MAIN TECHNICAL PROGRAM – ABSTRACTS

CONTENTS

MAIN TECHNICAL PROGRAM
MONDAY, 17 AUGUST 2009 – WORKSHOPS AND TUTORIALS

MO-AM-1 (T) Basic EMC Measurements (TC2)
Room 17A
Chair: Don Heirman, Don HEIRMAN Consultants, Lincroft, New Jersey, U.S.A.

This tutorial will be an introduction to basic EMC measurements with a primary focus on emission testing. While intended for those new to these disciplines, the latest activity in national and international standards related to EMC measurements and standards will be presented. A special focus will be on measurements and associated issues above 1 GHz as well as measurement uncertainty. An open discussion will follow the presentations.

8:30 AM - 8:50 AM
Emissions Measurements for Tabletop Equipment
S. Koster, Washington Laboratories, Gaithersburg, Maryland, U.S.A.

Test setup and testing information for radiated and conducted emissions.

8:50 AM - 9:10 AM
Basic Emission Measurements for Floor-Standing Equipment
H. R. Hofmann, Hofmann EMC Engineering, Naperville, Illinois, U.S.A.

EMC emission measurement requirements for floor-standing equipment are described.

9:10 AM - 9:30 AM
IEC Transient-Immunity Testing Overview
T. E. Braxton, Shure Incorporated, Niles, Illinois, U.S.A.

An introduction to the transient-immunity requirements of the IEC.

9:30 AM - 9:50 AM
Test Methods for Immunity to RF Electromagnetic Fields
J. S. Maas, IBM Corporation, Rochester, New York, U.S.A.

Basic test methods for evaluating equipment for immunity to radiated RF fields are described. Test types include the use of absorber-lined chambers, reverberation chambers, and TEM waveguides.

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 11:00 AM
Basic Measurement Sites, Methods, and Associated Errors
D. N. Heirman, Don HEIRMAN Consultants, Lincroft, New Jersey, U.S.A.

This talk will review the major types of emission and immunity test facilities including new test methods in unique test chambers. International standards that apply to measurement errors will be presented for radiated tests.

11:00 AM - 11:30 AM
Selecting a Quality EMC Lab
D. D. Hoolihan, Hoolihan EMC Consulting, Lindstrom, Minnesota, U.S.A.

This presentation will highlight various characteristics of ISO/IEC 17025 - General Requirements for the Competence of Testing and Calibration Laboratories.

11:30 AM - 12:00 AM
Uncertainty Considerations in Stating Pass/Fail
D. N. Heirman, Don HEIRMAN Consultants, Lincroft, New Jersey, U.S.A.

This talk discusses results of the first international standard (prepared by the Special International Committee on Radio Interference (CISPR)) on the treatment of measurement instrumentation uncertainty in EMC radiated and conducted emission testing. How measurement uncertainty is identified in ISO/IEC 17025 on lab competency is presented and how it is used to state pass/fail for product compliance results.

MO-AM-2 (T) Introduction to EMI Modeling Techniques (TC9)
Room 17B
Chair: Chuck Bunting, Oklahoma State University, Oklahoma, U.S.A.

This tutorial will provide an introduction to all of the commonly used numerical EMC modeling techniques. It is intended to provide EMC engineers who are interested in learning the basics of these modeling techniques a fundamental understanding of all the different techniques, without the need for detailed math. Practicing modelers will also benefit from learning the fundamentals of modeling techniques they are currently not using. Each technique will be presented along with their strengths and weakness, so engineers can decide which techniques are appropriate for their types of problems.

8:30 AM - 9:00 AM
Overview of Electromagnetic Modeling Software

T. H. Hubing, Clemson University, Clemson, South Carolina, U.S.A.

This presentation provides an overview of the various electromagnetic modeling codes available and the techniques they employ.

9:00 AM - 9:30 AM
The Transmission Line Matrix Method (TLM)
D. P. Johns, CST of America, Framingham, Massachusetts, U.S.A.

An introduction to modeling electromagnetic fields using the TLM method. The fundamentals of TLM are described along with typical EMC applications and a discussion of the advantages and disadvantages of the approach.

9:30 AM - 10:00 AM
Introduction to the Partial Element Equivalent Circuit (PEEC) Technique
G. Antonini; and A. E. Ruehli, — University of L'Aquila, L'Aquila, Italy

The solution of large 3D electromagnetic models is important for the modeling of a multitude of EMC problems. The geometrical complexity of today's electronic systems and the broadband frequency of interest make it necessary to adopt numerical methods to solve Maxwell's equations. Among the integral-equation based methods, the Partial Element Equivalent Circuit (PEEC) method has gained an increasing popularity among EMC engineers due to its capability to provide a circuit interpretation of the electric field integral equation (EFIE), thus enabling the user to handle complex problems involving EM fields and circuits. The aim of this lecture is to give a short introduction to the PEEC method and present some of the most recent advancements which make the PEEC approach well suited to be used for analyzing many different EMC problems including crosstalk, antennas, lightning, skin-effect modeling, power electronics, and signal integrity.

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 11:00 AM
Introduction to the Finite-Difference Time-Domain (FDTD) Technique
S. Connor; and B. Archambeault, — IBM Corp., Research Triangle Park, North Carolina, U.S.A.

This presentation is an overview of how the FDTD technique works, with a practical example and a discussion of FDTD's strengths and weaknesses.

11:00 AM - 11:30 AM
Introduction to the Finite Element Method
C. Bunting, Oklahoma State University, Stillwater, Oklahoma, U.S.A.

This presentation focuses on the basics of the finite element method.

11:30 AM - 12:00 AM
Integral Equation Methods - Method of Moments (MoM) - in Numerical Modeling
J. Chen, University of Houston, Houston, Texas, U.S.A.; and J. Drewniak, Missouri University of Science and Technology, Rolla, Missouri, U.S.A.

This tutorial presents the fundamental concepts of the Method of Moments for EMC Applications. Cautions on how to apply this technique for EMC applications are provided.

MO-AM-3 (T) Protection Against Short Pulse, High Power, IEMI Threats (TC5 & TC7)

Room 19A

Chair: Dr. William Radasky, Metatech Corporation, California, U.S.A.

In recent years, growing attention has been paid to the threat posed by high-power electromagnetic (HPEM) environments against the normal operation of important electronic systems of the civil infrastructure. This use of EM weapons against the civil infrastructure has been categorized by the term Intentional EMI (IEMI). The main objective of this tutorial will be to introduce the participants to special aspects of protection against a particular kind of HPEM environment, the short pulse high power electromagnetic fields. Current studies have demonstrated that classical EMC protection is unable to handle these short pulse threats of high power.

8:30 AM - 9:00 AM
Introduction to the Tutorial on Protection Against Short Pulse High Power IEMI Threats
F. Sabath, Bundeswehr Research Institute for Protective Technologies and NBC-Protection, Munster, Germany; and W. A. Radasky, Metatech Corporation, Goleta, U.S.A.

In recent years, growing attention has been paid to the threat posed by high-power electromagnetic (HPEM) environments, against the normal operation of important electronic systems of the civil infrastructure. This presentation introduces this IEMI tutorial on protection against short pulse high power IEMI threats.

9:00 AM - 9:30 AM
Overview of Intentional Electromagnetic Interference (IEMI) Threats
W. A. Radasky, Metatech Corporation, Goleta, California, U.S.A.

This presentation provides the background of the general category of high power electromagnetics (HPEM) and how intentional electromagnetic

interference (IEMI) is related. In addition, the recent activities of organizations working on the problem of IEMI are reviewed. The presentation then describes the classes of systems that could be affected, the different types of waveforms of concern, and a sampling of the threat generators that have been built. This presentation sets the stage for the effects and protection methods to be discussed later in the tutorial.

9:30 AM - 10:00 AM
Observed Electromagnetic Effects and Classification of Effects
F. Sabath; and S. Potthast, — Bundeswehr Research Institute for Protective Technologies and NBC-Protection, Munster, Germany

High-Power Electromagnetic (HPEM) environments are capable of causing effects like malfunctions, performance degradation, interferences, and destructions in electronic and electrical systems. This presentation provides an overview on observed effects, caused by HPEM environments. Due to the large plurality of effects, a scientific and systematic discussion requires a classification that abstracts the essential information. This contribution presents a systematic classification of electromagnetic (EM) effects. The presented system enables an assessment and comparison of EM effects on the system level.

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 11:00 AM
Estimation of the Coupling of Short Pulse Fields into Electronic Systems
S. Fisahn; and H. Garbe, Gottfried Wilhelm Leibniz Universität Hannover, Hannover, Germany

Ultra wideband pulses cover a large frequency range up to several GHz, thus they are able to cause malfunctions or even destructions of complex electronic systems. In this contribution, the coupling of short pulse fields into electronic systems will be examined. Measurements carried out with different EUTs will be presented as well as the coupling behavior to a generic microcontroller board.

11:00 AM - 11:30 AM
Protection Against Short Pulse High Power IEMI Threats; Protection Challenges, Possible Concepts, and Measurements 273
F. Brauer; and J. L. ter Haseborg, — Hamburg University of Technology, Hamburg, Germany

In recent years, growing attention has been paid to the threat posed by high-power electromagnetic (HPEM) environments, against the function of important electronic systems of the civil infrastructure. Targets, conceivable for an HPEM attack, could be telecom, radio/television, power networks, traffic control, financial systems, and computer networks. While the HPEM threat and the susceptibility of electronic systems to the HPEM environment has been recognized for rather a long time, the protection against HPEM effects has started to gain attention only during the last five years. The main objective of the proposed tutorial is to introduce the participants to special aspects of the protection against a special kind of HPEM environment, the short pulse high power electromagnetic fields. Current studies have demonstrated that classical EMC protection is unable to handle these short pulse threats of high power. This part of the tutorial introduces protection concepts, protective measures, and protective elements adapted to short pulse disturbances.

MO-AM-4 (T) MIL-STD-464 Updates

Room 19B

Chair: Kurt Sebacher, Naval Air Systems Command, Patuxent River, Maryland, U.S.A.

MIL-STD-464B Department of Defense (DoD) Interface Standard Electromagnetic Environmental Effects Requirements will be released in 2009. This standard is in use by all US DoD Agencies. The main objective of this tutorial will be to introduce the participants to changes in the Standard from previous versions to the proposed Version B, and subsequent impacts to E3 Test Facilities. The tutorial will start with an overview of the history of MIL-STD-464, followed by an overview of the proposed changes to MIL-STD-464B. Specific lectures will focus on updates to Electromagnetic Environments, an introduction of Directed Energy/ High Powered Microwave test levels, new Aircraft EMP MIL-STD, and other changes to test levels and test techniques. This will be followed by a detailed discussion of this new version's impact to E3 Test Facilities. A brief discussion of future changes to MIL-STD-464 will conclude this tutorial.

8:30 AM - 9:00 AM
Historical Perspective on MIL-STD-464 and Updates to 464B
M. J. Rodriguez, Air Force Materiel Command, Wright-Patterson AFB, Ohio, U.S.A.

This presentation provides a historical perspective and information on the various standards that preceded MIL-STD-464, and describes the different versions of 464. The presentation also provides an update on the ongoing 5-year Review Cycle of MIL-STD-464A, highlighting the most significant modifications currently proposed for the MIL-STD-464 Revision B and describing the remaining steps of the process to complete the revision of this Interface Standard.

9:00 AM - 9:30 AM
Update to the Navy Shipboard Electromagnetic Environments
R. B. Bozarth, EG&G Technical Services, Dahlgren, Virginia, U.S.A.

This presentation will explain the process used to update the U.S. Navy shipboard electromagnetic environments (EMEs) for Military Handbook 235C, Military Handbook 464B, AECTP-250 NATO, and the basis for Electromagnetic Vulnerability (EMV) testing. Assumptions and the calculation methods used as well as an introduction to the shipboard EME data collection programs will be discussed.

9:30 AM - 10:00 AM
Directed Energy and High Power Microwave Test Requirements
K. K. Sebacher, Navair, Patuxent River, Maryland, U.S.A.

Discuss the new requirements for Directed Energy and High Powered Microwave test requirements in Mil Std 464B.

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 11:00 AM
MIL-STD-464 Updates 5.2 Intra System EMC and 5.14 Unintentional Emission Part of MIL-STD-464 Updates
J. D. Craven, U.S. Army, Redstone Arsenal, Alabama, U.S.A.; and J. E. Douglas, U.S. Army, Ft. Huachuca, Arizona, U.S.A.

Discuss changes made in Intra System EMC and the addition of Unintentional Emission requirement.

MO-AM-5 (T) Practical Radiated Measurements using Antennas and Field Probes; the Fundamentals

Room 18C

Chair: Zhong Chen, ETS-Lindgren, Texas U.S.A.

This tutorial is designed to be a full-day two-part tutorial; the morning session will cover the basic theory and applications of EMC radiated measure-ments using antennas and field probes, and the afternoon session will cover more advanced topics. The morning session will introduce the basic theory and terminologies. Applications according to US and international standards will also be covered. The afternoon session will cover applications of antennas and field probes beyond those specified in typical manufacturer's data sheets. The discussions will concentrate on some specific aspects of antennas and probes in calibration and testing to EMC industry standards, such as background information and rationales for recent changes in the standards, and impact of these changes on daily EMC measurements.

Other topics will include time domain methods related to antenna calibration and usage, system integration, and instrumentation considerations in antennas and probes applications. The implications of the antenna characteristics on EMC testing will be discussed, including the nature and use of antenna factors, gain, radiation resistance, VSWR, etc. Uncertainty evaluations of the antenna and probe calibrations will be considered, along with the implications of the uncertainties in typical end use situations. Applications of the antennas and probes in radiated emissions and immunity tests as well as radiated site validation measurements will be addressed, including those for measurements below and above 1 GHz. This tutorial will also provide the latest updates on ANSI and CISPR standards on antenna calibrations, and IEEE 1309 and IEC 61000-4-3 standards on probe calibrations.

NOTE: The morning session will be devoted to fundamental topics while the afternoon session will be devoted to advanced topics. It will be helpful, but not necessary, to attend both sessions. Attendees should select one or both sessions depending upon their level of expertise.

8:30 AM - 9:00 AM
Half Power Beamwidth and High Power Measurements: The Dangers of Using Far Field Approximations in the Near Field
V. Rodriguez, ETS-Lindgren, Cedar Park, Texas, U.S.A.

A study of some of the dangers of using closed form equations without understanding the assumptions used to derive them.

9:00 AM - 9:30 AM
Antennas and Field Probes
Z. Chen, ETS-Lindgren, Cedar Park, Texas, U.S.A.

This presentation gives the basics for field probes applications.

9:30 AM - 10:00 AM
Test Equipment Fundamentals
W. J. Schaefer, Cisco Systems, San Jose, California, U.S.A.

This presentation first defines the meaning of features, characteristics, and specifications of test equipment. Then it will discuss two basic parameters of receiving instruments used for antenna calibrations: linearity and dynamic range. For E-Field probe calibrations, the proper delivery of precise power levels has a direct impact on the uncertainty of the calibration process. This contribution describes in detail how to determine the required net power level using a dual directional coupler.

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 11:00 AM
Anisotropy, Linearity, Multi-frequency Response, and Pulsed Field Response of Field Sensors

T. Kleine-Ostmann; T. Kotschy-Scholz; R. Pape; and T. Schrader, — Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

This contribution is about the behavior of field probes used for personal safety and EMC measurements.

11:00 AM - 11:30 AM
Basic Time-Domain Analysis of Antennas used for EMC
D. G. Camell, National Institute of Standards and Technology, Boulder, Colorado, U.S.A.

This presentation is an introduction to the use of time domain techniques for EMC antennas. Antenna pulse signatures are reviewed and a method for free space antenna factors is covered.

11:30 AM - 12:00 AM
Update on Antenna/Probe Standards and Applications
M. J. Windler, Underwriters Laboratories, Northbrook, Illinois, U.S.A.

This presentation will give a brief review of the latest developments in standards related to antenna and probe calibrations.

MO-AM-6 (T) Fundamentals of EMC
Room 18B
Chair: Daryl Beetner, Missouri University of Science and Technology, Missouri, U.S.A.

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, those who are seeking information on an aspect of EMC that they have not previously encountered, or those who desire a refresher on the proposed EMC topics.

8:30 AM - 10:00 AM
Basic Electromagnetics
A. Marvin, University of York, York, United Kingdom

This lecture will present an introduction to electromagnetics relying on verbal explanations and 'thought experiments' to circumvent the usual mathematical complexity. The lecture will start with Coulomb's Law and develop ideas of electric and magnetic fields and electromagnetic waves and their properties. A brief introduction to antennas and a précis of the mathematical description of electromagnetics will be included in the presentation slides.

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 12:00 AM
Transmission Line Fundamentals
E. Wheeler, Rose-Hulman Institute of Technology, Terre Haute, Indiana, U.S.A.

This lecture will present an introduction to the time and frequency domain behavior of transmission lines. Topics discussed will include signal propagation and the effects of reflections. Examples and simulations will explore time-domain reflectometry and the variation of impedance levels in transmission lines.

MO-PM-1 (W) How to Simplify Complex Systems into Realistic, Solvable, Accurate Models (TC9)
Room 17B
Chair: Bruce Archambeault, IBM Corporation, North Carolina, U.S.A.
Co-Chair: David Johns, CST, Massachusetts, U.S.A.

This workshop will introduce the audience to the techniques used to simplify real world complex systems into models for full wave simulation that are able to be solved with today's software tools, while maintaining the required accuracy to solve the problem of interest. Validation of these simplified models will also be discussed.

1:30 PM - 2:00 PM
Importance and Process of Validation for All Levels of Modeling Problems
B. Archambeault, IBM Corporation, Research Triangle Park, North Carolina, U.S.A.

Most real world problems are too large for realistic simulations with today's available tools. So, problems must be broken into small portions, but it is still vital to validate the individual portions.

2:00 PM - 2:30 PM
Model Partitioning for Solving Complex EMC Problems
C. E. Brench, Southwest Research Institute, San Antonio, Texas, U.S.A.

This presentation will discuss how to partition complex EMC problems in manageable pieces suitable for modeling.

2:30 PM - 3:00 PM
Full-wave EM-modeling and Test Verification in Aerospace Applications
C. G. Baldwin, Lockheed Martin Missiles and Fire Control, Dallas, Texas, U.S.A.

This presentation will show how complex systems can be broken down into a series of fundamental EMC interactions through the use of modeling tools. The importance of debugging an analytical model through

test and other analytical investigations is stressed to ensure that accurate predictions are made.

BREAK (3:00 PM – 3:30 PM)

3:30 PM - 4:00 PM
Automotive Applications: Selection of Techniques for Modeling "Real World" Challenges
M. A. Steffka, University of Michigan-Dearborn, Dearborn, Michigan, U.S.A.

This presentation will discuss the use of modeling/simulation techniques to determine electrical characteristics of vehicle structural components.

4:00 PM - 4:30 PM
Combining PCB, Enclosure, and Cable Modeling for EMC Assessment of an Automotive Module
D. P. Johns; and, S. W. Mee, — CST, Framingham, Massachusetts, U.S.A.

This presentation will discuss the challenges of modeling complex automotive EMC problems and will present a process for generating simplified models that can be solved in reasonable run times while still capturing the essential electromagnetic interactions. A trends model for an automotive display system is established and different design iterations considered. Simulation results are compared with measured data.

MO-PM-2 (T) MIL-STD-461 Updates

Room 19B

Chair: Kurt Sebacher, Naval Air Systems Command Patuxent River, Maryland, U.S.A.

MIL-STD-461F Department of Defense (DoD) Interface Standard Requirement for the control of Electromagnetic Interference Characteristics of Subsystems and Equipment was released on 10 December 2007. This standard is in use by all US Department of Defense Agencies. The main objective of this tutorial will be to introduce the participants to changes in the standard from Version E to Version F. The main focus will be on discussing changes to the standard and subsequent impacts to EMI Labs. The tutorial will start with an overview of the history of MIL-STD-461, followed by an overview of MIL-STD-461F. Specific lectures will focus on changes to specification limits, test set-ups, and the resurrection of past test requirements.

1:30 PM - 2:00 PM
History of MIL-STD-461
M. J. Rodriguez, Air Force Materiel Command, Wright-Patterson AFB, Ohio, U.S.A.

This presentation provides a description of MIL-STD-461, the purpose of the standard, and the history and evolution of the documents and “early days” standards that preceded MIL-STD-461. It also provides a tutorial on the various versions of 461 until the most recent revision of the document, which is MIL-STD-461F.

2:00 PM - 2:20 PM
An Insiders View of MIL STD 461F
F. M. O'Connor, Alion Science and Technology, W. Conshohocken, Pennsylvania, U.S.A.

This is a short review of the changes to 461F from a member of the TriService Committee.

2:20 PM - 2:50 PM
MIL-STD-461F Changes and Associated Impacts to Labs
D. R. Kempf; and K. A. Brezinski, — Naval Air Warfare Center, Patuxent River, Maryland, U.S.A.

This tutorial discusses how the updates of MIL-STD-461 that have been incorporated into the new F version affect EMI Laboratories. Changes in test setups, equipment, test limits, test requirements, and applicability will require labs to make changes in their test procedures, software, equipment purchases, time to perform testing, and may also require training.

BREAK (3:00 PM – 3:30 PM)

3:30 PM - 4:00 PM
Future EMI Concepts
K. B. Brezinski; and D. R. Kempf, — Naval Air Warfare Center, Patuxent River, Maryland, U.S.A.

The question arises whether our present avionics EMI standards are adequate for the future of DoD airframes. Our present EMI limits are based on sound engineering with many good guesses, but typically there are inherently very large safety margins built in due to uncertainties about the environment within the platform. Our airframes may also be subjected to ultra high power sources. Present laboratory evaluation techniques are likely to be financially out of range with the potential levels. We may need to design our avionics for the platform. To accomplish this, we must characterize platform electromagnetic characteristics. We have moved into a new business environment and to accomplish some tasks to come, we may need to ignore the paradigms we have embraced for so many years.

4:00 PM - 4:30 PM
Potential Changes to MIL STD 461F
F. M. O'Connor, Alion Science and Technology, W. Conshohocken, Pennsylvania, U.S.A.

Potential additional test requirements for MIL-STD-461 will be presented and discussed.

MO-PM-3 (T) Practical Radiated Measurements using Antennas and Field Probes; Advanced Topics

Room 18C

Chair: Zhong Chen, ETS-Lindgren, Texas U.S.A.

This tutorial is Part II of a full-day tutorial and will cover more advanced topics on the theory and applications of EMC radiated measurements using antennas and field probes. In particular, this afternoon session will cover applications of antennas and field probes beyond those specified in typical manufacturer's data sheets. The discussions will concentrate on some specific aspects of antennas and probes in calibration and testing to EMC industry standards, such as background information and rationales for recent changes in the standards, and impact of these changes on daily EMC measurements.

1:30 PM - 2:00 PM

Advanced Topics on Field Probes

Z. Chen, ETS-Lindgren, Cedar Park, Texas, U.S.A.

This presentation will cover advanced topics on field probes for radiated immunities measurements.

2:00 PM - 2:30 PM

Implementation of Traceable Antenna Calibration

T. Schrader; and T. Kleine-Ostmann, — Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

This contribution will take into account antenna calibration from 30 MHz to 1 GHz, and from 1 GHz to 325 GHz using an open area test site and a fully anechoic room, respectively.

