complexity of a transmitter circuit and the power consumption. Designed UWB SiP performance is verified by the measurement in time domain.

A Systematic Semi-Numerical Approach for Modeling of Signal and Power Integrity of Electronic Packages

En-xiao Liu, Institute of High Performance Computing, National University of Singapore; Yao Jiang Zhang, EMC Laboratory, University of Missouri-Rolla; and Erping Li, Institute of High Performance Computing, National University of Singapore

A novel method for system-level modeling of advanced electronic packages is presented which is able to provide fast yet accurate simulation for signal and power integrity analysis of the multilayered electronic packages. The method is a semi-numerical approach based on the combination of the moment method and the scattering matrix method.

Modeling and Verification to Analyze the Effect of Power/Ground Noises on a CMOS Feedback Operational Amplifier

Yujeong Shim; Jongbae Park; and Jongjoo Shim, — Korea Advanced Institute of Science and Technology (KAIST)

The operational amplifier is one of the most important circuits to compose ADCs, DACs and active filters. Now, there are many papers to analyze the noise characters of op amps. Most studies are to analyze effects of input signal noises which flow into circuits. However, an analysis of power/ground noises becomes important because there are power integrity issues on System in Package (SiPs) as the operating clock speed increases. Additionally, the magnitude and phase of digital noises flowing into circuits are not the same as generated noises from digital chips. For these reasons, in this paper, we analyze the mechanism of power/ground noises flowing into the op amp and effects of the noises on the op amp as chip-package PDN co-modeling and circuit modeling are proposed. Furthermore, the models are verified by experimental measurement.

Modeling of Signal and Power Integrity in System on Package Applications

Arif Engin; and Madhavan Swaminathan, — Georgia Institute of Technology

We present a method for fast analysis of signal and power integrity in system-on-package applications based on a recently developed, multilayered, finite-difference method (MFDM). First we present a rapid solver that can be used to extract materials properties of dielectrics. The extracted frequency-dependent dielectric constant and loss tangent can then be used in any field simulator for improved accuracy. Then we present MFDM for simulations of system-on-package applications. In order to accurately model multilayered planar structures, which are three dimensional, MFDM combines two-dimensional models for power/ground planes using a multilayered unit cell approach. In this way, noise coupling can be considered not only in the transversal direction between two planes, but also vertically from one plane pair to another through the apertures and via holes. For a co-simulation of signal and power integrity, transmission line models also need to be included. The interaction between the signal transmission and power distribution modes is taken into account using a modal decomposition technique. An equivalent circuit model becomes available based on this finite-difference approximation as well. Based on this network representation, second order effects such as fringe and gap fields can be included in MFDM using equivalent circuit models for these fields. This results in a very accurate method that can be used for fast analysis of signal and power integrity in arbitrary package and board designs having any stack-up configuration and number of layers.

Accurate Characterization of Package and Board Components for Efficient System Level Signal Integrity Analysis

Ivan Ndip, Fraunhofer IZM Berlin; Stephan Guttowski, N/A; and Herbert Reichl, N/A

In order to prevent or minimize signal integrity (SI) and electromagnetic compatibility (EMC) problems in high-speed microelectronic systems, efficient system-level analyses must be carried out at the pre-layout stage, so as to develop reliable design measures. For these analyses, an accurate characterization of package and board components is required to extract realistic circuit models within the frequency range of interest. In this contribution, novel techniques for the extraction of such models are presented.

SPECIAL SESSION: INDUSTRY STANDARD CABLES AND SHIELDING PERFORMANCE

The Shielding Performance of Industry Standard Cable Assemblies

Dana Bergey; and Nathan Altland, — FCI

Shielded cables are a common component in today's standard electronic systems that transmit high-speed video and data. However, industry standard cables don't necessarily exhibit standard shielding performance. This paper is a survey of the shielding performance actually measured on commercially available cable assemblies. When significant differences in performance were discovered, autopsies were performed in order to determine, where possible, the cause of the difference.

Cable Shielding Test Methods

Joachim Mueller, W. L. Gore & Associates GmbH

This paper presents a comparison between different cable shielding test methods. Examples of cable shielding measurements using the wire injection and absorbing clamp method will compare both methods. The limitation of simple methods like the close field probe will be illustrated. For frequencies from 1 to 18 GHz, the reverberation chamber is applied to characterize cable shields. It will be shown how the combination of the Wire Injection method with a reverberation chamber can provide a seamless cable shielding characterization from DC to 18 GHz. Finally, a correlation between the reverberation chamber results with far field measurements in an anechoic chamber will illustrate the correlation of the presented measurement methods to radiated emission testing.

Predictive Modeling of the Effects of Skew and Imbalance on Radiated EMI from Cables

Jue Chen, University of Missouri-Rolla

This paper provides an approach for predicting the effects of skew and

imbalance on radiated emission of cables inside a commercial 19-inch rack-based cabinet. Scattering parameters (S-parameters) for two sets of cable assembly are measured with a four-port vector network analyzer (VNA) and converted into mixed mode S-parameters. Time-domain input signals with different slew rates and different amount of skew are transferred into frequency-domain using fast Fourier transform (FFT). The spectra of radiation emission associated with different inputs are then estimated.

EMI Emissions from Mismatches in High Speed Differential Signal Traces and Cables

Bruce Archambeault; Jay Diepenbrock; and Sam Connor, — IBM Corporation

The use of so-called differential signaling for high speed signals has become very common in today's high speed system designs. While this signal strategy allows better data quality and signal integrity, there are some significant EMC and signal integrity issues that are not readily apparent. This paper demonstrates that a significant amount of common-mode current can be created when the two legs of the differential signal are skewed in time, or if the rise and fall times of the signals differ. These common mode currents can impact the EMC performance, causing significant levels of emissions unless careful design consideration is given to shielding and common-mode (ground) current return.

EMI Design of Shielded Cable Assemblies

Jim Nadolny, Samtec

Most discussions on shielding for EMC address the shielding of enclosures and give rules of thumb regarding the size of slots and holes. These recommendations are not applicable in general to the design of shielded cable assemblies. Because there exists a gap in published information on the unique shielding requirements for cable assemblies, this document was generated. The scope of this document is that it will apply to low cost, shielded multiconductor, cable assemblies. While some of this information will be applicable to coaxial RF cable assemblies, this is not the main focus of this document.

EMC MEASUREMENTS II

Analysis of Radiated Emissions and Shielding Effectiveness for a Metallic Enclosure with Shielding Springs

Giulio Antonini, University of L'Aquila; Antonio Orlandi, University of L'Aquila; and Antonio Ciccomancini, CST of America

The high speed digital processing in modern electronic products has made more difficult the achievement of conformity about limits emissions. To verify the requirements of standards on these emissions the use of a metallic enclosure is often necessary; in this way the power radiated by the system is reduced. In this paper the radiated emissions and the shielding performance of a metallic rack with shielding springs are studied both by dedicated experiments and by simulations. An internal source represented by a loaded monopole antenna is used to investigate the radiated emissions 3 meters from the box. A simplified model of the antenna source is proposed in the numerical model and a good agreement over a frequency range up to 1 GHz is achieved between measured results and simulated results. Shielding effectiveness is finally evaluated by means of two different kinds of sources: 1) near field (internal source) and 2) far field (plane wave source).

Logistic Regression in Immunity Testing

Giorgio Giunta; and Bruno Audone, — Oerlikon Contraves

Logistic Regression, a statistical analysis tool used for epidemiological studies, can be successfully exploited to interpret susceptibility test results with the twofold aim of understanding which are the most significant causes affecting the Device under Test (DUT) and of providing a technique to define a global figure of safety margin when many test parameters are involved. The background of Logistic Regression is briefly summarized and then a graphical interpretation of test results is provided. Finally, the experimental validation of the method is described.

The Proposal of a New Approach to Immunity Testing

Michela Audone, Centro Ricerche Fiat; and Bruno Audone, Oerlikon Contraves

The need of performing immunity tests with the aim of meeting the requirements of Functional Safety is addressed proposing several approaches based upon the data processing of test results. This represents a clear improvement with respect to the present situation of EMC standards based upon simple qualitative checks, which do not offer any warranty of safety. Even if the equipment under test (EUT) is declared immune in normal operative conditions, it may happen that a simple environmental effect such as temperature variation has catastrophic consequences. The test results of radiated immunity tests performed on a DC/DC converter are processed according to the Anova model, which is one of the proposed approaches.

REVERBERATION CHAMBER MEASUREMENTS I

Reverberation Chamber Calibration: Differences in Results When Using a Slot Instead of a Dipole Antenna

Tobias Aurand; John Dawson; Andrew Marvin; and Martin Robinson, — University of York

This paper considers the use of a slot antenna in the calibration of a reverberation chamber. In using a slot antenna the need for a balun is reduced which simplifies antenna construction. The behaviour of a slot antenna is compared to a dipole antenna and it is found that the field uniformity results obtained with a slot are more pessimistic than the ones with a dipole. Whilst the slot is usable for calibration of a reverberation chamber, it seems that the slot is more sensitive to some field nonuniformities than the dipole.

Pulsed Power 3 GHz Feasibility Study for a 36.7 m3 Mode Stirred Reverberation Chamber

Olof Lunden, FOI; and Mats Bäckström, Saab Communication

A feasibility study was conducted to investigate the field build up process in a 36.7 m3 reverberation chamber. The time to get a steady field state in the unloaded chamber will normally be about 10 to 20 µs. However, it is of great interest to investigate what field levels can be expected for an ordinary radar source. The particular 700 kW S-band radar we have at our disposal has a typical pulse duration of 1 µs. A maximum field strength of approximately 35 kV/m was achieved for 309 kW of input power. The voltage ratio, VR, between the ensemble maxima, with a chamber time constant equal to about 10 µs and the magnetron pulse of only 1 µs, was found to be 0.54 or -5.4 dB. The pulse characteristics have also been investigated when loading the chamber according to the aviation test standard RTCA DO-160.

Enhanced Backscatter in a Reverberation Chamber: Inside Every Complex Problem is a Simple Solution Struggling to Get Out

John Ladbury; and David Hill, — National Institute of Standards and Technology (NIST)

We encountered problems when we attempted to model the behavior of a transmitting antenna in a reverberation chamber. Our model

predicted the general statistical distribution of the complex reflection coefficient S11 of a test port connected to a transmitting antenna, but one measure of the variation was off by a factor of two. We eventually traced the increased variability to enhanced backscatter, in which reflections back in the direction of the source antenna tend to be larger than reflections in any other direction. Enhanced backscatter is a phenomenon generally associated with remote sensing, especially related to random media. We give general explanations of this effect based on a simple ray-optics model.

New Hybrid Mode-stirring Technique for Shielding Effectiveness Measurement of Enclosures Using Reverberation Chambers

Sandra Greco; and Maria Sabrina Sarto, — University of Rome "La Sapienza"

This paper presents a new method for the measurement of the shielding effectiveness of "small" enclosures. The technique implements a hybrid mode-stirring technique on nested reverberation chambers. The mismatching of the antenna radiating inside the enclosure under test is taken into account.

Sensitivity Analysis of a Reverberation Chamber With Respect to Tuner Speeds

Vignesh Rajamani; Charles Bunting; and James West, — Oklahoma State University

The energy distribution among the modes in an overmoded reverberation chamber operating at a particular frequency is studied for varying tuner speeds. The understanding of this spread is important in quantifying upsets of equipment in the chamber. The spectral characterization of a time varying electromagnetic field is done using the averaged periodogram approach. The complex insertion loss S21 is the measured quantity and an estimation of the power insertion loss that will be used in the determination of Q factor, is obtained from the sampling data for varying angular positions of the tuner. The same procedure is followed for varying tuner speeds and the Q is reported. The autocovariance for this random process can be found by taking a Fourier transform of the spectral density function. The autocovariance function helps in determining the number of independent samples of the field. The field experienced by an EUT in the usable volume due to a continuous rotation of the tuner is analyzed.

Evaluation of Test Reproducibility of Calibration in Reverberation Chamber

Jinliang He; Rong Zeng; Shuiming Chen; and Bo Zhang, — Electromagnetic Environment Research Group; Fan Wu, High Frequency & Microwave Division; and Zhiyong Yuan, Electromagnetic Environment Research Group

The position of the transmit antenna is analyzed and evaluated according to the measurement data in our developed reverberation chamber. The calibration parameters of the reverberation chamber are also evaluated for different working volumes. The key parameters such as the average normalized electric field and the receive antenna calibration factor are analyzed in detail. It is indicated that the definition of the working volume and the different position of the transmit antenna has a little influence on the test reproducibility of calibrations.

REVERBERATION CHAMBER MEASUREMENTS II

An Investigation of the Shielding Performance of PCB-level Enclosures using a Reverberation Chamber

Yuhui He; and Andrew Marvin, — University of York

PCB-level shielding enclosures differ from the other shielding products in several aspects due to their small volume and therefore pose new challenges to the evaluation of performance. This paper describes several possible approaches and issues about using a reverberation chamber to accomplish a fast and reliable measurement. The interaction between the internal source and the enclosure is also investigated. In addition, the performance of the enclosure in isolating near-field interference in a high-Q environment, which is general in practical applications, is compared with the measurement result from the proposed reverberation chamber method. An approach is also introduced to indicate the impact of changing environment to the near-field coupling.

In-situ High Field Strength Testing Using a Transportable Reverberation Chamber

Frank Leferink, Thales Nederland

A reverberation chamber can create a very high field strength with moderate input power. Existing chambers are making use of a paddle wheel to change the resonant modes in the chamber. In the case of a stepper motor, the field is stable for some time, and this type of reverberation chamber is called a mode tuned reverberation chamber. If the paddle wheel is continuously rotating we call it a mode stirred reverberation chamber. The mode stirred is much faster in measuring than the mode tuned, but for some applications where the equipment under test has a long dwell time the mode tuned is preferred. A transportable reverberation chamber with varying angles between wall, floor and ceiling and with vibrating walls has been used for in-situ testing of a large radar antenna system. Inside this Vibrating Intrinsic Reverberation Chamber (VIRC) a diffuse, statistically uniform, electromagnetic field is created without the use of a mechanical, rotating, mode stirrer. This chamber results in a better homogeneity and increased field strength compared to conventional mode stirred reverberation chambers. But the VIRC has a disadvantage because it cannot be used for mode tuning. In this paper, a Tuneable Intrinsic Reverberation Chamber (TIRC) is presented. The chamber is still made of flexible material and thus transportable, but the modes are changed using either a paddle wheel or by moving the walls in small incremental steps

Comparison of Different Definitions of Field Strength Used in Reverberation Chamber Standards

Luk Arnaut, National Physical Laboratory; Hans Georg Krauthaueser, Otto-von-Guericke-Universitaet Magdeburg; and Magnus Hoeijer, FOI Swedish Defence Research Agency

In different standards involving reverberation chambers, the field strength is defined either using the vector magnitude (total) electric field, or the magnitude of a Cartesian (rectilinear) component. We compare these methods for determining the maximum field strength. The ratio of the maximum of the total field to the maximum of a Cartesian component is a random variable whose probability distribution and statistics are derived and investigated. The mean value of this ratio is compared with the ratio of the respective mean values. Its standard deviation enables the estimation of confidence levels when comparing or converting between single measurements of the maximum total and maximum rectangular field. Theoretical results are compared with measured results obtained in different reverberation chambers.

How to Avoid Unstirred High Frequency Components in Mode Stirred Reverberation Chambers

Olof Lunden, FOI; and Mats Bäckström, Saab Communications

A goodness of fit test of the assumed Chi- Squared distribution, of the power received by an antenna in a reverberation chamber, is a very

efficient way to reveal the presence of unstirred components at frequencies above the lowest usable frequency. To reduce the risk of having an unstirred component, in RS-testing, the transmitting antenna has to be directed towards the stirrer. The distance between the transmitting antenna and the stirrer has to be so close that the main lobe of the antenna is enclosed by the geometry of the stirrer. In RE testing this will hold also for the reference antenna. Unstirred components are not possible to reveal and correct for in RS- and RE-testing, which might lead to erroneous testing.

Measuring Shielding Effectiveness of Small Enclosures/Cavities with a Reverberation Chamber

Chris Holloway, National Institute of Standards and Technology (NIST)

For various applications, there is a growing need to determine the shielding effectiveness of physically small (but electrically large) enclosures or cavities. This paper presents a reverberation chamber technique for measuring the SE of such enclosures. Data is presented from four different reverberation chamber approaches obtained from various enclosure configurations. These four different sets of measurements are used to validate the proposed approach.

TEM CELL MEASUREMENTS

A Field Uniformity Study of a TEM Cell by Using a Short Wire Scatterer

Takehiro Morioka, National Institute of Advanced Industrial Science and Technology (AIST); Robert Johnk, National Institute of Standard and Technology; and David Novotny, National Institute of Standard and Technology

TEM cells are widely used for EMC/EMI measurements. However, the electric field strength only at the center point of the cell is roughly estimated. By introducing a passive scatterer into the cell, such as a straight wire, the echo fields can be detected by the deviation of the reflection coefficient from that of the empty cell. This deviation is related to the incident electric field at the location of the scatterer. In this paper, the electric field uniformity of a TEM cell for the dominant and orthogonal polarizations is investigated by measurement.

New Test Method for the Pulse Immunity of Microcontrollers

Thomas Steinecke, Infineon Technologies AG

This paper presents a new test method for pulse susceptibility of microcontrollers which reflects the electromagnetic environment of microcontrollers in practical applications. The method includes a set of electromagnetic interference pulses and their injection networks. The waveforms of the pulses are deduced from measurements on real application boards of microcontrollers.

Mode Suppressed TEM Cell Design For High Frequency IC Measurements

Shaowei Deng, University of Missouri-Rolla; David Pommerenke, University of Missouri-Rolla; Todd Hubing, Clemson University; James Drewniak, University of Missouri-Rolla; Daryl Beetner, University of Missouri-Rolla; Sungnam Kim, LG Electronics; Dongshik Shin, LG Electronics; and Hocheol Kwak, LG Electronics

TEM cells or GTEM cells can be used to evaluate the radiated emissions of integrated circuits (ICs). The applicable frequency bandwidth of a TEM cell is limited due to the resonances of higher order modes. This paper describes how a TEM cell can be modified to extend the frequency range without changing the test topology. Several methods are proposed and implemented to suppress the higher order modes. The magnetic field coupling and electric field coupling are evaluated for the new design. The frequency bandwidth of the modified TEM cell is extended from the original 1 GHz to 2.5 GHz.

Evaluation of Electromagnetic Interference Between a UWB System and a Wireless LAN Using a GTEM Cell

Masashi Yamada, Musashi Institute of Technology; Kaoru Gotoh, National Institute of Information and Communications Technology (NICT); Shinobu Ishigami, NICT; Yasushi Matsumoto, NICT; and Masamitsu Tokuda, Musashi Institute of Technology

In this paper we propose a method of evaluating interference between the UWB and the wireless LAN by using the GTEM cell that can test the receiver with the built-in type of antenna. We show that the GTEM cell can be used in the frequency band of DS-UWB by the evaluation of the frequency response. The interference evaluation was conducted between a wireless LAN IEEE802.11a and a DS-UWB. As a result, even if the UWB signal is smaller than the receiver noise of the wireless LAN, the through put deteriorates more than that in the case of non-interference. Moreover, the signal of the DS-UWB was equivalent to the AWGN in a case of the through put variation of 64QAM. Finally, we evaluated the separation distances within the regulation limits of the FCC and Japan.

SPECIAL SESSION: EMERGING EMC TECHNOLOGIES IN JAPAN

New Radiated Immunity/Susceptibility Test Method Using a Four-Septum TEM Cell: Measurements and Field Analysis

Kimitoshi Murano, Tokai University; Hiroko Kawahara, University of Electro-Communications; Majid Tayarani, Iran University of Science and Technology; Fengchao Xiao, University of Electro-Communications; and Yoshio Kami, University of Electro-Communications

A four-septum TEM cell has been proposed as a new radiated radio-frequency immunity/susceptibility test device. The cell provides electromagnetic fields rotating at a very low rate by generating a set of two orthogonal balanced-mode fields. In this paper, a test method using the cell is clarified, and susceptibility characteristics of two types of microstripline models are investigated to verify the effectiveness of the cell and the role of the dielectric material is made clear. In addition, an analysis method of the internal electromagnetic fields, which are different from those used in an ordinary TEM cell, is discussed using an image method.

Methods of Evaluating Information Leakage from PC Displays

Toshihide Tosaka, National Institute of Information and Communications Technology (NICT); Kaori Fukunaga, NICT; Yukio Yamanaka, NICT; Ryo Ishikawa, NTT Advanced Technology Co.; and Mitsuo Hattori, NTT Advanced Technology Co.

To evaluate the possibility of information leakage (tapping) by observing electromagnetic disturbance radiated from a PC display, the most straightforward way is to reconstruct the displayed image from the measured signal using a special receiver. However, such a receiver is neither popular nor commercially available. Therefore, we propose two types of evaluation methods that are based on 1) the measurement of the difference in level when different images are displayed, and 2) the measurement of the frequency component of the horizontal sync signal within the electromagnetic disturbance. In both proposed methods, we only need a spectrum analyzer that is commonly used for EMI measurement.

Electromagnetic Field Distribution Measurements using an Optically Scanning Probe System

Masanori Takahashi, NICT; Katsumi Kawasaki, NICT; Hiroyuki Ohba, NICT; Hiroyasu Ota, NICT; Tatsuru Orikasa, Advantest Laboratories

Ltd.; Nobuyasu Adachi, Nagoya Institute of Technology; Kazushi Ishiyama, Tohoku University; and Ken Ichi Arai, NICT

An optically scanning electromagnetic field probe system, consisting of an electro-optic or magneto-optic crystal substrate and a galvano scanner, has been developed for high speed, low-invasive measurements of electromagnetic field distributions. We present some examples of measurements of electric field distributions using a LiNbO3 crystal substrate and the probe system. We have also measured magnetic field distributions above an MSL using a magnetic garnet thin film in the gigahertz range.

A Novel Metamaterial Based on the Concept of Autonomous Control of Systems of Living Cells and its EMC Applications

Youji Kotsuka; and Chikara Kawamura, — Tokai University

To develop the ultimate material similar to "Autonomous Controllable Systems of Living Cells" capable of responding to electromagnetic waves and of changing its material constants, Autonomous Control Metamateria (ACMM) has been thus far proposed. After introducing the fundamental concept of ACMM and its basic characteristics, new configurations of 3-D ACMM are proposed. As an application example of new 3-D ACMM, microwave absorbers are taken up. A roadblock yet to be broken through for the present metamaterial is to construct an ACMM which can change matching frequency characteristics broadly and obtain broad matching characteristics. To resolve these problems, ACMM composed of a double layer is newly proposed. The matching frequency can be changed broadly more than 1.3 GHz in a bandwidth by controlling both PIN diode bias voltages on the first and second layer.

Correlation Between Absorption Cross Section and Body Surface Area of a Human for Far-Field Exposure at Bands in the GHz Range

Akimasa Hirata; Yoshio Nagaya; and Osamu Fujiwara, — Nagoya Institute of Technology; Tomoaki Nagaoka; and Soichi Watanabe, — National Institute of Information and Communications Technology (NICT)

Our previous study revealed that a dominant factor influencing the electromagnetic absorption in a human body for far field exposure within the GHz bands is the body surface area. Based on this finding, we discussed the correlation between the absorption cross section and body surface area of a human for far-field exposure at 2 GHz. We employed a Finite-Difference Time-Domain (FDTD) algorithm for a large-scale specific absorption rate (SAR) calculation with anatomically based Japanese adult and child models. As a result, we found that good correlation is observed between body surface area and absorption cross section for a realistic human body. This relation was also found to be valid for homogeneous human models and cuboids with the same height, weight, and body surface area as those of the realistic human models. Based on this finding, we derived a formula to predict the whole-body average SAR from the height and weight of a human body with a given incident power density of electromagnetic waves. The uncertainty of whole-body average SARs at 2 GHz was discussed based on this formula.

Fast and Accurate Estimations of Radiated Emissions from a Printed Circuit Board Using a Common-Mode Antenna Model Based on Common-Mode Potential Distribution

Yoshitaka Toyota, Okayama University; Youhei Sakai, Okayama University; Tetsushi Watanabe, Industrial Technology Center of Okayama Prefecture; Makoto Torigoe, Hitachi America, Ltd.; Ryuji Koga, Okayama University; and Osami Wada, Kyoto University

This paper discusses the superposition of common-mode excitation sources that result from common-mode potential distribution. The authors have investigated the common-mode potential distribution on printed circuit boards and proposed a common-mode antenna model, which consists of a common-mode excitation source and a common-mode antenna element. The antenna model predicts common-mode radiation from PCBs fast and accurately because it focuses only on common-mode radiated emissions. In this paper, the model was applied to a rectangular printed circuit board with a signal trace bent at a right angle. In the process, the trace was divided into two straight elements at the corner to calculate the common-mode excitation sources separately with respect to each straight element. Then by gathering each source together, a set of composite common-mode sources for the entire common-mode antenna model was obtained. Through simulations and measurements, the superposition of common-mode sources was found to be valid for a good prediction of radiated emissions.

Time-Domain Simulation of CMOS Output Buffer with LECCS-I/O Model and Time-Variant Linear Switches

Osami Wada; Takashi Hisakado; and Atsushi Koyama, — Kyoto University

A new modeling technique is proposed to achieve fast time-domain simulations of digital circuits. A nonlinear switching device is modeled as a time-variant linear circuit, and the state equation is converted into a linear equation. As an example, a transient waveform simulation is demonstrated with a simple model of a CMOS output buffer. Once the state transition matrix for the device is calculated, then simulations for different conditions can be performed in linear calculations.

SPECIAL SESSION: ADVANCED EMI MEASUREMENTS

Investigation of Radiated Emission Measurement Method above 1 GHz

Chiharu Miyazaki, Mitsubishi Electric Corporation; Shozo Satake, N/A; and Jiro Kawano, N/A

The limits and the measurement methods for the radiated emissions above 1 GHz have been published as CISPR22 Ed. 5 Amend. 1, and CISPR16-2-3 Ed. 1 Amend. 1, respectively. The VCCI Technical Subcommittee has examined the measurement methods for the radiated emissions above 1 GHz. This paper describes the matter of the signal to noise ratio (S/N) for the radiated emission measurement system above 1 GHz, the setting for the video band width (VBW) of a spectrum analyzer, and the influence that the rotational speed of a turntable and the sweep time of a spectrum analyzer exert on radiated emission measurements above 1 GHz, based on the measurement results.

Adjacent Electromagnetic Field APD Measurement For Analyzing Auto-Jamming Issue on a Wireless Communication System

Satoshi Kazama; and Hiroshi Tsutagaya, — Taiyo Yuden Co., Ltd.

Receiving sensitivity reduction by internal noise in digital wireless communication equipment becomes problematic due to an auto-jamming issue. The internal noise in the equipment is at a very low level, broad and fluctuating. APD measurements can evaluate this type of noise. Because APD correlates with the BER of digital communication systems, APD measurements are useful for analyzing this auto-jamming issue. Near-field mapping with APD can get a clear distribution, free from the fluctuation of the noise and influence by thermal noise of the measurement system. It is necessary to measure both electric and magnetic field distributions for understanding the cause of auto-jamming. Therefore we have developed the APD mapping system, which measures electric and magnetic field simultane-

ously, for analyzing the auto-jamming issue in digital wireless communication equipment.

Common Mode Voltage Evaluation for Choosing Quiet MCU and Optimizing PCB Design

Atsushi Nakamura, Renesas Technology Corporation

Similar to the fact that the differential signaling interfaces radiate less than the typical single ended interfaces, radiation from a wire harness connected to electronic control units using single chip micro computers can be reduced by adjusting the common mode voltage fluctuations of supply lines. The radiation from a wire harness can be minimized when the Vcc and the Vss fluctuate with same magnitude, but in opposite phase. Using simulation techniques to estimate these fluctuations from real products that utilize hundreds of components on complex PCB layouts is currently quite difficult, so alternative solutions using measurement techniques to investigate the common mode voltage fluctuations were examined. By the Faraday cage work bench method, and the more advanced use of it with the hybrid balun, common mode voltage fluctuations of Vcc and Vss can be monitored. Examples of this measurement method are discussed and a way of reducing common mode radiation from the wire harness is explained in this paper.

EM ENVIRONMENT

Airborne RF Measurement System and Analysis of Representative Flight RF Environment

Sandra Koppen; Jay Ely; Laura Smith; Richard Jones; and Vincent Fleck, — NASA Langley Research Center; Maria Salud; and John Mielnik, — Lockheed Martin Corporation

Environmental radio frequency (RF) data over a broad band of frequencies were needed to evaluate the airspace around several airports. An RF signal measurement system was designed using a spectrum analyzer connected to an aircraft VHF/UHF navigation antenna installed on a small aircraft. This paper presents an overview of the RF measurement system and provides an analysis of a sample of RF signal measurement data over a frequency range of 30 MHz to 1000 MHz.

Small Aircraft RF Interference Path Loss

Truong Nguyen; Sandra Koppen; Jay Ely; and George Szatkowski, — NASA Langley Research Center; John Mielnik; and Maria Theresa Salud, — Lockheed Martin Corporation

Interference to aircraft radio receivers is an increasing concern as more portable electronic devices are allowed onboard. Interference signals are attenuated as they propagate from inside the cabin to aircraft radio antennas mounted on the outside of the aircraft. The attenuation level is referred to as the interference path loss (IPL) value. Significant published IPL data exists for transport and regional category airplanes. This report fills a void by providing data for small business/corporate and general aviation aircraft. In this effort, IPL measurements are performed on ten small aircraft of different designs and manufacturers. Multiple radio systems are addressed. Along with the typical worst-case coupling values, statistical distributions are also reported that could lead to better interference risk assessment.

Electromagnetic Environment Generated by Pulsed Plasma Thrusters

Andrey Plokhikh; Garri Popov; Nikolay Antropov; Nikolay Vazhenin; Gennady Shishkin; and Galina Soganova, — RIAME

This paper deals with the issues of analysis for the electromagnetic environment created on board spacecraft by electric propulsions as applied to the EMC problems. Electric propulsion systems on the basis of pulsed plasma thrusters, that are used for the orbit correction and attitude control of small satellites, are considered as the sources of unintended noise of artificial origin. Test results for the spectral characteristics of emission for the PPT model, with the discharge energy of 50 J obtained under ground conditions, and their discussion are presented in this paper.

Properties of Fields in Reverberant Environments and its Implications

Patrick Perini, EFR, Inc.; and Jose Perini

This paper addresses fields in reverberant environments, where many reflections exist, showing that they are elliptically polarized. To calculate the correct peak fields from measurements or simulations, it is necessary to know the amplitudes and phases of the fields of Cartesian Components (CCs). Since today's field probes do not have phase information it is not possible to measure the correct peak exposures! The usual sum of the squares of the CCs magnitudes may be as much as 50% off. Yet this is commonly used with no qualifications. As an example, in the statistical characterization of these fields, the CCs are assumed to be statistically independent variables with normal distribution leading to the Rayleigh distribution for the peak far field and the Exponential distribution for the peak square near field. In both cases the wrong variable, the sum of the appropriate CCs square magnitudes, is used. The paper also shows that the CCs are not statistically independent variables. The correct equations to calculate the peak values are derived. A suggestion of how to modify the present day probes to measure the CCs phases is also presented. All these questions are discussed in detail.

PRINTED CIRCUIT BOARD EMC I

A Study on the Correlation Between the PCB Layout and EMI from the Chassis

Hiroki Funato; and Takashi Suga, — Hitachi, Ltd.

Investigations of radiated emissions from a conductive chassis connected to the GND of a PCB with ICs showed higher emissions from a PCB mounted to a chassis than one without a chassis. The results also showed that the location of the ground connection between the GND plane on the PCB and the chassis can affect emission levels by up to 9 dB. To determine the path of the noise current from the PCB to the chassis, we measured the current at their junction with a thin-current-probe. The position dependence of the junction current frequency spectra correlated with that of the radiated emission spectra. Moreover, EMI levels correlated with the distance from the screw to the nearest bypass capacitor.

EMI Resulting from Printed Circuit Boards Interconnected by a Coaxial Cable

Yoshiki Kayano; and Hiroshi Inoue, — Department of Electrical and Electronic Engineering, Akita University

To provide basic considerations for the realization of methods for predicting the electromagnetic (EM) radiation from interconnected printed circuit boards (PCBs) by a coaxial cable, the characteristics of the EM interference of a test model PCB are investigated in this paper by experiment and numerical modeling. Comparing the cases with and without the interconnection, the ground plane of the interconnected PCBs and the interconnection cable are dominant radiation factor in the lower frequencies. These factors construct a large common-mode (CM) antenna. On the other hand, the total EM radiation at GHz frequencies is simply determined by the differential-

mode (DM) current on the signal trace, and cross-talk current on the victim traces. Consequently, correct predictions of CM current at lower frequencies and cross-talk are keys to the prediction of the total EMI behavior of the interconnected PCBs, because the DM current on the signal trace can be predicted by transmission line theory.