2:30 PM - 3:00 PM

Test Equipment Specifics

W. J. Schaefer, Cisco Systems, San Jose, California, U.S.A.

This material presents the major uncertainty components for antenna calibrations based on the three antenna method as well as for E-field probe calibrations within a two-port TEM cell. The uncertainty components that are related to test equipment are discussed in detail and suggestions for the estimation of their magnitude are provided.

BREAK (3:00 PM – 3:30 PM)

3:30 PM - 4:00 PM

Time-Domain Analysis and Usage of Antennas for EMC

D. G. Camell, National Institute of Standards and Technology, Boulder, Colorado, U.S.A.

Beyond the basics; usage of time domain processing for EMC antennas will be presented. Free space antenna factors, site validations, and shielding effectiveness are some of the topics covered.

4:00 PM - 5:30 PM

Background on ANSI C63.5 Biconical Dipole Correction Factors

M. J. Windler, Underwriters Laboratories, Northbrook, Illinois, U.S.A.

This will be a presentation on the development and validation of correction factors for biconical dipoles to achieve true free space antenna factors and to improve normalized site attenuation accuracy.

MO-PM-4 (W) Developing EMC Standards

Room 19A

Chair: Qiubo Ye, Communications Research Centre Canada, Canada

Co-Chair: Johan Catrysse, KHBO - FMEC Laboratory for Global Reliability, Belgium

The purpose of this workshop is to acquaint the international EMC community with selected EMC standards and standards-related issues applicable to the design, test, and production of electrical and electronic equipment for the worldwide market. With speakers from the U.S.A. and Europe, this workshop will include an introduction and description of the activity of worldwide accepted EMC standards developers, shielding effectiveness measurements of "small" enclosures, a discussion on getting involved with standard working groups, state of the art in characterizing conductive gaskets, the development of high power electromagnetics standards in IEC, the loading effect to the shielding effectiveness of small boxes due to PCB boards, and a brief on the Standard for replaceable electronic module electromagnetic interference (EMI) testing.

1:30 PM - 2:00 PM

Introduction and Activity of Major EMC Standards Committees

D. N. Heirman, Don HEIRMAN Consultants, Lincroft, New Jersey, U.S.A.

This talk will present a list of several major standards committees and then review the standards activities of both the IEEE EMC Society Standards Development Committee and the Special International Committee on Radio Interference (CISPR) of the International Electrotechnical Commission (IEC).

2:00 PM - 2:30 PM

Getting Involved with Standards Working Groups

K. O. Phipps, Electric Power Research Institute, Knoxville, Tennessee, U.S.A.

This presentation will describe the experiences and overviews obtained by working with and participating at the development and project management level from

two different IEEE EMC Standards, IEEE 1560 and P299.1.

2:30 PM - 3:00 PM
IEEE Std 1302: A Guidance Document for the Characterization of Shielding Gaskets
J. Catrysse, KHBO, Oostende, Belgium

An overview and detailed discussion will be given on the new updated IEEE Std 1302 on the measurement methodologies of shielding gaskets.

BREAK (3:00 PM – 3:30 PM)

3:30 PM - 4:00 PM
Status of the Development of High Power EM (HPEM) Standards
W. A. Radasky, Metatech Corporation, Goleta, California, U.S.A.

This presentation will describe the development of high-power electromagnetic standards in several standards organizations throughout the world. The presentation will begin with definitions of HPEM and intentional electromagnetic interference (IEMI). Most of the discussion will continue with the HPEM standards that have been developed in SC 77C of the IEC. The publications produced thus far will be reviewed, including some discussion of the newest work underway. The presentation will close with a brief discussion of HPEM standardization work being performed in the ITU-T, the IEEE EMC Society, and CIGRE.

4:00 PM - 4:30 PM
The Effects on the Shielding Effectiveness (SE) of Small Enclosures due to Dissipative Contents such as PCBs - Implications for the Measurement of SE
A. Marvin, University of York, York, United Kingdom

This Workshop paper will describe the work undertaken recently in association with the updating of IEEE Std 299 on the measurement of Shielding Effectiveness of enclosures. It is concerned with the effects of the inevitable dissipative contents found in enclosures on the measurement of the enclosure shielding effectiveness. It will offer insights into the possible measurement techniques particularly at microwave frequencies.

MO-PM-5 (T) Fundamentals of EMC
Room 18B
Chair: Daryl Beetner, Missouri University of Science and Technology, Missouri, U.S.A.

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, those who are seeking information on an aspect of EMC that they have not previously encountered, or those who desire a refresher on the proposed EMC topics.

1:30 PM - 2:15 PM
EMI-EMC Right the First Time: Planning, Modeling, and Measurement in Design and Development
R. G. Leventhal, Leventhal Design & Communications, Arlington Heights, Illinois, U.S.A.

Right the First Time focuses on the right way to go about designing for good EMI-EMC performance in electronic equipment design. The emphasis will be on practical examples relating underlying physics, modeling, simulation, and measurement of electromagnetic effects. The discussion will start with semiconductor drivers, continue with PCB, enclosure, cable, test bench, and test chamber effects. Cultural stumbling blocks and good design process issues will also be discussed. Right the First Time requires attention to all the above challenges. Right the First Time is the best opportunity for success. Miss it and you will rarely do as well.

2:15 PM - 3:00 PM
The Current Return Path
D. G. Beetner, Missouri University of Science and Technology, Rolla, Missouri, U.S.A.

Many EMC problems can be traced back to a misunderstanding of the current return path. This tutorial will introduce the concept of the current path and illustrate the concept through practical examples.

BREAK (3:00 PM – 3:30 PM)

3:30 PM - 4:15 PM
Introduction to Numerical Methods in Electromagnetics
Q. Ye, CRC Canada, Ottawa, Canada

This tutorial will present fundamentals of numerical methods in electromagnetics. Several most popular electromagnetic modeling methods will be introduced including the Method of Moments, Finite Element Method, and Finite-Difference Time-Domain method.

MO-PM-6 (T) EMC and Medical Devices
Room 17A
Chair: Dan Hoolihan, Hoolihan EMC Consulting, Minnesota, U.S.A.

This tutorial will provide important information on the interaction of the EMC world with electronic medical devices. It will address the immunity of both implantable medical devices and medical devices external to the human body. The electromagnetic emission characteristics of non-implanted medical devices will be addressed through a discussion of IEC 60601-1-2 standard on EMC of Medical Devices. It will also look at the harsh EMC environment generated by a

Magnetic Resonance Imaging (MRI) scanner and preview the activities taking place on the development of an International Technical Specification relative to Active Implantable Medical Devices and MRI.

1:30 PM - 2:15 PM
ISO 14708-3:2008, Implantable Neurostimulators
C. L. Sponberg, Medtronic, Inc., Minneapolis, Minnesota, U.S.A.

ISO 14708-3 is the first international standard written specifically for implantable neurostimulators. This presentation will describe the general contents and discuss the four new EMC tests contained in this standard.

2:15 PM - 3:00 PM
International EMC Standard for Electrical Medical Devices
D. D. Hoolihan, Hoolihan EMC Consulting, Lindstsrom, Minnesota , U.S.A.

This presentation will be an overview of Edition 3 of IEC/EN 60601-1-2 - EMC Standard for Medical Electrical Equipment - Requirements and Tests.

BREAK (3:00 PM – 3:30 PM)

3:30 PM - 4:15 PM
Active Implantable Medical Device Interactions due to Magnetic Resonance Imaging
J. Peltier, Medtronic Incorporated, Mounds View, Minnesota, U.S.A.

This presentation will provide a high-level discussion on the EMI environment present in Magnetic Resonance Imaging (MRI) Systems in use in the clinical environment. In addition, interactions and hazards with Active Implantable Medical Devices due to the MRI EMI environment will be identified. Finally, the development of technical specifications to address the compatibility of Active Implantable Medical Devices and Magnetic Resonance Imaging Systems will be discussed.

TU-AM-1 Measurement Antennas (TC2)

Room 17A

Chair: Don Heirman, Don HEIRMAN Consultants, New Jersey, U.S.A.

Co-Chair: Mike Royer, Foxconn, Texas, U.S.A.

8:30 AM - 9:00 AM

Calibration of Electric-Field Probe using Open-Ended Waveguides

S. Ishigami; I. Wu; K. Sato; K. Gotoh; and Y. Matsumoto, — NICT, Koganei, Tokyo, Japan

A calibration method using the open-ended waveguides was proposed. The measured and simulated gains of the waveguides were compared, and the standard uncertainties of the gain for all waveguides were calculated. The expanded uncertainty of the calibration system was calculated from the standard uncertainties given by all uncertainty factors. As a result, the expanded uncertainties of the system for most types of waveguide were about 1 dB.

9:00 AM - 9:30 AM

Optical Scanning Probe System for Electro-magnetic Near Field Measurements

M. Takahashi, Taiyo Yuden Co., Ltd., Takasaki, Japan; K. Kawasaki; H. Ohba; T. Ikenaga; H. Ota; and K. I. Arai, — Sendai Research Center, NICT, Sendai, Japan; T. Orikasa, Advantest Laboratories LTD., Sendai, Japan; N. Adachi, Nagoya Institute of Technology, Tajimi, Japan; and K. Ishiyama, Tohoku University, Sendai, Japan

An optical 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 measurement of electromagnetic near field distribution. We demonstrate the measurement of electric field distributions using a LiNbO3 crystal substrate and the probe system. We also measure magnetic field distributions above a microstrip line in the gigahertz range using a magnetic garnet thin film. The probe system is also used for measuring electromagnetic field distributions above a commercially available IC.

9:30 AM - 10:00 AM

Active Probes for Creating H-Field Probes for Flat Frequency Response

S. Mittal; J. Zhang; D. J. Pommerenke; and J. L. Drewniak, — EMC Laboratory, Rolla, MO, U.S.A.; K. Hu, Agilent Technologies, Inc., Colorado Springs, CO, U.S.A.; and X. Dong, Intel Corporation, Hillsboro, OR, U.S.A.

This paper presents an approach to obtain flat frequency response from first order derivative magnetic field loop probes by using them in combination with active probes. It also introduces the H-field differential probes built using flex circuit technology which have been designed to operate in GHz frequency range. These probes have loop dimensions as small as 3 mil by 3 mil and trace widths as small as 1.75 mils. They have a first order derivative frequency response. The probe terminals are connected to the differential amplifier built in the active differential probe which works as an integrator to achieve flat response. The integrator behavior compensates for the first order derivative response of the flex circuit probes.

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 11:00 AM

Antenna Design and Its Application for Near Field Disturbance Measurement in Upper VHF Band

T. Omori; H. Sasaki; and H. Jingu, — Intertek Japan K. K., Yokohama, Japan; and R. Robin, Intertek Testing Services, Pudong District, China

An undersized biconical antenna for radiated disturbance measurement nearby the equipment under test (EUT) is described. Considering the mutual coupling effect on its antenna factor, which one expects to be reduced by downsizing elements, it is confirmed that such antenna can be used for accurate measurement in MIL standard and in some standards of automotive and aerospace EMC. It is found that an antenna factor of the proposed antenna, derived from the two antenna method using a separation distance of 1 m, is very close to the one calculated in free space and measured by the three antenna method. The accurate measurement with more than 6 dB S/N margin to the severe limit in the upper VHF band of CISPR 25 class 5 test is discussed and illustrates the possible applications of the proposed undersized biconical antenna.

11:00 AM - 11:30 AM

Recent Improvements To Dual Ridge Waveguide Horn Antennas: The 200 MHz to 2000 MHz and 18 GHz to 40 GHz Models

V. Rodriguez, ETS-Lindgren, Cedar Park, TX, U.S.A.

Dual-Ridged Horn Antenna (DRHA) are a workhorse in EMC and Antenna Pattern Measurement laboratories. Their broadband capability allows the user to test over wide frequency ranges without the need to stop the test to change antennas. Recently these antennas came under scrutiny when Burns, Leuchtmann, and Vahldieck showed the pattern problems at the upper end of their band. Since their work, new models have been introduced that correct the problems of DRHA in the 1 to 18 GHz range. In the present paper a commercially

available Computational Electromagnetics package is used to analyze the 200 MHz to 2 GHz and the 18 to 40 GHz versions of the DRHA family. Gain, antenna factor, and VSWR are computed. A prototype of the new version is measured. The measured results validate the computed predictions. The result is a DRHA with a smoother gain. This antenna maintains a single lobe in the radiation pattern at 2 GHz, the upper end of its range than the traditional DRHA design. These improvements increase the frequency band of the antenna from 2 GHz to 2.5 GHz. The analysis of the 18 to 40 GHz antenna shows that the pattern illumination is improved by the use of open sides as shown by the author in previous papers. The resulting antennas are better suited for EMC measurements through their specified entire frequency range. Additionally, their better illumination makes these antennas ideal for use on other areas such as antenna measurements and reflector illumination.

TU-AM-2 PCB Design (TC4)

Room 17B

Chair: Philip Keebler, EPRI, Knoxville, Tennessee, U.S.A.

8:30 AM - 9:00 AM

Calculation of Radiated Emission from Chassis Connected to PCB with Screw

H. Funato, Hitachi America, Ltd., Farmington Hills, MI, U.S.A.; and T. Suga, Hitachi, Ltd., Yokohama, Japan

Calculation technique to obtain radiated electric far-field from assembled device: chassis with PCB has been investigated. Circuit model including ground and power planes are created in PSPICE in order to calculate frequency spectrum of the current flowing through the screw at a different location. Next, simplified 3D chassis model is created with simplified PCB model which does not have any traces or patterns. The relation between radiated electric field from the simplified model and the screw current is calculated from that 3D model. Lastly, the radiated electric field from the chassis with PCB has been calculated using both PSPICE circuit simulation results and the chassis 3D simulation results. The difference of far-field at a different screw location from the calculation was up to 6 dB, which shows good correlation with measurement results.

9:00 AM - 9:30 AM

Lumped Models for Vias in Multilayered PCBs

G. Heinrich; and S. Dickmann, — Helmut-Schmidt-Universität / Universität der Bundeswehr Hamburg, Hamburg, Germany

In this paper, lumped models for vias on PCBs are presented. The cascaded via model can be used for the modeling of vias in a multilayered PCB. After using a de-embedding algorithm to extract the S-parameters of the via, the elements of an assumed lumped via model can be derived. Also it is possible to estimate the parameters of the lumped model. The S-parameters of the via are computed using this model and afterwards they are combined with the description of the transmission lines to get the behavior of the overall geometry. To get suitable parameters for the via models, different algorithms can be used for a parametric extraction.

9:30 AM - 10:00 AM

On the Coupling Between the Signal Layers and the Power-Bus on Multilayered PCBs

G. Heinrich; and S. Dickmann, — Helmut-Schmidt-Universität / Universität der Bundeswehr Hamburg, Hamburg, Germany

In this paper, lumped models are used to describe the effects of vias on multilayered PCBs. Furthermore, possible effects of a via on a 4-layer PCB are explained and examined. One the one hand, the coupling between the via and the power-bus, and on the other hand the direct coupling of the waveguide modes from the power-bus into a transmission line, which runs between the power-bus planes, are investigated. The interference of the existing waveguide modes inside the power-bus cavity into a stripline is shown.

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 11:00 AM

An Investigation of the Effect of Grounding Pads on Power Bus Resonance Characteristics

K. Morishita; N. Kobayashi; and T. Harada, — NEC Corporation, Sagamihara, Japan; X. He; and T. Hubing, — Clemson University, Clemson, SC, U.S.A.

This paper describes the effect of grounding pads on power bus resonance characteristics in multilayer printed circuit boards (PCBs). The resonance characteristics of a four-layer PCB with and without grounding pads are investigated by full-wave simulation. The results show that the presence of the grounding pads shifts the resonant frequencies significantly lower. The grounding pads can be modeled as a series LCR circuit for SPICE simulation. Using the SPICE model, the effect of the locations of the grounding pads on the resonance characteristics is investigated.

11:00 AM - 11:30 AM

EM Emission of Differential Signals Across Connected Printed Circuit Boards in the GHz Range

X. Duan; H. D. Bruens; and C. Schuster, — Technische Universität Hamburg-Harburg, Hamburg, Germany; and B. Archambeault, IBM, Research Triangle, NC, U.S.A.

In this paper it is shown that when differential signals pass between printed circuit boards (PCBs) through connectors, common mode signals can be induced due to, for example, imbalanced current paths or asymmetrical line configurations. In the GHz range, connectors are electrically large. Therefore, we

describe connector pins and traces as transmission lines in order to analyze differential mode to common mode signal conversion. Two conversion mechanisms, conductor length mismatches and asymmetrical ground pin configurations, are investigated and validated against Method of Moment (MoM) simulations using the CONCEPT-II package. The common mode signal can return through ground pins or as displacement current between PCBs. Both of the mechanisms can cause EMI problems. The radiation from a daughter card on a motherboard structure is then studied using MoM for various configurations. The variation of board configurations can have little effect in the GHz range while the ground pin configuration has a much greater impact on the EMI performance.

11:30 AM - 12:00 PM
Decoupling Capacitor And Low Inductance Power Distribution Strategies For Achieving EMC Compliance: An Educational Approach Using MultiSim® And Mathcad®
D. Norte, InfoPrint Solutions Company, Boulder, CO, U.S.A.

Many companies and small universities do not have the financial means to purchase very expensive software or hardware resources that can be used to effectively teach EMC related design principles to engineers or students. However, most of these universities and companies do have access to cost-effective SPICE software tools, such as MultiSim®, as well as other math related software packages such as Mathcad®. This paper discusses the useful integration of MultiSim, which is a SPICE based circuit simulation software tool, with Mathcad, for delivering an EMC related design curriculum to students, as well as design engineers. Specifically, this paper discusses how these two tools were used to teach decoupling capacitor and embedded capacitance strategies for achieving EMC compliance at InfoPrint Solutions Company and ITT Technical Institute.

TU-AM-3 Shielding and PCBs (TC9)

Room 18B

Chair: Chuck Bunting, Oklahoma State University, Oklahoma, U.S.A.

Co-Chair: Antonio Ciccomancini Scogna, CST of America, Massachusetts, U.S.A.

8:30 AM - 9:00 AM
Hybrid MoM/FEM Modeling Of Shielding Effectiveness Of Loaded Rectangular Enclosures With Apertures
S. Yenikaya, Uludag University, Bursa, Turkey

This paper presents a hybrid formulation that combines MoM and edge-based vector FEM to the find the Shielding Effectiveness of an enclosure with an aperture. While the FEM is used to solve EM fields inside the enclosure, the MoM is used to solve the surface integrals related to the aperture field components, using equivalent surface currents. The hybrid method is applied to the enclosure with and without load. Results are compared with the analytical results and good agreement is reported.

9:00 AM - 9:30 AM
Characterization and Modeling of Parasitic Emission of a 32-bit Automotive Microcontroller Mounted on Two Types of BGA
E. Rogard; B. Vrignon; and J. Shepherd, — Freescale Semiconductor, Toulouse, France; and E. Sicard, INSA, Lattis, Toulouse, France

This paper presents the electromagnetic emission (EME) characterization and modeling of a 32-bit microcontroller designed for automotive purposes. The effect of different ball grid array (BGA) packages is investigated in terms of parasitic emission and associated EME model in conducted and radiated modes. Good agreements between measurements and simulations demonstrate the ability of an ICEM-based model to handle the emission prediction of complex micro-controllers mounted in high-density, high-performance, BGA packages.

9:30 AM - 10:00 AM
Shielding Effectiveness of Artificial Magnetic Screens in the VHF Band
R. Araneo; S. Celozzi; and G. Lovat, Sapienza – University of Rome, Rome, Italy

Performance of artificial planar screens composed of small magnetic elements are investigated through a full-wave approach involving a periodic Method of Moments formulation. The conventional split-ring resonator screen is first studied, and next the geometry of the single inclusion is modified in order to reduce the operating frequency of the screen. It is shown how the proposed spiral-resonator screen can operate in the VHF band and that a careful numerical analysis needs to be carried out to accurately predict the selective properties of the screen. Different commercial full-wave software are also used, and their limits in the analysis of such microstructured materials are pointed out.

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 11:00 AM
Impedance of an Infinitely Large Parallel-Plane Pair and its Applications in Engineering Modeling
A. R. Chada, Missouri University of Science and Technology, Rolla, MO, U.S.A.; Y. Zhang, Institute of High Performance Computing, Singapore, Singapore; G. Feng; J. L. Drewniak; and J. Fan, — Missouri University of Science and Technology, Rolla, MO, U.S.A.

In this paper, a closed-form expression for the impedance of the infinitely large parallel plane pair is presented. It is applicable to practical PCB design problems where there are lots of shorting vias around

the signal vias of interest. With the presence of many shorting vias, reflections from the plane pair edges can be neglected since the shorting vias prevent the electromagnetic energy from leaking away from the local cavity around the signal vias. The transfer impedance expression is obtained from the area average impedance definition using the Green's function in an infinitely large parallel plane pair and the addition theorem of cylindrical waves. The impedances calculated from both the rectangular cavity model and the infinitely large plane pair model for several design examples are compared to demonstrate the effectiveness of the infinite plane pair approximation.

11:00 AM - 11:30 AM
Measurement of Electromagnetic Parameters and FDTD Modeling of Ferrite Cores
J. Xu; M. Y. Koledintseva; R. E. DuBroff; J. L. Drewniak; and A. Orlando, — Missouri University of Science and Technology, Rolla, MO, U.S.A.; Y. He; and B. Matlin, — Laird Technologies, Chattanooga, TN, U.S.A.

The objective of this paper is to present a methodology for an efficient design of novel products based on magneto-dielectric (ferrite) materials with desirable frequency responses that satisfy EMC and SI requirements. This methodology starts from estimating complex permittivity and permeability of these materials. This requires measurement techniques, approximation resultant frequency characteristics for permittivity and permeability using a curve-fitting procedure, and the development of a full-wave numerical simulation tool that could deal with frequency-dispersive materials. An example of a ferrite material measurement, constitutive parameters extraction using a genetic algorithm, and corresponding FDTD modeling over the frequency range from 10 to 500 MHz is provided.

TU-AM-4 Nano-Technology (TC11)

Room 19A

Chair: Chris Holloway, NIST, Colorado, U.S.A.
Co-Chair: Maria Sabrina Sarto, Sapienza – University of Roma, Rome, Italy

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8:30 AM - 9:00 AM
Mechanical and Electrical Characterization of Epoxy Nanocomposites for Electromagnetic Shielding Devices in Aerospace Applications
S. Bellucci; G. De Bellis; F. Micciulla; and I. Sacco, Laboratori Nazionali di Frascati (INFN), Frascati, Italy; and G. Rinaldi, Sapienza – University of Roma, Rome, Italy

We report on the results of a systematic study of the electrical properties of carbon nanotube-based polymeric composite materials. Our purpose is the production and characterization of a light, thin, and mechanically strong, new composite material able to cover electric circuits against external electromagnetic interference. Setting the resistivity properties of carbon nanotube-based composites against those containing micro-sized graphite particles as constituent, we show the advantages of using carbon nanotubes. The change in the resistivity values for carbon nanotubes-based composites turns out to be significant, even for small changes in the added carbon nanotubes percentage. Mechanical characterizations of the nanocomposites will also be discussed. The study of mechanical performances is carried out focusing on the influence on the mechanical properties of different parameters, such as: Aspect ratio (defining the matrix-CNTs interface extension); CNTs chemical functionalization; and Synthesis method. These results might be important for determining the most suitable recipe for the realization of composite materials useful to high-fidelity circuits applications, aerospace applications, or in general for devices exposed to predominantly electromagnetic noise.

9:00 AM - 9:30 AM
Multiwall Carbon Nanotube Vias: An Effective TL Model for EMC Oriented Analysis
A. Tamburrano; and M. Sarto, — Sapienza – University of Rome, Roma, Italy

This paper presents an effective two-port model of a nano-interconnect constituted by a vertical multiwall carbon nanotube (MWCNT) between two horizontal planes. The newly developed model is derived combining the quantum-mechanical effects with the analysis of the EM field radiated from the vertical structure, and can be used to predict the signal integrity of MWCNT vias. EMC oriented analyses are performed in the frequency range up to several tens of gigahertz, and comparisons with the performance of scaled copper interconnects are presented.

9:30 AM - 10:00 AM
Analytical Modeling for Crosstalk Noise Induced by Process Variations among CNT-based Interconnects
P. Sun; and R. Luo, — Tsinghua University, Beijing, China

In this paper, we propose a statistical model to analyze the crosstalk noise induced by process variations on a single walled carbon nanotube (SWCNT). Our approach is based on a closed-form metric, which simplifies the noise peak voltage of SWCNT buses into a linear function of process variations. The method-ology is based on an assumption that if the variational parameters are independent Gaussian variables, then the performance of the interconnect also tends to have a normal distributed character. The experiment results reveal that while being able to save the long computa-tion time of SPICE-based tools, this approach yields little loss in accuracy. Also, it provides a compound result which covers all potentical cases and provides more information, promising it to be much closer to the truth in real manufacture processes. Compared with SPICE-based Monte Carlo simulations, the experiments report the error in mean and standard deviation of noise peak to be 1.8% and 4.6%, respectively.

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 11:00 AM
Design of Composite Materials Using a Genetic Algorithm
H. Yang; J. Shen; and J. Chen, — University of Houston, Houston, TX, U.S.A.; and C. Fuller, ATK, Plymouth, MN, U.S.A.

The ability to design dielectric composite material exhibiting maximum loss at a specific frequency is of interest in telecommunications and radar absorption. In this paper, an optimization procedure based on genetic algorithm is presented for the design of composite material with maximum loss at multiple frequencies using multiphase and multilayer of spherical filler particles. This approach can also be used to design composite materials having approximately constant maximum loss in a wide band.

11:00 AM - 11:30 AM
Measurement of Dielectric Properties of Carbon Nanotube Networks Used to Build Planar Transmission Lines
M. A. EL Sabbagh; and S. M. El-Ghazaly, — University of Arkansas, Fayetteville, AK, U.S.A.

In this paper, we explore building a planar transmission line from carbon nanotube (CNT) networks. We are successful in fabricating the transmission line and verifying the feasibility of potential planar transmission lines where carbon nanotube networks replace the metallic lines. The experimental realization and the two-port microwave measurements enabled us to accurately extract the fundamental parameters of the proposed transmission line. The frequency dependent phase velocity characteristics clearly show its dramatic reduction compared to the speed of light in a vacuum. The complex permittivity of CNT networks is also reported in our work.

TU-AM-5 Special Session - EMC in Asia
Room 18C
Chair: Leslie Bai, SIEMIC Testing and Certification Services, San Jose, CA, U.S.A.

8:30 AM - 9:00 AM
Regulatory Update in Asia Pacific Rim
L. Bai, SIEMIC Testing and Certification Services, San Jose, CA, U.S.A.

This paper will briefly update regulatory affairs in the Asia-Pacific Rim. Product Safety, EMC, Radio/Wireless, and Telecommunication Certifications in Asia Pacific Rim is covered. This paper is not intended to introduce the whole certification systems but update the new requirements instead.

9:00 AM - 9:30 AM
New VCCI Program - Kit Module Program
S. Satake, VCCI Council, Tokyo, Japan; T. Shimasaki, NEC Engineering, Ltd., Kawasaki-shi, Japan; and H. Yamane, NTT, Musashino-shi, Japan

VCCI Council introduced the kit module program designed to serve as an intermediary between module manufactures and equipment makers using their modules. The Magnetic Probe (MP) Method, one of the IEEE 61967 test methods, is employed in the program for its simplicity and low implementation cost. An interposer was developed to bridge target memory module and mother board for operation at the real frequency and aggregation of power supply circuits for measurement with the MP method. The results of pilot measurements of DDR2 memory modules are reported.

9:30 AM - 10:00 AM
Understanding KCC Certification: Indispensable Step for Korean IT Market Penetration
B. Hur, HCT Co., Ltd., Icheon-si, Republic of Korea

Most of the IT companies are looking at Korea as one of the major market for their products. However, there is one obstacle that gives companies tough times in deciding whether to enter the Korean market or not. Now is the time to get rid of this bothersome obstacle once and for all.

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 11:00 AM
EMC Technology Development of China
J. He, Tsinghua University, Beijing, China

As part of its commitment for entry into WTO in December 2001, China started the Compulsory Product Certification System on Dec 7, 2001 to unify the technical regulations, certification standards and conformity assessment, and published First Catalogue of Products Subject to Compulsory. This presentation summarizes EMC development in China. It discusses the status of EMC standards, test requirements, the relationship between Chinese EMC standards and International standards, voluntary certification, and future EMC technology development in China. At last, it also discusses issues for the EMC research works in the power systems.

11:00 AM - 11:30 AM
Product Certifications for Telecommunication Equipment for China
L. Bai, SIEMIC Testing and Certification Services, San Jose, CA, United States; and D. Li, SIEMIC InfoTech (China) Ltd., Nanjing, China

This paper will briefly introduce China's product conformity assessment systems and current major product certifications implemented under Chinese regulations for telecom equipment, including CCC Mark

Certification and Network Access License. It will focus on the uncertain aspects of the rules and challenges and issues foreign companies are facing in the efforts to get into the China Market.

11:30 AM - 12:00 PM
Radio Product Certifications for Russia
L. Bai, SIEMIC Testing and Certification Services, San Jose, CA, U.S.A.

This paper will briefly introduce radio product certifications for the Russian market.

TU-PM-1 Emission Measurements (TC2)

Room 17A

Chair: Bob Hofmann, Hofmann EMC Engineering, Illinois, U.S.A.

Co-Chair: Ross Carlton, National Instruments, Austin, TX, U.S.A.

1:30 PM - 2:00 PM
An Innovative Methodology for Evaluating Multi-Chip EMC in Advanced 3G Mobile Platforms
S. Akue Boulingui; and E. Sicard, — LATTIS INSA de Toulouse, Toulouse, France; C. Dupoux; N. Bouvier; and B. Vrignon, — Freescale Semiconductor, Toulouse, France; and S. Baffreau, LATTIS IUT de Tarbes, Tarbes, France

This paper presents an innovative approach which consists in emulating the behavior of a disruptive chip, by means of a specific probe, and analyzing the risks of interference with the victim component. Chip-to-chip interferences may be investigated without requiring any specific EMC test board. Details of this methodology are provided and illustrated in the case of a 3G mobile platform. Valuable information about the sensitive zones, coupling orientation and critical coupling distances are extracted easily using this approach.

2:00 PM - 2:30 PM
Analysis of the Propagation of Electromagnetic Disturbances Inside Integrated Circuits Using Direct Power Injection and Near-Field Scanning
A. Alaeldine; L. Bouchlouk; R. Perdriau; and M. Ramdani, — ESEO, Angers, France

This paper demonstrates how the direct power injection (DPI) and near-field scan (NFS) methods can be used to investigate the propagation of electromagnetic waves inside an integrated circuit (IC). In this study, a two-dimensional near-field cartography of the magnetic field generated by the circuit under test is achieved either in normal operation or while applying DPI into the Vdd pin of the IC, in order to visualize wave propagation. An unshielded (lidless) version of the test chip is used, making it easier to identify emission sources. Preliminary results demonstrate that the propagation of EM waves into a circuit depends not only on the impedance profile of the power supply network, but also on different EMI protection strategies implemented into the IC.

2:30 PM - 3:00 PM
A Flexible EMI Measurement Sheet to Measure Electric and Magnetic Fields Separately with Distributed Antennas and LSI's
N. Masunaga; K. Ishida; Z. Zhou; T. Yasufuku; and T. Sakurai, — University of Tokyo, Institute of Industrial Science, Meguro-ku, Japan; T. Sekitani; and T. Someya, — University of Tokyo, Quantum-Phase Electronics Center, Bunkyo-ku, Japan; and M. Takamiya, University of Tokyo, VLSI Design and Education Center, Bunkyo-ku, Japan

A flexible 12cm by 12cm EMI measurement sheet is developed to enable the measurement of the EMI distribution on the surface of the electronic devices by wrapping the devices in the sheet. The sheet includes 8 by 8 antenna array, 2V organic CMOS decoder, stretchable interconnects, and EMI detection LSI's in 0.18um CMOS. The distributed LSI's near the antennas enable the in-situ EMI measurement and have a potential to improve the measurement speed and accuracy. By changing the connection of the antenna to the LSI, the electric and magnetic fields are successfully measured separately. The minimum detectable magnetic field noise power was -70 dBm and the maximum detectable noise frequency was 1 GHz. The minimum detectable electric field noise power was -60 dBm and the maximum detectable noise frequency was 700 MHz.

BREAK (3:00 PM – 3:30 PM)

3:30 PM - 4:00 PM
Novel Assessment Technique for Investigating Potential Phased Array Effects of Passenger Aircraft
I. Schmidt; A. Enders; R. Geise; and M. Schwark, — Technische Universität Braunschweig, Braunschweig, Germany

Signals emitted inside the aircraft by onboard communication systems, e.g. GSM and UWB, propagate on different paths to the outside of the aircraft. In this paper the question is investigated if these signals could be emitted from the aircraft in the manner of a directive antenna or phased array due to the periodicity of the windows, whereby the aircraft itself becomes an aperture antenna. A superposition model is presented to calculate possible radiation patterns. The model was fed with either ideal, coherent excitation or measured phase and magnitude coefficients. The measured data was acquired during a measurement campaign on an Airbus A320 in the frequency range from 450 MHz to 2100 MHz. The innovative measurement technique to reliably acquire these coefficients is described in detail. No phased array effects were observed at the far field distance.

4:00 PM - 4:30 PM
On-Site EMC Testing and Interference Prevention
T. Schrader; K. Muenter; C. Jastrow; A. Daneschnejad; and T. Kleine-Ostmann, — Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

Complex measurement systems being assembled on site have been found to suffer from electromagnetic interference although components of the systems passed the required electromagnetic compatibility (EMC) tests. We present an on-site test system that allows for the EMC evaluation of on-site assembled large measuring system installations in the frequency range from 27 MHz up to 5.8 GHz, and propose a solution for interference prevention therein. E.g. weigh bridges for large vehicles and other measuring instruments being subject to legal metrology must not display readings influenced by radio frequency fields. A multi-sensor system integrated into the electronics detects any unintentional RF signals coupled into the measuring device and prevents further processing of measured data which are likely being disturbed by RF energy coupled into the system.

4:30 PM - 5:00 PM
Bulk Current Injection Testing of Cable Noise Reduction Techniques, 50 kHz to 400 MHz
A. T. Bradley; R. J. Hare; and M. Singh, — NASA Langley Research Center, Hampton, VA, U.S.A.

This paper presents empirical results of cable noise reduction techniques as demonstrated using bulk current injection techniques with radiated fields from 50 kHz to 400 MHz. It is a follow up to the two-part paper series presented at the Asia Pacific EMC Conference that focused on TEM cell signal injection. This paper discusses the effects of cable types, shield connections, and chassis connections on cable noise. For each topic, well established theories are compared with data from a real-world physical system.

5:00 PM - 5:30 PM
Developing a Universal Exchange Format for Near-Field Scan Data
J. Shepherd, Freescale Semiconductor, Toulouse, France; A. Nakamura, Renesas Technology Corp, Tokyo, Japan; F. Lafon, Valeo, Creteil, France; E. Sicard, INSA, Toulouse, France; M. Ramdani, ESEO, Angers, France; D. Pommerenke, Missouri University of Science and Technology , Rolla, MO, U.S.A.; G. Muchaidze, Amber Precision Instruments, Santa Clara, CA, U.S.A.; and S. Serpaud, Nexio, Toulouse, France

Near-field scan measurements and simulations generate a large amount of data. The format of the data is closely linked to the supplier of the acquisition or simulation software, rendering extremely difficult its exchange between suppliers, customers, EDA tool vendors, academics, etc. The paper describes how a universal exchange format for near-field scan data has been developed. The format caters for various coordinate systems and is suited to emission and immunity testing both in the frequency and time domains.

TU-PM-2 EM Issues and Case Studies (TC4)

Room 17B

Chair: John Archer, retired from RCA Military
Co-Chair: Jim Knighten, Teradata Corporation, San Diego, CA, U.S.A.

1:30 PM - 2:00 PM
Real World ASD Interference Case Study with Modeled Solutions
K. O. Phipps; P. F. Keebler; and R. F. Arritt, — EPRI, Knoxville, TN, U.S.A.

The installation of adjustable speed drives (ASDs) has been known to cause many types of radiated and conducted emissions related electromagnetic interference (EMI) problems. Solutions to resolve these problems are often not straightforward and involve the correction application of filtering and shielding devices. The process of identifying effective solutions is also not straightforward. This paper describes a real-world case study where the use of several high horsepower ASDs caused EMI problems with a cable tester in an industrial plant. Included are the approaches for investigating the problem and mitigating the problem. It is shown that the correction application of an isolation transformer combined with the application of a custom power-line filter designed for mitigation of ASD related conducted emissions resolved the problem.

2:00 PM - 2:30 PM
Reduction of In-band Intermodulation Products Caused by Adjacent Channel Signals Via the Design of Linear Out-of-Band Behavior
I. Demirkiran, Embry-Riddle Aeronautical University, Daytona Beach, FL, U.S.A.; D. D. Weiner, Syracuse University, Syracuse, NY, U.S.A.; A. Drozd; and I. Kasperovich, — Andro Computational Solutions, Rome, NY, U.S.A.

A design technique for reducing in-band inter-modulation products caused by adjacent channel signals is presented. The technique makes use of the fact that certain in-band nonlinear responses depend upon the out-of-band linear behavior of the network. The concept is illustrated by means of a simple example.

2:30 PM - 3:00 PM
A Multi-Fidelity Modeling Approach for Cosite Interference Analysis
F. German; M. Young; and M. C. Miller, — Delcross Technologies, Champaign, IL, U.S.A.

The accurate simulation of cosite electromagnetic interference (EMI) is often limited by the information that is available for characterizing the individual systems operating in the cosite environment. In this

paper, we present an analysis methodology to address cosite interference predictions using a multi-fidelity modeling approach that provides the analyst with a single integrated simulation environment that allows different prediction techniques to be used depending on what information is available, from fairly simple front-end radio models to more complex methodologies based on non-linear RF system level simulations. An overview of the analysis engines is provided as well as results for an example application using actual measured data.

BREAK (3:00 PM – 3:30 PM)

3:30 PM - 4:00 PM
Is Electrostatic Discharge Phenomenon A Well-Posed Problem?
T. Toh, Dell Inc., Round Rock, TX, U.S.A.

Electrostatic discharge phenomenon often proves to be an elusive problem for electromagnetic compatibility engineers to predict. Indeed, in order to understand electrostatic discharge at the fundamental level, it is necessary to determine whether electrostatic discharge is a well-posed problem. Studying electrostatic discharge as a boundary value problem of potential theory is the primary contents of this paper.

4:00 PM - 4:30 PM
Influence of Rise Velocity of Charge Voltage on Spark Discharge from a Metal Sphere
H. Tomita, National Institute of Occupational Safety and Health, Kiyose, Tokyo, Japan

An ESD event in the time during which a charged body moves toward a grounded body has a more significant effect on electronic equipment than an ESD event from a stationary charged body with the same charge voltage. This peculiar phenomenon is not well understood due to reasons such as the difficulty of reproducibility. To further the understanding of the ESD, the influence of the rise velocity of the charge voltage on ESD from a stationary metal sphere was measured in the gap length between 20 and 80um. The results of the experiment indicated that in instances where no sparking discharge occurred, at the same gap length the maximum voltage-charge value became higher with the rise in the charge-voltage velocity. In instances where the sparking discharge occurred for all applied charge voltages under each discharge condition, the average value of the sparking voltage increased with the rise in velocity of the charge voltage for the same gap length.

TU-PM-3 EM Transients (TC5 & TC7)
Room 18C
Chair: Bill Radasky, Metatech Corporation, Goleta, California, U.S.A.
Co-Chair: Mike McInerney, U.S. Army, Champaign, Illinois, U.S.A.

1:30 PM - 2:00 PM
On the Zero Crossing of Distant Electro-magnetic Fields Radiated by Lightning
A. Shoory; and F. Rachidi, — Swiss Federal Institute of Technology, Lausanne, Switzerland; M. Rubinstein, Ecole d'ingénierie et de Gestion du Canton de Vaud (HEIG-Vd), Yverdon-les-bains, Switzerland; R. Moini; and S. Sadeghi, — Amirkabir University of Technology, Tehran, Iran

We discuss the reasons why some return stroke models do not reproduce one of the characteristic features of the electromagnetic fields radiated by lightning, namely the far-field inversion of polarity with a zero crossing occurring in the tens of microseconds range. A property of time-domain radiation requires that far fields predicted by lightning return stroke channel models exhibit a zero crossing as long as the duration of the return stroke current and the height of the channel are finite. However, many of the available models predict the zero crossing to occur at times that fall well beyond those observed experimentally. Three mechanisms responsible for the time of occurrence of the reversal of polarity in the far fields are identified, namely (1) the current attenuation along the channel, (2) the width of the return stroke current, and (3) the return stroke speed. An analysis of the MTLL and MTLE return-stroke models shows that the higher the attenuation of the current along the channel, the earlier the polarity reversal of the vertical electric field. Also, for a given value of the attenuation factor, higher propagation speeds correspond to earlier polarity reversal times. For the TCS model, in which the only adjustable parameter is the return-stroke speed, we show that the far-field zero crossing occurs considerably later than the values predicted by both the MTLE and the MTLL models. This is shown to be essentially due to the fact that the decrease of the current wave along the channel according to the TCS model is less pronounced than the current attenuation predicted by the MTLE and MTLL models.

2:00 PM - 2:30 PM
Electrode Speed Effect on Discharge Properties in Short Gap Electrostatic Discharge
F. Ruan; and Z. Song, — Guizhou Normal University, Guiyang, China; D. Shi; and Y. Gao, — Beijing University of Post & Telecommunication, Beijing, China

Strong effect of moving electrode speed on discharge parameters exists in short-gap electrostatic discharge. Considering Townsend theory and streamer theory of electrostatic discharge, theoretical analysis with principles of fluid mechanics is employed on mechanism of electrode speed effect on discharge parameters. An algorithm is proposed and the simulation result gives estimation of theory description proposed.

2:30 PM - 3:00 PM
HEMP Field Coupling With Buried Power Distribution Cables
S. K; and J. T. Meledath, — Indian Institute of Science, Bangalore, India

The interaction of transient electromagnetic field due to an NEMP with multi core buried power distribution cables is studied in this paper. Using transmission line analysis, the induced current on the shield of the cable is computed. The cable transfer impedance is used to find the coupled current in the inner circuit. The variation of the current induced on the inner conductor as a function of the distance along the length of the cable is computed. The influence of the depth of burial of the cable on the induced current is evaluated to determine the soil attenuation effects.

BREAK (3:00 PM – 3:30 PM)

3:30 PM - 4:00 PM
Risk Potential of Radiated HPEM Environments
F. Sabath, Bundeswehr Research Institute for Protective Technologies and NBC-Protection , Munster, Germany; and H. Garbe, Leibniz Universität Hannover, Hannover, Germany

High-Power Electromagnetic (HPEM) environments are capable of causing effects like malfunctions, performance degradation, interferences, and destructions in electronic and electrical systems. This paper will discuss the risk potential of different HPEM environments for electronic systems. In addition to well known characteristics of HPEM environments aspects like mobility, ability to access the target and likelihood of occurrence will be taken into consideration.

4:00 PM - 4:30 PM
Automated Measurement of Intermittent Signals using a Time Domain EMI Measurement System
H. H. Slim; S. M. Braun; E. Gülten; A. Frech; and P. Russer, — Munich University of Technology, Munich, Germany

Traditionally, emission measurements are carried out in frequency domain using pre- and final scans. Time domain EMI measurement systems allow the reduction of the scan time by orders of magnitude, enabling novel test methods. In this paper, the measurement uncertainty for intermittent signals during pre- and final scans is investigated. The effect of the dwell time on the measurement accuracy in the peak and quasipeak detector mode is shown. For conducted emission measurements, two test procedures are presented: 1) a method that performs a separate evaluation according to the phase of the LISN, and 2) a full maximization method. Both methods are used for automated measurement of intermittent and narrowband drifting signals. The total test time is reduced by at least one order of magnitude. Intermittent and narrowband drifting signals, which are still measured manually today, can be measured by the presented procedure automatically. Measurements have been carried out in the frequency range from 9 kHz to 1 GHz.

4:30 PM - 5:00 PM
A Novel (Non Sinusoidal) Signal Delay and Attenuation Measurement of Long RF Cables with Variable Insertion Loss
M. A. Royer; and R. H. Flake, — University of Texas at Austin, Austin, TX, U.S.A.

This paper describes the use of a novel, non-sinusoidal pulse named “Speedy Delivery” (SD) to measure combined delay and attenuation with precision not found using the conventional methods of TDR or vector network analyzer analyses. The measurements accurately estimate the insertion loss through 200 feet of coax and two small magnetically coupled loops at varying separation distances in air, water, and seawater. The measurement method is TDT using the SD pulse as the test signal for improved resolution. The SD signal results are compared with the loss of a sinusoid chosen for having an “equivalent” frequency, i.e. equal to the bandwidth of the UWB SD pulse. The leading edge of the SD pulse does not change shape or exhibit dispersion, which makes accurate measurements of delay or attenuation possible, even on long cables with insertion losses exceeding 60 dB.

TU-PM-4 Special Session - Modeling/ Simulation Validation Standards and Applying the FSV Technique to Quantify Validation Quality (TC9)

Room 18B

Chair: Bruce Archambeault, IBM, Research Triangle Park, North Carolina, U.S.A.
Co-Chair: Greg Hiltz, Quality Engineering Test Establishment, Ottawa, Canada

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1:30 PM - 2:00 PM
Using the Feature Selective Validation Technique to Compare CEM Code Predictions and Measurements of Field Distributions for Cavity Problems
A. L. Drozd; I. Kasperovich; and C. E. Carroll, — ANDRO Computational Solutions, LLC, Rome, NY, U.S.A.