Power and Ground Bounce Effects on Component Performance Based on Printed Circuit Board Edge Termination Methodologies

Mark Montrose, Montrose Compliance Services, Inc.; and En-Xiao Liu, Institute of High Performance Computing

Printed circuit boards (PCBs) are one source of radiated EMI with digital components being the culprits. To minimize the development of common-mode currents within the silicon package of large current consuming circuits, a stable power distribution network (PDN) is required. Any noise (bounce) on either the power or 0 V reference (ground) plane may cause, simultaneously, switching noise (SSN) or signal integrity (SI) problems, as well as EMI. In addition, if planar bounce exceeds margin levels, components may not function. To ensure a stable PDN is present, decoupling capacitors and buried capacitive structures are mandatory, along with minimizing loop inductance. The uniqueness of this research lies in analyzing planar bounce that may exceed voltage margin levels from reflected EM waves that propagate back to components from the physical edge of the PCB. The edges of a PCB are in reality a high-impedance, non-terminated signal transmission line stub. With each reflection, ringing occurs. The magnitude of this ringing may cause digital components to have SSN and/or EMI problems. Popular board edge termination techniques are investigated to determine if a designer should be concerned with reflected wave switching noise on either a power or 0 V reference plane, which cannot be removed by capacitive structures or decoupling.

Analysis of Emissions from a Printed Circuit Board with a Conducting Wire Directed in Various Directions

Masahiro Takashima; Teruo Tobana; Takayuki Sasamori; and Kohshi Abe, — Department of Electronics and Information Systems, Akita Prefectural University

Emissions from a printed circuit board (PCB) with a finite size becomes serious when the common mode current is excited on it. The common mode current can occur at connections of conducting wires or at a discontinuity of a line or ground plane on a PCB. In order to clarify the relation between a junction of conducting wires to its emission, the authors analyzed emissions from a PCB with conducting wires directed in the upper direction and the lower direction at the ground edge using the Finite-Difference Time-Domain (FDTD) method. From numerical results, it is shown that in the case of a conducting wire connected to the upper direction, the radiation power is the largest. Moreover, for the position of a microstrip line, the radiation power is the largest when the distance between the microstrip line and the wire is small. Further, the experimental results of radiation power show the validity of the numerical results.

Radiated Emissions from Proximity Coupled Oversized Heat-Sinks

Dheena Moongilan, AT&T Bell Laboratories

Radiated emission characteristics of oversized heat sinks that have a surface area substantially larger than the top contact surface of the IC package are investigated. The heat sinks are found to radiate at higher levels when coupled in proximity to the package than the frequencies contained within the IC package. In this paper oversized heat sinks are modeled as proximately coupled patch antennas with a short-circuited Stub. Patch antenna characteristics such as input impedance that varies with the feed positions, and the patch resonance frequencies are applied in the analysis of the radiated emissions characteristics of oversized heat sinks. Radiated emission measurments from a physical proximity coupled patch antenna model and a highly integrated PCB with oversized heat sink are presented and the results discussed.

Modeling and Measurement of Mutual Coupling Resulting from Arbitrary 3-D Structures within Printed Circuit Board Designs

Leigh Cornock; and Ian Dilworth, — University of Essex

We report measurements and modeling of mutual coupling resulting from closely spaced copper plated through holes on printed circuit boards (PCB), known as vias. When the magnetic flux generated by a primary system couples with the inductance of a secondary system, a 'reflected impedance' is induced in series with the primary inductance. Our investigation includes practical measurements and electromagnetic (EM) modeling using the Transmission Line Matrix (TLM) code in order to establish the change in coupling and 'reflected impedance' as a function of distance between quasi resonant structures. With significant numbers of coupled vias, possible coupling permutations are large. We report models for 2, 3, and 4 via coupling, the results from which are extendable to arbitrary 3D structures.

PRINTED CIRCUIT BOARD EMC II

PPW Noise Mitigation in Multilayer PCBs by Means of Virtual Island and/or Array of Shorting Vias

Antonio Ciccomancini, CST of America

This paper describes the parallel-plate waveguide (PPW) noise mitigation by means of shorting vias and/or virtual islands. The proposed method is already know in literature, nevertheless important considerations are addressed here: 1) the same noise mitigation level can be achieved by using only shorting vias or virtual island in combination with shorting vias, 2) the noise mitigation is strictly related to the number of shorting vias, the position and the distance from the signal via, and 3) the PPW noise suppression is effective only if an array of shorting vias is used. The mitigation level is investigated both in the time domain and frequency domain. Different configurations are studied and the impact of the power plane with etched slots due to virtual islands on the signal quality is also analyzed (TDR and insertion loss).

Suppression Effect of Emissions from a Printed Circuit Board Using a Conducting Plate

Teruo Tobana; Takayuki Sasamori; and Kohshi Abe, — Akita Prefectural University

For emissions caused by the common-mode current on a printed circuit board (PCB), a suppression method based on the image theory of placing a conducting plate under the PCB is presented. In order to evaluate the suppression effect by this method, the radiation power from the PCB is calculated using the FDTD method. The numerical results show that by placing the conducting plate near the ground side of the PCB, the emissions from the common-mode current are effectively suppressed. Especially, using the conducting plate with bent sides, it is possible to suppress the emissions by the small conducting plate. Moreover, the method of bending the edges of the PCB is presented and it is shown that a large suppression effect is obtained using this method. Further, the experimental results of a maximum electric field intensity show the validity of the numerical results.

Numerical and Experimental Investigation of Power Supply Noise Decoupling Strategies on Single-Sided Printed Circuit Boards

Bruce Archambeault, IBM; Cyrous Rostamzadeh, Bosch; and Samuel Connor, IBM

In the high-volume and low manufacturing budget of the automotive world, printed circuit boards are designed without the use of a dedicated power or ground plane. Decoupling capacitors on single-sided printed circuit boards are connected between Vcc and return traces. In this paper, we evaluate a number of practical decoupling capacitor mounting strategies for these single-sided printed circuit boards used in the design of automotive control modules. The Partial Element Equivalent Circuit numerical modeling technique is used to validate measured data and to explore additional design options.

INTEGRATED CIRCUIT EMC

Thermal Influence on 16 Bits Microcontroller Emission

Sonia Ben Dhia; Etienne Sicard; Alexandre Boyer; and Yoan Mequignon, — Institut National des Sciences Appliquées (INSA) of Toulouse; and Jean Marc Dienot, IUT Tarbes

This paper deals with the thermal influence on integrated circuit performances in terms of parasitic emission. Emission measurement results conducted on a 16-bit microcontroller at extreme temperature conditions are provided, showing a difference of 10 dB between -40°C and 125°C. We detail a predictive approach for modeling the emission level variation with temperature. The simulation takes into account temperature-dependant passive and active device models. It is shown that the silicon substrate, drivers, and on-chip capacitance play significant roles in the increase in emission levels when lowering the operating temperature.

Comparison of Radiation from Two Microprocessor Test Packages

Xiaopeng Dong; Kevin Daniel; and Kevin Slattery, — Intel Corporation

Radiation directly from integrated circuits (ICs) packages is conventionally not considered significant since the size of the package is electrically small and not considered as an efficient antenna. However, as the technology evolves and operating frequency increases, the size of the microprocessor package is no longer electrically small. Moreover, in todays and in future mobile platforms such as notebooks and ultra-mobile devices (UMDs), the high performance wireless communication system and powerful computing system are integrated together. It is not necessary to have an efficient antenna to couple energy from the noise source to the wireless system and degrade its performance because of the sensitivity level of the wireless receiver. In this paper, the radiation from two microprocessor test packages is compared. The results show that the package design has significant impact on the radiation from the package.

Assessment of the DPI Standard for Immunity Simulation of Integrated Circuits

Johan Loeckx; and Georges Gielen, — K. U. Leuven

Ensuring immunity to electromagnetic interference (EMI) is a major challenge in present designs. Making integrated circuits intrinsically less susceptible to interference by adapted circuit design can reduce costs substantially in later stages. It is shown that small changes in the circuit topology can increase the immunity of IC's by several orders of magnitude. Being able to predict whether a chip will pass susceptibility tests before fabrication is essential in order to reduce costs. For this reason, accurate simulation of the standard test methods is needed. In this paper, a simulation framework is presented that allows accurate simulation and prediction of the IEC62132- 4 DPI standard.

Efficiency of Embedded On-Chip EMI Protections to Continuous Harmonic and Fast Transient Pulses with Respect to Substrate Injection

Ali Alaeldine, ESEO; Nicolas Lacrampe, LAAS-CNRS; Jean-Luc Levant, ATMEL Nantes; Richard Perdriau, ESEO; Mohamed Ramdani, ESEO; Fabrice Caignet, LAAS-CNRS; Marise Bafleur, LAAS-CNRS; Etienne Sicard, LESIA-INSA Toulouse; and M'hamed Drissi, IETR-INSA Rennes

This paper presents a comparative study of the efficiency of several embedded EMI protections for integrated circuits (ICs) with respect to direct power injection (DPI) and very fast transmission-line pulsing (VF-TLP) into the substrate of the IC. This study involves three functionally identical cores, differing only by their EMI protection strategies (RC protection, isolated substrate, meshed power supply network) which were initially designed for low-emission design guidelines. Through extensive measurements, a classification between these strategies is established for both injection methods, leading to the introduction of design guidelines for the minimization of conducted susceptibility to substrate injection.

Investigation on ESD Transient Immunity of Integrated Circuit

Nicolas Lacrampe, LAAS-CNRS; Ali Alaeldine, ESEO; Fabrice Caignet, LAAS-CNRS; Richard Perdriau, ESEO; Marise Bafleur, LAAS-CNRS; Nicolas Nolhier, LAAS-CNRS; and Mohamed Ramadani, ESEO

This paper presents a measurement methodology aimed at predicting the susceptibility of integrated circuits against electrostatic discharge (ESD) stresses. In our application, a Very Fast Transmission Line Pulsing (VF-TLP) test bench is used to inject a disturbance into an IC under operation. For simulation purposes, each part of the test bench is modeled separately, and these models are assembled in order to obtain a complete model representing both the injection set-up and the IC itself. The suggested injection model is validated thanks to correlations between measurements and simulations on a full custom 0.18 µm CMOS IC.

Latch-up Like Failure of Power Rail ESD Clamp Circuits in CMOS Integrated Circuits Under System-Level ESD Test

Ming-Dou Ker; and Cheng-Cheng Yen, — National Chiao-Tung University, Hsinchu, Taiwan

Two different on-chip power-rail electrostatic discharge (ESD) protection circuits, one with NMOS and PMOS feedback; and two with cascaded PMOS feedback, have been designed and fabricated in a 0.18-µm CMOS technology to investigate their susceptibility to a system-level ESD test. The main purpose for adopting the feedback loop into the power-rail ESD clamp circuits is to avoid the false triggering during a fast power-up operation. However, during the system-level ESD test, where the ICs in a microelectronics system have been powered up, the feedback loop used in the power-rail ESD clamp circuit provides the lock function to keep the main ESD device in a "latch-on" state. The latch-on ESD device, which is often designed with a larger device dimension to sustain high ESD level, conducts a huge current between the power lines to perform a latch-up like failure after the system level ESD test. The susceptibility of power-rail ESD clamp circuits with the additional board level noise filter to the system level ESD test is also investigated. To meet high system level ESD specifications, the chip level ESD protection design should be considered with the transient noise during system level ESD stress. The power-rail ESD clamp circuit

with feedback technique is also evaluated with the board level filter network.

SHIELDING

Shielding Specification Techniques and Measurement Methods for Aircraft

William Prather, U. S. Air Force Research Laboratory

If properly implemented, electromagnetic shielding can protect aircraft electronics from harmful interference over a wide range of frequencies. The first step is to create a properly written set of specifications in measurable engineering units. If this is done, then the shielding system can be analyzed and measured in the laboratory and on board the aircraft. Using large aircraft as an example, this paper discusses shielding element specifications and the measurement methods that can be used to verify them. Illustrative examples of measured data are presented.

Shielding Effectiveness of a Wire Mesh

Hans A. Wolfsperger, Emscreen GmbH

This paper describes an analytic solution to determine the shielding effectiveness (SE) of an infinite wire mesh. The electromagnetic coupling through the holes is represented by electric and magnetic dipoles, according to Bethe's theory. The dipoles are interacting with each other. They are rearranged in a way that allows calculating the reactive field strength as an infinite sum. Finally, the SE is calculated under consideration of the mesh's conductivity.

Evaluation of the Electromagnetic Penetration of the NASA Space Shuttle Endeavour Using an Ultra-Wideband Measurement System

Robert Johnk, National Institute of Standards and Technology (NIST); Robert Scully, NASA; David Novotny, NIST; Chriss Grosvenor, NIST; Nino Canales, NIST Emeritus; Dennis Camell, NIST; and Galen Koepke, NIST

This paper summarizes a joint NIST-NASA measurement effort to evaluate the electromagnetic penetration of the shuttle Endeavour. NASA is concerned about the effects that microwave imaging radar systems might have on critical avionics systems on its fleet of space shuttles. As part of a multifaceted effort, a portable, NIST-developed, ultra-wideband measurement system was deployed at the Kennedy Space Center to evaluate electromagnetic penetration over the frequency range of 30 MHz to 6 GHz at selected locations inside Endeavour. The measurements were carried out inside a large metal hangar, which exhibited robust reverberant behavior. A combination of reverb chamber techniques and time/frequency signal processing permitted the evaluation of electromagnetic penetration at six different locations inside the orbiter.

Engineering of Absorbing Gaskets Between Metal Plates

Marina Koledintseva; Sandeep Chandra; and James Drewniak, — University of Missouri-Rolla; and James Lenn, General Dynamics Land Systems

Engineering of absorbing material for gaskets that would be used between two metal plates to reduce electromagnetic emissions and improve immunity of electronic equipment is considered. An analytical model of a composite based on the Maxwell Garnett formulation for multiphase mixtures, as well as the shielding effectiveness of this material, are presented. The full-wave numerical computational results for the structure consisting of two overlapping metal plates and an engineered gasket composite material in the place of the overlap are presented.

Protective Properties of a Generic Missile Enclosure to Different Electromagnetic Influences

Sven Fisahn, University of Hannover; Heyno Garbe, University of Hannover; and Frank Sabath, WIS

Electronic components and subsystems of a time critical system (e.g. an aircraft) must be highly unsusceptible to electromagnetic influences. In order to predict the immunity of a generic missile (GENEC) against electromagnetic influences, not only the electronic system but also the enclosure has to be taken into consideration. Assuming a sufficient conductivity of the metallic enclosure, apertures in this enclosure effect a substantial reduction of the shielding effectiveness. The shielding properties of the generic missile could be investigated by means of a metallic hollow cylinder equipped with different apertures. Numerical simulations and measurements of this cylinder will be carried out and analyzed.

Rethinking Shielding Theory

David Larrabee, East Stoudsburg University

The traditional "shielding theory" for the shielding effectiveness of enclosures is examined. It is shown that there can be significant effects which are not included within a simple barrier based theory at high frequencies. It is shown that a 1-dimensional box (using the full Maxwell's equations solution) has 1-D resonances that can significantly affect the accuracy of a barrier based shielding calculation. Treating the enclosure as a resonant cavity with perturbations on the walls is a better approach to the analysis of radiated emissions and radiated susceptibility problems at high frequencies (at and above the first resonance). This has the added advantage of having been worked out quite thoroughly for wave guides and resonant cavities.

CABLES AND TRANSMISSION LINES

On Eliminating Crosstalk in a Multiconductor Telecommunication Cable

Roblot Sandrine; and Zeddam Ahmed, — France Telecom R&D

This paper presents a method of crosstalk reduction in a telecommunication cable composed of multiple conductors. Initially, an electromagnetic and topologic code is implemented to simulate the multi conductor transmission line when injecting the different signals following a particular combination of modes. Then, the far end crosstalk voltage is determined. To picture those results, the crosstalk results obtained by simulation will finally be injected on a real line transmitting VDSL signal. With such a method, it appears that is possible to decrease crosstalk on the line, and consequently to increase the bit rate level and reach of xDSL transmissions. Some studies have already been undertaken to minimize crosstalk. These approaches have been experimented on printed circuits, microstrip, etc. but rarely on telecommunication cables, which require a differential mode transmission of signals and use a frequency band that extends from 12 kHz to 30 MHz.

A Study on Suppression of Crosstalk Between Parallel Transmission Lines in the High Frequency Band

Takashi Kasuga, Nagano National College of Technology; and Hiroshi Inoue, Akita University

As the parallel transmission line is used in the high frequency range, it is necessary to decrease the crosstalk S41 between transmission lines (TLs). This study shows the basic idea of some effective structures which can suppress the S41. When the distance between TLs is significantly varied, the S41 is also varied at the resonance frequency. As the crosstalk S41 are measured and calculated for four

kinds of the multi layer structures, the S41 of the strip and shield structure are found to be -6dB smaller than that of MSL and embedded. To suppress the S41, the strip and shield structure are useful.

SYSTEM LEVEL EMC

Electromagnetic Topology: a Modular Junction Approach for a System Level Interaction Problem

Phumin Kirawanich, University of Missouri-Columbia; Christos Christodoulou, University of New Mexico; Justin Wilson, University of Missouri-Columbia; S. Yakura, U. S. Air Force Research Laboratory; and N. Islam, University of Missouri-Columbia

A new approach to perform electromagnetic topology based simulation is proposed by incorporating a modular scattering junction concept. This method substitutes the multistep computation technique and is convenient to implement. The method also allows for incorporating substructural modifications and does not require repeating solutions to the entire system. The overall simulation utilizes the transmission line matrix compaction, finite-difference time-domain method, and reciprocity theorem to simulate the system interaction. Results are compared with experiments conducted in the laboratory. A good agreement is shown for the simulated and experimental data.

Electromagnetic Coupling Inside Enclosures with Closely Coupled Electric Monopoles and Conducting Planes

Leonardo Sandrolini, University of Bologna; Ugo Reggiani, University of Bologna; David W. P. Thomas, The University of Nottingham; and Christos Christopoulos, The University of Nottingham

The efficiency and reliability of the multiple-mode transmission theory applied to predict the electromagnetic coupling between electric monopoles with conducting planes inside a metallic enclosure is assessed in this paper. The planes are represented with an equivalent impedance through a transmission line analogy. Particularly critical coupling configurations, such as close monopole-to-plane and plane-to-plane configurations are tested. The results obtained with the proposed method are compared to experimental measurements and transmission-line modelling (TLM) numerical simulations. The proposed model is attractive due to its rapidity and good accuracy in predicting the coupling configurations examined.

Design Philosophy for a Satellite with Extremely Low Radiated Emissions Requirements

Gregory Tettemer; William Elkman; and Steven Hungate, — Boeing Satellite Development Center

Trends in RF performance requirements for contemporary spacecraft are driving vehicle design to achieve extremely low RF emissions levels due to unintentional sources. This paper describes an approach to achieving very low spurious RF emissions in spacecraft by identifying, predicting and controlling emissions sources during architecture development. The approach incorporates detailed tailored analysis and test methods used to verify performance compliance. Specific test results are discussed in the context of showing the effectiveness of this design approach in meeting tailored MIL-STD-461E radiated emissions limits.

Reduction of Radiated Emissions from a PLC System by Studying Electrical Unbalance of the PLC Device and T-ISN

Mitsuhiko Kanda, Mitsubishi Electric Corporation; Yoshihiko Konishi, Mitsubishi Electric Corporation; Atsushi Morita, N/A; Masataka Kato, N/A; Shuichi Nitta, N/A; and Naoto Oka, Mitsubishi Electric Corporation

The relation of the common-mode current generated by a PLC, longitudinal conversion loss (LCL) and common-mode impedance (Zcm) of the T-ISN, and electrical unbalance that exists in the PLC device, is investigated in order to use it for the development of a low emission PLC device. It is necessary to decrease the common-mode current to decrease the radiated emission that is generated by the PLC. In this case, LCL and the common-mode impedance of the outlet are examined. For this examination, the relational expression of common-mode current, LCL, and common-mode impedance that is the common-mode current is obtained. First of all, the relation between the common-mode current and LCL and common-mode impedance is shown. Next, the effect of controlling the common-mode current according to the electrical balancing of the PLC device is shown. The effectiveness of improving balancing on the inside of the PLC device is shown.

Simulation of an Indoor Power Cable Network for PLC Applications

Concettina Buccella; Valerio De Santis; and Mauro Feliziani, — University of Laquila

A simulation model is proposed to evaluate the performances of power line communication (PLC) in an indoor environment. The power cable used as the PLC transmission vector is modelled by the multiconductor transmission line (MTL) theory and the MTL electrical parameters are obtained by the finite element method (FEM) analysis of the cable cross-section. The MTL network configuration is analysed by a CAD circuit simulator. Particular attention is focused on the characterization of junctions. Comparisons of calculated results with measurements are presented in the frequency range 1 to 30 MHz for different configurations of the power cable network.

POWER LINES AND POWER LINE FILTERS

Extending Winding Capacitance Cancellation to Three-Phase Power Filter Networks

Marcelo Heldwein; and Johann Kolar, — Swiss Federal Institute of Technology (ETH) Zurich

Techniques have been presented in the literature for canceling stray capacitances for inductors in single-phase power filters. With the same aim, the alternatives provided by three-phase systems are explored here. A thorough theoretical analysis is presented, where pros and cons of parasitic capacitance cancellation networks are highlighted and improvements are proposed. A systematic mathematical procedure to evaluate impedances for different noise modes in three-phase circuits is presented. The influence of parasitic effects is accessed and asymmetrical capacitance cancellation is proposed, facilitating applications in switched power circuits. Experimental results are presented and shall be extended for the final version of this work.

Analysis and Design of an EMI Filter for Induction Motor Drives Using the Butterworth Function

Vuttipon Tarateeraseth, Srinakharinwirot University; Werachet Khan-ngern, King Mongkut's Institute of Technology Ladkrabang, Thailand; Chanthea Khun, King Mongkut's Institute of Technology Ladkrabang, Thailand; and Masaaki Kando, Tokai University

This paper deals with a passive EMI filter designed for induction motor drives to mitigate the common mode (CM) and differential mode (DM) noise confirmed by the EN 55022 Class B. The proposed design procedure of the EMI filter uses an approximation function based on a high order Butterworth function to achieve not only the complied conducted noise but also the transfer function of filters. This procedure is also based on the knowledge of the base-line of the CM and DM noise. The measuring current probe is only used to separate the total conducted EMI into CM and DM components without

using a noise separator. A design example is carried out experimentally on the implemented filter according to EN 55022 Class B to verify the validity of the design procedure.

SPECIAL SESSION: AUTOMOTIVE EMC DESIGN AND MODELING

Circuit Board Layout for Automotive Electronics

Todd Hubing, Clemson University

EMC and environmental requirements placed on automotive electronics present unique board layout challenges. This paper discusses component placement and trace routing strategies for circuit boards that will be used in automotive applications.

Modeling Coax Cable EMI Shielding Performance for Automotive AM Broadcast Band Applications

Richard Wiese, General Motors

Automotive broadcast reception systems typically use common coax cable to convey RF energy from the antenna to the broadcast receiver. In special cases a modified low capacitance coax is used for cross vehicle runs to enhance performance in the AM band. Coax is specified by characteristic impedance, optical coverage, DC resistance per unit length, and RF loss versus frequency per unit length. Optical coverage and DC resistance serve to provide a gauge for relative shielding performance to EMI. EMI currents on the shield translate to an impressed voltage at the receiver via the transfer impedance of the coax. This paper examines the near-field magnetic shielding effectiveness of coax and the relationship to standard methods for shielding effectiveness. A 2-D quasi-static solver application is used for the analysis.

Validation of Worst-Case and Statistical Models for an Automotive EMC Expert System

Daryl Beetner, University of Missouri-Rolla; Haixiao Weng, Texas Instruments; Todd Hubing, Clemson University; and Meilin Wu, University of Missouri-Rolla

An EMC expert system has been developed to predict potential electromagnetic compatibility problems in a vehicle early in the design process. Here, the accuracy of inductive and capacitive coupling algorithms are verified through representative measurements of crosstalk within an automobile. Worst-case estimates used by the algorithms are compared to measured values and are compared to values estimated using statistical methods. While an approximate statistical approach is feasible even for sophisticated designs, worst-case estimates better ensure that problems will not be missed even in the absence of complete system information.

Impact of Intra-Vehicular Electromagnetic Interference on Tire Pressure Monitoring Systems

Vikas Kukshya, HRL Laboratories; Hyok Song, N/A; Hui P. Hsu, N/A; and Richard Wiese, General Motors

The next generation of vehicles will use a wide range of electronic sensors and systems to monitor and regulate various vehicular performance and safety functions. However, before such systems can be formally introduced in the vehicles, it is crucial that the potential impact of vehicular electromagnetic interference on these systems be evaluated thoroughly. In this paper, we use an end-to-end system simulator to quantify the impact of various levels and types of electromagnetic interference in a typical vehicular environment on the performance of a direct measurement Tire Pressure Monitoring System.

International Electrotechnical Commission Documents CISPR 12 and CISPR 25: An Overview

Poul Andersen, Consultant

This document presents an overview of CISPR 12 and CISPR 25 and discusses some of the changes being made in the new edition of each document currently in the balloting process.

Vehicle EMI Integration Issues Identified by Precompliance Test Methods

Scott Mee; Sreeniwas Ranganathan; Craig Harder; and Steve Mainville, — Johnson Controls Inc.

Automotive electronics systems are becoming increasingly complex each year. At the same time, interior styling and exterior body trends are causing these sophisticated electronics to be packaged in smaller spaces. As a result, vehicle integration testing has been a focus area for Original Equipment Manufacturers (OEMs) to ensure there is adequate evaluation of such systems prior to mass production. Vehicle level integration testing requires time and extensive resources to perform. The need for performing additional vehicle testing and correcting integration issues can be avoided by performing early precompliance testing. This paper discusses five unique precompliance test methods that correlate to the vehicle that identify EMC issues.

Evaluating Cell Phone and Personal Communications Equipment and Their EMC Effects on Automotive Audio and In-Cabin Components

Craig Fanning, Elite Electronic Engineering Inc

The purpose of this R&D project was to evaluate current and future personal communications technologies and their potential effect on vehicle components. Along with the increase in cell phone use in automobiles, the newer and smaller cell phones can be placed virtually anywhere within the cabin of the vehicle. As a result, cell phones now are being placed in unforeseen locations and often in close proximity to various electronic components, giving rise to potential interference and compatibility issues. This study focused on the frequency range of 800 MHz to 2.5 GHz. The analysis generated a summary of the frequency spectrums, modulations and output power levels used by these technologies. Following completion of the technology evaluation, various types of radiated immunity tests were performed on automotive component samples provided by a variety of manufacturers. The samples had known compatibility issues with cell phones when installed in the vehicle. The testing was performed to determine what type of test, test levels, and carrier signal modulations, could be used during component level evaluation in order to identify these potential compatibility issues before they reach the vehicle.

AUTOMOTIVE EMC MEASUREMENTS

Vehicle Active Antennas Face EMC and RF Reception Challenges

Jean-Roger K. Kuvedu-Libla, N/A

Presently, the vehicle active antennas are facing two big challenges. One of them is to meet the requirements of radio frequency (RF) reception and the next one is to respond to electromagnetic compatibility (EMC) demands at the same time. For that, the questions this paper answers are: 1) incorrect consideration / definition of these antennas; 2) influencing parts of the passive antenna structures, for example the ground influence; and 3) the specification of necessary amplifier noise floors and gains.

Automotive EMC: Key Concepts for Immunity Testing

Heri Rakouth, Delphi Steering Systems; Clane Cammin, Delphi Corporation; and Luke Comstock, Delphi Corporation

This paper is aimed at providing the rationales that gave birth to unique test methods used for both radiated and conducted immunity testing. This paper singles out three concepts: 1) the Constant Peak Amplitude method applied to AM testing, 2) the 4-probe averaging calibration method for the Vehicle Radiated Immunity (VRI) test, and 3) the variable injection probe location for Bulk Current Injection (BCI) measurements. Derived benefits are harmonic reduction for AM testing, over and under testing avoidance in BCI, and VRI. They are part of the ISO-11451, ISO-11452, and SAE J1113 standards since their publications in the 1990's.

Development and Evaluation of a Realtime Time-Domain EMI Measurement System for Automotive Testing

Stephan Braun, Institute for High Frequency Engineering; Martin Aidam, Daimler Chrysler AG; and Peter Russer, Institute for High Frequency Engineering

Time-Domain EMI measurement systems allow the measurement time to be reduced by several orders of magnitude. In this paper a real time time-domain EMI measurement system for automotive testing is presented. Automotive tests require smaller frequency bins and a smaller IF-Bandwidth. In the frequency domain, such measurements take an extremely long time, and sometimes they exceed the life-time of a component. A novel, real-time, time-domain EMI measurement system is presented that reduces the time for automotive measurements by a factor of 8000. By a numerical oscillator in the signal processing unit, the picket fence effect is reduced. Measurements have been performed on components and on a complete vehicle in the frequency range 30 MHz to 1 GHz. The real-time time-domain EMI measurement system has been evaluated and assessed in an automotive test environment.

Improving Automotive Radiated Emissions Repeatability When Using Optic Link Bus Converters

Ferran Silva; and Marc Aragon, — Technical University of Catalonia

This paper analyzes the effect of using an optic link bus converter in EMC tests. Although the optic link is used to avoid an additional conductive connection to the EUT, the interface could disturb the electromagnetic behavior of the EUT bus section. After showing several situations where the repeatability is compromised in automotive EMC tests, the paper analyzes the problem with several measurements and proposes a model to evaluate the effect. A proper position on a commercial optic bus link converter is discussed.

AUTOMOTIVE EMC MODELING

Transient Electromagnetic Field Computation in Automotive Environments using FDTD

Pere Riu; Ricardo Jauregui; Ferran Silva; and Mireya Fernandez, — Universitat Politecnica Catalunya

Numerical electromagnetic computation at high frequencies in automotive environments is a challenging problem because of the dimensions of the problem compared to the wavelength. Results obtained so far have been presented in the frequency domain. We are presenting comparisons between calculated and measured transient waveforms, in the time domain, by using a model of a realistic car body frame. Results are presented for different settings of grid parameters in the simulation. The agreement of the signals in time and also in the frequency domain allows us to conclude that such computations are feasible up to the GHz frequency band and using modest computation resources.

EMI Modeling in an Automotive Data Communication Structure

Frank Li, Youngstown State University; Tamer Taher, Youngstown State University; Jalal Jalali, Youngstown State University; Fred Esenwein, Delphi Packard; Nick Lockard, Youngstown State University; and Andrew Ptichkin, Youngstown State University

Data links are facing more internal and external electromagnetic noises due to high speed data communications in the automobile industry. A mathematical model is presented to predicate the EMI in automotive data link circuitries. This model is a useful mechanism that facilitates the future automotive cable designs in EMI reductions. Experimental results indicate that the model accurately predicts crosstalk-couplings of three, 1.7 meter, standard unshielded, multi-conductor cables up to 80 MHz where the signal wavelength is at least two times longer than the cable length. All experimental data are collected inside a fully enclosed NoiseKen tent. The tent is a shielded environment that minimizes background noises.

Electromagnetic Conductive Interference Characteristics in the Driving System of a Fuel Cell Bus

Jinliang He; Bo Zhang; Shaofeng Yu; Wei Li; Shuiming Chen; and Yong Huang, — Tsinghua University; Jae-bok Lee; and Sug-hun Chang, — Korea Electrotechnology Research Institute

Based on the multiconductor transmission line model, this paper analyzed the electromagnetic conductive interference in the driving system of a fuel cell bus by calculation. Firstly, the propagation characteristics of the conductive interference in the cable were analyzed. Then, the common mode current and its coupling effect were investigated. Finally, the coupling between the driving system and the low voltage system was researched. The results will be useful for restricting the electromagnetic conductive interference in the fuel cell bus.

A Statistical Model of Noises at the Input Port of an Inverter and its Coupling to a Low Voltage Cable on a Fuel Cell Bus

Wei Li; Shaofeng Yu; Bo Zhang; Jinliang He; Yong Huang; Shuiming Chen; and Rong Zeng, — Tsinghua University

The hybrid electric Bus has some serious EMC problems. A normal distribution is proved suitable to describe the noise fluctuation on the input port of an inverter. Typical noise patterns are summarized with seven key parameters. Then crosstalk between the power cables and nearby signal cables is analyzed with an injection of these typical noises. Time parameters of noises are observed that can influence the crosstalk significantly. It is concluded that an update should be made in the present standards for the conducted emission limitation on vehicles due to their neglect of the time parameters of noise sources.

HIGH-VOLTAGE EMC

Corona Onset Voltage at High Frequency for an Isolated, Cylindrical Electrode

William Price, The Boeing Company; John Drapala, The Boeing Company; David Thiel, Griffith University; and Robert Olsen, Washington State University

Corona on antennas or transmission lines is a significant source of electromagnetic interference on aircraft. A corona onset criterion, which describes breakdown in nonuniform RF fields, is derived from the Boltzmann transport equation. Predictions of corona onset are

made using recent formulae for net ionization. Measurements of 300 MHz corona onset for an isolated, cylindrical electrode were made and are compared with predictions. The results confirm that the derived breakdown criterion is a good predictor of RF corona onset at 300 MHz for cylindrical geometries where diffusion is the dominant electron loss mechanism in the range 0.1 < 10 rp <10 cm-torr.