This paper will illustrate the application of the Feature Selective Validation (FSV) technique embodied in the recent IEEE 1597.1 Standard for the Validation of CEM Computer Modeling and Simulations. Whereas various methods exist for comparing multiple sets of electromagnetic (EM) observable data for validation and verification purposes, there is no standard approach for accomplishing this in a repeatable way. A consistent method for cross-validating measurements with computer simulations or comparing results of multiple simulation runs can provide key insights into error mechanisms and ways to ensure accuracy and repeatability. This is best understood in the context of simulating large-scale problems where numerical codes are “stressed”, giving rise to errors that produce varying

differences between data sets that cover a common range. Such differences can lead to erroneous conclusions about the joint agreement of the data. Recent work towards the development of standardized techniques for comparing multiple data sets has led to the FSV technique as a consistent way of performing cross-validation applicable to EM observables acquired through measurement or simulation across any independent variable. The application discussed in this paper will focus on comparing a family of curves obtained via computer simulations for a cavity model to assess statistical filed distributions using several different CEM techniques, namely FDTD, MLFMA, and modal MoM. The curves will be compared to each other and to a reverb chamber measurement baseline to establish a level of goodness metric to validate results and to demonstrate the efficacy of the approach.

2:00 PM - 2:30 PM
Using the Feature Selective Validation Technique to Compare Data Sets
B. R. Archambeault, IBM, Durham, NC, U.S.A.; A. P. Duffy, De Montfort University, Leicester, UK; and A. Orlandi, University of L'Aquila, L'Aquila, Italy

The Feature Selective Validation (FSV) technique has been introduced as a method to quantify the agreement between data sets to closely match how a human expert would rate the agreement. While the origin of this was in validating numerical models against measurements for electromagnetic compatibility applications, it is finding that it is being used in a number of other applications such as comparing antenna directivities. Recently, IEEE Standard 1597.1 calls for the use of FSV to quantify the agreement between simulation results and validation comparisons. FSV has a tiered approach to presenting the comparison data, thus providing a number of various ways to rate the comparisons and use the resulting validation output. This paper will show how to use the FSV results to gain meaningful comparisons.

2:30 PM - 3:00 PM
Application of the Feature Selective Validation Method to Test Site Evaluation
C. E. Brench, Southwest Research Institute, San Antonio, TX, U.S.A.; and B. L. Brench, DJR EMC Engineering, Stow, MA, U.S.A.

IEEE Standard 1597.1 calls out the Feature Selective Validation (FSV) method to validate computational electromagnetics model solutions. This method can be used to compare any two data sets, and in this paper it is used in the application of evaluating a 3 m test site. Two comparisons are made; the first shows how the measured performance of a 3 m open area test site agrees to the expected normalized site attenuation. As well as providing an insight to the use of FSV, the use of a well documented set of data will help provide a good sense of what the FSV outputs mean to a wide range of engineers. In the second part of the paper, FSV is applied to the evaluation of the results obtained from an FDTD model of a 3 m test site. It is shown that FSV is a powerful tool for judging the real performance of a test site.

BREAK (3:00 PM – 3:30 PM)

3:30 PM - 4:00 PM
FSV Validation of Radio Path Loss Measurements
R. Johnk; and P. McKenna, — Institute for Telecommunication Sciences, Boulder, CO, U.S.A.; B. Archambeault; and Z. Wu, — IBM, Research Triangle Park, NC, U.S.A.

This paper describes the application of the FSV to measured propagation data. A mobile-to-mobile measurements program is currently being conducted at the Institute for Telecommunication Sciences under the sponsorship of the Office of Spectrum Measurement. Two different measurement systems are being used to collect mobile-to-mobile data in a number of selected outdoor environments. One system uses a wideband time-domain channel sounder that uses pseudo-random noise sequences to generate channel impulse responses. The other system transmits a narrowband CW signal, and it is received by a spectrum analyzer. This paper explores the possibility of using FSV to quantify how well data obtained from these measurement systems compare.

4:00 PM - 4:30 PM
Comparison among Different Via Models Based on Feature Selective Validation Technique
S. Pan; H. Wang; and J. Fan, — Missouri University of Science and Technology, Rolla, MO, U.S.A.

A new approach is proposed in this paper to validate different uncertain approaches without knowing a standard reference by applying the Feature Selective Validation (FSV) technique. New reference is established by the weighted average of the various approaches. Four via modeling methods including physics-based circuit model, equivalent transmission line model, multiple scattering model, and full wave model are compared and validated by the approach proposed in this paper to illustrate the effectiveness of different via modeling techniques.

4:30 PM - 5:00 PM
Characterization Study of the Feature Selective Validation (FSV) Technique on Simple and Complex Waveforms
G. Hiltz, Quality Engineering Test Establishment, Ottawa, Canada

The Feature Selective Validation (FSV) technique has been shown to be a useful tool in quantifying the agreement between two data sets. To assist in the use of this relatively new and unfamiliar technique for validation purposes, the FSV technique is characterized by applying it to a number of simple waveforms, chosen to emphasize different figures-of-merit generated by the FSV technique. The sensitivity of FSV to differences

between these representative data sets is demonstrated.

TU-PM-5 Open Forum #1

Room 19B

Chair: Richard Worley, Dell Computers, Austin, Texas, U.S.A.

1:30 PM - 3:00 PM

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

J. Tao; and S. Chen, — Wuhan University, Wuhan, China; and Z. Wang, The University of Manchester, Manchester, United Kingdom

As an important operation in an air-insulated substation (AIS), the disconnect switch operation is an electromagnetic interference (EMI) source to secondary control circuits. For analysis of the time and frequency characteristics, an electromagnetic transient program has been used to simulate the switching operation to get the transient microburst. Time-frequency analysis reveals that time of operation influences the amplitude of the interference wave, while the frequency characteristics are decided by the configuration of the substation and its connection. It is possible to forecast the frequency scope before certain operations and so the EMI coupling to secondary circuit can be filtered.

1:30 PM - 3:00 PM

Calibration of Double-Ridged Guide Horn Antenna Using Phase Center

K. Harima, National Institute of Information and Communications Technology, Koganei, Japan

In the three-antenna method, the phase center location is used to determine the gain of double-ridged guide horn antennas. The phase center of a conventional ridged horn antenna is calculated using the finite integration method. A comparison of the gain determined from the phase center location and that obtained from numerical analysis confirms the efficacy of using the phase center for antenna calibration.

1:30 PM - 3:00 PM

Increasing the Quiet Zone Performance in an Anechoic Chamber

D. Song, Huazhong University of Science and Technology, Wuhan, China; C. Fang; Q. Zhang; D. Wen; and J. Yu, — China Ship Development and Design Center, Wuhan, China

In the design of anechoic chamber with high quality, when requirements of quiet zone index are higher, it must use the geometrical theory of diffraction instead of the geometrical optics for accuracy. The utilities of the theory in design have been discussed in this paper. Besides, in analysis of reflectivity versus incident angle of absorbing materials, it used to use linear interpolating method and resulted in considerable error. In the present paper, a new relationship between reflectivity and incident angle of absorbing materials has been derived from the theory of electromagnetic fields. It has been demonstrated that new relationship can eliminate the error.

1:30 PM - 3:00 PM

EMC Issues of Power Electronic Converters

P. Drabek; and V. Kus, — West Bohemia University in Pilsen, Plzen, Czech Republic

Power electronic converters produce not only characteristic harmonics, but also both non-characteristic harmonics and inter-harmonics. This paper presents the physical background of both non-characteristic harmonics and inter-harmonics. Generation causes are explored and discussed in detail. An extensive series of simulations of different power converter topologies are provided and compared with experimental results and existing standards. This research offers missing background for standards covering low-frequency EMC.

1:30 PM - 3:00 PM

An Analytical Study on the Relationship between the Surface Conditions of the Rotary Slide Contacts and the Noise Waveforms

A. Mutoh, Tokyo Fuji University, Shinjuku, Japan; S. Nitta, Salesian Polytechnic, Machida, Japan; and R. Koyama, Tokyo University of Agriculture & Technology, Koganei, Japan

In this study, the characteristics of the noise generated across the rotary slide contacts are clarified by proposing the rectangular window function (that is, the surface roughness model of contact) derived from the observation results of the noise waveforms and the shapes of contact's surface changing for a long time. And, it is shown that the effective contact area can be simulated by the proposed rectangular window function and the proposed model is effective for the estimation of the noise generated across the rotary slide contact.

1:30 PM - 3:00 PM

Finite Element Method Model Improvement for the Conducted Emission Analysis of a Lighting Fixture

Y. Namba, Osaka University, Suita, Japan; T. Kida, Panasonic Electric Works Analysis Center Co., Ltd, Kadoma, Japan; K. Hirata; S. Ikejiri; and F. Obayashi, — Osaka University, Suita, Japan

This paper describes a technique for the multi-scale numerical modeling of conducted emissions for the inverter lighting fixture placed in a large space of a shielded room. The analysis employs the 3-D Finite Element Method (FEM). It is experimentally understood that conducted emissions are mainly generated by the common mode current, therefore the displacement current is also taken into consideration in the model. That is, a precise FEM model is employed only for the

region displacement current influences. The validity of the computation was confirmed by a comparison with the measured results of a lighting fixture.

1:30 PM - 3:00 PM
On the Study of Electromagnetic Environment Simulation for Shipboard Cabin
D. G. Xie; J. Yu; and D. Y. Hou, — China Ship Development and Design Center, Wuhan, China

The model of the shipboard cabin was developed and the electromagnetic environment (EME) in it was simulated by using the electromagnetic field analysis software FEKO. The EME in the shipboard cabin varying with the number of antennas on deck, the distance between the antenna and cabin, and the transmitting power of antennas was obtained, and their dependent relations were also presented. The results and methods adopted in this paper may provide ideas and foundations for the making or emendation of environment limits in military standards.

1:30 PM - 3:00 PM
Novel Methodology for Optimal On-board Decoupling Capacitors Selection and Placement
G. Han, Marvell Tech. Inc., Shanghai, China

Novel methodology for optimization of on-board decoupling capacitors is introduced, which can be performed easily based on common EDA or mathematic tools. And it greatly saves on both time and cost since it avoids a large number of repeated electromagnetic computations when finding the optimal solution. To perform the methodology, we first extracted the network parameters of the PCB, then set up the optimization topology in an Agilent Advanced Design System (ADS), finally, the optimum placement scheme of capacitors with the minimal impedance profile can be found by the optimizer in the ADS. Detailed applications of practical cases demonstrate the proposed methodology with reasonable goals achieved.

1:30 PM - 3:00 PM
Far Field Radiated Emission Prediction from Magnetic Near Field Magnitude-only Measurements of PCBs by Genetic Algorithm
H. Fan, ZTE Corporation, Shanghai, China

A Genetic Algorithm is used in this paper for predicting far field radiated emission of Ethernet switch and ADSL modem boards from near field magnitude-only measurements. The magnetic near field data are measured by EMSCAN, and the electric far field prediction is compared with the measurements in an anechoic chamber.

1:30 PM - 3:00 PM
The EMC Education at the Czech Republic in Consideration of Low Frequency Interference
V. Kus; P. Drabek; and M. Pittermann, — West Bohemia University in Pilsen, Plzen, Czech Republic

The phenomenon of electromagnetic compatibility (EMC) has been taken into account almost at the all faculties of electrical engineering in the Czech Republic. However there are very often only partial mentions of EMC in frame of individual electrical engineering subjects, and the education is focused on the one specific EMC area. At our Faculty of Electrical Engineering, we have paid attention to these questions in several special subjects in the bachelor and master studying program. In this paper, the education system of the Faculty of Electrical Engineering has been presented. The main attention has been given to the low frequency interference of power electronic converters.

WED-AM-1 Test sites, GTEM, and Regulations (TC2)

Room 17A

Chair: Don Heirman, Don HEIRMAN Consultants, New Jersey, U.S.A.

Co-Chair: Mike Royer, Foxconn, Texas, U.S.A.

8:30 AM - 9:00 AM

FDTD Analysis of Site Free Space VSWR in Test Site Used for Disturbance Measurement above 1 GHz

N. Kuwabara; and M. Midori, — Kyushu Institute of Technology, Kitakyushu, Japan; and M. Kawabata, Fukuoka Industrial Technology Center, Kitakyushu, Japan

The calculation of the site free space voltage standing wave ratio (SVSWR) is important to design the measurement facilities used above 1 GHz. In this paper, the relations between the area of the absorbers on the ground plane and the SVSWR were analyzed by the FDTD method. The space including the transmitting antenna, the receiving antenna, and the absorbers were modeled by the cells. The absorber constructed with the foamed ferrite, the ferrite tile, and the wood was also modeled by the cells. The calculation results almost agree with the measurement results, and the deviation between the calculation value by the FDTD method and the measurement value was smaller than the deviation between the calculation value by the ray trace method and the measurement value. The investigation suggested that the length similar to the distance between antennas was needed to acquire the result similar to the case where absorber was arranged in the entire ground plane (FAR), and that the width of 1.2 m also was needed to acquire the results similar to the case of FAR.

9:00 AM - 9:30 AM

Searching for the Elusive Correction Factor between 3m and 10m Radiated Emission Tests

E. Blankenship; D. Arnett; and S. Chan, — Hewlett-Packard Company, Vancouver, WA, U.S.A.

The authors investigate certain physical effects that complicate the use of radiated emission test data at one test distance to predict the results at a different test distance. The presumed 10 dB change in field strength between 3 m and 10 m test sites is shown to be an over-simplification. The mean correction factor varies with frequency, and has a +/- 5 dB uncertainty if one does not know the polarization of the source, or the height of the radiating element above the ground screen. At higher frequencies, such as above 1 GHz, the uncertainty band narrows significantly; however, the mean correction factor is still not 10 dB.

9:30 AM - 10:00 AM

On the Role of Essential Higher Order Modes in a GTEM Cell

D. Pouh'e; and G. Mönich, — Technische Universität Berlin, Berlin, Germany

The GTEM cell essentially combines the elements of a transmission line and anechoic chamber. Power absorption is therefore a mutual phenomenon between the lumped element resistors and the high frequency absorbers. The different locations of the two absorbers require a change in the energy flow. Investigation of this energy flow shows that essential higher order modes play a significant role in the transition between the two regime. In fact, once above the cutoff, higher order TM modes generate eddy regions within the cell. These eddies act as a barrier in the regions where they are located. As a consequence, most of the high frequency energy is linked to the lumped elements which can only absorbs low frequency energy. This results in a poor performance of the hybrid termination of the cell.

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 11:00 AM

Transient UWB Antenna Characterization in GTEM Cells

H. Thye; S. Sczyslo; G. Armbrecht; S. Dortmund; and H. Garbe, — Leibniz Universität Hannover, Hannover, Germany

This contribution presents a novel measurement approach to characterize the pulse radiation behavior of UWB-antennas using a GTEM cell by evaluating the respective reception properties via the Lorentz's reciprocity theorem. The cell is excited by an UWB pulse with a frequency range up to 10 GHz at its feeding port, and the antenna is placed inside the testing volume of the cell. Due to the fact that pure TEM propagation predominates within a distinct time interval, electrically small antennas can be characterized with a negligible influence of field distortion or dispersion effects. Hence, the time-gated receive signal of the antenna and the excitation pulse can be used to calculate the impulse response between the incident electric field and the voltage at the feeding point of the antenna directly via de-convolution.

11:00 AM - 11:30 AM

Characterization and Concept for Optimization of Planar Spiral High Power High Frequency Coils

I. Schmidt; and A. Enders, — Technische Universität Braunschweig, Braunschweig, Germany

Parasitic effects lower the self-resonant frequency of a coil and therefore limit its usable frequency range. In

this paper a method is presented to substantially expand the usable frequency range of high current rated inductors. The basic idea of the method is to control the resonant frequencies of a coil by placing a gap between groups of windings and to connect a resistor network in parallel. The concept is investigated at a planar spiral topology of a coil. An appropriate equivalent circuit is developed and calculated. Systematic investigations of the coil allow stating approximations about inductance, the parasitic capacitance and resonant frequency. The concept is finally approved by real measurements on a prototype coil. In a last step the proposed HF-Coil is assembled to a prototype filter.

11:30 AM - 12:00 PM
Radio Approval in Japan
G. Lin, Crestron Electronics Inc., Rockleigh, NJ, U.S.A.; and D. Schramm, Intertek Testing Services NA Inc., Duluth, MN, U.S.A.

This paper describes Japan's approval process for radio equipment.

WED-AM-2 PCB Design, 2 (TC4)

Room 17B

Chair: John Kraemer, Rockwell Collins, Rockwell Collins, Iowa, U.S.A.

Co-Chair: Ross Carlton, National Instruments, Austin, TX, U.S.A.

8:30 AM - 9:00 AM
Electrostatic Discharge Analysis of Multi Layer Ceramic Capacitors
C. Rostamzadeh, Bosch, Farmington Hills, MI, U.S.A.; H. Dadgostar, University of Stuttgart, Stuttgart, Germany; and F. Canavero, Politecnico di Torino, Torino, Italy

A rigorous analysis of Electrostatic Discharge susceptibility of Multi Layer Ceramic (MLC) capacitors is carried out. The impact of ESD stress applied at the connector pins of an electronic control module, protected by utilizing 0603 package MLC capacitors is evaluated. Effectiveness of MLC capacitors for protection of integrated circuits cannot be underestimated, nor should it be assumed as an effective ESD robust solution. Meanwhile, any degradation, or physical damage to MLC capacitors should not be ignored. This analysis concentrates on the permanent physical degradation to the ESD capacitors employed for the protection of active components for an automotive control module. However, this does not limit its scope to specialized automotive applications. In general, the same principles are applicable to all electronic products employing MLC capacitors as per ESD protection and filter mechanism.

9:00 AM - 9:30 AM
Transient-to-Digital Converter for Protection Design in CMOS Integrated Circuits against Electrical Fast Transient
C. Yen; and C. Liao, — National Chiao-Tung University, Hsin-Chu, Taiwan; M. Ker, I-Shou University, Kaohsiung, Taiwan; T. Chen; and C. Tsai, — Himax Technologies, Inc., Tainan, Taiwan

An on-chip transient-to-digital converter for protection design against electrically fast transient (EFT) is proposed. The proposed transient-to-digital converter is designed to detect fast electrical transients under EFT tests. The output digital codes can correspond to different EFT voltages during the EFT induced transient disturbances. The experimental results in a 0.18 um CMOS integrated circuit with 3.3 V devices have confirmed the detection function and digital output codes.

9:30 AM - 10:00 AM
Predicting Noise Voltage from Trace Crossing Split Planes on Printed Circuit Boards
W. Pan, Missouri University Science & Technology, Rolla, MO, U.S.A.; S. Connor; and B. Archambeault, — IBM, Research Triangle Park, NC, U.S.A.

Printed circuit Boards (PCBs) often have high speed data traces crossing splits in the adjacent reference planes due to space limitations and cost constraints. These split planes are usually different power islands on nearby layers. This work quantifies the effect of the split plane and the associated stitching capacitor for various stack up configurations.

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 11:00 AM
EM Radiation from Interconnected Surface Microstrip Line Structures by a Coaxial Cable
Y. Kayano; and H. Inoue, — Akita University, Akita, Japan

In recent years, effective methods for predicting and suppressing EMI over a broad band are required. In this paper, we focus on an equivalent circuit model for predicting EM radiation from a surface microstrip line (S-MSL) structure with an interconnection coaxial cable. Firstly, frequency responses of common-mode (CM) current on the interconnection coaxial cable and EM radiation are studied experimentally and compared with FDTD modeling. It was demonstrated that the ground plane of the interconnected PCBs and the interconnection cable are the dominant radiation factor at low frequencies. Secondly, an equivalent circuit model for predicting CM current in the ground-connection model was proposed. The equivalent circuit model is based on consideration of concepts of CM antenna impedance to current and voltage driven mechanisms. Its validity was discussed by comparing FDTD simulation results. The good agreement between the predicted and measured results indicates the validity of the equivalent circuit model.

11:00 AM - 11:30 AM
Radiation Characteristics of Short Un-terminated Transmission Lines
D. Moongilan, Alcatel-Lucent, Murray Hill, NJ, U.S.A.

Instead of relying on general “rule of thumb” guidelines, a precise theory is presented for computing the maximum allowable length of un-terminated transmission line (such as printed circuit board traces and twisted pair or coaxial cables) that must be properly terminated to minimize excessive and theoretically difficult-to-predict radiated emissions. Radiated emission from the un-terminated transmission line is modeled as a monopole antenna. The length at which a transmission line radiation gradually transitions from linear to non-linear performance is theoretically derived and experimentally verified. Radiated emissions data measured in a GTEM for twisted pair and coaxial cables, as well as unbalanced and balanced printed circuit board traces, are presented and discussed.

WED-AM-3 Power Integrity (TC10)

Room 18B

Chair: Jim Knighten, Teradata Corporation, San Diego, CA, U.S.A.

Co-Chair: Antonio Ciccomancini Scogna, CST of America, Framingham, MA, U.S.A.

8:30 AM - 9:00 AM
Frequency Dependent Via Inductances for Accurate Power Distribution Network Modeling
L. Ren; G. Feng; J. L. Drewniak; and J. Fan, — Missouri University of Science and Technology, Rolla, MO, U.S.A.; B. Archambeault, IBM, Research Triangle Park, NC, U.S.A.; and J. L. Knighten, Teradata Corporation, San Diego, CA, U.S.A.

In power distribution network (PDN) modeling, interconnection inductance can play a critical role. It often determines the effectiveness of a component, such as a decoupling capacitor. This paper studies a typical, one plane-pair, PDN structure with parallel power and ground planes and vertical vias in between. This work improves the conventional lumped circuit model for the PDN by introducing a model for the inductance of each via that is frequency dependent. This frequency dependency is obtained from a rigorous cavity model formulation. The improved lumped circuit model is validated with the cavity model and the HFSS full-wave model. Further, the frequency-dependent mutual inductance between two vias can have either a positive or a negative value depending on via locations in the PDN structure, which is an interesting property that has not been reported.

9:00 AM - 9:30 AM
Analytical Modeling of Power Distribution Network with Embedded Electromagnetic Bandgap Structure
C. Hwang; J. Kim; Y. Shim; and J. Kim, — KAIST, Daejeon, Republic of Korea

When an electromagnetic bandgap (EBG) structure is embedded in a power distribution network (PND), the impedance property of the PDN is changed in the forms of shifts of high impedance resonance peaks. In order to estimate the impedance property in the PDN with embedded EBG structure, a new modeling method of the PDN with embedded EBG structure based on equivalent circuit model and resonant cavity model is proposed in this paper. The proposed modeling method is verified by measurement in a frequency range from 10 MHz to 5 GHz.

9:30 AM - 10:00 AM
Equivalent Mixed-mode Characteristic Impedances for Differential Signal Vias
S. Pan; and J. Fan, — Missouri University of Science and Technology, Rolla, MO, U.S.A.

Differential signal via structures in multi-layer printed circuit boards (PCBs) and packages are studied using an equivalent coupled multi-conductor transmission-line model. Thus, easy-to-understand transmission-line concepts, such as mixed-mode characteristic impedances and propagation constants, can be used to characterize the performance of differential signal via structures in a signal path. The closed-form expressions of per-unit-length parameters in the equivalent coupled multi-conductor transmission-line model are derived based on a physics-based via circuit model with parallel-plane impedances and via-plate capacitances. Mode conversions are discussed for different via structures. Effects of geometrical parameters on equivalent differential via impedances are studied in the paper as well. The proposed method provides a straightforward approach to design differential via structures for better signal integrity.