Simulation and Time-Frequency Domain Analysis of a Microburst Caused by a Disconnect Switch Operation in an AIS

Jin-Song Tao, Wuhan University; and Zhongdong Wang, The University Of Manchester

Disconnect switch operation in an air-insulated substation (AIS) presents itself as a source of electromagnetic interference to the substation secondary control circuit. To analyze the time and frequency characteristics of these interference signals, i.e. the transient microburst, the electromagnetic transient program (EMTP) has been used to simulate the disconnect switch operation. A time-frequency analysis of the simulation results reveals that the time of operation influences the peak amplitude of interference while the frequency characteristics are determined by the configuration of the substation and to which the overhead line is connected. It is therefore concluded that using the time-frequency analysis, the frequency band of microburst can be predicted before operation and the EMI coupled to secondary circuits can be filtered.

HPM Testing and Transmission Measurements on Optical Sensors

Patrik Svensen, Saab Bofors Dynamics

This paper is a summary of a study made with regards to optical sensors in a High Power Microwave (HPM) environment. This study included coupling measurements through different optics, high power testing of built-in shielded optical sensors, and susceptibility testing of unshielded optical sensors with electromagnetic radiation for microwave frequencies. The purpose of this study is to determine if it is possible to make coupling measurements and susceptibility testing on the unshielded sensor, and from these two measurements estimate the HPM susceptibility of a shielded sensor, where the optical aperture is the only transmission path for radiated microwaves. The study also addresses conclusions about the coupling path and the HPM threat on optical sensors.

A Comparative Study of Electrode Geometry Affects on Corona Onset and Schottky Diode Breakdowns

Frank Li, Youngstown State University; Mark Barlow, N/A; Tom Oder, Youngstown State University; and Salvatore Pansino, Youngstown State University

A variety of methods were used to strengthen the electrically stressed regions of the Schottky diode contacts in order to prevent EMI due to electron avalanche breakdowns and ESD damages. This paper will present how the planar and spherical geometry of the Schottky contact will affect the high voltage performance of the devices. Different electrode geometries are tested with the voltage up to 18 kV, and corona discharges are photographed. Both experimental data and finite element analysis indicate that spherical geometry has the best performance for breakdowns. Sub micrometer wire and geometries that degrade performance are also tested and simulated.

Influence of the Exhaust Plume on the Lightning Induced Voltages and Currents on a Launch Vehicle

Sisir Nayak; and M. Thomas, — Indian Institute of Science

In this paper, an attempt has been made to study the time-domain characteristics of the induced voltage and current on a launch vehicle when an electromagnetic wave generated by a nearby lightning discharge is incident on it. The paper also reports the influence of the exhaust plume on the induced voltages and currents. For the computation, the finite-difference time-domain (FDTD) technique has been used. The distributed electrical parameters in each section of the launch vehicle and its exhaust plume along its axis are computed by using the Method of Moments (MoM).

TRANSIENT IMMUNITY

Evaluation of Falling Time Restriction of ESD Immunity Test Current Waveform

Masayuki Hirata, Fuji Xerox; Takehiro Takahashi; and Noboru Schibuya, —Takushoku University

This paper describes the results of the round robin test for the IEC 61000-4-2 ESD immunity test which was held in Japan. In order to reduce the variation of the test results of the ESD test depending on the ESD generator, an additional restriction for the ESD current waveform was proposed and considered in IEC SC77B/MT12. The effect of the restriction was evaluated by the round robin test in three countries; Japan, U.S.A., and Germany. The test results show that the restriction is effective in reducing the variation, however, an even more severe restriction is needed to reduce the dependency on the ESD generator.

The Effects of ESD in Multiple Testing Environments on Adhesive-Label RFID Tags

Cherish Bauer-Reich, North Dakota State University

The purpose of this study was to determine the ESD susceptibility of commercially available label-enclosed RFID tags. Six different types of adhesive labels with RFID transponders were subjected to ESD in different testing environments. Initial data shows that most of the tags were sufficiently protected from fairly large discharges by their covering material. However, the level of damage suffered depended on tag type and testing environment.

Experimental Investigation of the ESD Sensitivity of an 8-Bit Microcontroller

Lijun Han; Jayong Koo; David Pommerenke; and Beetner Daryl, University of Missouri-Rolla; and Ross Carlton, Freescale Corporation

In this paper, the susceptibility of an 8-bit microcontroller to electrostatic discharge (ESD) and electrically fast transients were tested by injecting currents through a capacitive probe into the microcontroller package pins. The reaction of the microcontroller to tests with different rise times and polarities were investigated by measuring the voltage on the tested pins and by observing the microcontroller's clock output. Susceptibility varied significantly from one pin to another. Interestingly, the clock was more sensitive to currents injected into I/O pins than into pins directly related to the clock (e.g. EXTAL). Further work is underway to explain the causes of susceptibility inside the IC.

Interference in Shielded Foil Twisted Pair (SFTP) Cables Due to ESD

Francescaromana Maradei, University of Rome "La Sapienza"; and Spartaco Caniggia, EMC Consultant, Italy

Interference produced by ESD events in shielded foil twisted pairs (SFTPs) is investigated. The typical installation setup of SFTP cables connecting the differential driver and the receiver RS422 both placed in shielded enclosures is considered. Experimental results of common and differential

mode interference obtained adopting different discharge points and different grounding configurations are presented. The influence of positive and negative discharges on the measured interference is verified.

Susceptibility of Electronic Devices to Variable Transient Spectra

Sven Korte; and Heyno Garbe, — University of Hannover

The subject of this paper is to investigate the susceptibility of microcontrollers to single transient signals. It is shown that the principle coupling of transient field pulses into electronic systems is limited in bandwidth. In order to investigate the different resulting pulseforms and to estimate the effect on the susceptibility of the electronic devices, a setup is presented that gives the opportunity to emulate the field coupling in systems with different coupling sizes. The degeneration of the disturbing signals by the input impedance of the chip is given attention as well as on the susceptibility of the chip itself.

Methodology for the HEMP Clearance of a Modern Air Fighter

Frank Sabath, WIS; Anthony Wraight, QinetiQ; Alfred Brenner, EADS; and Chris Jones, BAE Systems

In this paper, we will discuss the route to High-altitude Electromagnetic Pulse (HEMP) qualification of a modern fighter aircraft. We will describe the clearance process of the Eurofighter Typhoon program and discuss particular aspects due to technical considerations and in regard to cost efficiency. The systematic structure of the HEMP clearance process and the overall clearance philosophy will be presented. In order to get relevant information as early as possible the chosen clearance process is based on three essential measurement steps (equipment level qualification, coupling measurements, and system level test) that are linked together by a prediction algorithm for induced currents and data analysis. The final assessment process employs a set of response norms to compare the aircraft response with the results of equipment level qualification testing.

Systematic Description of the Protection Capability of Protection Elements

Roland Krzikalla, Hamburg University of Technology; Frank Sabath, WIS; and Jan ter Haseborg, Hamburg University of Technology

Higher demands on the safety and stability of electronic systems require the further development of protection concepts against electromagnetic interferences. Especially, interferences with an extremely broad frequency bandwidth combined with very high voltage amplitudes are a serious threat against sensitive electronic systems. Due to the very high frequency parts of the interference, the behavior of the nonlinear protection circuits that are used depends more and more on parasitic linear components. Therefore it is of special interest to know in which circumstances a system can be declared as protected against electromagnetic interferences. For that, a definition of the term “is protected” has to be discussed due to a definition of different success levels. These success levels are correlated with effects that can occur in the system which can also be classified. Together with a description of the prediction of effect threshold levels in complex systems, this paper describes a method for determining the protection capability of possible protection elements.

SPECTRUM MANAGEMENT

Wireless Mobile Communication Systems with High Frequency Efficiency — Without Pilot Signals

Michael Bank, HIT; Jakob Gavan, HIT; and Miriam Bank, N/A

Multipath propagation has always been a considerable technical challenge in radio communication systems with a mobile transmitter or mobile receiver. One of possible options to overcome the corresponding difficulties is the OFDMA method of data transmission. It provides rather good performance for the point-to-multipoint transmission in systems without considerable Doppler frequency offset. However, increasing of the used frequency band and permanent growing of the traffic make Doppler shift influence more and more a critical point in radio modem designs. Here a principally new method of multiple access — so called Frequency Bank Signal (FBS) — is proposed. FBS combines the phase shift compensation used in the PAL-TV system, OFDMA principle, and spread spectrum idea with Walsh functions.

Ultra Wideband EMI To Legacy Receivers

William Duff, SEMTAS

The application of FBL technologies to industrial controls is a logical step in the war on terrorism. Petroleum plants, chemical plants, mines and other automated industrial controls are susceptible to electromagnetic interference, electromagnetic intrusion, and electromagnetic pulse (EMP) weapons. Control of industrial elements such as valves and pumps cannot be hijacked or impeded by terrorists with electromagnetic weapons from outside of the facility if the industrial elements are controlled via optically switched actuators and passive optical sensors on inherently EMI immune fiber-optic networks.

Interference Characterization and Mitigation of 5.5 Mbps CCK Wi-Fi Signals

Ayham Z. Al-Banna; Xiaoguang Zhou; Tae Ri Lee; Joseph L. LoCicero; and Donald R. Ucci, — ECE Department, Illinois Institute of Technology

An exact Power Spectral Density (PSD) expression is derived for IEEE 802.11b 5.5 Mbps signals using Complementary Code Keying (CCK). The analytical result obtained is verified through computer simulation. The spectral signature of the 5.5 Mbps CCK – modulated signal is compared to the PSD of the Barker-spread Wi-Fi signals. The adjacent channel interference power resulting from the 5.5 Mbps CCK interferer is introduced and compared to that caused by Barker-spread signals. Adaptive antennas with tapped delay lines are used to mitigate the effect of these interference signals. Optimal ranges of the tapped delay lines are found such that performance is restored at minimum cost.

SPECIAL SESSION: WAVEFORM DIVERSITY

Why and What is Waveform Diversity, and How Does it Affect Electromagnetics?

John Garnham; and Jaime Roman, — SAIC

This paper provides a general overview of the new research area called waveform diversity (WD), and it’s potential impact to the EMC community. The scope of research that is considered WD is broad in both technical content and application. The two main application areas are radar and communications across the RF spectrum. As WD begins to transition from theory, to hardware experiments, to testing, and to operational systems, the effect on RF design and EMC analysis may be significant. This paper describes the broad area of WD, why people are researching it, and potential effects on EMC. A system can perform better in a multi-path fading environment than a conventional (single-channel) communication system without any multi-path fading.

Waveform Diversity and Electromagnetic Compatibility

Gerard Capraro, Capraro Technologies, Inc.; Ivan Bradaric, Capraro Technologies, Inc.; and Michael Wicks, U. S. Air Force Research Lab

Waveform diversity in multistatic radar systems can enhance distributed radar system performance. Dynamically changing the electromagnetic emanations of radar and communications systems, however, poses an electromagnetic compatibility (EMC) challenge. Data are provided illustrating how waveform diversity improves multistatic radar system performance. An approach for maintaining EMC in a dynamically changing environment is also provided.

Detection/Imaging of Buried Objects: Using Spatial/Angular Diversity with Distributed/Embedded Sub-Surface Sensors for Reduced Mutual Coupling and Suppressed EM Emissions

John Norgard, U. S. Air Force Research Lab/SNRT; Kevin Magde, U. S. Air Force Research Lab/Sensors Directorate; Michael Wicks, U. S. Air Force Research Lab/Sensors Directorate; Andrew Drozd, ANDRO Computational Solutions, LLC; and Randall Musselman, U. S. Air Force Academy

The proliferation of strategic subsurface sanctuaries has increased the need for enhanced remote sensing techniques providing for the accurate detection and identification of deeply buried objects. A new RF Tomographic Technique is proposed in this concept paper for developing RF CAT Scans of buried objects using spectral, spatial/angular, and polarization diversity. This imaging technique uses an embedded ring of subsurface radiators, delivered by earth-penetrating, non-explosive, electronic "e-bombs", as the source of strong underground radiated transmissions and uses distributed surface-contact sensors to collect the tomographic data for relay to a circling UAV and transmission to a remote control site (using layered sensing). Three-dimensional imaging algorithms are being developed to detect, image, and characterize deeply buried targets. Distributed transmitters and receivers significantly increase unwanted mutual coupling and EM emissions that interfere with signal reception. However, by embedding the transmitters underground, reduced mutual coupling and EM emissions (and improved signal-to-noise ratios) can be achieved. Simple surface SAR experiments over deep mine shafts have been performed to validate the 3D processing algorithms using 2D surface SAR sensor data. WIPL-D models have also been used to simulate the embedded and distributed sensors and to verify the significant enhancement in the received signal-to-noise ratio obtained by burying the radiating ring under the surface sensors.

Electromagentic Diversity and EMI Implications for Multiple Co-Sited Radars and Targeting Applications

Andrew Drozd, ANDRO Computational Solutions, LLC; Irina Kasperovich, ANDRO Computational Solutions, LLC; Ruixin Niu, Syracuse University; and Pramod Varshney, Syracuse University

Real-time fusion of data collected from a variety of co-located radars that acquire information in a cooperative manner from multiple perspectives and/or different frequencies, is being shown to provide a more accurate and effective way of tracking complex targets in a multi-target scenario. This is more advantageous than employing a single radar or a group of radars operating independently. This paper describes a cooperative multi-sensor approach in which multiple radars operate together in a non-interference limited manner. A three-fold approach is presented: (i) applying multiobjective joint optimization algorithms to set limits on the operational parameters of the radars to preclude electromagnetic interference; (ii) measuring and processing radar returns in a shared manner for target feature extraction based on electromagnetic diversity principles in conjunction with target scattering cross sections; and (iii) employing feature-aided track/fusion algorithms to detect, discriminate, and follow real targets from clutter noise. The results of computer simulations are provided that demonstrate the advantages of this approach.

The True Meaning of Electromagnetic Diversity Seen Through the First Principles of Fundamental Physics

Tapan K. Sarkar, Department of Electrical Engineering and Computer Science, Syracuse University

The word Diversity in the dictionary implies variety in form. And the basic concept derived from these principles is that if one has multiple copies of the same system, presumably one would have a better chance of achieving the desired goals. The fundamental problem with this simplistic way of reasoning is that one needs to understand the physical environment where such an experiment needs to be carried out and how one should interpret the final result. The current state of the art applies some statistical framework to the physical scene to explain the added advantage of diversity. To appreciate the true physical significance of diversity we have to go back to the roots! We need to understand first, what the statistical framework implies and secondly, how it relates to the problem at hand.

Distributed and Layered Sensing: Relevant EMC Issues

Michael Wicks; and William Moore, — U. S. Air Force Research Lab/Sensors Directorate

One can easily envision future military operations and emerging civilian requirements (e.g. intelligent unmanned vehicles for urban warfare, and intelligent manufacturing plants) that will be both complex and stressing and will demand innovative sensors and sensor configurations. The goal of our research into Distributed and Layered Sensing is to develop a cost effective and extendable approach for providing surveillance for a variety of applications in dynamically changing military and civilian environments. Within Distributed and Layered sensing, we foresee a new sensor archetype. In this paradigm, sensors and algorithms will be autonomously altered depending on the environment. Radars will use the same returns to perform detection and discrimination, to adjust the platform flight path, and change mission priorities. The sensors will dynamically and automatically change waveform parameters to accomplish these goals. Disparate sensors will communicate and share data and instructions in real-time. Intelligent sensor systems will operate within and between sensor platforms such that the integration of multiple sensor data provides information needed to achieve dynamic goals and avoid electromagnetic fratricide. Intelligent sensor platforms working in partnership will increase information flow, minimize ambiguities, and dynamically change multiple sensors' operations based upon a changing environment. Concomitant with the current emphasis on more flexible defense structures, Distributed and Layered sensing will allow the appropriate incremental application of remote sensing assets by matching resources to the situation at hand.

Effect of In-Band Intermodulation Interference on Direct-Sequence Spread Spectrum (DSSS) Communication Systems for Electromagnetically Diverse Applications

Ilteris Demirkiran, Embry-Riddle Aeronautical University; Donald Weiner, Syracuse University; and Andrew Drozd, ANDRO Computational Solutions, LLC

The goal of this paper is to analyze the effect of nonlinearities on the performance of direct-sequence spread spectrum systems in the context of electromagnetically diverse applications. Inter-modulation products due to nonlinear amplification are analyzed and the effect of nonlinearities is illustrated by means of a computer simulation result. For the performance measure, bit-error rate (BER) is considered to assess the effect of in-band intermodulation interference. The findings of this study will be of benefit to the waveform diversity community. This community is concerned with assessing the effects of

multiple RF sensor and communication systems used for enhancing cooperative target tracking and engagement. This involves multiple radars and communication systems that process acquired information in real time. The optimum performance, operation, and availability of these systems are assured through the application of adaptive spread spectrum waveforms and electromagnetic diversity schemes derived for the RF communications problem.

Polarization Diversity for Detecting Targets in Heavy Inhomogeneous Clutter

Martin Hurtado; and Arye Nehorai, — Department of Electrical and Systems Engineering, Washington University in St. Louis

Polarization diversity has proved to be a useful tool for radar detection, especially when discrimination by Doppler Effect is not possible. In this paper, we address the problem of improving the performance of polarimetric detectors for targets in heavy inhomogeneous clutter. First, we develop a polarimetric detection test that is robust to inhomogeneous clutter. We run this polarimetric test against synthetic and real data to assess its performance in comparison with existing polarimetric detectors. Then, we propose a polarimetric waveform-design algorithm to further improve the target-detection performance. A numerical analysis is presented to demonstrate the potential performance improvement that can be achieved with this algorithm.

EM MATERIALS

Method of Measuring Permittivity of Composite Materials with Hexagonal Ferrite Inclusions

Alexander Kitaitsev, Moscow Power Engineering Institute (Technical University); Gylnara Zhumabaeva, Moscow Power Engineering Institute (Technical University); and Marina Koledintseva, University of Missouri-Rolla

An electromagnetic shielding of objects using ferrite-graphite composites is considered. An analytical model using the Maxwell Garnett formulation for multiphase mixtures was made, and the results of computations based on this model and plane-wave formulation, and also some experimental results, are represented.

Effective Properties of Carbon Fiber Composites: EM Modeling Versus Experimental Testing

Igor De Rosa; Fabrizio Sarasini; and Maria Sabrina Sarto, — University of Rome "La Sapienza"

This paper discusses the critical issues related to the practical application of the Maxwell-Garnett approach to the electromagnetic modeling of the effective electric permittivity of diluted carbon fiber reinforced composites. In fact, recent studies have highlighted the interest in the use of such composites as a lossy sheet in broad-band dielectric absorbing screen in the gigahertz range. The a.c. electrical conductivity of the carbon fibers embedded in epoxy resin is determined from the best-fit between the data obtained from the experimental tests and the ones obtained from the electromagnetic modeling. Two different manufacturing processes of the test samples are investigated: pouring and dipping. Results show that, in the frequency range from 9 GHz to 12 GHz, carbon fibers having a length of a few millimeters embedded in epoxy resin are characterized by a constant value of the a.c. electrical conductivity only in the case of the sample preparation by pouring.

Shielding Effectiveness of a Metamaterial Slab

Giampiero Lovat; and Paolo Burghignoli, — University of Rome "La Sapienza"

A study of the shielding properties of a metamaterial slab is presented. The metamaterial nature of the slab arises from the negative values of its effective scalar dielectric permittivity in the considered low frequency region of operation. Such an effective permittivity is the result of a homogenization process of an actual periodic structure which consists of a finite number of periodic layers of thin conducting cylinders embedded in a dielectric matrix, screening an E-polarized plane wave. When the incident plane wave is arbitrarily polarized, a more sophisticated model for the effective permittivity has to be employed which takes into account anisotropy and spatial dispersion. Comparisons with conventional planar metal screens show that the proposed structure can be designed to be advantageous in terms of low density and weight savings.

Development of Lightweight Solid Phantom Composed of Silicone Rubber and Carbon Nanotubes

Takashi Hikage; Toshio Nojima; and Yuki Sakaguchi, — Hokkaido University; and Yuji Koyamashita, Fine Rubber Laboratories Co., Ltd.

A lightweight human phantom material that has a specific gravity below 1.0 is newly developed and a full sized realistic shaped human phantom model is constructed using this material. Fundamental material composites are carbon nanotubes and silicone rubber. The carbon nanotubes enable this material to simulate various biological tissues with less specific gravity values than those of original ones. In addition, using the silicone rubber allows us to construct phantom models of various shapes. This paper describes the design principle and estimates the relation between complex permittivity and composition ratio of the material experimentally. Finally, a full sized realistically shaped human phantom model is constructed to show the features of the proposed material.

Broad Band Electromagnetic Absorption of Flexible Foils in the High Frequency Range

Peter Goernert; Petra Payer; Oleksiy Surzhenko; and Lothar Michalowsky, — Innovent e.V.; Hanspeter Heegn; and Ernst Madai, — UVR-FIA

Foils filled with conductive and magnetic materials are developed for absorption of microwaves. The foils have a thickness of 0.5 to 1.5 mm and a basic composition of 25 wt.% polyethylene, 9 wt.% carbon, and 66 wt.% inorganic filler of a very different nature. The absorbed power is determined from measurements of reflexion and transmission with a closed coaxial measuring technique in the frequency range of 40 MHz to 1 GHz. Transmission measurements are carried out from 700 MHz to 18 GHz and 50 to 75 GHz. Foils with thicknesses of about 1 mm absorb more than 30% of the incident power.

Resonance Suppression in Enclosures with a Metallic-Lossy Dielectric Layer by Means of Genetic Algorithms

Antonio Lozano, Universidad Politécnica de Cartagena; Alejandro Diaz-Morcillo, UPCT; and Juan Balbastre-Tejedor, UPV

Conductive plastics have become an alternative to traditional metallic cabinets for shielding boxes from electromagnetic interferences. These materials allow a wide range of conductivities that can satisfy any particular design. A design with an outer metallic layer and an inner layer of conductive dielectric can obtain advantages from both materials. In this paper the damping of resonances in enclosures with an aperture through conductive dielectrics is evaluated by means of Genetic Algorithms with the aid of a three dimensional simulation tool. Genetic Algorithms are a general purpose optimization technique widely used in the last years for electromagnetic design. The relationship between obtained solutions and skin depth parameter is shown to help in design procedures.

ELECTROMAGNETIC BANDGAP STRUCTURES

Miniaturization of Electromagnetic Bandgap (EBG) Structures with High-Permeability Magnetic Metal Film

Yoshitaka Toyota; Kengo Iokibe; and Ryuji Koga, — Okayama University;

Arif Ege Engin; Tae Hong Kim; and Madhavan Swaminathan, — Georgia Institute of Technology

Electromagnetic bandgap (EBG) structures in a parallel plane pair are quite effective for suppressing simultaneous switching noise, but their size is large to apply to compact electronic devices. The authors have so far investigated the miniaturization of EBG structures by two approaches: 1) two narrow slits on each patch; and 2) use of a high-K material for a thin dielectric layer. In this paper, furthermore, a third approach was investigated: the insertion of a high-permeability magnetic metal sheet between the parallel plane pair. As a result, the miniaturization of 10 % was achieved by performing these three approaches simultaneously.

EMI Suppression in Microprocessor Packages Using Miniaturized Electromagnetic Bandgap Structures with High-k Dielectrics

Baharak Mohajer Iravani, University of Maryland; and Omar Ramahi, University of Waterloo

A novel miniaturized planar electromagnetic bandgap (EBG) structure is proposed for microprocessor packages. The design of the proposed EBG structure consisting of meander lines and patches are based on the use of high-k dielectric material with a relative permeability greater than or equal to 100. High-k dielectric material increases the effective capacitance of the EBG cell in comparison to commonly used materials with a much lower dielectric constant. Simulation results are provided to show that using the proposed EBGs with periodicities less than 2 mm; it is possible to obtain a very wide stop band (~10 GHz) in addition to more than 10 times in unit cell size reduction. This wide bandgap can cover the operating frequency of current processors and a wide range of the resonant frequencies of a typical package.

Simplified Computation of Electromagnetic Band-Gap Properties of Via-Holed Metal Patches

Jens Bornemann, University of Victoria; Karumudi Rambabu, N/A; and Marjan Mokhtaari, University of Victoria

An extended analytical method for the analysis and design of electromagnetic band-gap (EBG) structures formed by via-holed metal patches is presented. Contrary to a known approach, this technique correctly predicts the first stopband, which is often utilized in printed antenna applications and, therefore, significantly extends the frequency range of application. The approach is verified by comparison with results of commercially available software.

Noise Suppression in High Speed Digital Circuits by Means of a Novel EBG Structure with Triangle Patches and Hexagonal Arrays

Antonio Ciccomancini, CST of America

The aim of this paper is to describe the simultaneous switching noise (SSN) mitigation by means of a novel electromagnetic band gap (EBG) structure with triangle patches and hexagonal arrays. The proposed EBG achieves -40 dB of stop band in the range 6.5 to 9 GHz. Parametric studies including the radius effect of the metal plated vias and the substrate thickness are performed by means of full wave simulations. The impact of the proposed design on the signal integrity is also investigated both in time (eye-diagrams and TDR) and frequency domain (S-parameters). Finally, dispersion diagram and mode pattern distribution of the singular unit EBG cell are analyzed by means of eigenmode solver and periodic boundary conditions.

PRODUCT SAFETY TESTING

How to Perform EMI Testing within an Existing EMI Chamber on an EUT with Low Particle Count Cleanliness Requirements

Larry Freeman, Harris Corporation

The ability to perform EMI measurements on an EUT having cleanliness requirements has represented a significant obstacle for many compliance testing agencies. Whether due to inexperience or concern with overly restrictive requirements, many agencies simply decline the opportunity outright. This paper details the approach and techniques used to gauge viability of performing EMI measurement testing on high reliability hardware with low particle count, clean room requirements. The main emphasis is on exploring various options, outlining and weighing the benefits of each technique, as well as determining the pertinent parameters involved with making a clean environment within an EMI chamber capable of performing EMI measurements.

Medical Equipment Immunity Assessment by Time Domain Analysis Application to GSM Signals

Mireya Fernandez Chimeno, GCEM-UPC; Miguel Angel Garcia Gonzalez, UPC; and Ferran Silva, GCEM-UPC

This paper presents a measurement method to assess the immunity of medical equipment (bioelectrical signal recording systems) to short duration interferences, like that of a GSM signal during the call establishment and ringing phase. Frequency domain measurement methods do not allow the analysis of these signals due to their short duration and transient nature. To measure these interferences we use the intermediate frequency (IF) signal output of a spectrum analyzer working in “zero span” to obtain a signal in the time domain, and we connect it to the input of a digital oscilloscope. Then, we demodulate the IF signal to obtain the interference in base band. The combination of the characteristics of both instruments allow us to measure the interfering signal and to assess the effect of these kinds of signals in medical systems that record low-level, low-frequency signals.

Sensor Development and Data Collection for Hero Testing

John Chavarria, White Sands Missile Range

This paper provides a method for assembling Hazards of Electromagnetic Radiation to Ordnance (HERO) testing instrumentation and data collection. During HERO testing, inert ordnance is exposed to high electromagnetic fields based on criteria set by military standards. Specialized sensors are developed using fiber-optic thermocouples and unique molding methods to monitor critical areas for induced currents. The sensor is calibrated against a known current to provide a calibration curve used during test data collection. Frequency, field intensities, and current levels are used to calculate maximum exposure levels and safety factors. The data is then formatted into a table suitable for inclusion in the test report based on military standards. This document will discuss the aspects of this testing to include equipment utilized, the development of sensors, calibration, test setup, data collection, and display format.

Recent Developments in Standardization Related to EMC and Functional Safety

Bernd Jaekel, Siemens AG

Issues related to electromagnetic compatibility are dealt with in a broad range of standards, whereas the main focus lies in the IEC 61000-X-Y series of EMC documents, and this series is further accompanied by a lot of product specific standards. For several years, the topic of functional safety of electrical and electronic systems has

become more and more important. This topic is related to EMC insofar as an adequate immunity against electromagnetic phenomena is required to prevent safety-related systems, and the equipment used in them from being harmfully affected, i.e. the need to avoid an unsafe behavior of such systems when being exposed to electromagnetic phenomena. Hence, the need was identified to merge the topics of EMC and functional safety, respectively, not only from a technical point of view, but also in terms of standardization. This paper describes the current situation regarding standards dealing with both areas and discusses the challenges that appear in the frame of working out standards considering the approaches in both the areas appropriately.

Validation, Verification and Immunity Testing Techniques for EMC for Functional Safety

Keith Armstrong, Cherry Clough Consultants

Safety systems must maintain low risks over their lifetimes. Where electromagnetic interference (EMI) could affect risks, an adequate level of electromagnetic (EM) performance is required. This is known as "electromagnetic compatibility (EMC) for Functional Safety". It is not practical to prove that systems are safe enough solely by EM testing. In all technical areas (including software) safety requires appropriate design, validation, and verification techniques, including testing. This paper briefly describes validation, verification, and immunity testing techniques for EMC Functional Safety. Many of these techniques can also help control environmental, financial, or security risks in high-reliability, mission-critical, or legal metrology systems.

A Novel Assessment Methodology for the EMI Occurrence in Implantable Medical Devices Based Upon Magnetic Flux Distribution of RFID

Shunichi Futatsumori; Takashi Hikage; and Toshio Nojima, — Graduate School of Information Science and Technology, Hokkaido University; Ben Koike, Japan Automatic Identification Systems Association; Hiroshi Fujimoto; and Takeshi Toyoshima, — Medtronic Japan Co., Ltd.

With respect to the EMI affecting implantable medical devices caused by Radio Frequency Identification Reader/Writers (RFID R/W), experimental investigations are conducted to develop a risk assessment methodology based upon the measurement of the EMF distribution around RFID R/W. First, fundamental EMI occurrence mechanisms of implantable cardiac pacemakers and implantable cardioverter-defibrillators (ICD) are described. Second, the characteristics of the radio wave emitted by the RFID R/W are described. Next, EMI test experiments and measurements of the field distributions are performed. Then, a novel experimental assessment methodology is proposed. The EMI characteristics derived from magnetic flux distributions are compared with the experimental results to confirm the effectiveness of the proposed methodology. Finally, it is shown that the probability of EMI occurrence can be estimated using the statistical processing of the proposed methodology.

Noise Immunity in Electroencephalogram (EEG) Recordings at High-Field Magnetic Resonance Imaging (MRI)

Giorgio Bonmassar; Hernan Millan; Patrick Purdon; and John Belliveau, — Harvard Medical School

Medical instruments designed specifically for Magnetic Resonance Imaging (MRI) often require very high noise immunity levels to avoid any interference with the MRI system. Specifically, an MRI artifact or inappropriate object-like noise in a region of the image should be avoided since it may be misdiagnosed as pathology. In this paper we describe a system for recording electroencephalogram (EEG) and Electrophysiology signals for artifact free images at high-field MRI. The EEG/MRI System includes a 1 GHz shield that has been tested on humans with fields up to 7 Tesla.

SAR MEASUREMENTS AND MODELS

Study of Using Fractional Spherical Phantom on SAR Evaluation

K. H. Chan; L. C. Fung; C. K. Tang; W. K. Lam; S. W. Leung; and Y. M. Siu, — City University of Hong Kong

A fractional head model can effectively reduce the computational effort of Specific Absorption Rate (SAR) calculations, which are usually extremely complicated and time demanding. This paper studies the uses of a reduced-size fractional phantom head model for SAR evaluation. The effect of the fractional spherical phantom heads on the antenna performance and the SAR value are studied by using the Finite- Difference Time-Domain (FDTD) method. Results have shown that both the return loss and the radiation pattern of the mobile phone antenna are only slightly affected by the fractional head model for almost all cases when the phantom head is truncated to not more than 25% in volume. Results have also indicated that the percentage difference in the SAR value for the full head model and the fractional head model is less than 5%.

Relationship Between Temperature Elevation and Spatial Average SAR in Japanese Human Head Model Due to Dipole Antenna

Akimasa Hirata; Kazuyuki Shirai; and Osamu Fujiwara, — Department of Computer Science and Engineering, Nagoya Institute of Technology

This study investigated the relationship between temperature elevation and spatial average SAR (specific absorption rate) in a Japanese head model due to a dipole antenna. Much attention is paid to the effect of averaging mass on the relationship. As a main result, SAR averaged over 10g of tissue, and was better than that of 1g for correlating with temperature elevation. The rationale for this was explained in terms of Green's function for the bioheat equation.

Numerical Prediction of SAR and Thermal Elevation in a 0.25-mm 3-D Model of the Human Eye

Concettina Buccella; Valerio De Santis; and Mauro Feliziani, — University of L'Aquila

A numerical study is proposed to compute the specific absorption rate (SAR) and maximum temperature increase in the human eye due to RF fields. A very accurate procedure is proposed using a very fine discretization in the calculations. The human eye is discretized by 0.25 mm cubic cells so that many eye tissues can be considered. The 3-D model permits the prediction of the SAR and thermal elevation according to the ICNIRP limits for occupational and general public exposures.