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 11:00 AM
Impact of Photonic Crystal Power/Ground Layer Density on Power Integrity Performance of High-Speed Power Buses
A. Ciccomancini Scogna, CST of America, Framingham, MA, U.S.A.; A. Orlandi, University of L'Aquila, L'Aquila, Italy; V. Ricchiuti, Technolabs, L'Aquila, Italy; and T. Wu, National Taiwan University, Taipei, Taiwan

The aim of this paper is the analysis of the suppression of unwanted noise in high speed power buses by the adoption of Photonic Crystal Power/Ground Layer (PCPL) structures. In particular, the performances of PCPL with different densities of the high dielectric rods are compared in terms of S-parameters. An attempt is made to relate geometrical properties (like rods density and filling ratio) to the shift of the central frequency of the band gaps as well as their bandwidth. The

simulated results are validated by comparison with measured data obtained from literature.

11:00 AM - 11:30 AM
Common Mode Filtering Performances of Planar EBG Structures
F. De Paulis; A. Orlandi; and L. Raimondo, — University of L'Aquila, L'Aquila, Italy; B. Archambeault; and S. Connor, — IBM, Research Triangle Park, NC, U.S.A.

This paper approaches the filtering behavior of Electromagnetic Bandgap (EBG) structures. The transfer function, in terms of S-parameters, of a single ended and differential microstrip line referenced to an EBG plane are considered: the notches (causing signal attenuation) and flat regions (causing signal propagation) are related to the geometry and characteristics of the EBG structure and can be designed to filter out unwanted harmonic components of the signal. A different EBG-like structure is proposed and its performances analyzed.

11:30 AM - 12:00 PM
A GHz Common-mode Filter Using Negative Permittivity Metamaterial on Low Temperature Co-fire Ceramic (LTCC) Substrate
C. Tsai; T. Wu, — National Taiwan University, Taipei, Taiwan

A broadband common-mode noise suppression filter for GHz high-speed differential signals is proposed by using the concept of effective negative permittivity transmission line metamaterial. The proposed structure possesses a complete ground for the use of the multilayer structure. The equivalent circuit models for odd mode and even mode are developed to derive the dispersion relation and understand the characteristic of common-mode suppression. A practical configuration with four cells is designed and fabricated based on the low-temperature co-fire ceramic (LTCC) fabrication technology. It is found the common mode noise can be reduced by the structure over 10 dB from 3.8 GHz to 7.1 GHz (FBW = 60%) and about 50% of amplitude in the time domain. The differential signal integrity in terms of insertion loss and phase still shows a good quality in the proposed filter.

WED-AM-4 Special Session - Spectrum Engineering; Evolving Trends (TC3)
Room 18C
Chair: Larry Cohen, Naval Research Laboratory, Gaithersburg, Maryland, U.S.A.

8:30 AM - 9:00 AM
Electrothermal Nonlinear FET Modeling for Spectral Prediction
C. P. Baylis, Baylor University, Waco, TX, U.S.A.; and L. P. Dunleavy, Modelithics, Inc., Tampa, FL, U.S.A.

It has been shown in the literature that nonlinear distortion, which is responsible for spectral spreading, is affected significantly by slow memory effects in transistors. Pulsed current-voltage (IV) measurements, along with appropriate transient measurements, can be used to assess slow “memory” effects present in a device. Measurement of thermal resistance and capacitance for a Si LDMOSFET are unaffected by trapping effects, whereas insights into the voltage-dependent trapping behavior of GaN HEMTs is required to accurately model the slow processes in these devices. Measurement methods have been developed to estimate thermal resistance and capacitance in Si devices, and excellent progress has been made toward the characterization of thermal and trapping effects in GaN devices. It is proposed that more accurate modeling of these effects can assist in meeting the goal of obtaining first-pass design success on a consistent basis.

9:00 AM - 9:30 AM
Sub-Octave-Tunable Microstrip Notch Filter
D. R. Jachowski; and A. C. Guyette, — Naval Research Laboratory, Washington, D.C., U.S.A.

A frequency-agile narrowband microstrip bandstop filter technology able to maintain near constant absolute bandwidth while tuning over a frequency range of nearly an octave is described. The technology is demonstrated by a reconfigurable notch filter designed to selectively remove unwanted spectral content prior to final amplification in a transmitter’s output module. The six-resonator planar microstrip notch filter uses hyperabrupt GaAs varactor diodes to tune the operating frequency over a 92% range, from 480 MHz to 925 MHz. The filter maintains 3 MHz-wide stopband attenuation of 34 dB to 64 dB, absolute 3 dB bandwidth of less than 84 MHz, 3 dB bandwidth variation of less than 24%, and low stopband reflection over the full tuning range.

9:30 AM - 10:00 AM
A Mobile Propagation Measurement System
R. T. Johnk; P. M. McKenna; N. DeMinco; P. P. Papazian; G. A. Sanders; and H. E. Ottke, — Institute for Telecommunication Sciences (NTIA/ITS), Boulder, CO, U.S.A.

This paper describes a mobile-to-mobile propagation measurement system that is currently being developed at the Institute for Telecommunication Sciences under the sponsorship of the Office of Spectrum Measurement. This system uses a fixed transmitter truck and a moving receiver van to characterize radio-frequency channels of selected urban and rural environments. The transmitter and receiver architectures are described, and selected time- and frequency-domain measurement results are presented. The results obtained so far are very promising and demonstrate the versatility and effectiveness of this measurement system.

WED-AM-5 Open Forum #2
Room 19B
Chair: Michael Foegelle, ETS-Lindgren, Cedar Park, Texas, U.S.A.

8:30 AM - 10:00 AM
EMC Protections for High Voltage and High Power on a Wide Facility, the Mégajoule Laser
D. Rubin De Cervens; J. Raimbourg; J. Baggio; and J. L. Faure, — CEA DAM / DIF, Arpajon, France; J. C. Gomme; and J. P. Sceaux, — CEA DAM / CESTA, Le Barp, France; P. Bauer; and P. Trochet, — EADS / Nucletudes, Les Ulis, France

This paper discusses the global EMC protections for the Mégajoule Laser realized in France CEA DAM CESTA. In the first part, we present the ground system protection for the Laser room included in the general ground building protection for a high level industrial EMC environment. In the second part, we explain the harsh electromagnetic environment of the experiment room and the special EMC protections. The objectives are to understand the complex physic of nuclear fusion reaction and to validate the results of the simulation program. The ultraviolet 350 nm laser is designed to deliver 240 laser beams and 7.5 kJ each to transmit, in a few nanoseconds, 1.8 Mj on a 0.3 mg target filled with two isotopes of hydrogen, deuterium and tritium, like the same fusion energy process in star shine. The equivalent power will be about 550 TW. This experiment will allow the complex physic understanding of inertial confinement fusion and high energy density. The results take an active part in the validation of the simulation program.

8:30 AM - 10:00 AM
3-Antenna Height-Scanning-Average Method of EMI Antenna Calibration
J. Park; D. Jeong; H. Youn; M. Seo; D. Yu; and J. Ryoo, — Radio Research Agency of Korea Communication Commissions, Icheon, Republic of Korea

In this paper, Height-Scanning-Average (HSA) which calculates an average of the antenna factors depending on a height above the ground is introduced, which measures the free-space antenna factors of an EMI dipole antenna. Its uncertainty is also analyzed. The values measured by HSA are checked with the Curve Fitting Method, a kind of Standard Antenna Method (SAM) developed by the National Institute of Information and Communications Technology (NICT) of Japan. It is shown that there are good agreements on the results calibrated by both methods.

8:30 AM - 10:00 AM
Electromagnetic Topology Combined with Mode Matching for Electromagnetic Field Penetration Analysis of an Aperture Backed Cavity
Y. Park, Seoul National University, Seoul, Republic of Korea; Y. Lee, Kwangwoon University, Seoul, Republic of Korea; J. So, Agency for Defense Development, Daejeon, Republic of Korea; C. Cheon, University of Seoul, Seoul, Republic of Korea; Y. Chung, Kwangwoon University, Seoul, Republic of Korea; and H. Jung, Seoul National University, Seoul, Republic of Korea,

In this paper, a new method based on a combination of Electromagnetic Topology and Mode Matching is proposed for the analysis of electromagnetic field coupling phenomena from the external field to the inner electric system. The proposed method can solve electromagnetic field coupling in a complex system accurately and require short computation time and reduced memory. To verify the validity of this method, a wire within an aperture backed cavity model was analyzed and the electric field intensity in the cavity and the induced surface current on the wire were computed and the results compared with FDTD results.

8:30 AM - 10:00 AM
Hybrid Simulation Method to Analyze Anti-Jamming Receiver
H. Xiaomu; C. Wenqing; M. Qinhua; L. Jiantao; Z. Chaoxian; and B. Feng, — Navy Arm Academy of China, Beijing, China

Interference and anti-jamming of communication systems are key areas of electromagnetic compatibility research. Because of the restrictions of the complexity of communications systems, it is difficult to accurate analyze system characteristics by model and simulation. This paper presents a hybrid simulation method (a digital behavioral simulation and in-the-loop simulation analysis) to simulate effects of an anti-jamming receiver. After achieving an accurate model of the receiver, we realized analysis of the additive narrowband interference, additive modulation interference and band selective. Practice proved that the hybrid simulation method is accurate. It can achieve rapid analysis and verification for an unknown communication system.

8:30 AM - 10:00 AM
On the Signal Processing for an Exposure Assessment of Superimposed Magnetic Fields
C. Rueckerl; and K. Eichhorn, — University of Applied Sciences, Leipzig, Germany; and H. Bauer, University of Technology, Dresden, Germany

The aim of this paper is the treatment of three-dimensional measurement data when superimposed magnetic fields are measured in space. The introduced methods can simplify the exposure assessment of pulsed or broadband magnetic fields. A practical way to detect a superimposition of two or more field sources is introduced. Additionally two ways for a decomposition of superimposed fields are demonstrated. These methods can be integrated in a measurement device for an automatic and source oriented exposure assessment. Thereby, the time consuming processing of measurement data can be simplified. The examples show that under certain conditions the number of field

sources can be estimated. The application of decomposition methods or spatial filtering is useful for a source oriented assessment procedure.

8:30 AM - 10:00 AM
Characterization of the Electromagnetic Environment in a Hospital and Propagation Study
N. J. LaSorte; W. J. Barnes; and H. H. Refai, — University of Oklahoma-Tulsa, Tulsa, OK, U.S.A.

This work presents the results of a survey of the electromagnetic environment from 30 MHz to 7 GHz in St. Francis Hospital, in Tulsa, Oklahoma. Measurements were considered short term as the full spectrum was measured in twelve minutes. The results show the dynamic environment apparent in today's hospitals. There were no recorded cases in which the IEC immunity standard specifications, 3 V/m, was exceeded. Another contribution by this paper was to show an example of cross-floor attenuation in a hospital.

8:30 AM - 10:00 AM
On the Quantification of the State-of-the-Art Models for Skin-Effect in Conductors, Including Those with Non-Rectangular Cross-Sections
B. Curran; and I. Ndip, — Fraunhofer Institute - IZM, Berlin, Germany,

Predictability of transmission line parameters in both the frequency and time domains is very important for microelectronics packaging. Proximity effects and non-rectangular cross-sections can cause a drastic deviation in transmission line parameters from the theoretically calculated values. Filament models and full-wave techniques have offered improvements over analytical models for computing the parameters of transmission lines with arbitrary cross-sections including proximity effects. This work is an analysis of some state-of-the-art skin-effect models and a quantification of their limitations.

8:30 AM - 10:00 AM
Interference Voltage and Interference Threshold in Pacemakers with Unipolar and Bipolar Electrodes
S. Hille; and K. F. Eichhorn, — HTWK Leipzig, Leipzig, Germany; and K. H. Gonschorek, Dresden University of Technology, Dresden, Germany

This paper presents the coupling-model between low frequency magnetic fields and the induced voltage at the sensing input of the pacemaker (PMK) with unipolar and bipolar electrodes. For this purpose an analytical model has been developed, allowing the determination of induced voltage into a pacemaker in a magnetic field with low frequencies between 10 Hz and 30 kHz. Furthermore the electric conductivity of the surrounding tissue and the different positions of the bipolar electrode were taken into consideration. In that regard, measurements were carried out to investigate the induced voltage in bipolar and unipolar electrodes as well as interference thresholds. A comparison between the interference resistance of real pacemakers with unipolar and bipolar electrodes and the induced voltage in these electrodes are presented in this paper. The extensively discussed security factor of bipolar electrodes can therefore be calculated with the above-mentioned findings.

8:30 AM - 10:00 AM
Developing an SI Tool Set for Engineering Design Discovery, Physical Insight, and Education
A. Koul; A. Conrad; and J. L. Drewniak, — Missouri University of Science and Technology, Rolla, MO, U.S.A.; R. Jackson; A. Packard; J. Song; and E. Wheeler, — Rose-Hulman Institute of Technology, Terre Haute, IN, U.S.A.

This paper reports on the process of developing a signal integrity tool set for engineers and educators. These tools will complement well-known enterprise numerical tools by providing the designer, student, or educator a reliable means of finding accurate results for specific questions during SI design and troubleshooting. They are intended to find use as accurate, traceable, and easy-to-use aids in design discovery and in education. Their computational engines will use recognized methods from the literature and these will be made available so that interested users will be in complete control of their enquiries; there will be no calculations in which the user is kept in the dark about the methods used. The SI tool set will be made freely available on the internet.

WE-PM-1 Reverberation Measurements (TC2)

Room 17A

Chair: Tom Fagan, Raytheon, Arizona, U.S.A.
Co-Chair: Chris Holloway, NIST, Boulder, Colorado, U.S.A.

1:30 PM - 2:00 PM
Directive Wavefronts Inside a Time Reversal Electromagnetic Chamber
H. Moussa; A. Cozza; and M. Cauterman, — Supelec, Gif-Sur-Yvette, France

In this paper, the feasibility of directive wavefronts generation inside a time-reversal electromagnetic chamber (TREC) is investigated in order to propose the TREC system as an alternative EMC test facility. This may be accomplished by applying the time reversal technique on electromagnetic waves inside a reverberation chamber. We evaluate the performance of the TREC in creating directive radiation patterns towards an equipment-under-test. This evaluation is based on the directivity comparison of a wavefront generated by the TREC, and the one generated by a theoretical model of an antenna array in free space. Numerical simulations of the TREC are in a good agreement with the theoretical array model, showing a root-mean-square deviation from the mean value of the E-field, over a 3 dB main lobe angle, below 6%.

2:00 PM - 2:30 PM
A Describing Function Method for Evaluating the Statistics of the Harmonics Scattered from a Non-Linear Device in a Mode Stirred Chamber
A. C. Marvin; C. Jiaqi; I. D. Flintoft; and J. F. Dawson, — University of York, York, United Kingdom

The statistics of the received radiation from a non-linear device within a mode-stirred chamber are examined by measurement and Monte-Carlo simulation. A Describing Function formulation is used for the non-linear analysis that enables the complete dynamic range of the non-linear process to be described. The work is a precursor to developments in diagnostic immunity measurements for digital electronic hardware.

2:30 PM - 3:00 PM
Aspects of Field Statistics inside Nested Frequency-Stirred Reverberation Chambers
Y. He; and A. Marvin, — University of York, York, United Kingdom

The magnitude of a component of the electric field ERec inside a single mechanical stirred chamber is known to follow Rayleigh distribution, however, for the field inside an enclosure nested in a larger chamber, the probability distribution function (PDF) of the ERec is unclear. In this paper the hypothesis of the PDF of a frequency stirred ERec is provided and then examined by a number of goodness of fit tests (K-S test). The results show that for an electrically large enclosure nested in a larger reverberation chamber, the PDF of the internal electric field ERec will evolve from Rayleigh to double Rayleigh with the shrinking size of the interconnection aperture. ERec obtained from different positions in the nested equipment enclosure were examined and found consistent; single apertures as well as multiple apertures were investigated to account for the importance of the interfacing aperture to the internal field distribution. This adds to understanding the underlying principles of nested chambers used for Shielding Effectiveness measurements.

BREAK (3:00 PM – 3:30 PM)

3:30 PM - 4:00 PM
Numerical and Experimental Investigation of Unstirred Frequencies in Reverberation Chambers
V. Mariani Primiani; F. Moglie; and V. Paolella, — Universita` Politecnica delle Marche, Ancona, Italy

The paper analyzes the occurrence of unstirred frequencies in a reverberation chamber. Both experimental and numerical field data are checked applying the Kolmogorov-Smirnov test. The presence of these frequencies is unavoidable, even eliminating evident causes. Their value changes introducing small perturbations of the antenna relative position or stirrer starting points in the chamber. In the case of a simulated field, based on plane wave expansion, similar unstirred frequencies are still present and their variation are related to the change of the field observation points or of the plane wave set randomly generated.

4:00 PM - 4:30 PM
Quantifying Stirred and Unstirred Components in Reverberation Chamber with Appropriate Statistics
G. Lerideau; E. Amador; C. Lemoine; and P. Besnier, — Institute of Electronics and Telecommunications of Rennes (IETR), Rennes, France

Wireless devices have been massively developed in recent years, creating a real need to simulate controllable multipath channels. The reverberation chamber is a well-known cavity for electromagnetic compatibility testing and there is an increasing interest for wireless communication testing. In particular, it enables the generation of various measurement distributions from Rayleigh to Rician. In order to correctly estimate direct and scattered components of a transmitted signal in RC, we propose two new methods leading to an accurate evaluation of the direct-to-scattered ratio.

4:30 PM - 5:00 PM
Time-Domain Pulsed Measurements of the NASA Space Power Facility
R. Johnk; J. Ewan; P. McKenna; and N. DeMinco, — Institute for Telecommunication Sciences (NTIA/ITS), Boulder, CO, U.S.A.; and K. Shalkhauser, NASA Glenn Research Center, Cleveland, OH, U.S.A.

This paper describes a recent joint measurement effort conducted by the Institute for Telecommunication Sciences and NASA in a large chamber located at the NASA Space Power Facility (SPF) in Sandusky, Ohio. The paper describes the chamber, the measurement system, and provides some selected time- and frequency-domain results. A detailed description of the measurement procedures and post-processing is provided. The results obtained indicate that the SPF chamber exhibits robust reverberant behavior. The flexibility and efficiency of time-domain measurements is also demonstrated.

5:00 PM - 5:30 PM
Source-Stirring and Mechanical-Stirring Reverberation Chamber Measurement Comparison for 900 MHz and 1800 MHz
J. Kunthong; and C. F. Bunting, — Oklahoma State University, Stillwater, Oklahoma, U.S.A.

This paper presents comparison results between measurements using mechanical-stirring and source-stirring techniques in a reverberation chamber. Three criteria (S21 scatter plot, log normalized received power Cumulative Distribution Function plot, and the number of independent samples calculated from each data set) are used in the determination of the source-stirring method effectiveness. The results show that source-stirring is capable of producing good statistics and is

comparable to the standard mechanical-stirring technique that is often employed in reverberation chamber measurements.

WE-PM-2 Shielding (TC4)

Room 17B

Chair: Mike McInerney, U.S. Army, Champaign, Illinois, U.S.A.

Co-Chair: Ali E. Yilmaz, University of Texas, Austin, Texas, U.S.A.

1:30 PM - 2:00 PM

A Novel Method of Mitigating EMI on Implantable Medical Devices: Experimental Validation for UHF RFID Reader/Writers

Y. Kawamura; S. Futatsumori; T. Hikage; and T. Nojima, — Hokkaido University, Sapporo, Japan; B. Koike, Japan Automatic Identification Systems Association, Tokyo, Japan; H. Fujimoto; and T. Toyoshima, — Medtronic Japan Co., Ltd., Tokyo, Japan

A method of mitigating the electromagnetic interference (EMI) due to wireless communication devices on implantable medical devices (IMDs) such as implantable cardiac pacemakers and implantable cardioverter defibrillators (ICDs) is newly proposed. The key feature of the proposed method is that it does not require any modification of the IMDs. This method is based on the use of a “mitigation signal”, which lies in the idle periods of the wireless communication device. By using this mitigation signal, the low frequency noise signal generated in the IMDs internal circuits by nonlinear detection, can be reduced. This leads to a drastic improvement in the maximum interference distance. The proposed method is experimentally confirmed in this paper as applied to UHF RFID reader/writers. First, the proposed EMI mitigation method is detailed. An implementation of the method for UHF RFID reader/writers is then presented. The in vitro EMI experiment uses three types of actual implantable cardiac pacemakers. Finally, the mitigation results are shown. The results show that the proposed method can greatly shorten the maximum interference distance by more than 90% for all pacemakers. For example, the maximum interference distance of one pacemaker is reduced by 68 cm, from 71 cm to 3 cm.

2:00 PM - 2:30 PM

Predicting Multimode Chassis Resonance of Single or Nested Rectangular Computer Enclosures

T. W. Steigerwald, Dell, Inc., Round Rock, TX, U.S.A.

Designing standardized six-sided computer enclosures that contain multiple types of active circuitry across several products, it is critical to predict and qualify excited cavity resonances against the expected harmonic spectrum generated by the active circuits. Moreover, if the enclosure or chassis is housed within another enclosure, it is also important to predict resonances of the larger housing enclosure. This paper presents a simplified method of quickly determining rectangular chassis enclosure resonances using simple multimode resonant cavity formula and no electromagnetic field solvers. Key resonance frequencies are assigned a risk category depending on number of modes excited, and effective Q of each resonance frequency.

2:30 PM - 3:00 PM

Relationship between Connector Contact Points and Common-Mode Current on a Coaxial Transmission Line

Y. Hayashi; T. Mizuki; and H. Sone, — Tohoku University, Sendai, Japan

In this paper, we present the results from two independent experiments performed by adopting the Contact Failure Model, which provides an explanation of contact failures caused by faulty transmission line connectors, for the purpose of measuring the common-mode (CM) current, which is one of the factors causing noise radiation. The first experiment was carried out by gradually increasing the contact resistance, while in the second experiment the number of contact points was gradually decreased. Both experiments were performed within the uplink bandwidth of CATV Internet. From the results of these experiments, it was concluded that the relationship between the contact resistance and the CM current does not depend on the frequency. Furthermore, by analyzing the output from unit frequency within the uplink bandwidth of CATV, it was concluded that it is possible to predict the state of a faulty part causing contact failure. It was also shown that at least four contact points are necessary for the contact failure model in order to decrease noise radiation.

BREAK (3:00 PM – 3:30 PM)

3:30 PM - 4:00 PM

Achieving EMI Compliance with DVI and HDMI on Defense/Aerospace Platforms

J. G. Kraemer; and J. A. Shaw, — Rockwell Collins, Inc., Cedar Rapids, Iowa, U.S.A.

Digital Visual Interface (DVI) and High Definition Multimedia Interface (HDMI) have become very popular digital interfaces in the consumer electronics arena for high definition video and audio with personal computers and in-home theatre systems. Due to the off-the-shelf availability of hardware and software that supports these interfaces, DVI and HDMI present the opportunity to provide the aircraft industry and the war fighter with state-of-the-art high-definition video capabilities today. However, these interfaces were not designed for the defense/aerospace electromagnetic effects environments. This paper presents guidelines with respect to circuit modification and cable/connector system design to allow compliance with defense/aerospace equipment EMI standards such as MIL-STD-461E and DO-160E.