SA/SAR Analysis for UWB Pulse

Jianqing Wang, Nagoya Institute of Technology

With the rapid progress of electronic and information technology, an expectation for the realization of body area network (BAN) by means of ultra wide band (UWB) techniques has risen. Although the signal from a single UWB device is very low, the energy absorption may increase significantly when many UWB devices are simultaneously adorned to a human body. An analysis method is therefore required from the point of view of biological safety evaluation. In this study, we proposed two approaches, one was in the time domain and the other was in the frequency domain, for the specific energy absorption

(SA) and specific absorption rate (SAR) calculation. We demonstrated that the two approaches have the same accuracy but the time-domain approach is more straightforward in the numerical analysis. We also showed some SA/SAR calculation results for a UWB pulse exposure to an anatomical human body model.

BIOLOGICAL EFFECTS

Enabling the Use of Broadband Tissue Equivalent Liquids for Specific Absorption Rate Measurements

Mark Douglas; and Chung-Kwang Chou, — Motorola Labs

The aim of this study is to determine a robust prediction algorithm for the change in SAR due to deviations in the complex permittivity of a homogeneous phantom from standardized reference values. Several antenna sizes and distances to the phantom are investigated so as to study a large range of SAR distributions. Simulations using the Moment Method are presented. Results are analyzed over a frequency range of 30 to 6000 MHz. It is demonstrated that the prediction algorithm, while developed using dipole antennas, works equally well for realistic wireless devices. Employing the prediction algorithm reduces the SAR measurement uncertainty due to permittivity changes, thereby improving the reproducibility of SAR compliance assessment between laboratories. Another benefit of the algorithm is that it enables SAR measurement standards committees to relax their tolerances on the complex permittivity from defined targets, which allows for the use of broadband tissue equivalent liquids, thus reducing the cost of SAR measurement. The method presented in this paper has been adopted for inclusion in the next revisions of the IEEE 1528 and IEC 62209 measurement standards.

Electromagnetic Field Radiation of Mobile Phone Inside a Metallic Enclsoure

C. K. Tang; W. K. Lam; K. H. Chan; L. C. Fung; S. W. Leung; and Y. M. Siu, — City University of Hong Kong

A numerical study on the electromagnetic (EM) field radiation of a mobile phone inside a metallic enclosure, from the human safety aspect, is presented in this paper. The study on the effects of a number of human bodies and their positions inside the metallic enclosure on the induced E-field was carried out. Results have shown that the E-field induced on the human head of a mobile phone user is not sensitive to the loadings of human bodies inside the metallic enclosure. However, the E-field induced away from the mobile phone user that contributes to the E-field exposure of other people nearby is significantly changed for different human capacities inside the metallic enclosure. Results have also indicated that the E-field induced on the human head of a mobile phone user would be increased by 34% when other people using mobile phones are in proximity to the conducting walls of the metallic enclosure.

Inter-Laboratory Comparison Results of the Proficiency Testing Program of EMI Test Sites in Japan

Kunihiro Osabe, Voluntary EMC Laboratory Accreditation Center, Inc.

Recently, an inter-laboratory comparison of the proficiency testing program based on the ISO/IEC Guide 43-1 was performed at EMI test sites in Japan by VLAC (Voluntary EMC Laboratory Accreditation Center Inc.), the Japanese Accreditation Body for EMC test laboratories. A comb generator operated by AC mains was used for the artifact, since the technical proficiency of EMI measurement cannot be evaluated unless both of the conducted emissions and the radiated emissions are measured among the EMI test laboratories. This program, therefore, was performed to measure the conducted emission noise from the switching regulator incorporated into the power supply circuit of the artifact, and to measure the radiated noise emitted from the comb generator itself through the enclosure and AC mains cable. For the radiated emissions measurements, the artifact was connected through the VHF-Line Impedance Stabilization Network (LISN) to the supply and the AC mains. That is, the common mode impedance of of the mains power supply was specified to all participating test sites for the radiated emissions measurements. As a result of this program, the distribution width of the collected data from the group was kept from 6 dB to 10 dB, therefore it was easy to find the laboratory which had isolated data from the group.

Testing Large Industrial Systems, Preparations and Techniques

Kenneth Boston, L S Research LLC

The success of EMC tests of large systems, machines which cannot be accommodated within the typical EMC laboratory environment, depends on several factors, which will require careful planning in the initial stages of the project. Several of the issues surrounding the planning, staging, and testing of these types of systems will be discussed, and various observations and conclusions reached through study and experience will be presented. Some of these issues are regulatory, and some are technical in nature. With the current EMC directive being replaced in the summer of 2007, the regulatory environment for most of these systems will also be changing.

PRINTED CIRCUIT BOARD MODELING

The Effects of Signal Trace's Termination on Ground Bounce and Common-Mode Radiation

Eng Kee Chua, Institute of High Performance Computing; Kye Yak See, Nanyang Technological University; Weng Yew Chang, Nanyang Technological University; and Er Ping Li, Institute of High Performance Computing

Based on the Method of Moments (MoM), the ground bounce on any arbitrary printed circuit structure as well as the common mode current on any conductor that attached to the printed circuit structure are predicted. The MoM is applied to obtain the impedance matrix, which could be used to determine the unknown current vector as well as the inductance matrix. With the inductance matrix and current vector, the potential difference between any two adjacent nodes is predicted. The effects of the signal trace's termination on ground bounce and common-mode radiation are discussed through numerical results.

Capacitance of an Open Circuit Via Port

Franz Schlagenhaufer; and Matthew Wood, — The University of Western Australia

The via capacitance as part of a power plane structure is defined and calculated using a series expansion for the electrostatic field. Then by choosing a suitable surface surrounding the via, Gauss's Law is applied to obtain a numerically stable expression for the capacitance, written in series form. Attention is paid to the influence of dimensions and material on the capacitance value, and comparisons with Method-of-Moment based simulation packages are made.

Coupling Analysis of PCB-Chassis Systems with Signal Lines and Via Structures Using SPICE

Naoki Kobayashi, NEC Jisso and Production Technologies Research Laboratories; Todd Hubing, Clemson University; Ken Morishita; Manabu Kusumoto; and Takashi Harada, — Jisso and Production Technologies Research Laboratories

This paper describes the SPICE modeling of printed circuit boards (PCBs) with signal lines and via structures electrically connected to a

metal chassis. First, a PCB model is proposed, considering the coupling between signal lines and the power bus due to via structures. Next, the model is expanded to include the chassis and grounding posts. The calculated results using SPICE are shown to be consistent with experimental data. Furthermore, positioning of the grounding posts near the edges of the PCB is shown experimentally and numerically to reduce radiated emissions.

High-Accuracy Emission Simulation Models for VLSI Chips Including Package and Printed Circuit Board

Thomas Steinecke, Infineon Technologies AG

The electromagnetic emissions of complex, very large scale, integrated circuits is determined by their operational activity plus the manifold noise propagation paths through the on-chip power routing, the package traces, and the planes and traces on the printed circuit board. The design of any emission test board influences the emissions finally measured at defined connector probes. The emissions to be expected from a microcontroller plugged onto application boards are determined by the microcontroller's noise characteristics and the board's propagation characteristics. Good simulation models have to serve two main interests: 1) identification of emission-related IC design weaknesses and estimation of measured emissions from the IC manufacturer's point of view, and 2) identification of emission-related application board design weaknesses and estimation of measured emissions from the system manufacturer's point of view. This paper presents a target-leading approach for a full system emission simulation model which serves both the IC and system manufacturer's interests. The simulation model has been conducted for a 30-million transistor 32-bit automotive microcontroller.

SPICE-Compatible Cavity and Transmission Line Model for Power Bus with Narrow Slots

Yao Jiang Zhang, N/A

Segmental lumped circuits are derived from a coupled transmission line model for a narrow slot on the power bus. Both electric and magnetic coupling are taken into account by distributed inductances and capacitances. Then a SPICE compatible circuit model for the power bus with the narrow slot is proposed by connecting the segmental lumped circuits to the equivalent circuit derived by a hybrid cavity model and segmentation method for irregular power/ground planes. The model is validated by comparing it with the finite element method (FEM) for the self or mutual impedances calculation of two ports located in the power bus.

Modeling of a Mixed Signal Processor Susceptibility to Near-Field Aggression

Alexandre Boyer; Sonia Bendhia; and Etienne Sicard, — Institut National des Sciences Appliquées (INSA) of Toulouse

This paper deals with the measurement and modelling of the susceptibility of an integrated analog-to-digital converter of a 16 bit microcontroller to near-field localized aggression using a miniature near-field probe. A predictive simulation of the susceptibility threshold is detailed. Comparison between experimental and simulation results shows interesting correlations between measured and simulated susceptibility thresholds.

EM MODELING I

EMI Prediction Under a Different Program Behavior

Shih-Yi Yuan, Feng Chia University; Chi-Feng Yang, Feng Chia University; Etienne Sicard, INSA of Toulouse; Chiu-Kuo Chen, M.O.E.A; and Shry-Sann Liao, Feng Chia University

This paper discusses the estimation, measurement, and prediction of the EMI behaviors of a simple PIC controller under different program considerations. Using the "instruction current" concept, this work can predict, in the time domain, a very accurate current behavior of the conduct emissions. This paper also proposes a way to modify an ICEM model to achieve a good prediction of the impact of EMI by different program behavior. Prediction improvement can be done if further considerations are made of other effects. Various kinds of effects can also be applied to the adapted ICEM model with further studies. This work will be of great help to reduce parasitic emissions by SW technology and may propose another dimension of techniques for embedded system software design, software design methodology, driver design, and compiler optimization.

Patch Antenna Modeling Issues Using Commercial Software

William Coburn; Canh Ly; and Steven Weiss, — U. S. Army Research Laboratory

The Method of Moments, implemented in 2.5-D for multilayer antenna structures, or implemented as a fully 3-D solution of Maxwell's equations, is a popular method for microwave antenna simulations. Commercial software was used to simulate an aperture-coupled patch and a pin-fed patch antenna element. The simulation results are compared with experimental data measured for antenna prototypes having finite substrate and ground plane dimensions. The aperture coupled patch has a microstrip feed line extending to the edge of the substrate where a coaxial connector is installed between the microstrip and ground plane. The pinfed patch has a coaxial connector feed with a finite size ground plane and radome without dielectric substrates. We use a 3-D simulation to capture the effect of a finite ground plane compared to a 2.5-D model. We compare the calculated and measured antenna performance and conclude that the 2.5-D simulations are sufficient for the design of conventional patch antennas but detailed analysis or novel designs may require a fully 3-D model.

EM Fields Between Two Parallel Plates Supported by Conductive Multi-Poles

Hiroshi Echigo, Tohoku Gakuin University

In conductive multi-plates like printed circuit boards (PCBs) or pin grid array (PGA) connectors of CPU ICs, EM fields should be analyzed because undesired coupling between the vias and pins will occur. Adding them, the shield effectiveness of the pin-array to prevent the leakage of EM field should be estimated. In this paper, some examples are shown to prove that the analysis method for the scattering of a multi-wire system is effective. Some calculated results giving the electric near-field images are given for the thin wire systems and the multi-plate conductors. They clearly give the field pattern scattering out from the pole conductors. These results will give the estimations of the EMI intuitively and it leads to better treatments in the design.

EM MODELING II

Measurement of a Point Source Radiator Using a Magnetic Probe

Kevin Slattery; and Xiaopeng Dong, — Intel Corporation

A set of measurements have been performed on a test point source radiator. The near field, here assumed to be less than 0.01 m, was measured with a near field scanning system using a simple magnetic loop probe. This paper develops the analysis of those measurements and shows that the loop probe measures the far field component of the near radiated fields of a point source radiator when magnetic dipole equations are assumed to describe the radiation characteristics.

Efficient Low-Frequency Modal Analysis of an Anechoic Chamber

Luis Nuno, N/A; Juan Balbastre, N/A; and Ignacio Monterde, Polytechnic University of Valencia

An efficient method to analyze the electromagnetic fields inside rectangular anechoic and semianechoic chambers from 30 to 100 MHz is shown. A modal expansion is employed to develop the homogeneous and the inhomogeneous field. This is combined with circuital techniques to compute the effect of the layers of ferrite and dielectrics in the walls of the chamber. Several numerical results of the Free Space Transmission Loss (FSTL) of an anechoic chamber and the Normalized Site Attenuation (NSA) of a semianechoic chamber are provided.

Calculation of the H-Plane Pattern Influence to the Site VSWR Result Using the Monte Carlo Method

Wolfgang Müllner; and Alexander Kriz, — Austrian Research Centers GmbH - ARC

In this paper the error in site VSWR measurements caused by imperfect omnidirectional transmit antennas is investigated. On the basis of the H-plane pattern published by the manufacturer, the distribution of the error is calculated by means of the Monte Carlo Method. There are large differences between the products from the Austrian Research Centers GmbH and from Schwarzbeck GmbH. In the frequency range from 1 to 18 GHz, the systematic error is less than 0.5 dB for the PODs and more than 2 dB for the SBAs. The maximum deviation is -0.5 dB / +1 dB and -4 dB / +2 dB respectively. The contribution to the measurement uncertainty, the variance, is less than 0.1 dB and 1.4 dB respectively.

Predicting Electromagnetic Coupling between HF, VHF, and UHF Antennas Using NEC

William Duff, SEMTAS

There are many applications where it is desirable for transmit and receive antennas operating in adjacent frequency bands (e.g. HF, VHF, and UHF) to be co-located. In order to avoid EMI, it is necessary to provide adequate isolation between the co-located antennas. This paper presents the results obtained by using NEC to calculate the coupling for different geometric arrangements of the antennas.

EMI Analysis of a GSM 900 MHz Antenna for a Large Wind Turbine Hub with Method-of-Moments

Bastian Lewke, Technische Universität München; Florian Krug, during research work: GE Global Research; and Josef Kindersberger, Technische Universität München

Electro-magnetic fields resulting from a GSM transmitter mounted on a large wind turbine will be analyzed. This cellular system operates as a novel communications back-up in case the standard communication between the operator and hub control systems is interrupted. The method-of-moments is used to analytically describe the electro-magnetic fields caused by a GSM 900 MHz transmitter mounted on the hub of a wind turbine. Using a commercial simulation tool, the electromagnetic field distribution will be analyzed to determine an optimized wireless communication link to a base station. Different transmitter positions are evaluated based on their radiation patterns. Scattering and diffraction by the turbine's rotation is taken into account.

Ultra-Wideband Printed Circuit Antenna in Coplanar Technology

Harry Lam; and Jens Bornemann, — University of Victoria

A printed circuit antenna in coplanar waveguide technology for ultra-wideband measurements is introduced. The frequency of operation is 4 to 12 GHz with the VSWR less than 2 except for a very small band around 5.3 GHz. Omni-directional characteristics in vertical polarization are demonstrated at two selected frequencies. The analysis method is verified against previous measurements.

COMPUTATIONAL ELECTROMAGNETIC MODELING I

An Extended-Hybrid-Method: A Combination of MoM, GMT and UTD

Stefan Balling; Dirk Plettemeier; and Karl-Heinz Gonschorek, — Technische Universität Dresden

A new Extended-Hybrid-Method (EHM) is proposed. It unites the well known Method of Moments (MoM), the Generalized Multipole Technique (GMT), and the Uniform Geometrical Theory of Diffraction (UTD). With this EHM, it is possible to calculate special arrangements more efficiently in comparison to other standard computation methods. This is achieved by using the advantages of each method. As an example, the EHM is used to examine an antenna next to a human head model and a metallic door.

Razor Blade Functions in the PEEC Method

Volker Vahrenholt, Institute of Electromagnetic Theory; Heinz-Dietrich Brüns, Technical University Hamburg-Harburg; and Hermann Singer, Technical University Hamburg-Harburg

Modern electrical devices are of particular concern in terms of electromagnetic compatibility (EMC). Various numerical methods have been developed for EMC problems. One of those numerical methods is the partial element equivalent circuit (PEEC) approach, which was basically developed in order to combine electrical circuits and electromagnetic problems, because a circuit formulation of the electrical devices can be achieved. The standard PEEC formulation uses the Galerkin method in order to transform the EFIE into an equation system, and rectangular source functions are taken in order to apply analytical integration formulas. In this paper, the new possibility of applying razor blade functions is presented in order to allow the application of numerical integration within nearly the same computation time as the analytical way. In addition, a higher accuracy is achieved, because Green's function can totally be integrated including the retardation term. Examples are presented within this paper in order to show that a good agreement is obtained between the Galerkin PEEC, the PEEC based on razor blade testing, and a Method of Moments simulation (MoM), which is applied for validation.

Extended MagPEEC Model Including Dispersive Medium

Xiao Zhang; Haibo Long; Wenhua Chen; Yaqin Chen; and Zhenghe Feng, — Department of Electronic Engineering, Tsinghua University

This paper presents an extended MagPEEC modeling technique used to simulate arbitrary three-dimensional structures including a dispersive media. It remains the high precision of modeling with an acceptable increase in total computational complexity. This approach is verified by modeling a coaxial transmission line and magnetically enhanced RFIC inductors up to multi-GHz, including the significant frequency dependence of the permeability of the magnetic core in this band. The efficiency of the proposed method is validated by comparing its results with some commercial EM simulating software.

The Error Reduced ADI-CPML Method for EMC Simulation

Iftikhar Ahmed; and Erping Li, — Institute of High Performance Computing

In this paper, convolutional perfectly matched layer (CPML) is developed for the recently proposed error reduced (ER) ADI-FDTD

method to solve electromagnetic compatibility problems efficiently. Its numerical results are examined and compared with the conventional ADI-CPML method. It is found that for a CFL number equal to 5, the reflection error of the ERADI- CPML is approximately 12 dB better than the conventional ADI-CPML method.

Efficient 3D Simulation of Thin Conducting Layers of Arbitrary Thickness

Göran Eriksson, Saab Communication, Saab AB

In this paper it is demonstrated how a class of relatively complex EMC simulations can be performed at a low cost, both in terms of time and money. Using a symmetric, two-way boundary condition formulation, shielding metal layers can be included in a global electromagnetic simulation, without the need to resolve in detail the interior of the layer. This formulation, which has been previously used for some specific microwave and EMC problems, has no restrictions on the ratio of layer thickness to the skin depth. It is implemented in a commercial finite element method (FEM) solver installed on a standard PC, and no source-code programming is required. The method is validated and its usefulness demonstrated by applying it to a number of 3D examples of general EMC relevance.

Wide-Band Hybrid MM-PO Computational Electromagnetics Technique Using [Z] Matrix Interpolation and Adaptive Frequency Sampling

Andrzej Karwowski; and Artur Noga, — Silesian University of Technology

In this paper, we present a highly efficient computational electromagnetics technique for wide-band analysis of antennas radiating in the presence of electrically large conducting bodies (platforms). The technique is based upon the well known Moment Method–Physical Optics (MM-PO) hybrid formulation combined with the impedance matrix interpolation and a dynamic adaptive frequency sampling of the desired observable. Numerical examples are given to demonstrate considerable savings in both computer memory and CPU time offered by the proposed approach.

COMPUTATIONAL ELECTROMAGNETIC MODELING II

Fast FDTD Simulation Using Laguerre Polynomials in MNA Framework

Krishna Srinivasan; Ege Engin; and Madhavan Swaminathan, — Georgia Institute of Technology

In this paper, a fast transient simulation scheme using Laguerre polynomials, called Laguerre-MNA, has been developed for FDTD and circuit simulation. Companion models for the Yee cells and circuit components have been derived, permitting the use of MNA analysis to perform FDTD/transient circuit simulations using the Laguerre method. Companion models help simplify the matrix setup and reduce the matrix dimension that needs to be solved without employing long cumbersome equations. The FDTD simulation using Laguerre polynomials is unconditionally stable and has shown to be much faster than the conventional FDTD scheme. Prior work on transient electromagnetic simulations using Laguerre polynomials has a drawback of being able to simulate only for a certain time-duration. A memory/time efficient solution has been proposed by which simulation can be done for all time.

Application of a Hierarchical SVD/ACA Compression Technique to Near-Field Calculations of Monopole Antennas

Miguel Astner, TU Hamburg-Harburg; Heinz-D. Brüns, TU Hamburg-Harburg; Guido Bürger, HVB Systems GmbH; and Hermann Singer, TU Hamburg-Harburg

This paper describes the concept of hierarchical matrices and the application to near-field calculations of voltage or power driven antennas. The hierarchical matrix structure is based upon a binary partition of the structure to be analyzed, where blocks of the matrix can be represented as full matrices or R(k)-matrices, the latter yielding a data reduced representation of the initial block. It has been found that the application of only the adaptive cross-approximation (ACA) matrix reduction technique gave bad results in many practical 3D cases and failed to predict the physical current distribution. The way out of this dilemma is to combine ACA with singular value decomposition (SVD), yielding reliable results again. The new compression scheme turns out to be efficient and stable, and will be described in detail. By means of examples, the validity of the approach is demonstrated, where especially near-field investigations are carried out.

Efficient Evaluation of Equivalent-Principle Sources in MoM-FDTD Hybrid Method by Employing Spatial Interpolation and Adaptive Sampling

Andrzej Karwowski; and Tomasz Topa, — Silesian University of Technology

The MoM-FDTD hybrid approach requires the information to be exchanged back and forth between the MoM-regions and the FDTD-regions coupled through the Huygens' surfaces. For electrically large structures, evaluation of the electric and magnetic field components and the related equivalence-principle sources on the Huygens' surfaces can represent a significant (even dominant) fraction of the total solution time required for the problem. In this paper, we demonstrate a possibility of increasing the computational efficiency of the MoM-FDTD hybrid method by employing a spatial interpolation combined with adaptive sampling in calculating the electric and magnetic field components and the effective sources on the Huygens' surfaces. Numerical examples show that the proposed approach offers a considerable CPU time saving.

Near Field - Far Field Conversion Based on Genetic Algorithm for Predicting Radiation from PCBs

Hongmei Fan; and Franz Schlagenhaufer, — The University of Western Australia

A near field-far field conversion based on a genetic algorithm has been performed for a printed circuit board with a ground plane. A robust procedure for a pre-selection of dipole moments has been introduced. Important aspects of setting up the conversion problem, such as the number of equivalent dipoles and choice of matching points, have been addressed.

Use of Genetic Algorithms to Solve Inverse Scattering Problems

Dirk Plettemeier, Technische Universität Dresden; Stefan Balling, Technische Universität Dresden; Diemo Landmann, N/A; and Karl-Heinz Gonschorek, Technische Universität Dresden

The inverse scattering problem described in this paper is part of the quasi-tomographic Comet Nucleus Sounding Experiment by Radiowave Propagation (CONSERT) of the comet-mission Rosetta. This part of the experiment is based on the utilization of radiation coupling effects between the CONSERT antenna system on the Rosetta-Lander and the subsurface structure of the comet nucleus in the vicinity of the Lander. The scientific aim of this part of CONSERT is the reconstruction of the subsurface structure at the landing site, especially in view of the still open question: "Is a comet nucleus surround by a dust layer or not?" To solve this inverse scattering

problem, the line-of-sight link between Rosetta Orbiter and Lander will be used to measure the back lobes of the CONSERT Lander antenna with high angular resolution.

An Efficient Shielding Effectiveness Calculation on a Rectangular Enclosure with Numerous Square Apertures

Parissa Dehkhoda; Ahad Tavakoli; and Rouzbeh Moini, — Amirkabir University of Technology

Utilizing the traditional transmission line model, the shielding effectiveness of an enclosure with numerous apertures is efficiently calculated. Here, the array of apertures is represented by an appropriate admittance in the model. Since the representing admittance takes the mutual coupling between apertures into account, the results are more accurate than that of the traditional transmission line model. The results of this fast and accurate model are in very good agreement with the MoM and semianalytical methods.

COMPUTATIONAL ELECTROMAGNETIC MODELING III

Analytical HF Model of a Low Voltage DC Motor Armature Including Parasitic Properties

Jens Benecke; and Stefan Dickmann, — Helmut-Schmidt-Universität Hamburg

A high frequency (HF) electrical model of a DC motor armature is derived from its geometric and physical properties. This model includes the armature windings' properties as well as inductive and capacitive couplings between windings, armature, axis, and commutator surfaces. It provides sufficient detail to simulate the armature's complex impedance up to a frequency of approximately 1 GHz, provides expressions to calculate the model elements from construction parameters, and visualizes their influence on the impedance.

Simulation Analysis on EMI of an ±800 kV UHVDC Converter Station

Zhanqing Yu; Jinliang He; Rong Zeng; Bo Zhang; and Shuiming Chen, — Tsinghua University; Hong Rao; Jie Zhao; Xiaolin Li; and Qi Wang, — Technology Research Centre, China Southern Power Grid Co. Ltd.

Wide-band frequency EM noise is generated during the processes of firing and turn-off of thyristor valves in converter stations. The noise will be conducted along the primary circuitry, and may interfere with secondary systems by the way of conducted and radiated coupling. The ± 800 kV UHVDC transmission project is a newly developed technique and is not widely used in the world. The EMI problem is one of most important issue that should be studied deeply in the stage of designing. A method of conducted EMI analysis based on the time-domain wide-band circuit simulation, as well as a method of radiated EMI analysis based on the Method of Moments, are proposed and verified in the paper. The EMI levels of the ±800 kV converter station, which is planned and being designed in China right now, are presented.

An Investigation on ILCMs for Coupling of Fields into a Generic Missile Body through Apertures

Lawrence Chirwa, University of Ulster; John F. Dawson; and Martin P. Robinson, — University of York

The conventional way of analyzing electromagnetic coupling into cavities is by means of full-wave solvers based on techniques such as the finite-difference time-domain method, the method of moments, and the transmission line matrix (TLM) method. However, these methods require considerable computing resources and time to reach a solution. Intermediate level circuit models (ILCMs) have been shown to be far more efficient than these conventional methods. They are simpler and quicker to formulate and require significantly less time to reach a solution than conventional methods. This paper is on investigations in the bid to realize intermediate level circuit models for coupling into the generic missile body through apertures. A model for coupling via small apertures that yields credible results is realized, and is validated against TLM results for the same problem.

Simulation and Analysis of EMC Chambers by Ray Tracing Method

Ming-Shing Lin, National Yunlin University of Science & Technology; Jia-Ming Ji, Dayeh University; Chung-I Hsu, Dayeh University; and Han-Chang Hsieh, Deputy Director of Sixth DEPT

The ray tracing method in conjunction with image theory was used in this study to establish an analysis tool for evaluating the properties of EMC chambers. Computer codes were written in Matlab for simulating the normalized site attenuation (NSA), field uniformity (FU), and normalized site transmission loss (NSTL). By the simulation program, NSAs of a semi-anechoic chamber and NSTLs of a fully anechoic chamber were simulated and compared with measured results. The effects of the second-order reflection on the simulated NSAs of semianechoic chambers were discussed.

Reduced Order Modeling for Transient Analysis of Carbon Nanotube Interconnects

Giulio Antonini; and Antonio Orlandi, — University of L'Aquila

A state-space formulation for transient analysis of carbon nanotube interconnects is presented. Peculiar features of carbon nanotubes related to electron transport are modeled in terms of per unit length parameters. The multiconductor transmission line is firstly approximated by a ladder network; its admittance matrix Y is expressed in terms of Chebyshev polynomials in a closed form. The knowledge of the roots of such rational representation makes it possible to generate a compact state-space macromodel of the nanotube interconnect by selecting only the dominant poles. Numerical calculations, performed in both frequency and time domains, confirm that the proposed model can be used to model carbon nanotube interconnects as a building block of more complex systems.

TLM Simulation of RF Emissions and Confirmation of Results Through Testing

David Johns, Flomerics; and Boris Shusterman, EMC Corporation

The Transmission-Line Matrix (TLM) method has been developed for the EMC analysis of circuits and equipment packaging. TLM is usually formulated in the time-domain, enabling transient phenomena such as lightning, EMP, and ESD to be analyzed. In addition, equivalent compact models allow detailed features such as apertures and wires to be modeled in a computationally efficient manner when dealing with real-world structures. Recently the TLM technique has been enhanced to enable complex circuits to be replaced with equivalent radiating sources for the simplicity of the analysis.

SHIELDING PERFORMANCE MODELING

Numerical Modeling of Periodic Composite Media for an Electromagnetic Shielding Application

Dagang Wu; Rui Qiang; Ji Chen; and Ce Liu, — University of Houston; Marina Koledintseva, UMR; Jim Drewniak, UMR; and Bruce Archambeault, IBM Corporation

This paper describes a methodology to extract effective electrical properties for a periodic composite medium. The extraction algo-

rithm is based on a periodic finite-difference time-domain (FDTD) method. The results are compared with conventional mixing theories and 3D Fourier series expansion methods. Two results show satisfactory agreement. Having extracted effective permittivity and conductivity, one can readily use these parameters to study electrical properties of composite materials with arbitrary micro-geometry and the shielding effects of applying composite materials.

Wire-Mesh Shielding Performance Evaluation in a Reverberation Chamber

Franco Moglie; Valter Mariani Primiani; Anna Pastore; and Sara Pistolesi, — Università Politecnica delle Marche

The problem of the field penetration into a metallic enclosure with a large aperture protected by a wire-mesh screen is approached in this work, using our home made Finite-Difference Time-Domain (FDTD) code. This code, with a thin wire approximation, accurately accounts for the cross between wires of the mesh. All results are experimentally validated using a Reverberation Chamber (RC).

Effects of Aperture Thickness on the Shielding Effectiveness of Metallic Enclosures

Rodolfo Araneo; Giampiero Lovat; and Simone Paulotto, — University of Rome "La Sapienza"

The effects of apertures with finite thickness on the shielding effectiveness of rectangular metallic enclosures is investigated through an approximate but efficient formulation based on the method of moments. As expected, the analysis shows that the finite aperture thickness can help to increase the shielding effectiveness of the structure, especially in the high frequency region. Comparisons with rigorous full-wave results confirm the validity of the proposed technique.

Evaluation of the Frequency Characteristics of Absorbing Materials with the Time-Domain Single Antenna Method at a Standard Site

Satoru Kurokawa; Masanobu Hirose; and Koji Komiyama, — National Institute of Advanced Industrial Science and Technology

Frequency characteristics of absorbing materials are evaluated in a single-antenna calibration technique using a log periodic antenna on a standard ground plane. The technique is applied to the data both in the frequency-domain and time-domain, to evaluate the frequency characteristics of absorbing materials on the ground plane. Time-domain subtraction enables us to separate the wave reflected from absorbing materials. As a result, we have found that the dynamic range of our proposed method is more than 40 dB throughout a wide frequency range from 700 MHz to 2000 MHz.

Shielding Effectiveness of Rectangular Enclosures with Apertures Using Multi-Resolution Method of Moments

Fatemeh Hodjat; Rouzbeh Moini; and Masood Shafiee, — Amirkabir University of Technology

Apertures in a rectangular enclosure can be the coupling path of electromagnetic interference (EMI). A multi-resolution Method of Moments (MoM) formulation is used to evaluate the shielding effectiveness of metallic rectangular enclosures with apertures. To this end, the electric field integral equation (EFIE) is formulated for the surface currents. The use of fine meshing near the apertures and edges enables accurate results. Using multi-resolution analysis, considerable savings in calculation time is obtained. A study of the influence of the apertures' orientations is presented. Also the effect of considering different angles of incidence and polarization is shown to be significant.

SPECIAL SESSION: ALGORITHM AND TECHNIQUES FOR PARALLEL PROCESSING FOR EMI/EMC

Parallel Implementations of the PEEC Method

Jonas Ekman; and Peter Anttu, — Luleå University of Technology

This paper presents a parallel implementation of a partial element equivalent circuit (PEEC) based electromagnetic modeling code. The parallelization is based on the GMM++ and ScaLAPACK packages. The parallel PEEC solver was successfully implemented and tested on several high performance computer systems. Large structures containing over 50,000 unknown current and voltage basis functions were successfully analyzed, and memory, performance, and speedup results are presented. The numerical examples are both of the orthogonal and non-orthogonal types with analysis in the time-domain and frequency-domain.

A Parallel Electromagnetic Simulation Approach for the Signal Integrity Analysis of IC Packages

Erion Gjonaj, Technische Universitaet Darmstadt; Thomas Weiland, Technische Universitaet Darmstadt; Peter Thoma, CST GmbH; and Irina Munteanu, CST GmbH

A full-wave electromagnetic field simulation based on massive parallelization is proposed as a tool for the signal integrity analysis of complex IC packages. The simulations are based on a specialized domain partitioning method which allows for highly balanced parallel computations. As a real-world example, the analysis of a large computer chip spreader is performed. Numerical results including signal wave forms, and delay times are given.

Accelerated Integral Equation Solution Methods on Clusters and Multicore Processors

Vikram Jandhyala, University of Washington; Xiren Wang, University of Washington; and Chuanyi Yang, Cadence Design Systems

Boundary element based methods are now prevalent as analysis methods for large-scale microelectronic circuits. With the advent of fast multilevel techniques, these are comparable to and often surpass PDE-based solutions. The next challenge is to ensure these algorithms are scaleable on multi-core machines and parallel clusters. This paper discusses the parallelization of multilevel low-rank based algorithms for fast boundary element solvers applied to microelectronics.