4:00 PM - 4:30 PM
Shielding Effectiveness and Coupling of Cavity Connection Excited by UWB Pulse
Q. Wu; S. Zhang; L. Jin; and Y. Wang, — Harbin Institute of Technology, Harbin, Afghanistan

The coupling of Ultra Wideband (UWB) pulse entering cylindrical cavity connecting slot is simulated and analyzed employing the finite differential time domain (FDTD) method. Through time and frequency domain analysis, electric field coupling for different UWB pulse widths, resonant and enhancement effects of cylindrical cavity are investigated and the coupling characteristics of electric field and cavity resonance caused by cylindrical cavity connecting slot are also analyzed.

4:30 PM - 5:00 PM
Effectiveness of Shield Termination Techniques Tested with TEM Cell and Bulk Current Injection
R. J. Hare; and A. T. Bradley, — NASA Langley Research Center, Hampton, VA, U.S.A.

This paper presents experimental results of the effectiveness of various shield termination techniques. Each termination technique is evaluated by two independent noise injection methods; transverse electromagnetic (TEM) cell operated from 3 MHz to 400 MHz, and bulk current injection (BCI) operated from 50 kHz to 400 MHz. Both single carrier and broadband injection tests were investigated. Recommendations as to how to achieve the best shield transfer impedance (i.e. reduced coupled noise) are made based on the empirical data. Finally, the noise injection techniques themselves are indirectly evaluated by comparing the results obtained from the TEM Cell to those from BCI .

5:00 PM - 5:30 PM
Shielding Effectiveness Analysis of Enclosure with Aperture by High-order Mode Transmission Line Model
D. Shi; Y. Shen; F. Ruan; and Y. Gao, — Beijing University of Posts & Telecommunications, Beijing, China

An analytical formulation has been developed for shielding effectiveness calculation of rectangular enclosure with aperture. The theory has been extended to high frequency analysis by making use of high-order mode transmission line model. The number of high-order modes is according to the highest frequency. Analytical and simulation results prove high-order mode should be included when frequency is above the cut-off frequency of different modes. This paper investigates how many modes to choose in shielding effectiveness calculation in detail and gives a practical case, which is validated by simulation. Effect of aperture size, test point location, loss of enclosure as well as frequency can be obtained by the analytical formulation. In addition, shielding effectiveness of enclosure with PCB inside is also investigated.

WE-PM-3 Novel Methods in Modeling/ Simulation (TC9)

Room 18C

Chair: Marina Koledintseva, Missouri University of Science & Technology, Rolla, MO, U.S.A.
Co-Chair: Chuck Bunting, Oklahoma State University, Oklahoma, U.S.A.

1:30 PM - 2:00 PM
Effect on Electric Field of Foam Block in GTEM Cell
I. Wu; S. Ishigami; K. Gotoh; and Y. Matsumoto, — National Institute of Information and Communications Technology, Koganei, Japan

The effect on the electric field of a foam block in a GTEM cell was numerically investigated using the finite integration (FI) method. In particular, we focused on the frequency range of 1 GHz to 16 GHz, for which the effect has not yet been sufficiently analyzed. We only modeled the tip of the GTEM cell, to focus on the change in the electric field strength from the foam block and also to reduce the computational resources required. We showed that the foam block increases the electric field strength when it is placed at the tip of the GTEM cell. Even though the change in the electric permittivity was small, the effect on the electric field strength was great. We then compared the analysis results with measurement results and found that good agreement was obtained between the two. We also investigated the effect that the size of the foam block has on the electric field. The electric field strength was found to increase when the block size increased. We concluded that the foam block may affect the electric field and increases the electric field strength in a GTEM cell.

2:00 PM - 2:30 PM
A Technique for Representing Lightning Arresters in the FDTD Method
A. Tatematsu; and T. Noda, — Central Research Institute of Electric Power Industry, Yokosuka, Japan

Abnormal voltages occur in power and telecommunication circuits when lightning strikes electric power systems and buildings. Lightning arresters are installed to protect the circuits from such abnormal voltages. Recently, the Finite Difference Time Domain (FDTD) method, which can be used for computing electromagnetic fields, has been applied to lightning surge problems involving electrical wires in three dimensional arrangements such as power and telecommunication circuits. In this paper, a technique for representing a lightning arrester in the FDTD method is proposed. Then, the technique is validated by comparing the results obtained by the FDTD method with those by the Electromagnetic Transients Program (EMTP), which is a circuit-theory-based simulation program. Finally, as an application example of the proposed technique, we calculate lightning-induced voltages on a distribution line with lightning arresters.

2:30 PM - 3:00 PM
A Method to Decrease Computation Time of FDTD Calculations for Low Frequency Excitations
E. Perrin; C. Guiffaut; and A. Reineix, — XLIM, Limoges, France; and F. Tristant, Dassault Aviation, Saint-Cloud, France

In this paper, we propose a new way to decrease the computation time of the Finite Difference Time Domain (FDTD) method. We focus on signals presenting a very large damping time such as bi-exponential waveforms. The procedure consists first in calculating the transfer function of the system from its quasi-impulse response. Next, based on this transfer function, the response to any excitation (particularly low frequency ones) is calculated. The quasi-impulse response can also be extrapolated using the Matrix Pencil method in order to obtain a waveform totally damped. In any case, very good agreements with FDTD complete simulations are found.

BREAK (3:00 PM – 3:30 PM)

3:30 PM - 4:00 PM
Efficient Wide-Band Interpolation of MoM-derived Frequency Responses Using Stoer--Bulirsch Algorithm
A. Karwowski, Silesian University of Technology, Gliwice, Poland

Availability of computationally efficient techniques for system performance simulation over a broad frequency range is essential in electromagnetic compatibility. Deriving samples of the desired observable from frequency domain computations at uniform intervals may be prohibitively time consuming for highly resonant structures. This paper examines a technique for the generation of wide-band data from Method-of-Moments (MoM) simulations by employing the Neville-type Stoer--Bulirsch interpolation algorithm supported by adaptive frequency sampling of the observable. The key feature of the approach is its ability to perform interpolation over a wide frequency band with a single rational interpolant. Sample numerical examples demonstrate the capability of the approach to greatly improve the computational efficiency of MoM-based simulations over a broad frequency band.

4:00 PM - 4:30 PM
Block Latency Insertion Method (Block-LIM) for Fast Transient Simulation of Tightly Coupled Transmission Lines
T. Sekine; and H. Asai, — Shizuoka University, Hamamatsu, Japan

This paper describes a block matrix formulation of the Latency Insertion Method (LIM) for the fast transient simulation of the circuit which includes the elements such as mutual inductance and mutual capacitance. First, the basic formulation of LIM is shown. Next, the block LIM formulation for the network with mutual inductance and mutual capacitance is described. Then, the block LIM algorithm is applied to the tightly coupled transmission lines which are connected to each other by a number of mutual inductors and capacitors. Finally, some numerical results are shown and it is confirmed that the proposed technique is useful and efficient for the simulations of tightly coupled transmission lines.

4:30 PM - 5:00 PM
Electromagnetic Field Coupling into Cardiac Pacemaker Systems - Numerical Simulation Using Body Models With Dispersive Dielectric Tissues
S. Schenke; L. Fichte; F. Sutter; M. Clemens; and S. Dickmann, — Helmut-Schmidt Universität, Hamburg, Germany; F. Sabath; and M. Schaarschmidt, — Wehrwissenschaftliche Institut für Schutztechnologien, Munster, Germany

A novel method for calculating the influence of an electromagnetic field to an implanted cardiac pacemaker (PMK) is presented. For this a detailed human body model is used with the implementation of every tissue as a dispersive dielectric material. This way enables the calculation of the off-load voltage at the PMK's input over a wide frequency band within one simulation.

5:00 PM - 5:30 PM
Fast Memory-Efficient Full-Wave 3D Simulation of Power Planes
T. V. Narayanan; K. Srinivasan; and M. Swaminathan, — Georgia Institute of Technology, Atlanta, GA, United States

A circuit equivalent, frequency domain, electromagnetic simulation for packaging structures is proposed. Simulations are carried out using an iterative, memory efficient approach to quasi-minimal residual method. The convergence of the solver is accelerated by the use of suitable pre-conditioners. Results for a power plane example with and without aperture are presented.

WE-PM-4 Special Session - Multi-Gbps Interconnect Simulation and Measurement for Signal Integrity (TC10)

Room 18B

Chair: Xiaoning Ye, Intel, Hillsboro, OR, U.S.A.
Co-Chair: Jun Fan, Missouri University of Science and Technology, Rolla, MO, U.S.A.

1:30 PM - 2:00 PM
Mode Conversion Effects in Multi-Gbps Telecommunications Blade System
G. Pitner; D. N. de Araujo; and M. Mi, — Ansoft LLC, ANSYS, Austin, TX, U.S.A.; B. Mutnury; M. Cases; and N. Pham, — IBM , Austin, TX, U.S.A.

Prediction of radiation from multilayer circuit boards is an important problem which is of interest to the design of digital system such as servers. In particular, signal

mode conversion as the result of undesired imbalances in the board interconnects plays a significant role in the generation of noise emission. In this paper, we investigate methods for modeling common/differential mode conversion from relatively complex interconnection structures in a multi-Gbps system using an systematic approach. The strong correlation of good signal integrity practices to electromagnetic emission is discussed with emphasis on key structure contributors. The electrical modeling of key contributors (such as vias, connectors, traces, manufacturing techniques, etc.) to undesired mode conversion effects is also presented in a telecommunication blade environment.

2:00 PM - 2:30 PM

Efficient Methodologies to Study the Signal Integrity of Multi Gb/s Interconnects and Full System EMC Analysis

A. S. Ciccomancini Scogna; and D. Johns, — CST of America, Framingham, MA, U.S.A.

This paper presents modern simulation techniques for the Signal Integrity (SI) of high speed interconnects (HSI) and full system EMC analysis. Partial Element Equivalent Circuit (PEEC) is efficiently use for EM and SPICE simulation. Different test boards are studied and results are validated by comparing multiple numerical methods. Guidelines for a full channel analysis are also provided and system level EMC is also investigated by means of Transmission Line Matrix (TLM) method.

2:30 PM - 3:00 PM

Material Parameter Extraction Using Time Domain TRL (t-TRL)Measurements

A. Rajagopal; and B. Achkir, — Cisco Systems Inc., San Jose, CA, U.S.A.; M. Koledintseva; and J. Drewniak, — Missouri University Of Science & Technology, Rolla, Missouri, U.S.A.

Characterizing materials used in Printed Circuit Board (PCB) manufacturing is becoming increasingly important in link path analysis as the data rates are increasing. The material properties governing the performance of the signal passing through a transmission line are frequency-dependent. Using frequency-domain vector network analyzer (VNA) measurements and Through-Reflect-Line (TRL) calibration, these parameters can be determined accurately. But a Time-Domain Reflectometer (TDR) provides a relatively inexpensive way of characterizing transmission lines, and it is easily accessible to Signal Integrity engineers. Using the time-domain TRL (t-TRL) calibration technique, it is now possible to de-embed such discontinuities as connectors, cables, etc., in the path of the transmission line using time-domain measurements. From the calibrated results, material properties can be extracted just the same as in the frequency domain. This paper describes a t-TRL technique to obtain accurate frequency domain S-parameters from time domain measurements. The calibrated results are converted into the ABCD parameters. The propagation constant is obtained through the ABCD parameters, from which attenuation loss and phase constant are extracted. Dielectric constant is extracted from the phase constant and the total attenuation constant. Curve-fitting technique is used to split the losses into conductor and dielectric loss. Once dielectric loss is determined, loss tangent can be calculated. Three test vehicles are used, and the results are compared with frequency domain VNA measurements. The results from the t-TRL calibration technique are also compared with the extraction procedure used in the algorithm developed by NIST.

BREAK (3:00 PM – 3:30 PM)

3:30 PM - 4:00 PM

Serial Link Engineering: A Novel Jitter/Noise Metric to Qualify Channel Components

K. Keshavan; and T. Abou-Jeyab, — Sigrity, Inc., Santa Clara, CA, U.S.A.

System Interconnects are increasingly dominated by serial links. Understanding the contribution of different system components to jitter and noise, and subsequently tuning those components, is the key to a successful design. In this paper we're proposing a novel, eye-area based normalized jitter and noise metric. We show how this metric can consistently be used for different data rates, to offer insight into various components, and to identify the ones that are limiting the design. The study also reveals how seemingly small structures and device parasitics can non-linearly increase their jitter and noise contribution to the overall system.

4:00 PM - 4:30 PM

Building Accurate Spice Models for Multi-Gbps Interconnect in Computer Systems

X. Ye; and C. Huang, — Intel, Hillsboro, Oregon, U.S.A.; and K. Xiao, Intel, DuPont, Washington, U.S.A.

In this paper, we established an efficient methodology to build accurate Spice models for multi-Gbps interconnects in computer systems. The transmission lines are modeled with frequency dependent RLGC matrices, with surface roughness included. The vertical discontinuities are modeled with full-wave EM solver, and converted to equivalent Spice models through rational function approximation. VNA measurement were performed on a typical multi-Gbps interconnect that includes package, socket, PCB and via, etc. Calculated S parameters with the Spice models correlate very well to measurement data from DC up to 14 GHz or higher.

WE-PM-5 Open Forum #3

Room 19B

Chair: Jason Anderson, Professional Testing, Round Rock, Texas, U.S.A.

1:30 PM - 3:00 PM

Effect of the Mutual Inductances among Grounding Conductors on the Transient Performance of Grounding Grids
B. Zhang; J. He; R. Zeng; J. Hu; and Z. Yu, — Tsinghua University, Beijing, China

In this paper, a numerical model is presented to analyze the grounding grids. The effect of the mutual inductances among grounding system conductors on the performance of the grounding grid is investigated. It can be seen that although the effect of the mutual inductances is very small at power frequency, when a large grounding grid buried in soil with low resistivity is analyzed, the effect of the mutual inductances should be taken care of even though the frequency is not very high. What's more, when this kind of grounding grid is stricken by a 30 kA, 2.6/40 us lightning current, if the mutual inductances are neglected, although the waveform of the transient potential at the current injected point is almost the same with that considering the mutual inductances at the rise time, it falls more slowly than that considering the mutual inductances.

1:30 PM - 3:00 PM
Study on the Electromagnetic Influence of DC Bias on the Power Transformer
Y. Chen; T. Lu; L. Li; and Z. Zhao, — North China Electric Power University, Baoding, China

DC bias of power transformers will generate some important effects on power transformers. Furthermore it can bring about a malfunction of the power system. A simulation model is set up and the equivalent coupled electric circuit and magnetic circuit method is used to analyze the electromagnetic influence of DC bias. The method is testified by the experiment results. Some results are concluded from the analysis of different DC bias conditions. The results are helpful to propose some methods to decrease the influence of DC bias.

1:30 PM - 3:00 PM
Assessment of the Power Balance Method for E Field Calculations in Complex Cavities
A. Schaffar; and Y. Herlem, — Astrium Space Transportation, Les Mureaux, France

This paper reports the results of a study the aim of which being to assess the conditions of the application of the Power Balance Method for E field calculations in electromagnetic complex cavities. The paper presents a short summary of the method, and a detailed description of the assessment based on a numerical simulation of the field distribution in a representative model.

1:30 PM - 3:00 PM
Comparison of Shielding Effectiveness Approximations to Measurements for Perforated Shields
J. C. Hailey, Dell, Inc., Round Rock, TX, U.S.A.

Within the EMC community, there exist simple approximations of shielding effectiveness of an array of rectangular apertures in a wall. To quantify the usefulness of these approximations, they are compared to measured data. A simplified measurement setup was used, and details are provided on this.

1:30 PM - 3:00 PM
Electromagnetic Field Measurement Using Circular Wire Scatterers
T. Morioka, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan

Simultaneous measurement of the electric and magnetic field using a loop antenna was proposed and widely applied to the EMC measurements. However, the attached circuits, such as baluns, are necessary for the loop antenna. In the present paper, a method to measure electric and magnetic field using a set of simple circular scatterers is proposed. By expanding the current on a circular scatterer and the incident field into Fourier series, the theoretical equations containing the electric and magnetic-field effects on the deviation of the voltage at the port are obtained. To validate the proposed method, a TEM cell is employed to generate electromagnetic fields, and the responses of the circular wires are measured.

1:30 PM - 3:00 PM
Relevant Parameters of SPICE3 MOSFET Model for EMC Analysis
J. Ben Hadj Slama; and S. Hrigua, — LSE - INSAT, Tunis, Tunisia; F. Costa; C. Gauthier; and B. Revol, — SATIE, Cachan, France

Design of static converter circuits and virtual prototyping of power electronics systems requires the use of heavy semiconductor components models, with a large number of parameters where exact knowledge often requires several delicate experimental measurements and heavy optimization procedures. This paper presents a sensitivity survey that permits the determination of which parameters of the MOSFET model are applicable for EMC analysis with the goal to reduce the number of measurements to carry out at the phase of parameter extraction.

1:30 PM - 3:00 PM
A Near Field 3-Antenna Method for Short Monopole Antennas in Low Frequency Bands
M. Ishii; and Y. Shimada, — National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan

There are some measurement methods proposed for an electrically short monopole antenna. In this paper, a new three-antenna method for electrically short monopole antennas is proposed and investigated by a numerical simulation. The target of the frequency bands is less than 30 MHz. The results show that the proposed measurement method is available and

effective to obtain the antenna factor of an electrically short monopole antenna.

1:30 PM - 3:00 PM
A Novel Interconnected Patch-Ring (IPR) Structure for Noise Isolation
I. Ndip; S. Guttowski; and H. Reichl, Fraunhofer Institute - IZM, Berlin, Germany

Electromagnetic bandgap (EBG) structures are currently the most effective means to suppress noise coupling in microelectronic packages and boards. Since EBGs are periodic structures, they require periodically arranged patches, vias, and in some cases, surface mount capacitors and inductors, to suppress noise within a desired frequency range. However, all these components take up much of the board/package space and very little space is left for the placement and routing of the "actual" components needed for system functionality. EBGs, therefore, reduce the integration density of electronic packages and boards. Furthermore, due to the periodicity of the patches, transmission lines referenced to the patterned layers of EBGs suffer from return-path discontinuity problems, which severely degrade their electrical performance. In this work, we quantify some of the electromagnetic reliability problems caused by EBGs. We then propose a novel planar noise isolation structure, the Interconnected Patch-Ring (IPR) structure, which is just as effective as EBGs in noise isolation, but overcomes some of the limitations of EBGs.

1:30 PM - 3:00 PM
Full Wave Model for Simulating a Noiseken ESD Generator
D. Liu; A. Nandy; and D. Pommerenke, — Missouri University of Science and Technology, Rolla, MO, U.S.A.; S. Kwon; and K. Kim, — Advanced CAE Lab, Telecommunication R&D Center, Seoul, Republic of Korea

A CST Microwave Studio model was generated to simulate the discharge current and the transient field of a Noiseken ESD generator. The ESD generator conforms to the IEC 61000-4-2 standard. Individual components of the ESD generator were modeled, validated, and combined. The complete full wave model was verified by comparing the simulated discharge current waveform and induced loop voltage with the measured results.

1:30 PM - 3:00 PM
Electromagnetic Compatibility Learning Process Experience in Argentina
C. M. Munoz; R. Saint-Nom; and B. Alvarez Ovide, — Buenos Aires Institute of Technology, Buenos Aires, Argentina

The study of electromagnetic compatibility (EMC) involves an amount of content significant to the career development of a young telecommunication engineer. But the inclusion of EMC courses in a EE curricula, is characterized by high costs due to necessary equipment in order to take forward laboratory practices, and a total unawareness of its potential, from students, professors and professionals. Coupled to this reality, in Argentina, due to various political, economic and social facts, the need to develop expertise in the field of EMC has been totally neglected. CAERCEM, a laboratory and research group on EMC of ITBA (Buenos Aires Institute of Technology), has designed and implemented a plan to prove to our society the need to acquire technical knowledge in EMC, and as a second instance to the creation and implementation of relevant courses, both in undergraduate and graduate levels. This paper explains how we did it, hoping that the reader could profit from some ideas and help us spread EMC in many countries.

TH-AM-1 Immunity Measurements (TC2)

Room 17A

Chair: Cliff Hauser, Ratheon Missile Systems, Tucson, Arizona, U.S.A.

Co-Chair: Richard Georgerian, NewsFlex Ltd., Colorado, U.S.A.

8:30 AM - 9:00 AM

Electromagnetic Field Immunity Test System applying Array Antenna Technology

U. Takeshi; C. Miyazaki; N. Oka; K. Misu; and Y. Konishi, — Mitsubishi Electric Corporation, Kamakura-City, Japan

We examine the electromagnetic field immunity test system applying an array antenna technology. This system is able to get an electric field uniformity and high power electric field near the antenna, in a wide band, by beam forming. In this paper, we calculated a uniformity of electromagnetic field immunity test system applying 64 (8x8) elements plane array antenna using a wide band antenna. We constructed an electromagnetic field immunity test system applying 64 elements array antennas as a prototype, measured an electric distribution, and compared the calculated value and measured value.

9:00 AM - 9:30 AM

Examinations of Higher Order Mode Cutoff Frequencies in Symmetrical TEM Cells

Z. Chen, ETS-Lindgren, Cedar Park, TX, U.S.A.

Previous studies on the higher order mode cutoff frequencies for symmetrical TEM cells include matrix solutions from a mode matching method, approximate expressions based on the assumption of small gaps between the inner conductor and the sidewalls, or numerical simulations based on meshing the cross-section. Good agreement among the methods has been achieved in most cases. However, some discrepancies among results have remained, and these differences are investigated in this paper. A computer code is made available to compute higher order mode cutoff frequencies of any symmetrical TEM cells. In addition, a simple curve-fit algebraic expression for the first higher order mode cutoff frequency of 50 ohm TEM cells is presented.

9:30 AM - 10:00 AM

The Time Domain Response of BCI Transformers

J. S. McLean; and R. Sutton, — TDK R&D Corp., Cedar Park, TX, U.S.A.

A representative bulk current injection transformer is characterized experimentally in both the time and frequency domains with the goal of quantitatively predicting its time domain response to the trapezoidal pulse specified in MIL-STD 461E. The time domain responses of the representative transformer as computed from the experimentally obtained frequency domain transfer function and measured directly in the time domain are in good agreement. We present for the first time a figure of merit, the time-domain pulse injection efficiency, which indicates the fraction of the available pulse energy from the generator that is inductively coupled into to a particular structure such as a test fixture. This concept is generalized to the time-gated pulse injection efficiency in order to account for a finite time window. It is seen that about 31.5 percent of the available energy in the trapezoidal pulse is delivered to the test fixture and that of this fraction most (30 percent of the total available energy) is delivered during a 30 nanosecond window, despite the overall extremely long time response of the probe. Finally, frequency domain power efficiency measurements are presented and compared with the time domain pulse injection efficiency.