Waveform Relaxation for the Parallel Solution of Large PEEC Model Problems

Giulio Antonini, University of L'Aquila; Albert Ruelhi, IBM Corporation; and Jonas Ekman, Luleå University of Technology

The solution of large 3D electromagnetic models is important for the modeling of a multitude of EMC, PI, and SI problems. In this paper, we explore new algorithms for the parallel solution of large time-domain 3D electromagnetic problems. Our approach is to use a volume Partial Element Equivalent Circuit (PEEC) electromagnetic formulation in combination with a Waveform Relaxation (WR) algorithm. In WR, we split the system into smaller subsystems and we break weak couplings so that the problem can be solved iteratively. WR has been used to solve a multitude of different problems. It is especially suited for parallel processing due to its favorable compute time to communication ratio. We consider a specific example for the application of WR to PEEC models.

The Discontinuous Galerkin Finite Element Time Domain Method (DGFETD): A High Order, Globally-Explicit Method for Parallel Computation

Stephen Gedney, University of Kentucky; Chong Luo, University of Kentucky; Bryan Guernsey, University of Kentucky; J. Alan Roden, Aerospace Corporation; Robert Crawford, Aerospace Corporation; Jeffrey Miller, Aerospace Corporation; and Stephen Gedney, University of Kentucky

A discontinuous Galerkin Finite-Element Time-Domain method is presented. The method is based on a high order finite element discretization of Maxwell's time-dependent curl equations. The global volume is decomposed into contiguous sub-domains of finite-elements with independent function expansions. The fields are coupled across sub-domain boundaries by enforcing the tangential field continuity. This leads to a locally implicit, globally explicit difference operator that provides an efficient high-order, accurate, time-dependent solution.

An Efficient Implementation of Parallel FDTD

Xiaohe Chen; Michael Cracraft; Yaojiang Zhang; Jianmin Zhang; and James Drewniak, — University of Missouri-Rolla; Bruce Archambeault, IBM Corporation; Samuel Connor, IBM Corporation

A parallel FDTD algorithm has been realized based on 1-D domain decomposition. Data communication among different adjacent processors is manipulated by a self-defined C++ class, MPI FDTD, in which portable functions of the message passing interface (MPI) library are used. The details of the implementation are discussed. EMC applications of the code such as cross talk of traces, cavity, vias, as well as an IC package are provided to demonstrate the parallel efficiency.

POSTER SESSION 01: SYSTEM EMC

EMC Management in a High Power Pulse Laser

Joel Raimbourg, CEA

The Ligne d'Integration Laser (LIL) is the biggest European laser facility. The plant is a 150 by 80 meter building which includes 8 high power lasers and a target chamber for experiments. We need to stock 20 Mjoules in capacity banks and commute 250 kA to feed the laser beams. The 60 kJ of light power are concentrated on one target for physics experiments. This generates electromagnetic pulses with levels of up to 10 kV/m and frequencies up to 3 GHz. Many electromagnetic victims (such as laser beam diagnostic detectors) need to function under serious interference conditions. This paper gives an overview of the electromagnetic compatibility management of this project. One of the principal difficulties is the single shot aspect of the process. All electromagnetic victims must work under normal conditions during the experiment. A temporary dysfunction is not permitted in our case.

EMI Sub-System Level Emission Limits Based on Statistic Analysis

Qin Yu; and Zijue Zhang, — Alcatel-Lucent

Product EMI pre-compliance evaluation becomes more important nowadays than before due to the growing industrial trend in outsourcing OEM. Precompliance testing involves measuring the radiated and power port conducted emissions of a complex system at the unit, shelf and/or sub-system levels. Defining the appropriate EMI limits at the sub-system level is crucial for the compliance of the overall system. The suppliers rely on the product specifications to design their products. If the sub-system level limit specified is too conservative, the product would be over designed and the cost would go up. However, if the sub-system level limit specified is too loose, the system EMI compliance will be in jeopardy. This paper utilized the statistical modeling recommended by ITU to estimate the maximum increase in the radiated and power-line conducted emissions from a multi-unit system. The results are useful in determining appropriate product sub-system level EMI limits and enhancing engineering judgment for compliance evaluation. The sub-system level limits based on the statistical analysis provide plausible and rational criteria for sub-system level compliance evaluation and prevent the product from being over-designed.

Development of Apparatus for Measuring Electromagnetic Shielding Effectiveness at the GHz Frequency Band

Jong-Hwa Kwon, ETRI; Jae Ick Choi, ETRI; and Jong Gwan Yook, Yonsei University

We have designed and manufactured a flanged double ridged waveguide as a sample holder for measuring the electromagnetic shielding effectiveness (SE) of planar material in broadband frequency ranges up to 10 GHz. The newly proposed sample holder in this paper has a tapered section for broadband impedance matching to the 50 ohm coaxial feed section. And we compared the measurement results with the simulation results by using the commercial software tool. The results from the designed sample holder agree well with those from the fabricated ones when considering the design specification of S11 < -20 dB at the operational frequency range. Also, to verify the measuring apparatus, we have tried to measure and compare the SEs of commercial shielding material made of 100% NiC by the proposed sample holder and ASTM D4935 holder.

Analysis of the Shielding Effectiveness of a Rectangular Cavity with Apertures to an ESD Radiated Field by the Transmission Line Method

Liuping Wang; and Yougang Gao, — Beijing University of Posts and Telecommunications

In this article, we first analyze the characteristics of an electrostatic discharge (ESD) electromagnetic pulse (EMP) and introduce the basic theory of the transmission line method (TLM), which is used to analyze the shielding effectiveness of rectangular enclosures with apertures. The calculations show that the TML shielding efficiency contours are in agreement with the FDTD calculated results. Then we expand the fundamental formulas to deal with the cases of round holes, multi-holes, and arbitrary angles of polarization.

Distribution and Characteristic of the Disturbances in the Driving System of a Fuel Cell Bus

Bo Zhang; Jinliang He; Shaofeng Yu; Wei Li; Rong Zeng; and Yong Huang, — Tsinghua University; Jae-bok Lee; and Sug-hun Chang, — Korea Electrotechnology Research Institute

This paper analyzes the distribution and the characteristic of the disturbances in the driving system of a fuel cell bus by measuring both the conductive and radiative emissions. A statistical method was used to investigate the parameters of the typical voltage waveforms, which were compared with the standard ones in ISO7637-2. The results are useful for the further investigation of the EMC problems in the fuel cell bus.

Electromagnetic Cross Coupling between Ground Support Power Lines and Spacecraft Umbilical Cables

J. Chai, The Aerospace Corporation; E. Dressel, N/A; and D. Taylor, N/A

The transients recorded by the hybrid On-line Lightning Monitoring System (OLMS) led to the investigation of the electromagnetic cross coupling between the ground support power lines and spacecraft umbilical cables. It was discovered that the associated Power-On events had sufficient temporal association and amplitude correlation to cause the recorded transients, and some recommendations were made to further address the issue.

Development of a Maritime Electronic Warfare and Sensor Systems EMI Mathematical Assessment Capability

Giuseppina Dall'Armi-Stoks, DSTO; Guy Morris, N/A; and Annie Yau, N/A

Electronic Warfare and Sensor (EW&S) Systems have to meet their operational capability in a maritime environment. However, with the ever increasing number of EW&S systems being fitted onboard maritime platforms, and the reality that maritime platforms are being required to operate jointly, the likelihood of adverse electromagnetic interference (EMI) between EW&S systems is prominent. Investigating EW&S systems' electromagnetic compatibility (EMC) can be an extremely complex problem. If EW&S system EMC is not addressed and managed in a correct procedure, the solutions to minimize EMI problems can be expensive and more importantly can affect the operational capability of the systems. What has been recommended, by many in the EMC community, as a means of managing the complexity of systems' electromagnetic interference and/or electromagnetic compatibility (EMI/EMC) problems, is that the EMI/EMC must be assessed at the planning, designing and development, installation, and/or operation of electrical and electronic equipment stages, each governed by an EMI control plan.

EMC Analysis for Sustainer Electric Propulsions and Deep Space Communication Systems

Nikolay Vazhenin; Andrey Plokhikh; Alexey Volkovsky; and Galina Soganova, — RIAME

A general solution for the problem of EMC calculation as applied to the sustainer electric propulsion (EP) in rockets and deep-space radio communication systems is considered in its classical statement. EP is described as a source of unintended noise of artificial origin of the white Gaussian noise type with the known spectral characteristics of radiation. An onboard receiver of the deepspace communication radio link is considered as the receptor, the noise susceptibility of which is assessed by the variation of the radio link quality parameters – communication range and information rate. The calculation results for the EP emission susceptibility of both information channel and phase synchronization channel of the deep space communication radio link designed for a spacecraft in the orbit of Mars are presented. Recommendations are given for securing EP EMC with the onboard systems of a spacecraft.

Effective Technique for System Level Prediction of the Radiated Emissions of Electronic Devices and Cables inside Satellites from Unit Level Measurements

Francisco Saez de Adana; Manuel Felipe Cátedra; and Jose Manuel Gomez, — Universidad de Alcala; and Raj Mittra, Pennsylvania State University

A method to predict the electromagnetic emissions from unknown electronic devices and cables at the system level is presented in this paper. The method is based on measurements at the unit level, equivalent source decomposition, and numerical electromagnetic simulation of the integrated system. The approach is also valid for the analysis of cables and conductors carrying electrical currents from the interior to the exterior of the measurement surface (Huygen's surface) and is useful for the prediction of the electromagnetic compatibility characteristics of electronic devices inside satellites.

POSTER SESSION 02: PCB AND IC EMC

Effectiveness of PCB Simulation in Teaching High-Speed Digital Design

Jianjian Song; Edward Wheeler; and Keith Hoover, — Rose-Hulman Institute of Technology

Signal integrity for high-speed digital design at the printed-circuit board (PCB) level is an issue of increasing importance in electronic design that requires coverage in more undergraduate classes. This paper describes how simulation tools offer an economical alternative to hardware-based experiments in undergraduate courses in high speed design. A simulation tool, Hyperlynx, has been used in our high-speed digital design class to help students understand fundamental concepts and ideas in signal integrity as well as to experiment with different techniques for maintaining signal integrity in a PCB design. We present examples in which traditional approaches employing only closed-form expressions can be effectively supplemented with simulation to help students gain a deeper understanding of basic concepts such as time-of-flight, parasitic parameters, nonlinear driver and receiver models, characteristic impedance, per-unitlength parameters, termination techniques, and crosstalk.

Transmission Line Attenuation-Impedance Realistic Corner Modeling by Scaled-Down Tolerence Boundary Scan

Zhaoqing Chen, IBM Corpration

This paper discusses a method to generate transmission line attenuation-impedance realistic corner models by a scaled-down tolerance boundary scan. Based on nominal and tolerance specifications of the transmission line physical and geometric parameters, the scaled-down tolerance boundary scan is used to find the realistic corners in the attenuation-impedance space. The tolerance scaling factor is determined or verified by comparing the derived corners with the attenuation-impedance distribution by Monte Carlo statistical electromagnetic simulations. This scaling factor can be used for similar structures in future applications. The system eye diagrams based on different bounding models are shown.

Impact of Linear Regulator Topology on Integrated Circuit Emissions

Kevin Lavery, Texas Instruments

The type of linear, on-chip voltage regulator is important to the measured emissions from a device. A p-channel VREG is found superior to an n-channel VREG in terms of suppressing emissions.

Degree of Unbalance about Earth and Radiated Emission of Differential Type Microstrip Line in GHz Band

Masahiro Shiota; Kiyotaka Matsubara; and Masamitsu Tokuda, — Musashi Institute of Technology; and Chiharu Miyazaki, Mitsubishi Electric Corporation

Balance-unbalance conversion factors and radiated emissions from differential type microstrip lines (DML) have not been examined in the frequency range above 1 GHz, because it is difficult to obtain the balun that can be used in GHz band. In this paper, we tried to measure them in the frequency range above 1 GHz by using a mode analysis function of a network analyzer instead of the balun, and compared the measurements with the calculated values by using the 4-terminal pair networks chain matrix theory. The comparison results confirmed that this calculation method is effective in the frequency range above 1 GHz.

A Scalable Model of Board to FPC Interconnect Using Neural Networks

Hoon Hwangbo, Sungkyunkwan University

In this paper, I propose the equivalent circuit model which includes the board to flexible printed circuit (FPC) connector transition region and the FPC connector to FPC cable transition region. Full wave simulations of the FPC interfaces are performed and the s-parameters of the simulators are compared to those of the vector network analyzer (VNA) measurements. The simulation shows very similar s-parameters compared to the VNA measurements verifying it as the reference tool for the equiva-

lent circuit model. Lumped capacitors and inductors are used as the parameters of the equivalent circuit model. I extracted the parameters by fitting the s-parameters of the equivalent circuit model to those of the 3D full wave simulator. The frequency range of the proposed model is 500 MHz to 3 GHz which is suitable for use with modern high speed applications. The neural network approach is then introduced as the novel behavioral modeling method of the board to FPC interfaces. Each length of the board to FPC interfaces are scalable parameters and used as the training data of the neural network structures. The predictions of the s-parameters using the neural networks when arbitrary transition length is given are very good compared to the 3D full wave simulations, and these results validate the neural network as the promising candidate for the modern high-speed interconnects modeling techniques.

The Solutions of LCD Panel (T-Con) EMI Noise for Wireless Integration

Sungkyu Lee, KEES; Jung-Man Lim, N/A; Ki-Seob Lee, N/A; Onsik Choi, N/A; Bae-Won Lee, N/A; Do-Wan Kim, N/A; Masashi Hayakawa, The University of Electro-Communications; and Yoshio Kami, The University of Electro-Communications

Electromagnetic interference (EMI) noise from a liquid crystal display (LCD) panel reduces the performance of wireless network systems in a notebook, including two Wireless network cards: Wireless Local Area Network (WLAN) card and Wireless Wide Area Network (WWAN) card. One of the main EMI noise sources for the wireless network system in an LCD panel is the timing controller (T-Con) IC. This paper introduces an approach to solve the problems of the EMI noise in the T-Con of an LCD panel, and a method of measuring the EMI noise of the T-Con itself by the use of the TEM-cell. Secondly, the solutions from the TEM cell tests, signal analyses and other measurements, suggest that there is a reduction in the EMI noise level of the T-Con. Finally, the measurement results of the EMI noise level of the LCD panel, with the improved T-Con, are presented. Because the EMI noise problem becomes more and more important issues for wireless network systems, the solutions to the problem and the right proposals have to be studied. We suggested them in this paper.

Comparative Analysis of Intel Pentium 4 and IEEE/EMC TC-9/ACEM CUP Heat Sinks

Junwei Lu; and Xiao Duan, — Griffith University

This paper presents finite element frequency domain results for electromagnetic radiation emitted from high power microelectronic circuits connected to a heat sink. The heat sink model associated with one of the IEEE EMC TC-9 challenge problems, 2000-4 CUP heat sink, has been used to investigate different grounding configurations. A new simulation model for the Intel P4 CPU heat sink is proposed. In contrast to the 2000-4 EMC challenge model, the Intel P4 CPU heat sink model exhibited different results. A resonant frequency of 2.6 GHz with a reflection coefficient of 8.3 dB was found for the Intel P4 CPU heat sink, which is close to the operating frequency of 2.4 GHz for IEEE and Bluetooth wireless communication systems. The comparison of frequency sweeping results shows that the reflection coefficient was found to be -6 dB at 3.6 GHz and -20 dB at 3.4 GHz from the conventional CUP heat sink. The CPU heat sink can perform as an efficient radiator at these frequencies.

Chip Level EMI Approach for LCD TV Panels

Dowan Kim, Samsung Electronics

In this paper, chip level approach is accomplished for solving EMI problems of LCD TV panels. All the EMI noises from 30 MHz to 1 GHz are classified into three noise groups by their sources, that is, the IC blocks generating the signals. Then, IC level solution is applied in order to reduce the noises and it is proved that this approach is more powerful and essential than the traditional countermeasures such as gasket tape or shielding method. Finally, this method is applied to a real LCD module and it is verified that the proposed method will have excellent effects on eliminating EMI troubles from LCD TV panels.

A Study on the Reduction Method of the Magnetic Field Radiated from a PCB Including Multi-Loops (n=2)

Atsuo Mutoh, Tokyo Fuji University; Shuichi Nitta, Salesian Polytechnic; and Yuxin Yan, Tokyo University of Agriculture & Technology

The near magnetic field radiated from a printed circuit board (PCB) including two multi-loops is studied in this paper. It is found that the magnetic field radiated from the PCB can be reduced by means of the parts layout making the current direction flowing through Vcc-GND pins of the adjacent IC to be opposite, based on the following phenomena: 1) the total amounts of near magnetic field cannot always be obtained from the addition of each near magnetic field from a single sub-circuit; and 2) Digital ICs can be characterized by the current model flowing from the Vcc pin to GND pin of the digital IC.

POSTER SESSION 03: EM MEASUREMENTS

Low Cost Noise Sources

Lukas Vojtech, Czech Technical University in Prague

EMC Measurements are a classic and necessary condition of device testing procedures. In the case of testing power EMI filters or device immunity, we need simulators of the interfering signal. We are teaching the main principles of EMC in our department. Practical measurements for students are realized in the EMC laboratory. For continual interference testing, students have an older, but still working, interference simulator; but they need an another one. This paper presents a few types of low cost broadband noise sources. Designed and practical working models could be helpful for everybody who needs to assemble cheap, but good working devices.

A Low Cost Line Impedance Stabilization Network for EMC Laboratory Institution

Vuttipon Tarateeraseth, Srinakharinwirot University; Werachet Khangern; and Damrong Sakulhirirak, — King Mongkut's Institute of Technology Ladkrabang, Thailand

This paper proposes how to analyze and design the Line Impedance Stabilization Network (LISN). Details of the component characteristics are described, along with the design of the air coil inductors in single and multi layers based on a high, self resonant, frequency response concept. According to the CISPR 16-1 standard, the stabilized impedance of 50 for the LISN at the frequency range 150 kHz to 30 MHz is proved by simulation and experimental results. The proposed LISN is a successful low cost design in comparison with a commercial LISN. Finally, the performance of the proposed LISN is achieved compared to the CISPR standard and also with a commercial LISN.

3-D Radiated Spurious Emission Test System

Lin Guo, Ministry of Information Industry

With the rapid advent of the wireless technologies, wideband high frequency wireless systems are becoming more popular. These products bring a new challenge to the EMC compliance testing, especially for the radiated spurious emission test. The traditional 2D test method of the spurious emission is no longer suitable for the high frequency technologies certification test. A new radiated spurious emission test system is being studied in this paper, which is more suitable for the higher directive radiated emission measurements. The use of this test

method can substantially reduce the measurement uncertainty.

Understanding and Selecting Measurement Antennas for Use in Congested Electromagnetic Environments

Philip Keebler, EPRI

It is not uncommon for electromagnetic compatibility (EMC) engineers who conduct surveys of electric and magnetic fields in some commercial, industrial, power plant, and healthcare facilities to encounter congested areas where challenges are presented in selecting the appropriate survey antenna. Site surveys and laboratory experiments conducted by our EMC survey group have been conducted with a variety of antennas in an effort to compare techniques and measurement results. This paper presents two examples of electromagnetic field measurements, one conducted in an open area test site (OATS) and the second conducted in a doubly-isolated shielded enclosure (DISE). In comparing electromagnetic field measurements, we use a biconical log periodic dipole (BLPD) as the radiating antenna, and two antennas, the biconic and discone, as the receiving (or antennas under test) antennas. Comparison of the laboratory data to the OATS data clearly shows that the reflections that do occur may attenuate or amplify the signal from an interferer at the point of installation. Considering this phenomena, it is important not only to consider a survey when a new piece of equipment is installed, but it may be necessary to perform a survey to determine the change in the electromagnetic environment when structural metallic objects are present at the site.

Investigation of Wave Propagation Using a Smart Antenna for Indoor Wireless Communication

Junwei Lu; and Zhaohui Sun, — Centre for Wireless Monitoring and Applications, Griffith University

This paper presents the investigation of wave propagation characteristics for indoor wireless communications using a smart mobile terminal antenna. The Finite Element Method (FEM) frequency-domain based computation model is used to characterize electric field intensity for a typical office environment. The signal to noise ratio and signal strength are measured according to different placements of transmitting antennas, including a conventional antenna and a smart mobile terminal antenna array. To validate the numerical computational result, a measured result using a wireless network card, with an on board antenna and built-in signal strength measurement software, are employed to replace expensive and heavy apparatus.

Circuit Specifications for Radio Noise Reduction in Vehicle-Mounted Communication Network

Youichirou Suzuki, Nippon Soken, Inc.; Noboru Maeda, Nippon Soken, Inc.; and Nobuyuki Iwasaki, Denso Corporation

EM noise emission in the radio bands from the communication harness of vehicle-mounted LAN is evaluated by performing an actual measurement test complying with CISPR 25. This report provides a method used to define the specifications for the transmitter circuit and receiver circuit required to satisfy the AM noise limit in the test. The noise propagation is analyzed in common and differential modes, and an inverse calculation is applied to obtain the specifications. Radio noise from the communication harness will be able to pass the test by designing the transmitter and receiver to meet the specifications developed using this method.

Investigation of the Coupling Paths of a Galvanic Isolated AC-AC Converter

Anne Roc'h, University of Twente; Dongsheng Zhao, N/A; Frank Leferink, N/A; and J. A. Ferreira, N/A

A galvanic, isolated, three-phase, AC/AC converter with a high-frequency AC-link has been analyzed from an EMC point of view. This configuration is novel because of a large number of switches, a high frequency transformer, and a fourwire output. The essential coupling paths are identified. Corresponding suppression remedies are given. The results, before and after measurements, have been taken to demonstrate the improvement in EMC.

Using Nested Reverberation Chambers to Determine the Shielding Effectiveness of a Material: Getting Back to the Basics With an Intuitive Approach

Jason Coder, University of Colorado; John Ladbury, National Institute of Standards and Technology; and Christopher Holloway, National Institute of Standards and Technology

We examine the current method for determining the shielding effectiveness of a material using nested reverberation chambers and show a simplified approach. Included in our examination is a discussion of the purpose for using a four antenna measurement system and a simplification of the equations used in the data processing portion of the measurement. The result of this simplified approach will be a measurement process that is more intuitive and makes use of S parameters along with power ratios in all portions of the measurement effort. To validate our simplifications and data processing methods, we will provide an experimental demonstration and verification.

Measurement of Shielding Effectiveness in the Microwave Frequency Range Using a Dual Focus Flat Cavity

Toshihide Tosaka, National Institute of Infromation and Communications Technology; Atsuhiro Nishikata, N/A; Kaori Fukunaga, N/A; and Yukio Yamanaka, N/A

We suggested a new measurement method of Shielding Effectiveness (SE) in the microwave frequency range using a Dual Focus Flat Cavity (DFFC). TE waves are transmitted from the transmitting point to the receiving point through the testing material. The shape of the DFFC is oval and the transmitted waves are focused at the receiving point with the same phase. This method has a large dynamic range of about 100 dB. We evaluated this method at a number of frequencies by comparing the calculated value with the measured value using isotropic materials. The differences were less than 3 % at each frequency. The measurement repeatability error was less than 2 %.

POSTER SESSION 04: POWER LINE COMMUNICATIONS, SAFETY AND BIOLOGICAL EFFECTS

Terminal Condition Dependency of Transmission Characteristics for High-Speed Power Line Communication

Shunichi Sakuta, Musashi Institute of Technology; Yosuke Watanabe, Musashi Institute of Technology; Toshiyasu Higuma, Mitsubishi Electric Corporation; and Masamitsu Tokuda, Musashi Institute of Technology

In this paper, we studied the dependency of transmission characteristics to the differential mode impedance of the power line for power line communication with the high frequency band from 2 MHz to 30 MHz. Real indoor wirings of the power line have various branch forms. We focused on a typical blanch model such as an outlet blanch model that diverges in parallel, and composed this model. We calculated and compared transmission characteristic by the Method of Moment which is used for the electromagnetic field analysis. As a result, it is understood that the transmission loss and radiated emission characteristics of the power line depend on the differential mode impedance value.

LCL Characteristics of Power Line for Power Line Communication Using the Four Port Network Theory

Jun Karino; Yosuke Watanabe; Akira Mori; and Masamitsu Tokuda, — Musashi Institute of Technology

We calculated the transmission characteristics and the degree of unbalance to the ground of the power line in the high frequency band, in order to obtain the characteristics of the power line. The calculation model of the power line is made by a four port network theory, which has a circuit constant as a chain matrix of the distributed constant on the transmission line. And we compared the calculated value with the measured value. As a result, in the transmission loss characteristic, it is confirmed that the calculated value agrees well with the measured value, by considering the conductance of the insulating dielectrics of a power line. From the comparison of the measured and calculated values with the four port network, it is revealed that the frequency and the level occurring hump in the Longitudinal Conversion Loss (LCL) characteristics agree well with each other. Comparing the calculated results from the Method of Moment (MoM) and the four port network theory, it was shown that the four port network theory is better than MoM in calculation accuracy.

Transmission Characteristics of an OFDM Signal for a Power Line Communication System with High Bit Rate

Akira Mori; Yosuke Watanabe; and Masamitsu Tokuda, — Musashi Institute of Technology; and Koji Kawamoto, Sumitomo Electric Industries, Ltd.

In this paper, we measured what influence the transmission loss characteristics of the electric power line with various forms gave to the transmission rate of the Orthogonal Frequency Division Multiplexing (OFDM) signal through the power line communication system (PLC) modem. We classified the electric power transmission line with various forms in a real environment into two basic elements, which are an outlet type branch and a switch type branch. Next, the transmission rate is measured for a concise power line model composed of the outlet type and the switch type branches, which is connected with the PLC modem. As a result, it is revealed that the transmission rate is marginally affected by the two branches mentioned above. At this time, the transmission characteristics of the electric power line are simulated from measured data. The OFDM sending and receiving systems are composed on the computer and the transmission rate is simulated. It is clear that the transmission rates simulated agree with that measured.

EMC Analysis of a Wind Turbine Blade's Lightning Protection System

Bastian Lewke; Josef Kindersberger; Sebastian Krämer; and Fernando Puente León, — Technische Universität München; Yarú Méndez Hernández, GE Global Research; and Jörg Kirchhof, Institut fuer Solare Energieversorgungstechnik

An electromagnetic analysis of a wind turbine blade's lightning protection system will be given. Impedance measurements on a 16 m blade tip are performed for a frequency sweep up to 30 MHz. The influence of the blade's position is analyzed. Measurement data is used to derive a method-of-moments model with a commercial tool. The method-of-moments model will be compared to a finite element model. Both models will be used to derive the electromagnetic interference caused by the electromagnetic fields radiated by the lightning protection system after a lightning strike.

Effect of Subject's Size on Electromagnetic Radiation from a Source in the Human Body Following a 2450 MHz Radio Frequency (RF) Exposure

Lisheng Xu; Qinghu Meng; and Hongliang Ren, — The Chinese University of Hong Kong

For assessment of compliance with the safety guidelines, the radiation effects and efficiencies of ingested wireless devices in human body trunk models of five-year-old children, ten-year-old children, and adults are studied using several homogenous models and a half-wavelength dipole at the frequency of 2450 MHz in this paper. The finite-difference time-domain (FDTD) method was used for analyzing the radiation effects and efficiencies. Results show that radiation efficiencies decrease with the increment of body size greatly, ranging from -53 db to -116 db. Considering the signal efficiency of wireless devices and safety guidelines of radiation exposure, we recommend to set the ingested wireless device to different power levels for users with different body size such as five-year-old children, ten-year-old children, and adults.

Evaluation of the Genotoxic Potential of Microwave Electromagnetic Fields in Onion (Allium Cepa)

Mirta Tkalec; Zeljka Vidakovic-Cifrek; and Branka Pevalek-Kozlina, — Department of Botany, University of Zagreb; Kresimir Malaric; Roman Malaric; — Department of Wireless Communication, University of Zagreb

Allium cepa seeds were exposed to 900 MHz EMF in a GTEM cell at four different field strengths (10, 23, 41 and 120 V m-1) for 2 hours. The effects of a longer exposure time (4 hours) and modulation was also investigated. The germination rate and root length did not change significantly after EMF exposure. However, the EMF at higher strengths (41 and 120 V m-1) and with modulation, as well as longer exposure, significantly increased mitotic index compared to corresponding controls. The percentage of mitotic abnormalities, mainly consisting of laggards, anaphase bridges, C-mitosis, vagrants and unequal distribution, increased with all the given field conditions.

The Study of Electric Field Effect to Bending on the Growth of the Primary Root of Rice

Thyanuch Rotcharoen, Phetchabun Rajabhat University

The growing of rice seeds (Oryza sativa L.) on a primary root stage are tested under the conditions of an electric field at 28.5 kV/m, a varying electrode in the horizontal direction, and without an electric field. This work focused on examining the bending of the root direction and measuring the space angle after 8, 16 and 24 hours. The values with E-field and without E-field are compared. The results indicate that the preferred direction of root bending is toward the negative electrode.

Analysis on the Propagation of Wideband EM Waves Emitted from a Partial Discharge Using the Constrained Interpolation Profile (CIP) Method

Masatake Kawada, The University of Tokushima; and Katsuo Isaka, N/A

Measurements of partial discharge (PD) have been used to assess the condition of insulation material used in electric power equipment. Analysis of the electromagnetic (EM) waves emitted by the PD is useful from the viewpoint of non-contact diagnosis because a PD emits wideband EM waves. The constrained interpolation profile (CIP) method is used to visualize the EM waves emitted from a PD for understanding the physical mechanisms. The PD is numerically obtained by the total amount of charge and the rise time. Numerical results show that the CIP is useful for analyzing the relationship between the PD current and the EM waves.

WORKSHOPS - 8 and 9 July 2007

The information is current as of 30 April 2007; visit www.emc2007.org for updates

Nanotechnologies and Advanced Materials

Format: Half-day Workshop

Chairs: Dr. Christopher L. Holloway, NIST, Boulder, Colorado
Prof. Maria Sabrina Sarto, University of Rome "La Sapienza", Rome, Italy

Abstract
Nanotechnology is functional engineering on an extremely small scale that can be used to develop innovative advanced materials (e.g. metamaterials, frequency selective surfaces, photonic band gap, etc.), components 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. Nanotechnology is currently exploited in microelectronics, optoelectronics, and material science, but its application in EMC is still not very wide.

Planned Topics
- The application of carbon nanotube based nanodevices and nanostructured materials for nanointerconnects and shielding materials. Issues related to the fabrication, the measurement of the electrical and electromagnetic properties, and the electromagnetic modeling at radio frequency will be treated.
- The application of metamaterial for antennas and electromagnetic filters.

EMC and Wireless Devices

Format: Full-day Workshop

Chair: Dan Hoolihan, Hoolihan EMC Consulting, Minnesota

Abstract
The overall workshop will provide key information on EMC concerns as they pertain to present and future wireless/cellular phone technologies and associated packaging issues. More specifically, this workshop will address the electromagnetic interference (EMI) aspects of the proliferation of modern wireless devices such as current radio and cell phone technologies. It will address both EMI from product to product such as cellular phones, wireless radio devices, and packaging, as well as relevant spectrum allocation issues.

Planned Topics
- EMI from Licensed Cell and Wireless Transmitters
- EMI for Unlicensed Cell and Wireless Transmitters
- Telecom Certification Body (TCB) Issues with Wireless/ Telecommunications Devices
- EMI and Future Wireless and Cellular Technologies
- International and Regulatory Aspects of EMI And Wireless/Cellular Devices
- The New ANSI C63.10 Standard For Testing Unlicensed Wireless Devices

Planned Speakers
1. Dave Case, Cisco Systems, Richmond, Ohio
2. Mike Violette, Washington Laboratories, Maryland
3. Michael Foegelle, ETS-Lindgren, Cedar Park, Texas
4. Kevin Slattery, Intel Corporation, Oregon
5. Harry Skinner, Intel Corporation, Oregon
6. Steve Berger, TEM Consulting, Georgetown, Texas
7. Andrew Drozd, ANDRO Computational Solutions, Rome, New York
8. Art Wall, Radio Regulatory Consultants, Inc., Maryland

Advanced EMC Technologies in the Pan-Pacific Region

Format: Half-day Workshop

Chair: Professor Ryuji Koga, Okayama University, Japan

Abstract
Taking the opportunity of 2007 IEEE International Symposium on EMC being held in Hawaii, to focus on and introduce the latest EMC technologies in the Pan-Pacific region, EMCJ Technical Group in the Institute of Electronics, Information and Communication Engineers proposed the workshop entitled "Advanced EMC Technologies in the Pan-Pacific Region".

Planned Topics
- Crosstalk in Complex Printed Circuits
- Environmental EMC
- PCB analysis
- EMC in Power Electronics
- Biological EMC

Planned Speakers
1. Dong Chul Park, Chungnam National University, Daejeon, Korea
2. Gao Yougang, Beijing University of Posts & Telecommunications, Beijing, China
3. Werachet Khan-ngern, King Mongkut's Institute of Technology Ladkrabang, Thailand
4. Osamu Fujiwara, Nagoya Institute of Technology, Japan
5. Le-Wei Li, National University of Singapore, Singapore
6. Shuichi Nitta, Salesian Polytechnic, Japan

Managing Regulatory Access to Asia Pacific Markets

Format: Full-day Workshop

Chairs:
Mr. Kwok Soohoo, Site EMC Coordinator, IBM, Poughkeepsie, New York
Ms. Mary Jo DiBernardo, Program Manager, National Institute of Standards and Technology (NIST), Maryland
Mr. William Hurst, Chief of Technical Research Branch, Federal Communications Commission (FCC), Washington D.C.