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 11:00 AM

A Measurement Technique for ESD Current Spreading on a PCB using Near Field Scanning

W. Huang; D. Pommerenke; J. Xiao; and D. Liu, — Missouri University of Science and Technology, Rolla, MO, U.S.A.; J. Min; and M. Giorgi, — Amber Precision Instrument, Santa Clara, CA, U.S.A.; S. Kwon; and K. Kim, — Samsung Electronics, Suwon, Republic of Korea

Electrostatic discharge (ESD) can cause interference or damage to circuit in many ways, e.g., E- or H- field coupling or via conduction paths. Although we can roughly estimate the voltage and current at the injection point during an ESD event, the real offending parameter is mostly the ESD current spreading throughout the system. Those currents can be simulated if great simplifications of the system are accepted. However, even in moderately complex systems the ability to simulate is limited by lack of models and computational resources. Independent of the complexity, but obviously not free of its own limitations, is a measurement technique that captures the current as a function of time and location through the system. This article describes the proof on concept of ESD such a measurement technique that allows reconstructing the spreading current as a movie from magnetic field measurements. It details the technique, question of probe selection, and how to process the data to present the current spread as a movie.

11:00 AM - 11:30 AM

Electromagnetic Penetration Studies for Three Different Aircraft
C. A. Grosvenor; D. Novotny; D. Camell; and G. Koepke, — National. Institute of Standards and Technology, Boulder, CO, U.S.A.; R. Johnk, Institute for Telecommunication Sciences, Boulder, CO, U.S.A.; and N. Canales, NIST-Retired, Firestone, CO, U.S.A.

The National Institute of Standards and Technology has completed penetration studies on three different aircraft for the Federal Aviation Administration. These studies are used to understand cavity coupling characteristics between antennas placed at various angular positions around an aircraft and to understand the field uniformity within these cavities with antennas placed in various compartments inside the aircraft. This paper shows how penetration varies as a function of frequency, antenna type, antenna polarization, and cavity susceptibility for three different aircraft types, a commercial airline jet, a business jet, and a composite aircraft. The quality factor and time decay of fields for internal coupling between two antennas placed in the aircraft at different locations is also presented.

11:30 AM - 12:00 PM
Why increasing Immunity Test Levels is Not Sufficient for High-Reliability and Critical Equipment
K. Armstrong, Cherry Clough Consultants, Stafford, United Kingdom

It is often assumed that passing an EM immunity test at 100% of the level of the worst-case disturbance that can occur over the lifecycle, and taking measurement uncertainties into account, will prove that the design of the tested equipment will almost never suffer from errors or malfunctions due to that disturbance in real life. Unfortunately, although the above is necessary when testing the EM immunity of equipment that must function with high reliability, such testing is insufficient to demonstrate that high-reliability, security, mission-critical, or safety-critical equipment or systems will achieve tolerable failure levels over their lifecycles despite the EM disturbances in their environments. Part I of this paper discusses the requirement for immunity test levels and dealing with measurement uncertainty, when testing high-reliability equipment. Part II explains why although these requirements are necessary, they are not sufficient, and why this is so. Part III briefly introduces the techniques that are necessary for achieving sufficient confidence in EM immunity, when high reliability is required.

TH-AM-2 EMC and Modern Power Electronics Systems (TC4)

Room 17B

Chair: Philip Keebler, EPRI, Knoxville, Tennessee, U.S.A.

Co-Chair: Ali E. Yilmaz, University of Texas, Austin, Texas, U.S.A.

8:30 AM - 9:00 AM
Effects of CAN Filter on EMI Performance of Switching Power Supplies
E. N. Chikando; S. R. Connor; and B. Archambeault, — IBM Corporation, Research Triangle Park, NC, U.S.A.

In this paper, common issues associated with incorporation of an inline filter cable, also know as CAN filter are investigated. In the analysis presented, it is shown that impedance interactions resulting from the integration can significantly affect the overall performance of the power supply often resulting in non-compliance to regulatory emissions requirements for the supply.

9:00 AM - 9:30 AM
EMI Prediction in Switched Power Supplies by Full-wave and Non-linear Circuit Co-simulation
A. Bhargava; D. Pommerenke; K. Kam; and X. Chang, — Missouri University of Science and Technology, Rolla, MO, U.S.A.; F. Centola; C. Lam; and R. Steinfeld, — Apple Inc., Cupertino, CA, U.S.A.

This paper treats the problem of electromagnetic interference in switched mode power supplies using co-simulation. Co-simulation combines full-wave EM solution with a non linear SPICE circuit. Voltages and currents (at different nodes in the circuit) that drive the EMI can be simulated. Different co-simulation strategies are discussed along with their pros and cons. Also, different commercial software tools have been evaluated for this simulation technique and promising results have been compared to measurements or voltages, TEM cell coupling and coupling to an antenna. The circuit investigated is a DC-DC buck converter.

9:30 AM - 10:00 AM
EMC Guideline for Synchronous Buck Converter Design
K. W. Kam; and D. Pommerenke, — Missouri University of Science and Technology, Rolla, MO, U.S.A.; C. Lam; R. Steinfeld; and F. Centola, — Apple Inc., Cupertino, CA, U.S.A.

Synchronous buck converters generate broadband noise typically in the 50 MHz to 300 MHz range. In this paper, the root cause of this broadband noise and possible coupling mechanisms are analyzed. Then, a list of EMC design guidelines for minimizing the broadband noise is presented. The guidelines contain circuit level guidelines which involve input filtering, component selection, and an effective snubber strategy using a parallel resistor and inductor. The guidelines also contain a layout level guideline, which involves decoupling capacitor placement, layer stackup, and minimizing exposed phase voltage area. For each suggested guideline item, an example illustrating the impact of the particular strategy through experimental results or SPICE simulations, leading to a strong reduction of broadband noise from the synchronous buck converter is presented.

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 11:00 AM
Finding Return Current Paths via Synchronized Measurements in a Multiphase DC-DC Buck Converter
P. Shao; and D. Pommerenke, — Missouri University of Science & Technology, Rolla, MO, U.S.A.; F. Chang; C. Reade; and P. Ilavarasan, NVIDIA Corporation, Beaverton, OR, U.S.A.

Evaluation of a product in terms of radiated emissions involves identifying the current return path. In a complex system, multiple sources can contribute to the current at one place and frequency. Identifying the source of the current can be achieved by correlating the current to different sources. In a multiphase buck converter, currents in the capacitors are caused by all phases of the converter, however, the phases do not switch at the same time. Thus, synchronizing to a specific phase allows evaluating how the current of this specific phase spreads throughout the board. With the objective of localizing current, one can evaluate if the capacitor placement is optimal and find improved layout and placement solution for a multi-phase buck converter.

11:00 AM - 11:30 AM
Solution for the Reduction of Electromagnetic Influences from an Electric Driving System
P. T. Nicolae; I. V. Nicolae; and I. V. Sirbu, University of Craiova, Craiova, Romania

This paper presents a series of simulation results and experimental data concerning the operation of an equipment based on power electronics placed on a tram. One toggles with problems related to electromagnetic influences from an urban electric driving system and modalities to remove them. The recordings of the current and voltage waveforms obtained experimentally during the normal running stage of the system are presented and explained. They revealed that the system was designed correctly and fulfils the EMC conditions.

11:30 AM - 12:00 PM
Design of Impedance Matching Couplers for Power Line Communications
R. Araneo; S. Celozzi; and G. Lovat, — Sapienza – University of Rome, Rome, Italy

The low-voltage power line communication (PLC) field constitutes today a hot open research area. Power lines, that often already exist to support energy distribution, can provide an economical broadband medium for high-speed reliable communication traffic, not only for equipment monitoring, protection, and control purposes, but especially today for supporting the smart home technology. However, despite several attractions, the low-voltage electrical network provides an unfriendly environment for data communications. Besides interferences, noise, attenuation, and multi-path reflections, the extremes as well as the unpredictability of the access impedance are limiting factors in the performance of PLCs. This paper presents a preliminary study about a possible methodology of designing an optimal broadband impedance matching circuit (BIM) for providing gain equalization and mitigation of the effects of low-impedance loads on the PLC modem in a wide frequency range. The design is achieved in successive steps by means of the Vector Fitting method, rational parametric approximation of the driving impedance and nonlinear optimization through a novel Meta Particle Swarm Optimization (MPSO).

TH-AM-3 Cavities, Reverberation Chambers, and Statistics (TC9)

Room 18C

Chair: Jun Fan, Missouri University of Science & Technology, Rolla, MO, U.S.A.
Co-Chair: Vignesh Rajamani, Oklahoma State University, Stillwater, OK, U.S.A.

8:30 AM - 9:00 AM
Electromagnetic Cavity Effects from Transmitters inside a Launch Vehicle Fairing
D. H. Trout, NASA - Kennedy Space Center, Kennedy Space Center, FL, U.S.A.; P. F. Wahid, University of Central Florida, Orlando, FL, U.S.A.; and J. E. Stanley, Florida Institute of Technology, Melbourne, FL U.S.A.

This paper provides insight into the complicated issue of launch vehicle resonate cavity effects that has applicability outside of the space industry. Radiation from spacecraft or launch vehicle antennas located within the enclosures of a launch vehicle generates an electromagnetic environment that is difficult to predict accurately. This paper discusses the test results of power levels produced by a transmitter within a representative scaled vehicle fairing model and provides preliminary modeling results at critical frequencies using a commercial tool. Initially, fairing walls are aluminum and are then layered with materials to simulate acoustic blanketing structures that are typical in payload fairings. The effects of these blanketing materials on the power levels within the fairing are examined. Industry data is also reviewed for comparison purposes.

9:00 AM - 9:30 AM
Analysis of Antenna Behavior in a Multipath Environment Generated by a Reverberation Chamber
A. Cicchi; V. Mariani Primiani; and F. Moglie, — Universita` Politecnica delle Marche, Ancona, Italy

This paper investigates the effects of the voltage on the antenna caused by a multipath propagation environment. This type of environment was reproduced by a reverberation chamber. Both scattered and direct components were considered for the excitation of the receiving antenna, ranging from line-of-sight to non-line-

of-sight conditions. A numerical solution based on a Finite Difference Time Domain code was achieved and compared with measurements inside a reverberation chamber. The method allows to balance the amount of random contributions, direct contribution, and deterministic multipath contributions, just as in actual propagation conditions.

9:30 AM - 10:00 AM
SAR Numerical Analysis of the Whole Human Body Exposed to a Random Field
R. De Leo; V. Mariani Primiani; F. Moglie; and A. P. Pastore, — Universita` Politecnica delle Marche, Ancona, Italy

This paper concerns the numerical computation of the specific absorption rate (SAR) of a human body exposed to a random field. The model has been taken from the "Visible Human Body Project". It is placed in a reverberation chamber (RC) where the internal field is simulated using the plane wave integral representation and which is numerically solved by a superposition of N plane waves repeated M times. This method is largely used for the electromagnetic compatibility measurements and is also applied to calculate the absorbed power, and subsequently, temperature distribution of an object heated in an RC. In this paper it is used to calculate the SAR at various frequencies for the whole human body and for some tissues, thereby recreating an environment which has characteristics very similar to the real environment that bombards us with dangerous radiations coming from different directions, and the field may assume random characteristics.

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 11:00 AM
Calibration of a Numerically Modeled Reverberation Chamber
V. Rajamani; C. Bunting; and J. West, — Oklahoma State University, Stillwater, OK, U.S.A.

Calibration of a reverberation chamber is a time consuming process, involving a number of parameters that must be optimized for the chamber to pass the calibration requirements. One of the major factors for calibration at the low frequencies is the tuner efficiency (size and complexity of the tuner). Modeling of the tuner before building it is a cost effective option. Many tuner designs can be modeled for a chamber of given size and requirements and the best tuner design can be chosen from the simulation. Calibration of the simulated data to obtain the desired performance, both in terms of uniformity and maximization of the usable volume over a range of frequencies, may be useful. Numerical modeling of the electromagnetic fields within an enclosed space such as a reverberation chamber is a particularly difficult problem due to the resonant modes supported within the space, leading to poor convergence of computational electromagnetic methods. In this paper, the ability of MLFMA to model the fields within a reverberation chamber with lossy walls and a tuner is investigated, and a calibration of the simulated chamber is performed for a specific tuner design and operating frequency of the chamber.

11:00 AM - 11:30 AM
Crosstalk Statistics via Collocation Method
F. Diouf; and F. Canavero, — Politecnico di Torino, Torino, Italy

A probabilistic model for the evaluation of transmission lines crosstalk is proposed. The geometrical parameters are assumed to be unknown and the exact solution is decomposed into two functions, one depending solely on the random parameters and the other on the frequency. The stochastic collocation method is used to estimate the crosstalk statistical moments. The results are obtained from a limited number of carefully-chosen values of the random geometrical parameters. The estimated statistical moments are then used to build the probability density function of the crosstalk parameters. A Monte Carlo validation demonstrates the accuracy and efficiency of the advocated method.

TH-AM-4 Special Session – Automotive EMC
Room 18B
Chair: Roger Kuvedu-Libla, Delphi Electronics & Safety, Bascharage, Luxembourg

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8:30 AM - 9:00 AM
The Present Status of the International Automotive EMC Standards
P. H. Andersen, Poul Andersen Consulting, Richmond, MI, U.S.A.

The automotive standards have been the subject of previous symposia presentations. But, as they are not status documents, it is useful to review the changes to previously published documents and to discuss new documents. The presentation will cover the CISPR/D documents and the several documents developed in ISO/TC22/SC3/WG3. The documents are applicable not only to "Road Vehicles" but also to all products using internal combustion engines and some other products as well (e.g. battery powered, self-propelled machines).

9:00 AM - 9:30 AM
Improving Monopole Radiated Emission Measurement Accuracy; RF Chamber Influences, Antenna Height and Counterpoise Grounding (CISPR 25 & MIL-STD-461E vs. MIL-STD-461F)
C. W. Fanning, Elite Electronic Engineering Inc, Downers Grove, IL, U.S.A.

For many years, the automotive industry has used a monopole antenna to measure the radiated emissions from modules at frequencies less than or equal to 30 MHz. Over the past few years, the chamber to chamber measurement deviation of the monopole

antenna measurements has become a topic of concern. Studies have shown that significant chamber to chamber measurement deviations, as large as 20 dB, may exist when making monopole measurements in an ALSE. Recommendations to modify the absorber lined shielded enclosure (ALSE) have been made in order to improve the measurement deviation. However, requiring all test laboratories to modify their ALSE(s) is not practical. MIL-STD-461F recently changed the monopole antenna setup (antenna height and counterpoise grounding) in order to improve measurement deviation. Should the modified MIL-STD-461F monopole antenna setup be adopted by the automotive industry for the next revision of CISPR 25?

9:30 AM - 10:00 AM

Time Domain Measurements in Automotive Applications

W. Winter; and M. Herbrig, — emv Gmbh, Taufkirchen, Germany

Time domain measurements are required to analyze and interpret transient disturbing RF signals. In the area of future automotive applications, transient RF disturbances are becoming critical because comfort options like blue tooth connection, external devices with complex integrated RF functionality (automotive WLAN, UMTS, GSM, WCDMA, MIMO devices, multiband smart phones, Net-books) have to interface with integrated car entertainment and control systems. Due to the technical concept of such wireless communication networks with digital modulation schemes, the interferences are often short events with transient characteristics. The detection and reproducible measurement of such signals is difficult because of missing trigger signals and can be performed today with Time Domain Measurement Systems using fast A/D converters, digital filters, and the Fourier Analysis to transform the measured data into the frequency domain.

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 11:00 AM

Proposal for the Validation of Absorber-Lined Shielded Enclosures for CISPR 25 Emission Tests

F. Bongartz, Landesamt fuer Zentrale Polizeiliche Dienste NRW, Duisburg, Germany; J. Deckers, Mooser EMC Technik GmbH, Ludwigsburg, Germany; M. Heina, Mooser Consulting GmbH, Egling / Thanning, Germany; H. Hirsch, University Duisburg-Essen, Duisburg, Germany; J. Mooser, Mooser Consulting GmbH, Egling / Thanning, Germany; J. Nickel, Continental Automotive GmbH, Regensburg, Germany; and M. Seiger, EMC Test NRW GmbH, Dortmund, Germany

CISPR 25 defines several methods and limit classes for emission measurements for vehicle components. With regard to the measurement of electric field strength the test set-up consist of a table with metallic surface, on which the EUT and a specified length of cable harness is to be located. This set-up is placed in an absorber lined shielded enclosure (ALSE). The question of suitability of a certain ALSE for this measurements is not yet solved. A joint task force (JTF, between CISPR/D and CISPR/A) has been established to develop an appropriate validation method. In preparation of the international work in the JTF, the authors of this paper propose a validation method, which is based on an arrangement similar to the test set-up. In contrast of a real cable harness the proposed radiator is well defined, which allows to use results from numerical field computations as reference values. An ALSE including table and test set-up is suitable for measurements according CISPR 25, if the deviations between measurement results and theoretical results are within certain limits. In the paper the method is introduced and results of the field computations and measurement results obtained in different ALSEs are shown and evaluated.

11:00 AM - 11:30 AM

Design Limitations of Powertrain Electronics - Automotive EMC Challenges

J. K. Kuvedu-Libla, Delphi Electronics & Safety, Bascharage, Luxembourg

Today's safety features for modern vehicles require electronic controls for many functions such as engine command, fuel injection of diesel or gasoline, air bag deployment, and gas/brake pedal operation. Powertrain Electronics such as the Engine Control Module (ECM), Power Control Module (PCM), Diesel Control Module (DCM), or Vehicle Control Module (VCM) support these functions when utilized. The electromagnetic compatibility (EMC) performance of these modules is challenged by small physical areas and volumes that are required by the vehicle manufacturer and the printed circuit board (PCB) design. The challenges are due to: 1) the large sizes of PCB components such as capacitors and inductors; 2) the increasing number of the integrated circuits such as IGPT and VSEP, the rapidly increasing number of in/output pins, and the complexity of connectors, causes even further reductions of available PCB area for EMC components; 3) Ground Via Port Techniques required for thermal management are caused by high voltages or currents of IGPT-elements. This paper reports on the design limitations for the issues described above. The conclusion of this is that the EMC performance of these Modules is compromised when enough space is not allocated for EMC components. In addition, compact PCB elements with small sizes are not available for applying EMC design rules such as in-/output filtering, grounding or multi layer traces/planes decoupling. A study about the challenges of ground via ports required to achieve dynamic thermal performance and automotive EMC will conclude the present investigations.

11:30 AM - 12:00 PM

Analysis of Electromagnetic Resonances in The Case of a Vehicle Using Different Sets of Field Points

S. Tapigue; M. Klingler; and S. Benhassine, — PSA Peugeot Citroen, Vélizy villacoublay, France; P. Besnier; and M. Drissi, — IETR/INSA Rennes, Rennes, France

In order to improve the electric/electronic architecture of the vehicle, resonances should be identified and solved upstream. In this paper, we present a study of the resonances occurring inside a vehicle using a numerical code based on the Method of Moments. Three different types of sets of field points have been used to carry out this study. The first set is composed of points localized in the entire volume of passenger compartment. Points at the location of several vehicle equipment constitute the second set. The third set is made up of points along the route of the harnesses. The methodology used for this investigation is based on the computation of the electromagnetic fields on the different sets of field points, followed by the identification of the resonant frequencies by post-processing the field values. An analysis of these results shows that it is possible to study resonance occurring inside the vehicle using only the two first sets of field points, allowing the identification upstream of immunity risks to external sources.

TH-PM-1 EMC Measurement Test Equipment (TC2)

Room 17A

Chair: Bob Hofmann, Hofmann EMC Engineering, Illinois, U.S.A.

Co-Chair: Ross Carlton, National Instruments, Austin, Texas, U.S.A.

3:00 PM - 3:30 PM

Novel Electromagnetic Field Measuring Instrument with Real-Time Visualization

J. Rioult; D. Seetharamdoo; and M. Heddebaut, — INRETS, Villeneuve d'Ascq, France

Nowadays, a wide variety of terminals are proposed to nomadic users. Generally, these terminals provide wireless communication operating at frequencies between one and a few GHz. For technical reasons, including multiple access to the communication channel and battery autonomy, these terminals transmit only during very short periods, i.e., transmission bursts. For a direct observation of certain characteristics of the transmitted signals radiated by such terminals, only a few measurement setups exist. This paper proposes such a novel, real-time, 3D electromagnetic field measurement instrument with direct visualization. The prototype used for validation is based on an array of probes regularly attached on a non-conductive rigid loop which is put into fast rotation around the terminal under test.

3:30 PM - 4:00 PM

Time-Domain EMI Measurements in the Presence of Ambient Noise

A. Frech; S. Braun; and P. Russer, — Technische Universität München, Munich, Germany

This paper presents adaptive cancellation techniques to suppress ambient noise in electromagnetic interference measurements (EMI) on open area test sites. The measurements are carried out in time-domain to reduce the total measurement time. To achieve optimum cancellation, time-domain as well as frequency domain adaptive filter algorithms have been investigated and compared with respect to their suppression performance. An advanced digital signal processing technique for fast measurements of EMI from electronic devices is presented. Fast measurements of EMI of electronic devices and systems are carried out in a test site polluted by electromagnetic ambient noise. Frequency domain adaptive filtering using the overlap-save method is applied. Measurements of a personal computer as a device under test are carried out on an urban test site and show the successful cancellation of ambient noise in the frequency range from 30 MHz to 1 GHz.

4:00 PM - 4:30 PM

A Realtime Time Domain EMI Measurement System for Measurements above 1 GHz

S. M. Braun; C. Hoffmann; A. Frech; and P. Russer, — Munich University of Technology, Munich, Germany

Emissions measurements performed in time domain using ultra-fast analog-to-digital converter and real-time digital signal processing allow to reduce the measurement time by several orders of magnitude. In this paper a novel real-time operating time domain EMI measurement system is presented for the frequency range up to 3 GHz. For the frequency range up to 1 GHz, a noise figure of about 8 dB has been achieved, while above 1 GHz the noise figure is below 6 dB. The system uses a multi-resolution analog-to-digital converter system. Above 1 GHz an ultra-broadband down converter system with 325 MHz bandwidth allows to perform ultra-fast emission measurements. In comparison to existing heterodyne systems, the measurement time is reduced by about a factor of 60 for 1 MHz IF bandwidth, and by a factor of 2000 for an IF bandwidth of 120 kHz. Measurements have been carried out in the frequency range 30 MHz to 3 GHz, and have proven that the system provides enough sensitivity for measurements over the complete frequency range.

4:30 PM - 5:00 PM

Impedance Measurements from 1 to 20 MHz with up to 200 A (50 Hz) Bias-Current for the Optimization of High Power High Frequency Coils

I. Schmidt; and A. Enders, — Technische Universität Braunschweig, Braunschweig, Germany

In this paper, proper measurement techniques are presented to evaluate the impedance, resonances and parasitic effects of very large coils up to 30 MHz. Moreover, a setup is presented to enable measurements up to 20 MHz in on-load operation with 50 Hz nominal currents up to 200 A. This incorporates the issue that the filter performance can change

significantly in operations, especially if ferromagnetic core materials are used in the coils.

5:00 PM - 5:30 PM
Impulsive Noise Measurement Methodologies for APD Determination in M2M Environments
J. Chilo; C. Karlsson; and P. Angskog, — Center for RF Measurement Technology, Gavle, Sweden; and P. Stenumgaard, Swedish Defence Research Agency, Linköping, Sweden

Wireless communications in industrial environments are maintained under persistent adverse conditions, such as noise, fading and many electromagnetic interference sources. These electromagnetic interferences exhibit usually impulsive characteristics and it can seriously degrade the performance of the current wireless systems. Over the last few years, the Amplitude Probability Distribution (APD) had been formally written into CISPR16 as a measure of the emitted electromagnetic energy from electrical equipment. In this approach we present two APD measurement methods. The first method is based on a 12-bit A/D converter, and the second one is based on in-phase and quadrature components of the impulsive noise at frequencies between 20 and 2500 MHz. Electromagnetic interference measurements in three different industrial environments were performed using the developed methods with promising results.