Abstract
Markets in the Asia Pacific region are heavily sought after, but keeping up with technical regulations around the world can be a challenge. EMC regulatory requirements vary widely, and rules regarding testing, product certification, declaration of conformity, registration, and MRAs (Mutual Recognition Agreements) can be confusing and costly for manufacturers – and the test labs and certification bodies who serve them – to effectively market their products in these countries. In this workshop, participants will learn about the EMC regulatory requirements of various Asia Pacific countries, as well as the U.S. and Canada, and the steps that are necessary in order to successfully market a product to some of the countries in this region.

Planned Speakers
1. Mr. Kwok Soohoo, IBM, Poughkeepsie, New York
2. Ms. Mary Jo DiBernardo, National Institute of Standards and Technology, Maryland
3. Mr. William Hurst, Federal Communications Commission, Washington D. C.
4. Mr. Wei Chen, China Quality Certification Center, China

5. Professor Guili He, China Telecommunication Technology Laboratories, China
6. Mr. K. Santhosh Kumar, Dell India R&D Center, India
7. Mr. Satoshi Shibata, Voluntary Control Council for Interference (VCCI) International Relations SC Chair, Panasonic, Japan
8. Ms. Melinda Tan, Info-Communication Development Authority, Singapore
9. Mr. Su-Jin Song, Radio Research Laboratory, Ministry of Information and Communication, Korea
10. Mr. Andy Kwan, Industry Canada, Ottawa, Canada
11. Mr. Yung-Chi Tang, Bureau of Standards, Metrology and Inspection, Taiwan
12. Mr. Mick Owens, Australian Communications and Media Authority, Australia
13. Mr. W. K. Luk, Office of the Telecommunications Authority, Hong Kong

TUTORIALS – 8 and 9 July 2007

The information is current as of 30 April 2007; visit www.emc2007.org for updates

Limitations of Simulation Techniques and Proper Model Validation for Both Signal Integrity and EMC

Format: Half-day Tutorial

Chair: Bruce Archambeault, IBM, North Carolina

Abstract

This tutorial discusses the limitations and applications of different simulation techniques, as well as how to properly validate simulation results. It is intended to help SI and EMC engineers who know the basics of the modeling techniques learn the details of the method limitations, and to help them run simulations properly and efficiently. Experienced modelers can also benefit from the discussions of model validation.

Planned Speakers

1. Bruce Archambeault, IBM, North Carolina
2. Jim Drewniak, University of Missouri-Rolla, Missouri
3. Colin Brench, Hewlett-Packard, Richardson, Texas
4. Charles Bunting, Oklahoma State University, Oklahoma
5. Jim Nadolny, Samtec, Pennsylvania
6. Jun Fan, NCR, San Diego, California

Introduction to EMI Modeling Techniques

Format: Half-day Tutorial

Chair: Charles Bunting, Oklahoma State University, Oklahoma

Abstract

This tutorial will provide an introduction to all of the commonly used numerical EMC modeling techniques, beginning with circuit based approaches and ending with Maxwell's equation – full field solution methods. Each technique will be presented along with their strengths and weakness.

Planned Speakers and Topics

1. The Transmission Line Method
Dr. David Johns, Flomerics, Massachusetts
2. Introduction to the Partial Element Equivalent Circuit Technique
Giulio Antonini, University of L'Aquila, Italy
3. The Finite-Difference Time-Domain Technique
Dr. Bruce Archambeault, IBM, North Carolina
4. Understanding the Finite Element Method
Dr. Charles F. Bunting, Oklahoma State University, Oklahoma
5. Introduction to the Method of Moments
Dr. Ji Chen, University of Houston, Texas

EMC and Modern Power Electronic Systems

Format: Half-day Tutorial

Chair: Dr. Firuz Zare, Queensland University of Technology, Australia

Abstract

The purpose of this tutorial is to address basic and advanced concepts of EMC in modern power electronic systems that help EMC experts to analyze EMC problems of power electronics used in different applications. Introducing power electronics in details such as transformer and motor design, modulation strategy, and switching losses to EMC experts may open a new research area and help development engineers to find better solutions to minimize sources of EMI noise at the development phase and improve cost, size and performance of the system.

Planned Topics

- Power Electronics: topologies, applications, pulse width modulation
- Major EMI problems in power electronic systems
- Active EMI filters used in motor drives
- Methods to predict and minimize conducted emission noise in motor drive systems
- Important feedbacks from EMC experts to development engineers

Basic EMC Measurements

Format: Half-day Tutorial

Chair: Don Heirman, Don HEIRMAN Consultants, New Jersey

Abstract

The tutorial will present an introduction to basic EMC measurements with primary focus on emission testing. While intended for those new to this discipline, the tutorial will provide to the attendees the latest activity in national and international standards related to EMC measurements and standards. A special focus continues to be on measurements and associated test facility and calibration issues above 1 GHz as well as associated measurement uncertainties.

Planned Speakers and Topics

1. Table Top EUT Emission Measurements
Steve Koster, Washington Laboratories, Maryland
2. Floor Standing EUT Emission Measurements
Bob Hofmann, Hofmann EMC Engineering, Illinois
3. Transient Immunity Testing
Tom Braxton, Braxton EMC Consulting, Illinois
4. Continuous RF Immunity Testing
John Maas, IBM, Minnesota
5. Measurement Sites and Associated Errors
Don Heirman, Don HEIRMAN Consultants, New Jersey
6. Selecting a Quality Test Lab
Dan Hoolihan, Hoolihan EMC Consulting, Minnesota
7. Measurement Uncertainty as it Applies to Pass/Fail Results
Don Heirman, Don HEIRMAN Consultants, New Jersey

EMC Aspects of Lightning
Part 1: Lightning Characteristics and Modeling

Format: Half-day Tutorial

Chairs:

Dr. Farhad Rachidi, Swiss Federal Institute of Technology,

Switzerland
Vladimir Rakov, University of Florida, Florida
Rajeev Thottappillil, Uppsala University, Sweden

Abstract
Lightning represents one of the most important sources of electromagnetic disturbances. The objective of this tutorial is to give an overview of measured and modeled lightning parameters and to describe lightning's major EMC interactions with systems for engineering applications with an insight into protection methods.

Planned Speakers and Topics
1. Lightning Currents for Engineering Applications
Alberto Borghetti, University of Bologna, Italy
Gerhard Diendorfer, Austrian Electrotechnical Association, Austria
Vladimir Rakov, University of Florida, Florida
2. Lightning Electric and Magnetic Fields
Vladimir Rakov, University of Florida, Florida
3. Lightning Return Stroke Models and Electromagnetic Field Computation
Rajeev Thottappillil, Uppsala University, Sweden
Vernon Cooray, Uppsala University, Sweden
Nelson Theethayi, Uppsala University, Sweden
4. Lightning to Tall Structures
Yoshihiro Baba, Doshisha University, Japan
Fridolin Heidler, University of the Federal Armed Forces, Munich, Germany
Farhad Rachidi, Swiss Federal Institute of Technology, Switzerland
Rajeev Thottappillil, Uppsala University, Sweden
5. Lightning Location Systems
Gerhard Diendorfer, Austrian Electrotechnical Association, Austria
Marcos Rubinstein, University of Applied Sciences, Switzerland

EMC Aspects of Lightning
Part 2: Lightning Interaction with Systems and Protection

Format: Half-day Tutorial

Chairs:
Dr. Farhad Rachidi, Swiss Federal Institute of Technology, Switzerland
Vladimir Rakov, University of Florida, Florida
Rajeev Thottappillil, Uppsala University, Sweden

Abstract
Lightning represents one of the most important sources of electromagnetic disturbances. The objective of this tutorial is to give an overview of measured and modeled lightning parameters and to describe lightning's major EMC interactions with systems for engineering applications with an insight into protection methods.

Planned Speakers and Topics
1. Grounding Systems for High Frequencies and Transients
Leonid Grcev, Sts. Cyril and Methodius University, Skopje, Macedonia
2. Lightning Protection of Buildings and Laboratory Testing
Stanislaw Grzybowski, Mississippi State University, Mississippi
3. Lightning-Induced Voltages on Overhead Lines
Carlo Alberto Nucci, University of Bologna, Italy
Farhad Rachidi, Swiss Federal Institute of Technology, Switzerland
4. Lightning Protection of Power Systems
Carlo Alberto Nucci, University of Bologna, Italy
Mario Paolone, University of Bologna, Italy
5. Lightning Interaction with Electrified Railways
Nelson Theethayi, Uppsala University, Sweden
Rajeev Thottappillil, Uppsala University, Sweden
6. Lightning Interaction with Aircraft
Anders Larsson, Swedish Defence Research Agency, Sweden

Fundamentals of EMC and NARTE Exam Preparation

Format: Full-day Tutorial

Chair: Randy Jost, Utah State University, Utah

Abstract
Organized by the EMC Society Education and Student Activities Committee, this tutorial is designed to present the basics of EMC to those who are new to the field of EMC, for those who are seeking information on an aspect of EMC that they have not previously encountered, or for those who desire a refresher on the proposed EMC topics. The last 90 minutes of this tutorial is devoted to providing assistance to those who are preparing to take the examination to become NARTE certified EMC engineers or technicians.

Speakers and Topics
1. EM Radiation
John Norgard, University of Colorado, Colorado Springs, Colorado
2. Electrostatic Discharge
David Pommerenke, University of Missouri-Rolla, Missouri
3. EMI Troubleshooting
David Hockanson, Sun Microsystems, Menlo Park, California
4. EMC Case Histories
Lee Hill, SILENT Solutions, Amherst, New Hampshire
5. NARTE Overview and Exam Preparation
Brian Lawrence, NARTE Executive Director

Fundamentals and Applications of Antennas and Field Probes in Radiated Measurements

Format: Half-day Tutorial

Chair: Zhong Chen, ETS-Lindgren, Cedar Park, Texas

Abstract
This tutorial provides an introduction to antenna and probe theory and application relevant to EMC. This tutorial covers fundamental principles of operation for various common antenna and field probe configurations covering the frequency spectrum associated with EMC testing. The essential descriptive characteristics of antennas and probes are defined. The implications of the antenna characteristics on EMC testing are discussed including the nature and use of antenna factors, gain, radiation resistance, VSWR, etc. Applications of the antennas in radiated emissions and immunities tests, and radiated site validations measurements are covered. Processing and interpretation of antenna signals by receivers and analyzers are discussed including discussions of signal type, signal bandwidth, and filtering of signals. This tutorial will also provide the latest updates on ANSI and international standards on calibration of the antennas and applications of antennas in radiated emissions and immunities measurements.

Planned Speakers
1. Dr. Vince Rodriguez, ETS-Lindgren, Cedar Park, Texas
2. Mike Windler, Chairman of ANSI ASC C63 Subcommittee 1 (C63.4/C63.5), Underwriters Laboratories, Illinois
3. Zhong Chen, ETS-Lindgren, Cedar Park, Texas
4. Tom Holmes, Agilent Technologies, Ohio
5. Dr. Qin Yu, Lucent Technologies, Ohio

Electromagnetic Bandgap Structures for EMI/EMC Applications

Format: Half-day Tutorial

Chair: Omar Ramahi, University of Waterloo, Canada

Abstract

We will discuss the theoretical background behind Electromagnetic Bandgap structures with the intention to dispel any myths that prevent the common EMI/EMC practitioner from using this simple yet highly effective technology. We will discuss design rules and present simulation technique that assist the designer in extracting the full potential of EBG structures.

Planned Topics

- Electromagnetic Bandgap: Concept and Background
- Planar and non-planar EBG structures
- EBG for noise mitigation in boards
- EBG for noise mitigation in packages
- EBG for noise reduction of coupling between system components
- EBG: Design and Simulation

Planned Speakers

1. Omar M. Ramahi, University of Waterloo, Canada
2. Madhavan Swaminathan, Georgia Institute of Technology, Georgia

EMC in Modern Defense Systems

Format: Half-day Tutorial

Chair: Eli Recht, EL-OP Industry, Israel

Abstract

The EMC in defense systems has made major developments in recent years because of more sophisticated systems, high speed digital technology, developing advanced RF and electro optic sensors, and very high sensitivity systems together with harsh electromagnetic environment. This tutorial will describe the EMC design in modern defense platforms – airborne, ground, naval, and space. The tutorial will concentrate on various EMC design methodology and techniques from component level to system and platform level.

Planned Speakers

1. Eli Recht, EL-OP Industry, Israel
2. Vidi Bar-Natan, EL-OP Industry, Israel

International Advances in Site Validation Techniques and Related Activity Above 1 GHz

Format: Half-day Tutorial

Chairs:
Janet O'Neil, ETS-Lindgren, Seattle, Washington
Dr. Vince Rodriguez, ETS-Lindgren, Cedar Park, Texas

Abstract

For some time now, the American National Standards Institute (ANSI) Accredited Subcommittee (ASC) C63™ (Electromagnetic Compatibility) has had a working group in place tasked with developing new procedures for validating EMC test sites above 1 GHz. IEC/CISPR is addressing this topic as well as other associated topics such as measurement methods and test instrumentation in this frequency range. This tutorial is intended to bring a number of contributors together to detail the progress to date and look at options available for EMC testing at higher frequencies in the future. This tutorial will provide an introduction to the validation techniques that are likely to be required in the near future, as well as discussion of the difficulties likely to be faced, and will include the status of associated test instrumentation and measurement methods above 1 GHz. It is an ideal opportunity for attendees to obtain valuable information about upcoming requirements in an informal atmosphere.

Planned Topics and Speakers

1. EMC International Standards Update On Measurement, Test Instrumentation and Site Validation Associated With Radiated Emission Application Above 1 GHz, Including Related Activity in ANSI ASC C63™, and IEC/CISPR
   Don Heirman, Don HEIRMAN Consultants, New Jersey
2. Site Qualification above 1 GHz: A comparison of the CISPR Site Method and the ANSI Time-Domain Method
   Mike Windler, Underwriters Laboratories Inc., Illinois
3. Absorber Placement Requirements, Including a Summary of Specific CISPR/A Activity in this Area
   Werner Schaefer, Cisco, San Jose, California
4. Antenna Characteristics Above 1 GHz, Including a Review of Antenna Theory and the Importance of Pattern Information
   Vince Rodriguez, ETS-Lindgren, Cedar Park, Texas
5. Site Validation Above 1 GHz in Europe: Antenna Applications and Chamber Impact
   Alexander Kriz, Austrian Research Centers (ARC) GmbH, Austria

Design and Modeling Methods for Power Integrity

Format: Half-day Tutorial

Chair: Madhavan Swaminathan, Georgia Institute of Technology, Georgia

Abstract

The focus of this tutorial is on the design of advanced packages and systems with respect to signal integrity and power integrity. The emphasis will be on modeling and simulation methods for power delivery networks in semiconductor systems.

Planned Topics

- Trends in multi-core processors
- Target impedance
- Frequency range addressed by chip, package and board
- Chip – package resonance
- Embedded decoupling in package
- EMI issues with embedded communication devices
- Electronic bandgap (EBG) structures
- High-frequency materials characterization
- Frequency and time domain methods for modeling chip, package and board
- Modeling of non-ideal planes
- Modal decomposition
- Stability, passivity and causality
- Accurate modeling and simulation methods
- Linear and non-linear macro-modeling methods
- Applications such as multi-core processors, cellular, WLAN and ADC
- Near field and far field radiation

Planned Speakers

1. Dr. Ege Engin, Georgia Institute of Technology, Georgia
2. Madhavan Swaminathan, Georgia Institute of Technology, Georgia

Experiences in Crafting EMC Standards

Format: Half-day Tutorial

Chair: Qiubo Ye, IEEE EMC Society SETCom, Communications Research Centre, Canada

Abstract
This half-day tutorial aims to providing opportunities for those who would like to learn EMC standards. General knowledge will be given on the following standards for: methods of measurement of radio frequency power-line interference filter in the range of 100 Hz to 10 GHz, the broadband over power line, the assessment of human exposure to radio frequency electromagnetic fields from portable wireless devices, and next generation wireless and spectrum management.

Planned Topics and Speakers
1. A Tutorial on IEEE Standard 1560
   Kermit Phipps, EPRI PEAC Corporation, Knoxville, Tennessee
2. Introduction to the BPL Standards
   Ed Hare, W1RFI, ARRL Laboratory, Newington, Connecticut
3. IEEE Standards for the Assessment of Human Exposure to Radio Frequency Electromagnetic Fields from Portable Wireless Devices
   Mark Douglas, Motorola Labs, Ft. Lauderdale, Florida
   Wolfgang Kainz, Food and Drug Administration, Rockville, Maryland
4. A Tutorial on IEEE Standard 1900
   Stephen Berger, TEM Consulting, Georgetown, Texas
5. Standard Technique for the Shielding Effectiveness Measurement of "Small" Enclosure: the Ongoing Project P299.1
   Maria S. Sarto, University of Rome, "La Sapienza", Italy
6. Automotive EMC Standards in Europe and the U. S. A.
   Huadong Li, EMC Laboratory, Pioneer Automotive Technologies, Inc., Springboro, Ohio
7. EMC Standards in China
   Jinliang He, Tsinghua University, Beijing, China

SPECIAL TUTORIAL: IEC ACEC EMC Standards Tutorial
A Conversation with the IEC Advisory Committee on EMC
Format: 90-Minute Tutorial

Chair: Bill Radasky, Metatech Corporation, Goleta, California; Chairman of IEC ACEC

Abstract
Come and hear about the IEC EMC Standards. Worldwide leaders of the IEC (International Electrotechnical Commission) Advisory Committee on EMC (ACEC) will be holding a 90 minute tutorial on the work and goals of major IEC EMC standards committees. Not only will you hear what is happening but also you will have a chance to meet them and share your views and get their reactions. This will be a first such event at our EMC Symposium. We hope you all can come as this will start at the end of the afternoon workshops/tutorials on the second day of the symposium, and will not be in conflict with any parallel activity.

NARTE WORKSHOP, EXAMINATION AND EVENTS SCHEDULE AT EMC 2007

NARTE is pleased and privileged to support this 50th Anniversary of the IEEE EMC Society at EMC 2007. Please note that 2007 is also the 25th Anniversary of NARTE and we will be having a special presentation ceremony for our 25 longest standing EMC members at the Awards Luncheon on Thursday, July 12th. We hope that these long serving members will be present in person at this event.

Please make a note of the following important dates:

Sunday, July 8
The NARTE Examinations Preparation Tutorial will be included as a part of "The Fundamentals of EMC" Tutorial. This is a recommended Tutorial for all who plan to take the NARTE Certification Examinations at the end of EMC 2007, and all those who plan to attend The Global EMC University. At the Tutorial we will advise attendees as to the format of the two part examinations, we will discuss the best approach to ensure success and provide some working examples of typical exam questions.

Tuesday, July 10 to Thursday, July 12
NARTE will be at our usual Exhibition Booth each day. We invite all our members and anyone interested in learning more about NARTE and our Certification programs to come and visit us there. We can register you for the Saturday examination at our Booth if you have not previously registered. We will also have on display, and for purchase, books and CD's that may be used as Study Guides for the Examinations.

Thursday, July 12
NARTE will have a special presentation at the Awards Luncheon to recognize the 25 longest serving members of our EMC Certification Programs.

Saturday, July 14
The NARTE Certification Examinations will be held at the Hilton Hawaiian Village Hotel from 8:00 am to 5:00pm. We hope that many who attend the Global EMC University lectures during the week will validate their knowledge and experience by becoming a NARTE Certified Engineer or Technician. This is an ideal time and place to take the open book Examination element of our Certification Process. The Exams for EMC Engineer and EMC Technician will run concurrently. Each is a two-part paper, and each part is scheduled to run for four hours with an optional one hour break at lunchtime (lunch is on your own). Candidates may bring any reference materials and a PC to the examination room. We do not guarantee to provide wireless Internet access, but it may be used if available.

If you are looking for a reason to come to Hawai'i this year, then sign up for NARTE certification and take the examination at EMC 2007. Pass or fail, you will be assured of having a great experience.

www.narte.org

JOIN US FOR THE CONTINUED EDUCATION PROGRAM AT EMC 2007 July 8-13

EMC 2007
honolulu, hawaii

IEEE East meets West Through Education, Networking & Celebration

New for the EMC Symposium is the "Global EMC University"

Recognizing the need for low cost, high quality education on EMC, the Global University was developed to provide tutorials with Continuing Educational Unit credits. (CEU's) Nowhere else will one find these noted experts from all over the world in one place at one time for EMC Education at this level.

Registration Fee: $250.00 before May 14 and receive a FREE Global University Cap.

Registration after May 14: **$350.00**

Attendance is limited, sign up early
Registration to EMC 2007 is required
In addition to the GU Class Fee.


The Global EMC University

Clayton Paul, Mercer University
Flavio Canavero, Politecnico di Torino
Global EMC University Co-chairs

Monday, 9 July 2007 through Thursday, 12 July 2007
This dedicated track is devoted to those relatively new to EMC and includes a well-planned curriculum taught by world-renowned EMC experts. Nowhere else can one receive this level of EMC education from instructors all over the world in one place at one time. If you are new to EMC, this track is for you!

A certificate of completion will be provided to students who have signed in and signed out Monday through Thursday, thereby confirming 100% attendance at all lectures. CEUs will be assigned to this course.

Students of the Global EMC University are encouraged to attend The Fundamentals of EMC Tutorial on Sunday, 8 July as the material presented during this full day tutorial was designed to complement the Global EMC University curriculum.

Learning Objectives/Outcomes:
At the end of this sequence of lectures, the participant will:
(1) Understand and be able to use the PSPICE circuit analysis program in solving EMC problems;
(2) Be able to view the typical digital signals both in the time and the frequency domains, and will understand the relationship between the time-domain parameters and the spectral content of the signal;
(3) Understand the nonideal (parasitic effects) of components (wires and PCB lands, resistors, capacitors, inductors, ferrites, etc.);
(4) Understand how to redesign a power supply filter to reduce the conducted emissions of a product;
(5) Understand the basic properties of all antennas whether they be used for measurement of compliance or in immunity testing;
(6) Understand how radiated electromagnetic fields are produced in an electronic product and design methods that reduce those emissions;
(7) Understand how electromagnetic shielding is accomplished and the factors that affect those properties;
(8) Understand how to design high-speed digital circuit to preserve signal integrity;
(9) Understand crosstalk and the options that the designer has to control crosstalk;
(10)Understand the basic principles of proper PCB layout that controls radiated and conducted emissions.

GLOBAL EMC UNIVERSITY SCHEDULE

Sunday, 8 July 2007

8:30am to 5:30pm
The Fundamentals of EMC Tutorial
Multiple Speakers
Students of the Global EMC University are encouraged to attend The Fundamentals of EMC Tutorial held as part of the regular Symposium schedule. The material presented during this full day tutorial was designed to complement the Global EMC University curriculum below.

Monday, 9 July 2007

8:00am to 9:50am
Use of PSPICE in Solving EMC Problems
Instructor: Professor Clayton Paul
Outline: Download PSPICE, basic program preparation and coding rules, solving DC circuits, solving AC circuits using the phasor circuit analysis method (frequency response and filters), solving for the time-domain solution of circuits.

10:10am to 12:00pm
Signal Spectra
Instructor: Professor Flavio Canavero
Outline: Fourier series, computational techniques, digital signal spectra and the relation to time-domain parameters, using PSPICE to compute the Fourier series, processing of the series by linear systems.

1:00pm to 2:50pm
Nonideal Behavior of Components
Instructor: Professor Todd Hubing
Outline: High-frequency behavior of resistors, capacitors, inductors, ferrites.

3:10pm to 5:00pm
Conducted Emissions and Power Supply Filters
Instructor: Professor Mark A. Steffka
Outline: Brief review of the conducted emission regulatory requirements, the LISN, common-mode and differential-mode currents, analysis of typical power supply filters.

Tuesday, 10 July 2007

8:00am to 9:50am
Antennas
Instructor: Professor Andy Marvin
Outline: Review of electromagnetic waves (field structure, propagation velocity, power flow, relationship to constitutive parameters), general properties of antennas (gain, directivity, effective aperture, antenna factor, input impedance), Friis transmission formulas, multipath, Hertzian and loop dipoles, near-field/far-field criteria, practical dipole antennas, baluns, examples of common EMC antennas.

10:10am to 12:00pm
Radiated Emissions
Instructor: Professor Tom Jerse
Outline: Simple models for common-mode and differential-mode radiation.

Wednesday, 11 July 2007

8:00am to 9:50am
Shielding
Instructor: Professor Christos Christopoulos
Outline: Meaning and uses of shielding, quantitative evaluation of shielding, gasketing, effects and mitigation of apertures.

10:10am to 12:00pm
Transmission Lines and Signal Integrity
Instructor: Professor James Drewniak
Outline: Time- and frequency-domain solution of the transmission-line equations, use of PSPICE to provide solutions, effects of mismatch and when the line doesn't matter, series and parallel matching, series and parallel distribution, power distribution and decoupling, effects of losses.

Thursday, 12 July 2007

8:00am to 9:50am
Crosstalk
Instructor: Professor Antonio Orlandi
Outline: Models for electrically short lines (inductive and capacitive coupling), shielded wires and twisted pairs.

10:10am to 12:00pm
PCB Layout and System Configuration for EMC
Instructor: Professor Kye Yak See
Outline: PCB layout considerations vs. radiated emissions; correlation of ground bounce and radiated emissions; common mode on cables and its radiation.

NOTE: In order to take complete advantage of the presentations, attendees are strongly encouraged to BRING LAPTOP OR NOTEBOOK COMPUTERS TO THE SEMINAR.

Please note that full registration at the IEEE EMC Symposium is required in addition to the Global EMC University registration fee.

The additional fee for the Global EMC University is $250 USD if received by May 14 or $350 USD if received after this date. Attendance at the Global EMC University is limited to ensure interaction with the instructors. Please register early to reserve your space.

Thank you to the following exhibitors for your participation in the 2007 IEEE International Symposium on Electromagnetic Compatibility!

Company	Booth #
19th Int'l Zurich Symposium on EMC	208
2008 IEEE EMC Symposium	908; 910
3M Electronic Adhesives & Specialties	703; 705; 707
A.H. Systems	302; 304; 306
Advanced Test Equipment Rentals	802
Agilent Technologies	303; 305
Alion Science & Technology/R&B Laboratory	741
American Assoc. for Lab Accreditation/A2LA	435
American TCB	535
Amplifier Research	402 - 413
ANDRO Computational Solutions	822; 824
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EMC Solutions Ltd.	432
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EMS-Plus LLC	T-1
ETS-Lindgren	503 island
Ferroxcube USA	711
Fischer Custom Communications Inc	323, 325, 422, 424
Flomerics	811
Haefely EMC	634
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IEEE PSES Society	906
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Intermark (USA) Inc.	833; 835
Isodyne Inc.	214
ITEM Publications	609; 611
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Lambda Americas	840
Liberty Labs, Inc.	631; 633; 635
Mentor Graphics	702
Michigan Scientific Corp.	217
Milmega Ltd	630; 632
MuRata Electronics, Inc.	211
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NEC Informatec Systems	431; 433
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Noise Laboratory Co. Ltd.	316
Northwest EMC	307
NVLAP	340
Oak-Mitsui Technologies	222
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Pearson Electronics Inc.	629
PPM (Pulse Power & Measurement) Ltd.	625
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Seven Mountains Scientific Inc.	823
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Simlab Software GMBH	723
Solar Electronics Co.	228
Southwest Research Institute	534
Spectrum Control, Inc.	322
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Sypris Test & Measurement	709
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Taiyo Yuden USA, Inc.	324
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TUV Rheinland of N.A.	716
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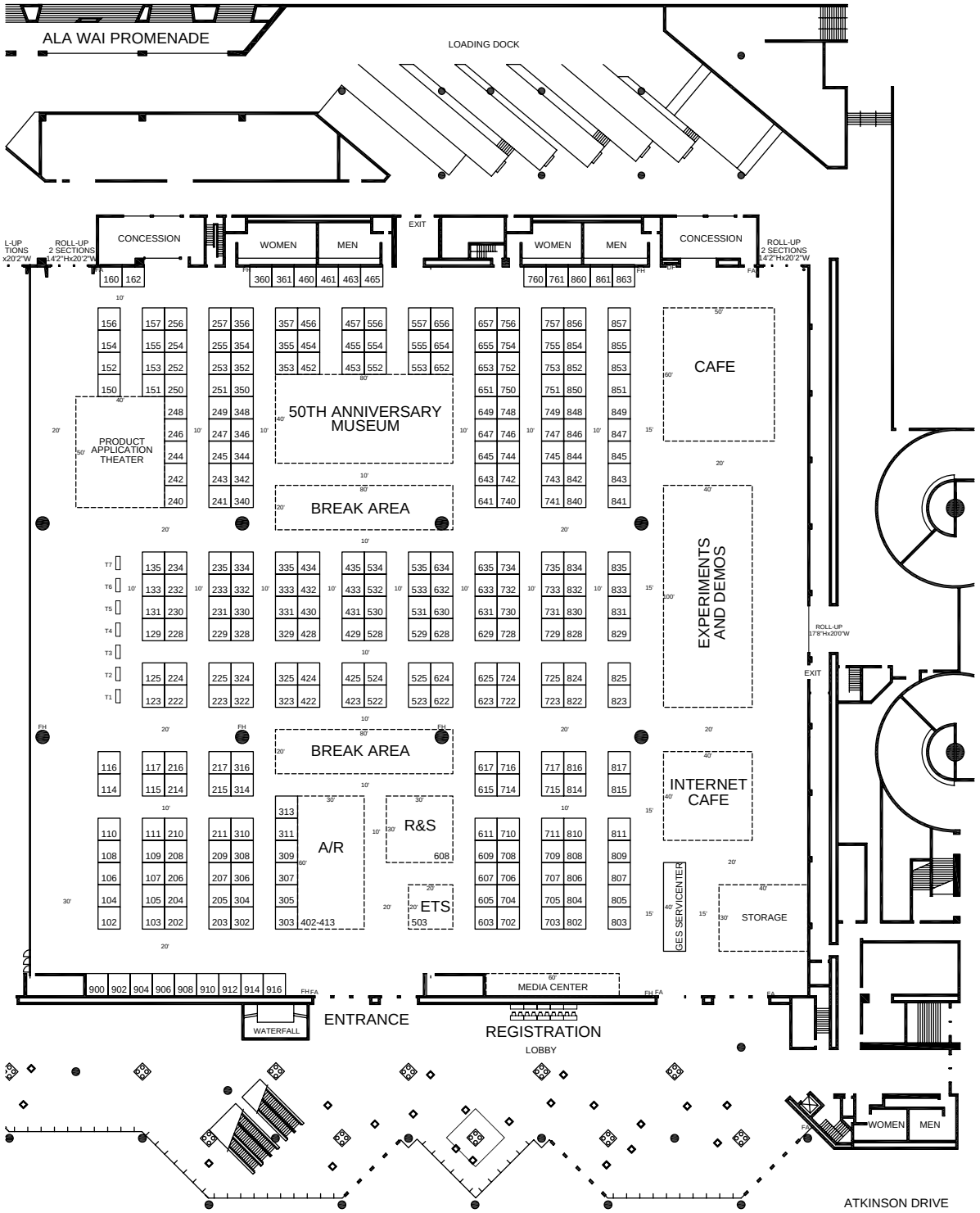
Underwriters Laboratories	308; 310
Vanguard Products Corp.	335
VCCI	817
Vishay Intertechnology, Inc.	607
W.L. Gore & Associates	215
WaveZero	530
Webcom Communications	T-2
Wyle Laboratories	334

Exhibtor listing is current as of 30 April 2007. Please see www.emc2007.org for updates to the exhibitor list.

IEEE EMC SYMPOSIUM

JULY 10-12, 2007



HAWAI'I CONVENTION CENTER
HONOLULU, HAWAII
EXHIBIT HALL LEVEL

ALL BOOTHS 10'x10' UNLESS OTHERWISE NOTED.

PLAN PREPARED BY:
GES
5560 Katella Avenue
Cypress, CA 90630
PH: 562-370-1500 FX: 562-370-1699
SUBJECT TO FIRE MARSHALL APPROVAL

M-9777	22-04054	04-18-06
	J.HAAS	07-19-06
	P.PIETROK	12-18-06
		12-20-06

SCALE
0' 5' 10' 15' 20' 30' 40' 50'

FE -FIRE EXTINGUISHER
FA- FIRE ALARM
FH -FIRE HOSE

EXHIBITORS

You are invited to take part in the 2007 IEEE International Symposium on Electromagnetic Compatibility from 8-13 July at the Hawai'i Convention Center. This symposium is your gateway to the emerging and dynamic markets in the Pacific Rim.

We are expecting record attendance at this symposium for several reasons:

- The technical program is targeting engineers new to EMC in the Pacific Rim where much EMC design work has in recent years been off-shored. They need the level of education that our symposium provides, the access to our industry experts, and the products and services our exhibitors' offer.
- The technical program features a record number of papers, special sessions, workshops, and tutorials. This response by authors has exceeded our expectations!
- It's the 50th anniversary of the founding of the EMC Society; many will want to attend to join in the unique celebrations planned.
- The vacation destination appeals to engineers and their families who will want to combine business and pleasure.
- Hawai'i is currently not that expensive, relatively speaking, for non-US citizens whose currency goes further than US dollars these days. With our assistance in travel planning and obtaining visas, travel to Hawai'i has never been easier or more affordable for European and Asian engineers.
- We've learned the tools to effectively cross-market EMC Society technical activity within its related IEEE Societies, such as Microwave Theory and Techniques, Vehicular Technology, Instrumentation and Measurements, Antennas and Propagation, and the like. We will reach new engineers who have a common interest in EMC and promote their attendance at our symposium

Join us in Hawai'i where "East Meets West" for Education, Networking and Celebration. Remember, this anniversary symposium was 50 years in the making! For more information, visit the EMC 2007 Symposium web site at www.emc2007.org.

CONNECTION PROGRAM ("PATRON PROGRAM")

Go beyond just being an exhibitor at the 2007 IEEE International Symposium on EMC. Take advantage of our Participant Connection Program to let our participants know that you're there and you care.

The program provides numerous opportunities for high-visibility marketing to the participants at the symposium. In addition, we will recognize those that take significant advantage of this opportunity to connect by having four levels of awards with corresponding announcements of appreciation for our outstanding benefactors.

Promotional opportunities are available for all marketing budgets, including:
Refrehment Break Sponors
Tuesday Welcome Reception Sponsors
Pocket Guide Sponsor
Shaved Hawaiian Ice Carts
Exhibit Hall Bingo
Overhead Aisle Banner Signage
Convention Bus Signage
Product Application Pavilion Patron
Internet Access
Paper Print Stations
Speaker Gifts
Final Program Ads

For More Information:
Sue Kingston
Phone: (310) 937-1006
Cell: (310) 699-2609
Email: s.kingston@ieee.org

ATTENTION SYMPOSIUM ATTENDEES!

VISIT THE EXHIBIT HALL AT EMC 2007 WHERE YOU'LL FIND:

World Class EMC Exhibits – Learning and Career Opportunities
You'll see large and small exhibits showcasing the latest developments in EMC products and services, staffed by friendly and knowledge people. You can also learn about related EMC organizations that can help you further your career including the IEEE EMC Society, NARTE, VCCI, American Association for Lab Accreditation/A2LA, American TCB and NVLAP booths, to name a few. Get involved in EMC standards and visit the IEEE EMC Society and American National Standards Institute (ANSI) C63™ booths. Expand your horizons by dropping by the booths of EMC trade publications, including Conformity Magazine, Microwave Journal, ITEM Publications, Test and Measurement World, and Webcom Communications, to name a few. Wear comfortable walking shoes to navigate over 100,000 sq. ft. of the exhibit hall.

Product Application Pavilions
Drop in on these informal presentations led by EMC exhibitors where you'll learn how to use a product, the nuances of instrumentation, and more. These sessions are designed to show you how to maximize the use of available equipment and techniques so you can do your job more confidently and efficiently.

EMC Museum
As part of the 50th Anniversary of the EMC Society, this display featuring items from the EMC Society archives and exhibitors will show you where we've been and just how far we've come in the science of EMC. From historic Stoddart receivers, to a collection of IEEE EMC Symposium proceedings covers, you'll be fascinated by today's connection to the last 50 years of the EMC Society. Ken Javor, a noted EMC technical expert, will also be giving live demonstrations of older EMI receivers and connecting their development with the development of EMI standards, both military and commercial. Also, in this area, Jerry Ramie will personally review the "History of the EMC Society", the power point presentation you've been hearing about. Jerry has been working on this for several years; come see the fabulous results of his efforts!

Demonstrations and Experiments
Several software and hardware demonstrations will be scheduled in the exhibit hall showing important EMC concepts and covering a wide range of elctromagnetic effects. These informal, practical sessions are always very well attended! See www.emc2007.org for the schedule of demonstrations and experiments along with their topic titles.

And, last but not least, come for the FOOD CONCESSIONS, BREAK AREAS, REFRESHMENTS, WIRED AND WIRED INTERNET ACCESS, RESTROOMS, and more…

50TH ANNIVERSARY OF THE IEEE EMC SOCIETY

Dan Hoolihan, Hoolihan EMC Consulting
50th Anniversary Committee Chair

The 50th Anniversary Celebration of the Electromagnetic Compatibility Society of the IEEE will take place throughout the 2007 IEEE EMC Symposium week in Hawai'i (8-13 July 2007).

A special exhibit will run in the Exhibit Hall of the Symposium at the Hawai'i Convention Center. This exhibit will have both live and passive displays of historic test equipment representing the last 50 years of Radio Frequency Interference and EMC Engineering technical development. The passive equipment display will feature Stoddart Receivers that will be explained and illustrated with verbal placards; there will also be an opportunity to "peek" inside the receivers and see the vacuum-tube construction. The live display will include actual demonstrations of NF-105 receivers and similar test equipment devices by a volunteer from the EMC Society of the IEEE. These historical exhibits will run from Tuesday through Thursday of the Symposium week.

We will also have special events during the week for the original Founders of the EMC Society. This will include a public session on Thursday morning in the Exhibit Hall, where the Founders will share stories of their experiences in the 1940s, 1950s and 1960s.

Poster displays of Past-Presidents and other past officers of the EMC Society will be on public display in the Exhibit Hall of the convention center. There will also be a power point presentation on the history of the EMC Society that will be narrated live by Jerry Ramie, the originator of the PP presentation.

An EMC booklet on the history of the EMC Society will be distributed to each attendee of the Symposium.

Additional mini-celebrations are planned throughout the week to highlight the 50th Anniversary of the EMC Society.

A unique 50th Anniversary Celebration will be held on Friday, 13 July, the final day of the EMC 2007 Symposium. It's a Hawaiian road trip, with the sights and sounds of beautiful Oahu as your companion! Join us for a scenic drive revealing some of the best sightseeing the island has to offer. The narrated coach tour includes the gorgeous Pali Cliffs in Nuuanu Valley, where King Kamehameha conquered the island of Oahu. Then it's on through the varied communities of Windward Oahu as you make your way to the northernmost part of the island.

A Cocktail Reception and Luncheon honoring the Original Founders and Past Presidents of the EMC Society will be served at the Turtle Bay Resort on the Northern Shores of Oahu. Also honored will be the Most Influential Papers presented since the founding of the EMC Society plus some honorary awards for unique contributions to the Society.

On your return trip to Waikiki, view the world-famous North Shore surfing beaches at Sunset, Pipeline and Waimea Bay. In colorful contrast to the brilliant blue of the crystalline waters, you'll also find emerald oceans of shimmering pineapple and sugar cane fields waving gently in the breeze. Take a glimpse into the Hawai'i of long ago as you pass remnants of old homesteads. Be sure to bring your camera to record the marvels that gave Hawai'i its name and reputation as Paradise.

This EMC Society 50th Anniversary Celebration is open to all members and acquaintances that register for it.

One ticket for the EMC Society 50th Anniversary Celebration Luncheon & Island Tour on Friday, 13 July, is included with Full Conference Registrations. A separate ticket purchase is required with One Day Registrations and Guest Registrations. Ticket purchase on site during the Symposium is subject to space availability. Attendance is not recommended for children under the age of 8.

Pristine Kawela Bay near the Turtle Bay Resort. You'll want to walk on this beach before the Anniversary celebration begins!

The lush lawn of the Turtle Bay Resort where the EMC Society will hold its 50th Anniversary celebration on July 13.

PHOTOS COURTESY OF TURTLE BAY RESORT

2007 Chapter's Retreat

Invitation to the IEEE EMC Chapter's Retreat

July 9th, 2007, 9:00 AM – 4:00 PM

Hawai'i Convention Center – Honolulu, Hawaii USA

Dear Chapter Chairperson,

The IEEE EMC Society is pleased to wholeheartedly extend an invitation to all IEEE EMC Chapters to attend the **Chapter Chair Retreat** (meeting) taking place in Honolulu, Hawaii.

The one day Retreat will be held in conjunction with the 2007 IEEE EMC Symposium in Honolulu, Hawaii, http://www.emc2007.org/, held from Sunday, July 8, to Friday, July 13, 2007 at the Hawai'i Convention Center, Honolulu, Hawaii.

Goals

The main objective of the Chapter Chair Retreat is the exchange of information between the chapter chairpersons and the EMCS Global and Regional officers (e.g. VP for Member Services, Regional Membership and Chapter Coordinator, Regional Conference Coordinator). More active chapters could assist less active chapters by exchanging their experiences, knowledge as well as methods about developing a chapter and organizing events. From the regional point of view the chapter chair meeting is a forum to discuss recent problems and plans between chairpersons and regional officers.

EMCS VP for Member Services
Dave Staggs
d.staggs@ieee.org

Symposium Chairman
Janet O'Neil
j.n.oneil@ieee.org

EMCS Chapter Coordinator
Francesca Maradei
fr.maradei@ieee.org

Regions 1-7 Conference Coordinator
Janet O'Neil
j.n.oneil@ieee.org

We plan to start with presentations made by the EMCS Board of Director Officers and Membership/Chapter Coordinators followed by short presentations by the Chapter Officers on the activities and best practices in their chapters.

Planned Topics include:

- Exchange of information
- Administrative information for Chapter Chairs
- Membership development at the Chapter Level
- Global development of EMCS and particularly in Regions 1-7
- Regional Events (discussion of proposal, planning of Regional Workshops and Conferences on EMC, and coordination of global, regional and local events)
- Cooperation between chapters
- Chapter Best Practices Presentation (by Chapter Representatives)

Please, prepare a short presentation (2-3 Power Point slides) of your chapter status, activities and top 5 best practices. You will be given time to present your chapter to the attendees at the retreat.

Summary

Following the success of the previous retreat held in Region 8 and 9, we are certain that this Retreat will be of great value to you and your Chapter. Therefore, we recommend that you and/or a representative of your chapter attend the meeting.

Kindly confirm your participation to the IEEE EMC Chapter Coordinator Francesca Maradei at: fr.maradei@ieee.org and a copy to Dave Staggs, VP for Member Services at d.staggs@ieee.org, **no later than June 20, 2007**.

We look forward to welcoming you in Honolulu.

Best wishes,
Francesca Maradei and Janet O'Neil

Mark your Calendar: Date and Venue of the Retreat

Venue: **Hawai'i Convention Center – Honolulu, Hawaii USA**
Date: **July 9th, 2007, 9:00 AM – 4:00 PM**

SOCIAL ACTIVITIES

WELCOME RECEPTION

Hilton Hawaiian Village Beach Resort & Spa
Rooftop Garden
Tuesday, July 10, 2007
6:30pm to 8:30pm

Aloha and welcome to EMC 2007! The Symposium Steering Committee invites attendees to join old friends and make new acquaintances during an evening of refreshments amidst spectacular views of the ocean and Honolulu skyline at sunset. This event has proven to be very popular and is an excellent way to meet and network with others from the EMC community. The tropical sun sets late in July, so be sure to wear your best sun hat. We will be awarding fun prizes for the best hats.

One ticket for this event is included with Full Conference Registrations and Guest Registrations. Separate registration is required with One Day Registrations.

GALA EVENT

TRADITIONAL HAWAIIAN LUAU
Royal Hawaiian Hotel
Wednesday, July 11, 2007
6:30pm to 10:30pm

Join your fellow attendees and their companions for an unforgettable evening! With a backdrop of Diamond Head and Waikiki Beach, your evening begins with Hawaiian melodies and refreshing Mai Tais or Luau Punch in the Coconut Grove, where each guest is greeted with a lei. The evening continues with a feast of foods from the Islands. The crowning glory is the spectacular Royal Polynesian Extravaganza. Everyone is sure to enjoy the song and dance of the islands as well as those from other Pacific Rim locations that have influenced the unique culture found only in Hawai'i. (See photos on this page.)

One ticket for this gala event is included with Full Conference Registrations. A ticket purchase is required with One Day Registrations and Guest Registrations. Ticket purchase on site during the Symposium is subject to space availability. Attendance is not recommended for children under the age of 8.

AWARDS LUNCHEON

Hawai'i Convention Center
Thursday, July 12, 2007
1:00pm to 2:30pm

Please join us as contributors to the IEEE EMC Society are honored and the 2007 Best Paper Award winner is announced.

EMC 2007 GUEST HOSPITALITY SUITE

Aloha! We are glad that you plan to join us in lovely Honolulu, Hawai'i.

As a fully registered EMC 2007 Guest, you are welcome to visit the EMC 2007 Guest Hospitality Suite located at the Hilton Hawaiian Village Hotel.

As a fully paid registered EMC 2007 Guest, your registration packet should include a color-coded name badge that will allow you access to the suite and entitles you to receipt of a companion gift bag. The bags this year will help to make your beach experience more enjoyable. We have great canvas navy floral print bags with a zipper closure and a side zip pocket. The smaller matching two-zipper pouch is perfect for credit cards, keys, driver's license, and small items if you want to travel light. The bag contains a beach towel in multiple tropical colors for drying off as well as sunscreen and lip balm, which are essential in the tropics. To sustain you on your jog to the beach, also included are coffee and chocolate!

EMC 2007 Registered Guests are welcome to enjoy an extended complimentary continental breakfast to start each day. There will be a "Destination Management Consultant" available in the suite to sign you up for the complimentary tours offered each day to Hilo Hattie's or Maui Divers.

As a fully paid EMC 2007 Registered Guest, come and enjoy the EMC 2007 Guest Hospitality Suite, Sunday through Thursday, 7:00am to 12:00 noon.

CHILDREN'S WORKSHOP

Boys and girls, join us in building "Crazy Dune Buggies" at the EMC 2007 Children's Workshop on Tuesday, July 10, and Wednesday, July 11. All kits will be prepared individually with everything you will need to build your project. We will learn the importance of building them precisely as well as how important it is to troubleshoot beforehand in order for them to hold up for the duration of their race in the sand on Thursday, July 12. We will be decorating our individual dune buggies so we will be able to recognize them in the race.

On Thursday, July 12, we will again be visiting selected booths on the exhibit floor where exhibitors will explain in layman's terms what the symposium is really all about.

We're looking forward to seeing all of our returning little engineers who outdid themselves last year in making the boat and the race so successful on Lake EMC in Portland.

Registration for this event is included with Junior Guest Registrations. Registration on site during the Symposium is subject to space availability.

PHOTOS COURTESY OF ROYAL HAWAIIAN HOTEL

TOURS

The IEEE EMC 2007 Symposium is pleased to offer the following tours during this year's symposium. Please sign-up for these tours (except for complimentary tours listed on pae 60) when registering for this year's symposium. (Pre-registration and pre-payment are required for optional tours. Registration on site during the Symposium is subject to space availability.)

Sunday, July 8, 2007

Grand Circle Island with Dole Plantation

Price:	$67.00 US per adult
Departs	8:15a.m.
Returns	5:30p.m.
Minimum requirement:	40 passengers

Get to know Hawai'i from the inside out with an all-day tour that circles the entire island, covering 120 miles of O'ahu's best sightseeing spots. For a close-up view of a seawater eruption, you'll visit Hawai'i's own Old Faithful known as the "Blow Hole", where you'll witness oceanside water play at full-force. Besides Sandy Beach — a favorite for body surfers — you'll venture to the most celebrated surfing zones in the world along the North Shore: Waimea Bay, Sunset Beach and the spectacular Banzai Pipeline. At Dole Plantation you will ride the pineapple express train and learn about the history of Hawai'i's pineapple industry. You may choose between a stroll through plantation gardens or test your skill at the pineapple garden maze. In colorful contrast to the brilliant blue of the crystalline waters, you'll also find emerald oceans of shimmering pineapple and sugar cane fields waving gently in the breeze. Take a glimpse into the Hawai'i of long ago as you pass remnants of old homesteads on your return to Waikiki. Be sure to bring your camera to record the marvels that gave Hawai'i its name and reputation as Paradise.

A non-hosted lunch stop will be made at historic Crouching Lion Restaurant. Located on the slopes of Ka'a'awa, you will experience the warm feeling of Hawai'i hospitality, while enjoying an extensive lunch menu that includes seafood, beef dishes, sandwiches, and salads. Surrounded by expansive ocean views this traditional Hawaiian restaurant lives up to its "landmark" status. (Pre-registration and pre-payment are required for optional tours. Registration on site at the Symposium is subject to space availability.)

NOTES:
A stop will be made at the Crouching Lion Restaurant for lunch, but the cost of lunch is not included.

There is no charge for children under age 4, provided they do not occupy a seat in the vehicle.

Monday, July 9, 2007

Stars and Stripes

Price:	$60.75 US per adult
Departs	7:30a.m.
Returns	4:00p.m.
Minimum requirement:	40 passengers

Celebrate the honor, valor and courage of the U.S. Servicemen who served during World War II on this special Stars and Stripes tour. It's a nostalgic journey to the two historic places that marked the beginning and end of the war for the United States – Pearl Harbor and the USS Missouri.

At the site of Pearl Harbor, you'll view the Arizona Memorial where the remains of the USS Arizona lay silent beneath the waves. The events of the 1941 attack on Pearl Harbor unfold through detailed narrations and photos. While at Pearl Harbor, you'll travel across the Ford Island Bridge to the historic USS Missouri battleship, otherwise known as the "Mighty Mo". It was on the decks of this celebrated warship that the Japanese surrender ceremony took place, signaling the end of their involvement in World War II. Explore the passages, rooms and corridors on a special guided tour.

From Pearl Harbor, you'll take a drive through metropolitan Honolulu and up to the Punchbowl Crater for a personal guided tour by the American Legion of the National Cemetery of the Pacific. After enjoying the serenity and spectacular view atop Punchbowl, you'll wind through Downtown Honolulu for a view of its many highlights. (Pre-registration and pre-payment are required for optional tours. Registration on site during the Symposium is subject to space availability.)

NOTES:
Lunch on own at the snack bar on the ship.
No backpacks, fanny packs, or bags permitted.
We recommend wearing good walking shoes and don't forget your camera.

Tuesday, July 10, 2007

Honolulu Hidden Treasures

Price:	$63.00 US per adult
Departs	8:30a.m.
Returns	12:30p.m.
Minimum requirement:	21 passengers

Learn about Honolulu's most interesting historic sites, see an amazing collection of rainforest and tropical plants, and relax by hidden waterfalls on this professionally guided and narrated tour. Start the day with exquisite panoramic views of Diamond Head, Waikiki, Honolulu, and the southwest coast of Oahu as we travel up into the Ko'olau Mountains to famous Mount Tantalus. We'll pause at a breathtaking overlook to take in the vista from this unique vantage point. An excellent place to take a memorable photo! We'll also learn about the rainforest plants in the park, and look for the vibrant yellow Oahu Amakihi, a rare and endangered Hawaiian honeycreeper bird species.

From there we will take a step back in time as we visit the Royal Mausoleum and learn about the Hawaiian monarchy. A short walk takes us next to misty Kapena falls, where you will view ancient Hawaiian petroglyphs (rock carvings) near the bank of Alapena pool, and learn the legend of Kaupe, the ancient guardian spirit that is said to protect travelers at this unique place.

We venture next to Queen Liliuokalani Botanic Garden, where you will learn about endemic Hawaii an plant species on the grounds of this former Hawaiian Monarch's home near a scenic waterfall. Our next stop is Foster Botanical Garden, where your professional naturalist guide will describe the unique tropical plants such as cacao, pepper, cinnamon and allspice trees. See the famous Foster orchid collection, as well as the "Bo Tree", grown from a cutting of the original tree planted in India 800 years ago by the first Dalai Lama. Our guides have trained with the docents of this famous garden, and will provide an unsurpassed narrative.

Finally, you'll relax and enjoy a visit to Iolani Palace grounds, where you will marvel at one of the world's largest Banyan trees while learning more about the Hawaiian monarchy and the history of the only royal palace in the United States. See the King Kamehameha Statue, the Hawai'i State Capital, and historic Honolulu sights along the way.

This tour requires no hiking, is accessible for all skill levels, and is a great way to experience Oahu's world famous botanical gardens, Honolulu's most significant historic sites, and scenic waterfalls all in one day. (Pre-registration and pre-payment are required for optional tours. Registration on site during the Symposium is subject to space availability.)

NOTES:
Fitness/Hiking Level (easy).
Distance is approximately 1.5 miles (total walking distance).
Shoes may get wet, depending on the weather.
Participants should be in overall good health.
Guests should wear comfortable, but sturdy footwear (Flip Flops are not recommended).
No valuables other than those that fit in your daypack.

Wednesday, July 11, 2007

Shangri-la Tour

Price:	$62.00 US per adult
Tour 1	
Departs	7:30a.m.
Returns	11:30a.m.
Tour 2	
Departs	10:00a.m.
Returns	2:00p.m.
Minimum requirement:	24 passengers



There is a limit of 25 guests per tour. A third tour may be possible if needed.

Fiercely independent, rich beyond avarice, an international celebrity and socialite, activist and philanthropist, Miss Doris Duke, one of the wealthiest people in history was certainly a force to be reckoned with! Unbeknownst to the world, Miss Duke inconspicuously created a veritable palace of treasures on the southern shore of O'ahu. Shangri-La, Miss Duke's Honolulu estate, is now open to our group exclusively for a glimpse into the life of this extremely remarkable, private and fascinating individual.

During her round-the-world honeymoon after marrying would be Senator James "Jimmy" Cromwell, Miss Duke fell in love with the gentle people and tropical haven of Hawai'i. Vowing to return and make a home in the islands, Miss Duke acquired nearly five acres on Diamond Head's south shore where her dream home would be built. Although her marriage to Mr. Cromwell did not last, Miss Duke created Shangri-La on this site and embarked on a 60-year journey of collecting what would become the largest private collection of Islamic art in the world.


Upon her death in 1993, Miss Duke's last will and testament called for the creation of the Doris Duke Foundation for Islamic Art. As her collection grew during her lifetime, Miss Duke realized that these treasures must forever remain intact as a collection and serve to educate the public in the manner in which she so diligently displayed them on the grounds of her lush estate.

Our guests will begin their journey at the Honolulu Academy of the Arts where they will be shown an orientation video of the Shangri-La residence and get a first peak at the treasures housed on property. From there, guests will be escorted via minicoach to Diamond Head's exclusive Black Point district, location of the estate. Upon completion of the tour, guests will then be returned to the Honolulu Academy of the Arts where they may experience the museum's revolving collection at their leisure. (Pre-registration and pre-payment are required for optional tours. Registration on site during the Symposium is subject to space availability.)

NOTES:
Children under 12 not permitted.
Picture taking is not allowed inside the estate.
Secured bins are available at the estate for handbags. We do not recommend bringing large bags or valuables.

Thursday, July 12, 2007

Honolulu City Iolani Palace and Queen Emma's Summer Home

Price:	$68.00 US per adult
Departs	8:30a.m.
Returns	1:00p.m.
Minimum requirement:	20 passengers

Besides being a tropical centerpiece of natural beauty, O'ahu holds the most cosmopolitan flavor of all the Hawaiian Islands. Ranging from old Chinatown to the modern business district, you'll discover a side of Hawai'i rich with cultural and historical significance. Stop for one hour at the majestic Iolani Palace and a docent-guided tour of this incredible structure. You'll see the distinctive State Capital Building, Aloha Tower down by the pier, the serene University of Hawai'i grounds, and Punchbowl, the National Cemetery of the Pacific. A brief journey to the lush Nu'uanu valley brings you to the former home of Queen Emma, consort of King Kamehameha IV. This New England-style house was constructed on the East Coast, transported around Cape Horn by ship, and assembled in its present location in 1848. The verdant garden of tropical flowers is worth a stroll to take in the marvelous views and aromatic landscape. This tour is a terrific way to get a well-rounded idea of all the marvels modern O'ahu offers. (Pre-registration and pre-payment are required for optional tours. Registration on site during the Symposium is subject to space availability.)

Complimentary Activities

The Store of Hawai'i - Hilo Hattie

Sign up for this activity in the EMC 2007 Guest Hospitality Suite

(Open Sunday through Thursday from 7:00am to 12:00pm at the Hilton Hawai'ian Village)

Hilo Hattie is Hawai'i 's largest chain of Hawaiian stores. Shoppers discover Hawai'i's largest selection of Hawaiian fashions, gifts, gourmet foods, souvenirs, T-shirts, home accessories, beauty products and island jewelry. Hilo Hattie is also the world's largest manufacturer of Hawaiian resort and casual fashions, offering hundreds of prints and styles only found at Hilo Hattie. Shoppers enjoy low manufacturers direct prices on thousands of Hawaiian products. Recently, Hilo Hattie was awarded the prestigious Kahili Award by the Hawai'i Visitors Bureau as "The Best Retailer in Hawai'i" and "The Best Attraction in Hawai'i". Volume discounts are available on uniforms, VIP gifts, gift baskets, customized T-shirts and VIP amenities. Hawaiian Shirt Shacks are also available in which Hilo Hattie will take garments to the hotels for group check-ins.

Maui Divers Jewelry Design Center

Sign up for this activity in the EMC 2007 Guest Hospitality Suite

(Open Sunday through Thursday from 7:00am to 12:00pm at the Hilton Hawaiian Village)

You don't need to be an experienced diver to discover Hawai'i's rarest deep ocean treasures. Maui Divers will reveal them for you in an unforgettable half-hour tour. Fresh from an underwater grove, you'll see how Hawai'i's enchanting State Gemstone — Black Coral, is turned into a master jewelry designer's work of art. Experience close-up how artisans create numerous fine pieces by hand, and how stunningly beautiful native Hawaiian jewelry settings can be.

Holoholo Ka'a (to go for a drive or a ride)

In addition to the pre- and post-conference activities, the island of Oahu offers a wealth of activities that will create indelible memories. Take a surfing lesson on Waikiki Beach. Watch a dolphin show at Sea Life Park. See 350 species of aquatic animals and plants at the Waikiki Aquarium. Learn about Hawaiian history at the Bishop Museum. Take a drive to Haleiwa and the North Shore. Hike to Makapu'u Lighthouse on the South Shore. Eat a plate lunch and malasadas in Kapahulu. See Hawai'i's largest collection of fine arts at the Honolulu Academy of Arts. Seek tranquility at the Byodo-In temple, a meticulous replica of a 900-year old Japanese Temple. Your hotel concierge will be happy to assist you with information and arrangements.

PHOTO COURTESY OFHAWAII CONVENTION & VISITORS BUREAU

PHOTO COURTESY OFHAWAII CONVENTION & VISITORS BUREAU

ACCOMMODATIONS

Hilton Hawaiian Village Beach Resort & Spa

2005 Kalia Road
Honolulu, HI 96815-1999
Phone: (808) 949-4321
Toll Free: 1-800-HILTONS
www.hiltonhawaiianvillage.com

Conference Rates:
Garden View $189 US
Partial Ocean View $205 US
Ocean View $219 US
Government 2007 Prevailing rate

Hilton Hawaian Village® Beach Resort & Spa is Waikiki's only true resort destination, offering the perfect mix of exceptional resort accommodations and classic Hawaiian hospitality, all nestled on 22 beachfront acres. Imagine the widest stretch of white sand on Waikiki, a serene beachfront lagoon, lush tropical gardens with exotic wildlife and cascading waterfalls, majestic views of Diamond Head and stunning seaside sunsets. Discover 90 shops and boutiques and a diverse, international selection of restaurants. The resort's beachfront Super Pool is the largest on the island, and on Friday night it becomes the stage for a celebration of Hawaiian culture and entertainment, ending with a spectacular fireworks show! The Hilton Hawaiian Village is Oahu's most prestigious and productive place to mix business and pleasure.

For the convenience of the EMC 2007 conference attendees, a block of sleeping rooms have been reserved for attendees at the Hilton Hawaiian Village's Tapa Tower in Honolulu, Hawai'i. Accommodations may be booked directly through the Hilton 808-949-4321 (direct) or Toll Free 1-800-HILTONS. Hotel reservation deadline for these rates is June 10, 2007, OR when the IEEE contracted room block is sold out. Make your reservations early!!!

The conference rates are subject to applicable state and local taxes (currently 11.41%) and are based on single or double occupancy. There will be a $45 US per person per night charge for each third and fourth adult in the room. Children 18 years of age and under, when sharing the room with a parent, will not be charged when utilizing existing bedding.

The conference rates are available for the dates of 4 July through 14 July 2007 based on availability. When making hotel reservations, please refer to the IEEE EMC Conference to receive the discounted rate. Reservations must be made by 10 June 2007 to ensure the conference rate.

The Hotel requires a one-night deposit in advance to accompany the reservation either in the form of a credit card or check. Guaranteed reservations are held until 6:00am the following morning, at which time the reservation and deposit are forfeited.

In the event a guest who has a confirmed room check outs prior to the reserved checkout date, the Hotel will add an early checkout fee of $50 US to that guest's account.

Reservation cancellations must be received 72 hours prior to the scheduled arrival date. If notice is not received by that time, the deposit will be forfeited or the credit card will be charged a one night's stay.

Requests for accommodations received after the deadline will be accepted on a space available basis at the prevailing rate. Reservation requests for specific room types, views and bedding are subject to availability at the time of arrival and are not guaranteed.

Attention Families: The Hotel has dedicated children's programs and babysitting services. Check the hotel web site at www.hiltonhawaiianvillage.com for more information.

Ala Moana Hotel

410 Atkinson Drive
Honolulu, Hawai'i 96814
Phone: 808-955-4811
http://www.alamoanahotel.com

EMC 2007 CONFERENCE RATE: $169 US

The all-new Ala Moana Hotel is the definitive Honolulu address for urban relaxation. A multi-million dollar transformation reveals a stunning hotel with a contemporary character and island-style appeal.

Deluxe guest rooms reflect the cool colors of paradise and warm hues of refined hospitality. Casually sophisticated and comfortably appointed for business or leisure, you'll find mountain and ocean views enhanced by the rhythms of the city, splendid sunsets, and the pleasure of your surroundings.

Five diverse restaurants, Honolulu's popular Rumours nightclub, a spacious new sundeck with poolside cocktail bar, and an impressive fitness center provide guests with desired amenities.

Adjoining the world-class Ala Moana Shopping Center, it's a pleasant stroll to over 260 retailers showcasing the finest names in fashion and a delightful array of dining. The Hawai'i Convention Center is a conveniently located just step away, and when business is done, the 76-acre Ala Moana Beach Park welcomes swimming, surfing, and day-dreaming in a shady setting by the sea.

GENERAL INFORMATION

Symposium Venue

The spirit of the Hawai'i Convention Center is the spirit of Aloha – welcoming and serving all who visit the Center with unconditional Aloha. The Hawai'i Convention Center combines the modern requirements of a state-of-the-art meeting facility with the beauty, comfort and culture that are uniquely Hawai'i. Soaring forms and breathtaking space call to mind tropical palm trees and Polynesian sailing canoes. The design of the glass-front center represents the unique culture of Hawai'i, with its bold architecture, $2 million Hawaiian art collection, and features such as a rooftop tropical garden, glass-encased meeting rooms and outdoor function spaces lined with giant palm trees. All EMC 2007 workshops, tutorials, technical sessions and the exhibition will be held at the Hawai'i Convention Center, along with many committee meetings. Please check the symposium website and the final program for an updated list of EMC 2007 events and locations.

Shuttle busses will run between the host hotel — the Hilton Hawaiian Village Beach Resort & Spa — and the Hawai'i Convention Center throughout the symposium week. The Ala Moana Hotel is just a short walk away.

Demonstrations and Experiments: Now in Its 15th Consecutive Year!

The EMC 2007 Technical Program also includes hands on demonstrations and experiments. Several software and hardware demonstrations will be scheduled in the exhibit hall during exhibit hours at the Hawai'i Convention Center over July 10-12. The hardware experiments are devoted to demonstrating important EMC concepts through a series of interactive experiments. The experiments cover a wide range of electromagnetic effects. This year's experiments will include measurement automation, the use of RF field probes, reverberation chamber techniques, TEM cells, ESD and time domain techniques. In the software demonstrations, fundamental EMC modeling approaches and simulation methods are illustrated through a series of interactive computer demonstrations. Various computational electromagnetic (CEM) modeling techniques will be demonstrated illustrating their application to both well defined canonical-type problems and real world EMC problems in order to show specifically how these techniques can be applied. These informal, practical sessions are always very well attended! Please see www.emc2007.org and/or the final program for a schedule of demonstrations and experiments along with their topic titles.

RAC/SACCom Lunch

The annual luncheon of the Representative Advisory Committee and the Standards Advisory and Coordinating Committee will be held on Monday, July 9 from 11:00am to 2:00pm at the Hawai'i Convention Center. Those interested in attending should contact RAC Chair Fred Heather (heatherf@ieee.org) or SACCom Chair Dave Guzman (dguzman@rftek.net) by July 1. Advance reservations are required!

History Luncheon

The EMC Society History Committee will host a luncheon on Wednesday, July 11 at noon. This year the committee will honor six of the original founders of the EMC Society at the luncheon, which will include invited students, Board of Directors members, and other distinguished guests. Attendance is by invitation only; please contact Dan Hoolihan for more information at d.hoolihan@ieee.org.

Chapter Chair Luncheon

The annual Chapter Chair Luncheon will not take place this year. Instead, the Chapter Retreat will be held on Monday, July 9. For more information, please see the invitation on the retreat included in this program on page 56.

Internet Access

Complimentary wired Internet access will be available at the Internet Café stations in the Exhibit Hall at the Hawai'i Convention Center. In addition, complimentary wireless Internet access will also be available throughout the Exhibit Hall.

Message Center Information

This will be located next to the registration desk at the Hawai'i Convention Center. Details will be provided in the final program. Contact April Coles at a.coles@ieee.org for more information.

Speaker Ready Room

The speaker ready room at the Hawai'i Convention Center will be open from 7:00am – 5:00pm Sunday through Thursday of the symposium week. Speakers will have various audio visual aids available for assistance in preparing and fine tuning their presentations.

Speakers Breakfast

A speakers breakfast will be held for all speakers and session chairs from 7:00am-8:00am at the Hawai'i Convention Center from Sunday through Thursday. The objective of the breakfast is to review planning for the individual session(s) as well as allow speakers and session chairs to get to know each other. All speakers and session chairs are required to attend the breakfast on the day of their presentation to ensure a seamless transition of speakers, correct pronunciation of presenter names, correct bio information is relayed, and coaching on the question and answer period is provided, thus resulting in a professional, well-organized session.

Exhibitors Breakfast

All exhibitors are invited to attend this annual breakfast buffet on Thursday, July 12 from 7:00am to 8:00am at the Hawai'i Convention Center. Chaired by Barry Wallen, the EMC Society VP for Conferences, this breakfast provides a forum for exhibitors and the Society to exchange best practices and ideas for improving the exhibitor experience at the annual Symposium. Attendees will hear plans for the future IEEE EMC Symposia as well as receive the registration facts and summary of EMC 2007 activity.

Student Activities

The EMC Society Education and Student Activities Committee (ESAC) sponsors many activities during the annual IEEE EMC Symposium, including the Fundamentals of EMC Tutorial, Experiments and Demonstrations, Student Paper Contest, Student Design Contest, Beranek Travel Awards, and the University Grant Award. Stop by the ESAC table at the Symposium to learn more about the activities and opportunities the EMC Society offers for students. There will be a limited number of EMC Society Experiment

CDs available for faculty members, IEEE Section Chairs and EMC Chapter Chairs. This CD includes three EMC experiments that were filmed at previous Symposia and features Jasper Goedbloed, Douglas Smith and Clayton Paul sharing some interesting insights. (available while supplies last). Contact the ESAC Chair, Professor Robert Nelson, for more information at r.m.nelson@ieee.org.

Committee Meetings

Many committee meetings will be held during the Symposium week at the Hawai'i Convention Center. These will typically be held from 7:00am-8:30am and include the annual meetings of the EMC Society Technical and Standards Committees. Please visit the website www.emc2007.org for the schedule of committee meetings scheduled during the Symposium. Most meetings are open to guests who are interested in the meeting topic. For a list of the EMC Society Technical and Standards Committees and contact information, please see page 67 in this program. If you wish to hold a committee meeting at EMC 2007, reservations for rooms must be made in advance; the latest acceptable date is June 10, 2007. Please contact April Coles at IEEE Conference Management Services at a.coles@ieee.org for more information on scheduling a meeting room.

IEEE Press

IEEE Press will staff a large booth near the registration desk at the Hawai'i Convention Center. This is an opportunity to browse many interesting books on EMC and related topics. You might just find an author of one of the books nearby which you can ask to personally autograph your copy, if the timing is right! Credit cards accepted.

RELATED INDUSTRY ACTIVITY

EMC Aviators Club

EMC Society members Andy Marvin and Antonio Orlandi recently formed the NEW EMC Aviators Club. To be part of the Club, one should be involved in EMC, have a pilot's license (power or gliding) and a wish to share one's adventures and pictures with others. You can use the club web site http://orlandi.ing.univaq.it/EMCfly/index.htm to post photos or links to your own sites. You can arrange to share flights with other EMC people when traveling to meetings or conferences. They will arrange informal meetings at the main EMC conferences, probably over lunch or an evening with beer or wine. There is no membership fee. Simply send your profile details and any pictures (please use standard and efficient file formats) to Antonio Orlandi at orlandi@ing.univaq.it. Planning is now underway for some flying in Hawaii in conjunction with the 2007 IEEE International Symposium on EMC. Contact Professor Orlandi for more information.

NVLAP Assessor/Laboratory Training Seminar

There will be a free NVLAP training seminar on Saturday, July 7. The seminar is open to all current and potential NVLAP assessors, NVLAP-accredited laboratories, and laboratories considering accreditation. Presentations will be conducted by the NVLAP staff on the various elements of laboratory accreditation. This is a great opportunity to better understand the NVLAP business practice, accreditation process, and what to expect during the on-site assessment activity. For more information or to attend, please contact Brad Moore: brad.moore@nist.gov or phone 301-975-5740.

Amateur Radio Luncheon

The Amateur Radio Lunch will take place on Wednesday, July 11 from 12:00pm – 1:30pm at the Hawai'i Convention Center. All IEEE EMC Hams are welcome to attend this annual luncheon. Reservations are required by June 30. Please contact Tom (W3IA) or Josie (K3SJS) Chesworth, Seven Mountains Scientific, Inc., P.O. Box 650 Boalsburg, PA or phone 814-466-6559; e-mail: Jo@7ms.com

dB Society Dinner

The dB Society will meet on Sunday, July 8 at 6:30pm (note the new day this year for the annual "picnic"). This is a privately held function for dB Society members only. Members please contact Janet O'Neil for more information at j.n.oneil@ieee.org.

Please join us on Thursday, July 12, 2007 for the annual EMC Society Awards Luncheon

1:00 – 2:30 pm
Hawai'i Convention Center

The following awards will be presented:

EMC Society President's Memorial Award
Richard R. Stoddart Award
for Outstanding Performance
Honorary Life Member Award
Laurence G. Cumming Award
for Outstanding Service
Certificate of Acknowledgement
Certificate of Recognition
Best Transactions on EMC Paper Award
Best Symposium Paper Award
Best Student Paper Award
And more....

PHOTO BY KEN WYATT

At the conclusion of the luncheon, in commemoration of the EMC Society's 50th Anniversary, one lucky attendee will receive a complimentary "dB clock" designed by EMC Society legend, the late Al Parker, founder of Solar Electronics. Stop by the "Exhibitor Museum" in the exhibit hall to see this unique clock on display.

NEW REVISED ANTENNA CALIBRATION STANDARD (ANSI C63.5-2006) WORKSHOP

In December 2004, ANSI ASC C63 published its long awaited antenna calibration standard that replaced the 1988 and 1998 versions. Late last year ASC C63 added to this standard an interpretation that clarified some text and a flow chart. The standard takes into account the errors that are introduced when using certain broadband antennas especially at frequencies below 200 MHz and provides correction factors when these antennas are used for site validation. The standard also introduces measurement techniques for determining antenna factors for other types of antennas. The workshop will lead the user through the new document, highlighting which calibration path should be used based on the type of antenna being calibrated. This is essential to ensure that the right antenna factor is used especially when validating semi-anechoic chambers. As time permits, attendees will get a chance to apply what they learned via problem solving and/or performing an antenna calibration in the lab at the meeting venue.

Workshop Overview

In this seminar, you will learn about:

- General calibration test conditions
- Appropriate measurement geometry
- Methods to determine antenna factors
- Application of standard site method
- Reference antenna method
- Equivalent capacitance substitution method
- Discrete and continuous frequency calibration considerations
- Rationale for geometry specific correction factors for biconicals
- Guidelines for measurement uncertainty
- Participate in hands-on calibration setup and calibration

Expert Instructors

Donald N. Heirman, Workshop Director,
(Don HEIRMAN Consultants)
Dennis Camell (National Institute of Standards and Technology)
Michael J. Windler (Underwriters Laboratories)

Support Material

- ANSI C63.5-2006
- A complete lecture notebook
- Handouts and references

Who Should Attend

- Those responsible for using and calibrating antennas in making radiated emission compliance measurements and site validation
- Calibration technicians
- Calibration accreditation bodies
- Lab quality assessors
- Regulatory Compliance Managers
- Test Instrumentation and chamber manufacturers

Date and Location

Friday, July 6, 2007
Hilton Hawaiian Village Hotel
(Headquarter Hotel for the IEEE EMC Symposium)
2005 Kalia Road
Honolulu, HI 96815-1999

Agenda (approx.)

Registration and Continental Breakfast: 8:00 am
Class: 8:30 am to 5:00 pm

Registration Fee Includes

Complete lecture notebook, continental breakfast, lunch, and breaks, roundtrip local transportation between hotel in Waikiki and the university, as well as a copy of ANSI C63.5-2006.

Hotel

The Hilton Hawaiian Village Hotel has rooms reserved for those attending the IEEE EMC Symposium, (headquarter hotel for symposium). Please visit the website www.emc2007.org for complete hotel information and registration or see information included on the hotel in this program.

Registration Form

Contact: Janet O'Neil
Telephone: 425-868-2558 Fax: 425-868-2558 (Call First)

Ms./Mr./Dr. _____

Company _____

Address _____

City _____ State _____ Zip _____

Daytime Phone _____ Fax _____

Email _____

Credit Card (check one): MC ____ Visa ____ Amex ____

Credit Card No: _____

Expiration Date: _____

Signature: _____

C63.5 workshop— 6 July 2007

By 10 June 2007 *:

Attendees	$400 USD	_____
C63™ & S/C Members	$350 USD	_____
Add $100 if after 10 June or at the door**	$100 USD	_____
Add'l copy of notebook**	$100 USD	_____
	Total $	_____ USD

* Please do not mail after 15 June 2007.
**With prior telephone or fax registration only.

Check or Credit Card Number must accompany registration.
Make check payable to U.S. EMC Standards Corporation in U.S. dollars drawn on a U.S. bank. Mail to:

Janet O'Neil, ETS-Lindgren
22117 Northeast 10th Place
Sammamish, WA 98074
Email: j.n.oneil@ieee.org

NOTE: You are not registered until you receive confirmation

Important: The organizing committee may substitute speakers, modify the program (or lecture notes), restrict class size or cancel the workshop. No refunds will be made to individuals who cancel after 10 June 2007. Substitutions are allowed. Registration will be confirmed on a first come, first served basis. *Workshop requires a minimum of 15 attendees; it will be cancelled if less than 15 sign up by 10 June 2007. Please do not wait to register and do not miss the 10 June 2007 absolute deadline. Registration fees will be returned if workshop is cancelled. Book refundable travel arrangements as appropriate if workshop is cancelled.*

2007 IEEE International Symposium on Electromagnetic Compatibility

8-13 July 2007 • Honolulu, Hawaii
NARTE Exams 14 July 2007
www.emc2007.org

Symposium Registration Form

NAME & ADDRESS: *(please print)*

EMCS Member? ❑ Yes ❑ No IEEE Member? ❑ Yes ❑ No IEEE Member #_____ ❑ Amateur Radio Call Sign _____

Please check appropriate box (check one only): ❑ Manufacturer ❑ Government ❑ Education ❑ Consultant/Other

Family/Surname | Personal Name | MI

Company/Institution

Address

City | State/Province | Postal Code

Country | Phone | Fax

Email

Are you an author? ❑ Yes ❑ No Author Paper Number(s): _____

Indicate if vegetarian meal(s) are required for: Attendee ❑ Yes ❑ No Companion ❑ Yes ❑ No

Other special requirements (special diet, wheelchair, etc)? ❑ Yes ❑ No _____

GUEST(S): *(please print name(s) as you would like them to appear on the badge)*

Name _____ Name _____

Name _____ Name _____

REGISTRATION FEES: *(please indicate quantity and amount)*

	on or before 14 May 2007	after 14 May 2007	Quantity	
Full Registration *1*				
Member	$522.00	$626.00		$_____
Non-Member	$696.00	$812.00		$_____
EMCS Life Member	No Fee	No Fee		$_____
IEEE Life Member	$122.00	$139.00		$_____
Retired/Unemployed *2*	$232.00	$261.00		$_____
Full Time Student *3*	$122.00	$139.00		$_____
Guest Registration *4*				
Guest (ages 18 and up)	$75.00	$80.00	_____	$_____
Jr. Guest (ages 8 - 17)	$30.00	$35.00	_____	$_____
Children under 8 free				
One Day Registration *5*				
Please mark the day(s) you wish to attend				
Member S M T W TH	$174.00	$185.00	_____	$_____
Non-Member S M T W TH	$232.00	$261.00	_____	$_____
Full Time Student *3* S M T W TH	$40.00	$50.00	_____	$_____
Exhibit Hall Only	No Fee	No Fee	_____	$_____
Additional Options				
Symposium Record CD & Print Copy Workshop Notes	$35.00	$35.00	_____	$_____
Symposium Record - CD Only	$20.00	$20.00	_____	$_____
Tuesday Welcome Reception (Adult)	$60.00	$65.00	_____	$_____
Tuesday Welcome Reception (Jr. Guest)	$20.00	$25.00	_____	$_____
Wednesday Gala/Luau (Adult)	$100.00	$115.00	_____	$_____
Wednesday Gala/Luau (Jr. Guest)*	$45.00	$55.00	_____	$_____
Thursday Awards Lunch (Adult)	$40.00	$45.00	_____	$_____
Thursday Awards Lunch (Jr. Guest)	$25.00	$30.00	_____	$_____
Friday Event/Luncheon (Adult)	$50.00	$75.00	_____	$_____
Friday Event/Luncheon (Jr. Guest)*	$25.00	$45.00	_____	$_____

Note: Print copies of the complete Symposium Record are not available.

* Attendance at the Wednesday Gala and Friday Event is not recommended for children under the age of 8.

TOURS: *(please indicate quantity, amount, and total)*

		Quantity	
Sunday 8 July			
Grand Circle Island Tour	$67.00	_____	$_____
Monday 9 July			
Stars and Stripes Tour	$60.75	_____	$_____
Tuesday 10 July			
Honolulu's Hidden Treasures Tour	$63.00	_____	$_____
Wednesday 11 July			
Shangri La Tour #1 Departs at 7:30 AM	$62.00	_____	$_____
Shangri La Tour #2 Departs at 10:00 AM	$62.00	_____	$_____
Thursday 12 July			
Honolulu City & Palace Tour	$68.00	_____	$_____

	on or before 14 May 2007	after 14 May 2007	Quantity	
Global EMC University*	$250.00	$350.00	_____	$_____

*Attendance is limited – Register Early!

Full registration at the EMC 2007 symposium is required in addition to the Global EMC University fee.

TOTAL REMITTANCE: $_____

NARTE Exam

On Saturday, 14 July, the NARTE EMC Certification exam will be held at the Hilton Hawaiian Village Hotel. Please indicate below if you plan to participate in the NARTE exam.

❑ Yes, I plan to attend the NARTE exam.

Friday Event

On Friday, 13 July, there will be a 50th Anniversary Event at the Turtle Bay Resort. This Event is included with FULL registrations. "FULL Registrants," please indicate whether or not you plan to attend the Friday Event.

❑ Yes ❑ No

2007 IEEE International Symposium on Electromagnetic Compatibility

8-13 July 2007 • Honolulu, Hawaii
NARTE Exams 14 July 2007
www.emc2007.org

Symposium Registration Form

1. Full, 6 day (Sunday, 8 July - Friday, 13 July) registrants are entitled to: CD ROM of Symposium Record, Print Copy of Workshop Notes, admission to the Symposium which includes Technical Sessions, Exhibit Hall, Workshops, Tuesday Welcome Reception, Wednesday Banquet, Thursday Awards Luncheon and Friday Event.
2. A reduction of the Registration Fee was approved for retired or unemployed IEEE EMC Society Members only. The registrant must provide the name of the company that they left and the date for retirement/unemployment.
3. Student registrations are open to full time students, and include the CD ROM of Symposium Record, Print Copy of Workshop Notes, admission to the Symposium which includes Technical Sessions, Exhibit Hall, Workshops, Tuesday Welcome Reception, Wednesday Banquet, Thursday Awards Luncheon and Friday Event. Students will be required to show a Student ID at the conference to confirm their status as full-time students.
4. Guests may include an adult companion and any accompanying children. Each guest must be registered to receive admission to the Guest Lounge, Children's Workshops, and Tuesday Welcome Reception. All guests are welcome into the Exhibit Hall.
5. One-Day Registrants are entitled to admission for one day and the CD ROM of Symposium Record and Print Copy of Workshop Notes.

EMC MEMBERSHIP:

Free First year membership to IEEE/EMC if you join at the Symposium. See IEEE EMC or IEEE Marketing Booth in the Exhibit Hall for details.

METHOD OF PAYMENT:

❑ Check (in USD) made out to IEEE/EMC ❑ Visa ❑ MasterCard ❑ American Express ❑ Diners Club

Credit Card Number _____ Expiration Date _____

Cardholder Name _____ Authorized Signature _____

❑ Wire Transfer If you are paying by wire transfer please contact Andrea Sadlowski (emc07reg@ieee.org) for bank information.

CANCELLATION POLICY:

All requests for refunds prior to 30 May 2007 must be in writing. A $50 service charge will apply. No refunds will be made after 3:00 PM EDT on **30 May 2007**. Substitutions are permitted.

The 2007 Committee reserves the right to cancel any tour that does not meet the minimum requirement. If a tour is cancelled, you will receive a full refund and will be contacted prior to the symposium.

EMERGENCY CONTACT:

Name _____ Relationship _____

Day-time Phone _____ Evening Phone _____

Mail or Fax completed form and payments to:

IEEE/CMS, 445 Hoes Lane, Piscataway, NJ 08855-1331, USA

Phone: +1 732 562 5337 Fax: +1 732 465 6447 Email: emc07reg@ieee.org

2007 IEEE Electromagnetic Compatibility Society Membership Offer

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Access the world of Technology

IEEE has been there since 1884, supporting professionals from academia and industry. IEEE Membership includes a personal subscription to the award winning ***IEEE Spectrum***, world's most widely read electrical and electronics magazine. Over 360,000 IEEE members receive timely articles on the status of contemporary professional topics, as well as careers and education, applications of state-of-the-art technology and various historical and tutorial issues.

Exclusive Benefits no other organization can match:

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- Newsletter ***"The Institute"*** to keep you current
- Save money on standards, conference proceedings, books, conference fees and more
- Discounts on flights, car rental and hotels with IEEE Travel Services
- Healthcare, life insurance, mortgage services, auto and home insurance, professional liability insurance with IEEE Financial Advantage Program
- Obtain an @ieee.org e-mail alias with virus and spam scanning

IEEE

For more information Visit our web site at:

http://www.emcs.org/

EMC SOCIETY

Focus Your Career With IEEE Electromagnetic Compatibility Society (EMC-S)

Society membership enhances the benefits you receive as an IEEE member. Network with the top minds in your field and develop the support structure you need for success in your career. Your membership connects you with innovators and practitioners around the world – people you may not otherwise meet in the course of your daily job. Society membership offers many opportunities to volunteers. Whether you volunteer to serve on technical committees, edit a journal, get involved in local and regional activities through your EMC chapter or in any other way, the experience you gain puts you on the career path for continued success.

Introducing… the EMC Society of the IEEE

The EMC Society encompasses the design, integration, testing and analysis of electrotechnology products and systems to control electromagnetic interference. It strives for EMC enhancement through the generation of engineering standards, measurement techniques, instrumentation and procedures, the study of equipment and systems characteristics, improved techniques and devices for EMI control, education in EMC and studies of the origins of interference.

The EMC Society promotes close cooperation and exchange of technical information among its members and other professional societies. To facilitate the exchange, local chapter and annual international symposia meetings are held for the presentation of papers, workshops and tutorial sessions and for the meeting of the EMC-S's various committee meetings. More than 4,000 members of the Society are active in more than 60 chapters world-wide, while several new chapters are under construction.

The EMC Society of the IEEE was founded on October 10, 1957, when the IRE approved the petition signed by 326 engineers wishing to form a Professional Group on Radio Frequency Interference. Since then, the contributions made by the EMC Society have been numerous. In 2007, the EMC Society will be celebrating its 50th anniversary.

Member Benefits Highlights

IEEE and EMC-S Membership

- ✓ ***FREE*** online access to EMC-S Newsletter
- ✓ ***FREE*** access to EMC-S Digital Library
- ✓ ***FREE*** Quarterly EMC-S Newsletter
- ✓ ***FREE*** Quarterly IEEE Transactions on EMC (on line access)
- ✓ ***FREE*** IEEE Web Account, e-mail @ieee.org alias, virus scanning and more
- ✓ ***FREE*** subscription to ***"IEEE Spectrum"*** and ***"The Institute"***

Plus these benefits:

- ✓ ***FREE*** CD-ROM from the annual International IEEE EMC Symposium on EMC
- ✓ Registration ***discounts*** at the EMC-S annual symposia
- ✓ IEEE ***exclusive*** insurance services

EMC-S Affiliate Membership

- ✓ ***FREE*** online access to EMC-S Newsletter
- ✓ ***FREE*** access to EMC-S Digital Library
- ✓ ***FREE*** Quarterly EMC-S Newsletter
- ✓ ***FREE*** Quarterly IEEE Transactions on EMC (on line access)
- ✓ ***FREE*** IEEE Web Account

Plus these benefits:

- ✓ ***FREE*** CD-ROM from the annual International IEEE EMC Symposium on EMC
- ✓ Registration ***discounts*** at the EMC-S annual symposia

Bring your completed IEEE & EMCS Member Application to the IEEE EMC-S Membership Booth ➪

2007 IEEE Electromagnetic Compatibility Society Professional Membership/Subscription Application

Membership subscriptions are annualized to, and expire on, 31 December 2007.
Pay full or half-year rate depending upon the date of receipt by the IEEE

☑ ***Yes!*** *I want to join:*

- ***IEEE*** *benefits include a monthly subscription to* ***IEEE Spectrum*** *magazine*
- ***IEEE EMC-S*** *benefits include a quarterly subscription to the* ***EMC-S Newsletter*** *and the* ***IEEE Transactions on Electromagnetic Compatibility***

Membership Options:

All prices quoted in U.S. dollars

	FULL YEAR Applications received 16 Aug 06 – 28 Feb 07	HALF YEAR Applications received 1 Mar 07 – 15 Aug 07
I do not belong to the IEEE. I want to join *only* the EMCS. Professional Affiliation(s): _____	$ 87.00 ❑	$44.00 ❑
I reside in the United States	$189.00 ❑	$94.50 ❑
I reside in Canada (Including HST)★	$187.72 ❑	$94.43 ❑
I reside in Canada (Including GST)★	$175.88 ❑	$88.47 ❑
I reside in Africa/Europe/Middle East	$159.00 ❑	$80.00 ❑
I reside in Latin America	$152.00 ❑	$76.50 ❑
I reside in Asia/Pacific	$153.00 ❑	$77.00 ❑
I reside in Asia/Pacific (Tokyo Council)	$178.00 ❑	$89.50 ❑
I already belong to the IEEE and I now want to join the EMCS.	$ 25.00 ❑	$13.00 ❑
I am a **student** (select the category that applies):		
I Reside in USA and wish to join the IEEE and the EMCS	$ 43.00 ❑	$22.00 ❑
I reside in Canada (HST★) and wish to join the IEEE and the EMCS	$ 49.02 ❑	$25.08 ❑
I reside in Canada (GST★) and wish to join the IEEE and the EMCS	$ 45.48 ❑	$23.32 ❑
I reside outside USA/Canada) and wish to join the IEEE & the EMCS	$ 38.00 ❑	$19.50 ❑
I am a **Student IEEE member** and wish to join the EMCS	$ 13.00 ❑	$ 7.00 ❑

(IEEE members only need to furnish name, address, and IEEE number with payment.)

★ Canadian residents pay 6% GST or 14% HST Reg. No. 125634188 on Society payment(s) and Publications only

Minimum Income or Unemployed Provision

Applicants who certify that their prior year income did not exceed US$11,900 (or equivalent) or were not employed are granted 50%reduction in full year dues, regional assessment and fees for one IEEE Society. If applicable, please check appropriate box and adjust payment accordingly. Student members are not eligible.

I certify I earned less than US$11,900 in 2005 ❑
I certify that I was unemployed in 2005 ❑

Are you now or were you ever a member of the IEEE?
Yes ❑ No ❑ If yes, provide IEEE number if known: _____

Personal Information:

Please enter your name as you want it to appear on correspondence.

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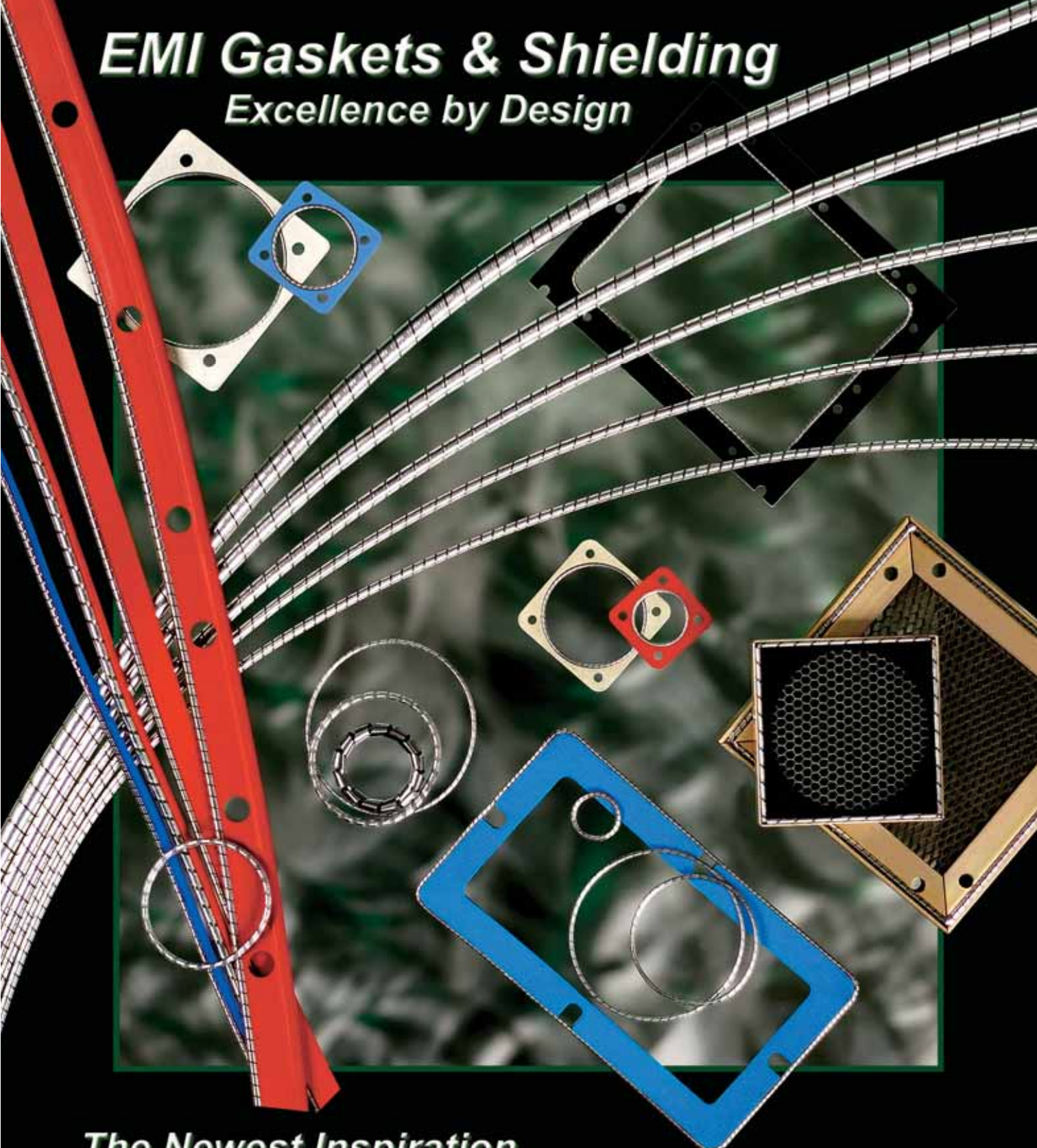

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EMC SOCIETY TECHNICAL COMMITTEES

What is a technical committee? The technical committees play an important role in the overall success of the EMC Society by promoting activities in their fields and providing expert knowledge and assistance to generate and review technical papers, organize and operate sessions at symposia, generate and develop standards and evaluate the "state of the art" in EMC science.

You are invited to join the EMC Society Technical Committees. See the committee meetings scheduled at EMC 2007 on www.emc2007.org

Technical Committee 1: EMC Management

Chair: Dave Southworth (d.southworth@ieee.org)
Vice Chair: Bob Scully (bob.scully@ieee.org)
Secretary: Doug Kramer (drkramer@ieee.org)
This committee is concerned with the development and dissemination of Best Practices and Methodologies for the successful leadership, supervision and guidance of EMC related activities. These Best Practices and Methodologies shall be structured so as to provide assistance to all managers, and engineers. Appropriate and convenient tools shall serve as a foundation to these Best Practices and Methodologies.

Technical Committee 2: EMC Measurements

Chair: Don Heirman (d.heirman@ieee.org)
Vice Chair: Thomas J. Fagan (tjfagan@ieee.org)
Acting Secretary: Bob Hofmann (hrhofmann@att.net)
This committee is concerned with the measurement and instrumentation requirements in EMC standards and procedures and how they are interpreted. Also concerned with the adequacy of measurement procedures and measurement instrumentation specifications for radiated and conducted emission and susceptibility tests and the rationale for performance limits for these tests.

Technical Committee 3: Electromagnetic Environment

Chair: Graham (Bill) Strauss (straussgw@navair.navy.mil)
Vice Chair: vacant
Secretary: vacant
The charter of TC3, the Technical Committee on Electromagnetic Environment is to encourage research on the:

- Electromagnetic environment (EME),
- Development of standards for EME measurement and characterization,
- Natural and man-made sources of electromagnetic environment that comprise this environment,
- Effects of noise (unwanted portions of EME) on systems performance, and
- Effects of international civil and military standards intended to control man-made intentional and unintentional emissions of electromagnetic energy.

Technical Committee 4: Electromagnetic Interference Control

Chair: Bob Scully (bob.scully@ieee.org)
Vice Chair: Kermit Phipps (KPhipps@epri-peac.com)
Secretary: John Archer (archerj@indy.net)
This committee is concerned with the fundamentals of transmission/propagation media and interference control technology, together with associated design, analysis, and techniques useful for the identification, characterization, control and mitigation of electromagnetic interference at the system, subsystem and unit levels.

Technical Committee 5: High Power Electromagnetics

Chair: Dr. William A. Radasky (wradasky@aol.com)
Vice Chair: Mr. Michael K. McInerney (mkmcinerney@ieee.org)
Secretary: Dr. Randy J. Jost (randy.j.jost@usu.edu)
This committee is concerned with the effects and protection methods for electronic equipment and systems for all types of high power electromagnetic environments. These environments include electromagnetic pulse (EMP), intentional EMI environments (e.g. high power microwaves and ultra wideband), lightning electromagnetic currents and fields, and electrostatic discharge. Interactions with aircraft and other mobile systems are included.

Technical Committee 6: Spectrum Management

Chair: Thomas J. Fagan (tjfagan@ieee.org)
Vice Chair: Larry Cohen (lcohen@ieee.org)
Secretary: Karen Dyberg (kdyberg@ieee.org)
This committee is concerned with frequency coordination, management procedures for efficient spectrum use, band occupancy and congestion, federal regulations and their adequacy.

Technical Committee 7: Nonsinusoidal Fields

Chair: Dr. William J. Croisant (w.croisant@ieee.org)
Vice Chair: Michael K. McInerney (mkmcinerney@ieee.org)
Secretary: Dr. Frank Sabath (frank.sabath@ieee.org)
This committee is concerned with the application of electromagnetic signals with large relative bandwidth, commonly referred to as non-sinusoidal waves, delineation of the differences between time-domain and frequency-domain principles, analytical and numerical treatments of the Maxwell postulates directly in time-domain, conceptualization, design, fabrication and testing of materials and devices for ultra-wide bandwidth systems.

Technical Committee 8: Electromagnetic Product Safety

Chair: Richard Georgerian (richardg@ieee.org)
Vice Chair: Dan Modi (Dan.Modi@alconLabs.com)
Secretary: Jim Bacher (j.bacher@ieee.org)
To provide a professional forum for Product Safety professionals, both to develop their own skills, and to provide Product Safety outreach to engineers, students, and others.

Technical Committee 9: Computational Electromagnetics

Chair: Dr. Jun Fan (jf151005@ncr.com)
Vice Chair: Dr. Chuck Bunting (reverb@okstate.edu)
Secretary: Dr. Alan Roden (JAlan.Roden@aero.org)
This committee is concerned with broad aspects of Applied Computational Electromagnetic techniques that can be used to model electro-magnetic interaction phenomena in circuits, devices, and systems. The primary focus is with the identification of the modeling methods that can be applied to interference (EMC) phenomena, their validation and delineating the practical limits of their applicability. Included are low and high frequency spectral-domain techniques and time-domain methods.

Technical Committee 10: Signal Integrity

Chair: Jim Nadolny (jim.nadolny@samtec.com)
Vice Chair: Prof. Antonio Orlandi (orlandi@ing.univaq.it)
Secretary: Prof. Giulio Antonini (antonini@ing.univaq.it)
This committee is concerned with the design, analysis, simulation, modeling and measurement techniques useful in maintaining the quality of electrical signals. These activities encompass all aspects of signal integrity from the integrated circuit level to the system level.

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