TH-PM-2 Emissions and Immunity (TC4)

Room 17B

Chair: John Archer, retired from RCA Military
Co-Chair: Michael Foegelle, ETS-Lindgren, Cedar Park, Texas, U.S.A.

3:00 PM - 3:30 PM
Conducted EMI Simulation of Switched Mode Power Supply
H. Li; D. Pommerenke; and W. Pan, — Missouri University of Science and Technology, Rolla, MO, U.S.A.; S. Xu; H. Ren; F. Meng; and X. Zhang, — Huawei Technologies Co., Ltd., Shenzhen, China

This paper introduces an efficient method to predict the conducted EMI of a switched mode power supply (SMPS) through time domain SPICE simulation, which can be used to design or optimize the filter circuit and quantify the suppression degree of the filter. The SMPS modeling method permits modeling of the SMPS as a noise signal source even when its internal structure is unknown. The method is verified by comparing predicted and measured noise signals.

3:30 PM - 4:00 PM
Potential Interference Issues between FCC Part 15 Compliant UHF ISM Emitters and Equipment Passing Standard Immunity Testing Requirements
D. R. Novotny; and J. R. Guerrieri, — NIST, Boulder, CO, U.S.A.; and D. G. Kuester, University of Colorado, Boulder, CO, U.S.A.

The potential of electromagnetic (EM) interference between multi-channel, FCC Part 15 UHF (902-928 MHz) ISM emitters and devices that have passed immunity requirements under international standards is examined. At close ranges, the fields from a Part 15 compliant emitter may exceed minimum standard immunity testing levels. This does not imply interference will occur, only that the device may not be qualified to operate in the EM environment near the emitter. Recent studies have indicated that an interference potential can exist between some UHF emitters and medical, commercial, and military systems. The range at which Part 15 compliant devices may pose a risk to Industrial, Consumer, and Medical devices is estimated and compared to some previously published data. Because Radio Frequency Identification (RFID), especially passive UHF RFID, emitters may be deployed in numerous locations and in close proximity to many devices, it has been the focus of many of the studies of interference potential. RFID emitters are one of the largest populations of the examined Part 15 devices, but the potential of all frequency-hopping, digitally-modulated emitters are addressed.

4:00 PM - 4:30 PM
Differential Mode Noise on the PCB's Signal Traces Converted from External Common Mode Noise
N. Oka; and K. Misu, — Mitsubishi Electric Corporation, Kamakura, Japan; T. Kumamoto, Mitsubishi Electric Engineering Company Limited, Kamakura, Japan; and S. Nitta, Salesian Polytechnic, Machida, Japan

This study experimentally clarifies the relationship between the common mode noise induced on the cable connected to the signal trace of PCB, and the differential mode noise on the signal trace, converted from the common mode noise, due to the unbalance of differential signal trace by applying the measurement method that Test baluns are used as a load of the cable and a signal source. In this study, S13 (Differential mode noise) and S23 (Common mode noise) are measured by the network analyzer for evaluation. Finally, the effectiveness of the common mode choke on signal trace and the shielding for the cable for both common mode and differential mode noise reduction are evaluated.

4:30 PM - 5:00 PM
Bandwidth Improvement of Multilayer Common Mode Filter by Time Domain Method
B. Tseng; and J. Ling, — Feng Chia University, Taichung, Taiwan; and L. Liao, Chaoyang University of Technology, Taichung County, Taiwan

In demand of high-speed differential data communication, the common mode filter is usually presented. The new common mode filter demonstrated in this paper is designed by differential pairs with edge coupled. By using a double loops routing structure, the

coupling inductance is increased. To achieve sufficient common mode noise suppression while introducing minimal signal insertion loss, the full-wave, time-domain, EM simulator is applied.

5:00 PM - 5:30 PM
Ultra-Wideband and Compact Novel Combline Filters
B. Mohajer-Iravani, EM Wave Dev, Fayetteville, AR, U.S.A.; and M. A. EL Sabbagh, University of Arkansas, Fayetteville, AR, U.S.A.

This paper presents a novel method of designing ultra-miniaturized, cavity based, combline filter integrable in PCB technology for EMI filtering. Each combline resonator is designed based on concepts of designing a unit cell of metamaterials. The other design steps follow the conventional design procedure of microwave filters. Choice of metamaterial unit cell leads to extreme size reduction and conventional design method results in optimum number of resonators. A strong inter-cavity coupling value not realizable with conventional evanescent method is realized by TEM section. Therefore, the final structure is very compact and broadband. The design is realized using multilayer planar technology. A design example is provided where a dramatic reduction of the volume of filter by a factor of 7 is obtained.

TH-PM-3 Signal Integrity (TC10)
Room 18B
Chair: Antonio Orlandi, University of L'Aquila, L'Aquila, Italy
Co-Chair: Tzong-Lin Wu, National Taiwan University, Taipei, Taiwan

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3:00 PM - 3:30 PM
Parameterized Models for Crosstalk Analysis in High-Speed Interconnects
F. Ferranti; T. Dhaene; and L. Knockaert, — Ghent University-IBBT, Ghent, Belgium; and G. Antonini, University of L'Aquila, L'Aquila, Italy

We present a new parametric macromodeling technique for lossy and dispersive multiconductor transmission lines (MTLs), that is suitable to interconnect modeling. It is based on a recently introduced spectral approach for the analysis of lossy and dispersive MTLs extended by utilizing the Multivariate Orthonormal Vector Fitting (MOVF) technique to build parametric macromodels in a rational form. They can handle design parameters, such as substrate or geometrical layout features, in addition to frequency. The presented technique is suited to generate state-space models and synthesize equivalent circuits, which can be easily embedded into conventional SPICE-like solvers. Parametric macromodels allow us to carry out design space exploration, design optimization, and crosstalk analysis efficiently. A numerical example validates the proposed approach in both frequency and time domain, and is focused on the crosstalk analysis.

3:30 PM - 4:00 PM
Investigation of Crosstalk among Vias
S. Wu; and J. Fan, — Missouri University of Science and Technology, Rolla, MO, U.S.A.

Crosstalk among vias is a critical problem in high-speed digital circuits, deteriorating signal quality and increasing jitter, especially when circuit density is high. The underlying mechanism of crosstalk among vias is investigated in this paper. Using a physics-based equivalent circuit model, crosstalk as a function of various geometrical parameters, including parallel plane pair thickness, layer count in printed circuit board (PCB) stackup, ground via patterns, and parallel plane pair dimensions, has been investigated. A multi-step crosstalk evaluation procedure is proposed based on the study for PCB layout-design verifications.

4:00 PM - 4:30 PM
Improved Technique for Extracting Parameters of Low-Loss Dielectrics on Printed Circuit Boards
P. K. Anmula; A. Koul; M. Y. Koledintseva; and J. L. Drewniak, — Missouri University of Science & Technology, Rolla, MO, U.S.A.; and S. Hinaga, CISCO Systems, Inc., San Jose, CA, U.S.A.

This paper is devoted to the methodology of characterization of low-loss dielectrics on printed circuit boards. The technique is based on measuring S-parameters and recalculating them into a complex propagation constant. An effect of dielectric loss upon a dielectric constant is considered in the analytical model for dielectric parameter extraction. Dielectric and conductor loss are separated using a model which includes surface roughness of conductors. Network asymmetry is taken into account in the model. The proposed model allows for extraction of dielectric constant and dissipation factor with an increased accuracy. Extracted parameters for frequency-dispersive dielectrics satisfy Kramers-Kronig causality relations.

4:30 PM - 5:00 PM
Using a Single-Ended TRL Calibration Pattern to De-embed Coupled Transmission Lines
J. Zhang; Q. B. Chen; and Z. Qiu, — Cisco Systems, Inc., San Jose, CA, U.S.A.; J. L. Drewniak, Missouri University of Science and Technology, Rolla, MO, U.S.A.; and A. Orlandi, University of L'Aquila, L'Aquila, Italy

Transmission line port de-embedding is critical in characterization and modeling for high-speed digital systems. The de-embedding technique for single-ended transmission lines has been developed and widely used. However, few de-embedding techniques for coupled transmission lines have been reported in the literature. In this paper, a de-embedding technique for coupled transmission lines using a single-ended Thru-Reflect-Line (TRL) calibration pattern is proposed. It is based on directly obtaining Vector Network

Analyzer (VNA) error correction data from measurement and post data processing. As accurate de-embedding is related to the equipment used in the measurement, the proposed technique is verified on two different VNAs with different architectures including a three-sampler VNA and a four-sampler VNA. Good agreement of de-embedded mixed-mode S-parameters has been achieved on both VNAs.

5:00 PM - 5:30 PM
Investigation of Mixed-mode Input Impedance of Multi-layer Differential Vias for Impedance Matching with Traces
H. Wang; J. L. Drewniak; and J. Fan, — Missouri University of Science and Technology, Rolla, MO, U.S.A.; W. Cheng; J. Zhang; J. Fisher; and L. Zhu, — Cisco Systems, San Jose, CA, U.S.A.

In multilayer printed circuit boards (PCBs), vias are commonly used to connect traces on different signal layers. This paper derives the mixed-mode input impedance of differential vias in typical multilayer structures, and proposes the use of the input impedance concept to achieve impedance matching at the via and trace connections. Effects of several geometrical parameters on the input impedance of differential vias have also been studied in this paper. This method can be used to optimize via structures in PCB design processes for smooth via-trace transitions.

TH-PM-4 EM Environments (TC3)

Room 18C

Chair: Dave Southworth, SPAWARSYSCEN (SSC) Pacific, California, U.S.A.

Co-Chair: Bill Strauss, U.S. Naval Air Warfare Center, Patuxent River, MD, U.S.A.

3:00 PM - 3:30 PM
Electromagnetic Complex Cavity Characterization of a Fighter Aircraft Main Weapons Bay
G. Tait; and M. Hatfield, — Naval Surface Warfare Center, Dahlgren, VA, U.S.A.; O. Corder, United States Air Force, Eglin AFB, FL, U.S.A.; M. Rodriguez; and B. Bernard, — United States Air Force, Wright-Patterson AFB, OH, U.S.A.

Frequency-swept power insertion loss measurements have been performed on a fighter aircraft main weapons bay to assess the reverberant electromagnetic environment created by radio frequency emissions into the confined, reflective space at 915 MHz (telemetry module fundamental frequency), 1830 MHz (telemetry module second-harmonic frequency), 2250 MHz (S-band), and 5650 MHz (C-band). Cavity calibration factors are calculated from these measurements and are subsequently used to predict resultant maximum reverberant electric fields for any given total radiated power into that space. The cavity calibration factors for the aircraft main weapons bay (left side) are on the order of 10 to 20 V/m/uW, making them comparable to those found in the most highly reverberant below-deck spaces in Navy ships.

3:30 PM - 4:00 PM
The Electromagnetic Characterization of the Radiated Environment in the 2.4 GHz Band
G. Lin; and X. Li, — TMC, Beijing, China; and L. Wei, MIIT, Beijing, China

Rapid advents of WLAN devices operating in the unlicensed 2.4 GHz frequency band for radio telecommunication services have created a complex electromagnetic operating environment in which interference between services may occur. This paper investigates a few typical 2.4 GHz band electromagnetic **(**EM) environments for home, office and commercial conditions. Both theoretical prediction and EM Site Survey results are presented. Based on this study, recommendations are provided for the determination of interference levels and immunity levels for other electronic devices if they are to operate near WLAN devices.

4:00 PM - 4:30 PM
EMI Disruptive Effects on Wireless Industrial Communication Systems in an Paper Plant
J. Chilo; C. Karlsson; and P. Angskog, — Center for RF Measurement Technology, Gavle, Sweden; and P. Stenumgaard, Swedish Defense Research Agency, Linköping, Sweden

It is well known that industrial and factory environments present considerable challenges for wireless communications. Because every industrial environment is different, and may offer a unique set of obstacles to effective wireless communication, a site characterization is needed at first step in determining improvements of existent wireless technologies to increase the reliability. In this work, electric field strength and APD measurements have been performed to characterize electromagnetic interference in an industrial paper plant. Common characteristics of the industrial environments affecting wireless communication were identified. Additionally, results show high interference levels at the frequencies for the DECT band, 1880 MHz to 1890 MHz. The interference level is correlated to the working mode of the electrical motors used in the process.

4:30 PM - 5:00 PM
Exposure Assessment of a Distributed Antenna System
O. H. Darwish, University of Ain Shams, Cario, Egypt; L. Dawson; I. D. Flintoft; and A. C. Marvin, — University of York, York, United Kingdom

In this paper we present an exposure assessment for a low profile distributed antenna fitted within an archway for a walk-through counter-surveillance application. A numerical electromagnetic model, based on the Method of Moments, is used to develop a simple distributed

structure antenna with optimum return loss factor in the frequency band of interest. An exposure assessment is then made using the FDTD method to determine the full-body and local specific absorption rate. The results are validated indirectly using measurements on representative systems.

TH-PM-5 Special Session - High-Power UWB Interaction with Electronic Systems (TC5 & TC7)

Room 19A

Chair: Bill Radasky, Metatech Corporation, Goleta, California, U.S.A.

Co-Chair: Mike McInerney, U.S. Army, Champaign, Illinois, U.S.A.

3:00 PM - 3:30 PM

Special Coupling Effects of UWB Pulses to Short Signal Traces

S. Fisahn; and H. Garbe, — Gottfried Wilhelm Leibniz Universität Hannover, Hannover, Germany

Ultra wideband (UWB) pulses cover a large frequency range up to several GHz, thus they are able to cause malfunctions or even destructions of complex electronic systems. Previous investigations of the coupling effects of fast transient pulses to complex electronic systems have shown, that increasing the system dimensions leads to an increased coupling efficiency. This statement seems to be universally applicable for all electronic systems, but susceptibility measurements of a generic microcontroller board with UWB pulses show surprisingly different results. In this contribution, this effect is investigated by measurements and numerical methods. Measurement results of the generic microcontroller board are presented as well as numerical results of the coupling behavior of different fast transient pulses to short PCB traces. Furthermore, the results of both measurement and numerical methods are compared to each other.

3:30 PM - 4:00 PM

Susceptibility of IT Network Systems to Interferences by HPEM

F. Brauer; and J. ter Haseborg, — Hamburg University of Technology, Hamburg, Germany; and F. Sabath, Bundeswehr Research Institute for Protective Technologies and NBC-Protection, Munster, Germany

Intentional electromagnetic interferences (IEMI) have become a threat to various kinds of technical applications. Different high power electromagnetic (HPEM) sources may cause a disturbance or destruction of complex electronic systems like communications systems. Even a temporary breakdown of the data transfer is very critical in some applications. In this contribution a COTS IT network system is investigated under HPEM conditions. The susceptibility of the system to interferences by ultra wideband (UWB), damped sinusoid (DS) and high power microwave (HPM) sources is tested and the interference signals on the critical coupling paths are measured. The performance of the system with additional COTS protection devices is also taken into account. The results are to allow first statements about the potential of protecting complex electronic systems against HPEM interferences.

4:00 PM - 4:30 PM

EMT Based Methodology for the Vulnerability Analysis of Complex Systems to IEMI

R. Kanyou Nana; S. Dickmann; B. Schetelig; and J. Keghie, — Helmut Schmidt University, Hamburg, Germany; and F. Sabath, Bundeswehr Research Institute for Protective Technologies and NBC-Protection, Munster, Germany

In the field of vulnerability to Intentional Electromagnetic Interference (IEMI), relevant coupling mechanism into complex electronic systems must be investigated. Thereby the estimation of the coupled disturbances into the systems is of special interest. This paper presents a detailed method, which allows an estimation of the vulnerability of complex systems to electromagnetic attacks. It is based on the characterization of external interfering sources and it characterizes the system by segmenting it into sub problems with respect to the different coupling mechanisms. Then the obtained sub problems are solved with the Electromagnetic Topology (EMT), and finally they are superposed to the overall solution. This procedure allows the identification of the critical coupling paths of the investigated system. Afterwards a specific implementation of different solutions for electromagnetic hardening is possible.

4:30 PM - 5:00 PM

Classifying Facilities with respect to Intentional EMI

D. Mansson, High Voltage Valley, Ludvika, Sweden; R. Thottappillil, Uppsala University, Uppsala, Sweden; and M. Backström, Saab Communication, Linköping, Sweden

Due to the internal complexity, the human intent, and the large physical distribution of a facility, a classification of the vulnerability of a facility or a distributed system based on shielding effectiveness is inadequate. This latter concept is more suitable for enclosures. Also, the hardening of such facilities against IEMI requires a correspondence between the electromagnetic zone boundary and physical access control boundary. Therefore a method, based on three key terms; Accessibility, Susceptibility and Consequence, is proposed here. Also, examples of how this method could be implemented are given.

FR-AM-1 (T) EMC Leadership (TC1)

Room 17A

Chair: Kimball Williams, Past President IEEE EMC Society, Denso International America Inc., Michigan, U.S.A.

Sufficient training in the 'soft skills' is often lacking in the curricula of engineers. The industry approach of 'sink or swim' can be harsh. This session will provide opportunities to learn or brush up on critical communications and business skills necessary for career success as an engineer in today's market.

8:30 AM - 9:00 AM
Introduction to Leadership
E. B. Joffe, KTM Project Engineering, Hod Hasharon, Israel

Everybody talks about it; few understand it. Most people want it; few achieve it. "What is Leadership?" Leadership is influence! This presentation is intended to shed some light on the principles of leadership, on what makes a great leader, and on the levels and roles of leadership. Each of us, in the IEEE and the EMC Society, at our work or our home, are leaders. This presentation serves as an introduction to a tutorial intended to serve as a primer for leadership, and provide basic skills for each of us in our leadership roles.

9:00 AM - 9:30 AM
How to Give Effective Presentations
B. Archambeault, IBM, Research Triangle Park, North Carolina, U.S.A.

It is extremely important to be able to convey ideas to others. Engineers often tend to give poor presentations because they tend to focus on the technical material rather than making sure the audience understands the ideas. This talk will discuss some important points to help engineers make more effective presentations.

9:30 AM - 10:00 AM
IEEE Code of Ethics - Ethical Challenges in the Engineering Professions
E. B. Joffe, KTM Project Engineering, Hod Hasharon, Israel

Ethics are of special importance to practicing professionals, including engineers. Professions such as doctors, teachers, lawyers, and engineers have a greater responsibility to society to do their jobs ethically. The actions that society finds acceptable versus the actions which society does not accept create the ethics by which a member of society must abide. From this definition, ethical action on the part of an engineer can be partially simplified, as the simple mandate that an engineer's greatest responsibility is to the public good. This presentation addresses the question of "why codes of ethics?" and describes in detail the Code of Ethics of the IEEE.

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 11:00 AM
EMC Leadership Tutorial "Effective Meetings"
K. M. Soohoo, IBM Corp., Poughkeepsie, New York, U.S.A.

Business managers and technical professionals spend an equivalent of many weeks in meetings per year, therefore it is important to spend the appropriate efforts in making them as effective as possible. In this tutorial, many tips will be given for holding an effective meeting.

11:00 AM - 11:30 AM
Effective Memos and Reports
R. Scully, NASA, Houston, Texas, U.S.A.

Writing effective memos and reports is an important part of an engineer's job.

FR-AM-2 (W) EMC and Wireless Devices

Room 17B

Chair: Dan Hoolihan, Hoolihan EMC Consulting, Minnesota, U.S.A.

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 and lap-top computers, as well as intra-product interference issues.

8:30 AM - 9:15 AM
EMC and Wireless Devices, The Impact of Performance Trends
J. Raab, OakTree Wireless Consulting, Austin, Texas, U.S.A.

Innovative technology and consumer demand is driving higher performing radios and devices. Trends and Future possibilities are explored in this presentation.

9:15 AM - 10:00 AM

Wireless and EMC Workshop - RF Interference: Problem and Scope
H. G. Skinner; and K. P. Slattery, — Intel Corporation, Hillsboro, Oregon, U.S.A.

Workshop Materials

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 11:15 AM
Wireless and EMC Workshop: Analysis of Digital Display Frame Signals
K. P. Slattery; and H. G. Skinner, — Intel Corporation, Hillsboro, Oregon, U.S.A.

Workshop Materials

FR-AM-3 (T) Preparation for Above 1 GHz

Room 18B

Chair: Akihisa Sakurai, IBM Japan, Ltd. / VCCI, Japan

Co-Chair: Hiroshi Yamane, NTT/VCCI, Japan

Radiated emission measurements above 1 GHz specified by CISPR 22 Ed.5.2 and Methods of radiated disturbance measurements specified by CISPR 16-2-3 Ed.2 have been published. Every country will need to prepare to include these new requirements within their own regulatory agencies. The VCCI Council in Japan has evaluated the radiated emission measurements and site validation by measurements of the site voltage standing-wave ratio above 1 GHz.

This tutorial will discuss various problems associated with EMI measurements and site VSWR evaluation methods above 1GHz that will be a new requirement to comply in Japan, Taiwan, and others in 2010, and also discuss the antennas EMI testing from 1 GHz to 6 GHz.

8:30 AM - 9:00 AM
Overview of International Standardization on EMI measurements above 1 GHz
D. N. Heirman, Don HEIRMAN Consultants, Lincroft, New Jersey, U.S.A.

This talk presents the latest information on standards in preparation and published by the Special International Committee on Radio Interference (CISPR) of the International Electrotechnical Commission (IEC). The focus is on the activity that directly applies to measurements above 1 GHz which continues to be a highly active area.

9:00 AM - 9:30 AM
EMI Requirements above 1 GHz in BSMI, Taiwan
Y. Tang; C. Chent; J. Dong; J. Tsai; and H. Lai, — BSMI, Taipei, Taiwan

BSMI EMI requirements above 1 GHz and its investigation of site VSWR validation will be presented.

9:30 AM - 10:00 AM
Evaluation of Site Validation by the Site Voltage Standing-Wave Ratio above 1 GHz
H. Yamane, NTT/ VCCI Council, Musashino-Shi, Japan; C. Miyazaki, Mitsubishi Electric Corp./ VCCI Council, Kamakura-Shi, Japan; J. Kawano, VCCI Council, Minato-ku, Japan; and A. Sakurai, IBM Japan, Ltd. / VCCI Council, Yamato, Japan

The VCCI Council in Japan has evaluated the radiated emission measurements and site validation by measurements of the site voltage standing-wave ratio above 1 GHz. The receive antenna, transmission antenna, and the absorber were arranged on the semi-anechoic chamber floor to measure the site VSWR, and the results are described.

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 11:00 AM
Issues and Solutions on EMI Testing above 1GHz with Practical Experience
C. Miyazaki, Mitsubishi Electric Corpration, Kamakura, Japan; H. Yamane, NTT, Musashino, Japan; J. Kawano, VCCI Council, Minato, Japan; and A. Sakurai, IBM Japan, Ltd., Yamato, Japan

The VCCI Council in Japan has evaluated the radiated emission measurements above 1 GHz. Those evaluated results will be described in this presentation.

11:00 AM - 11:30 AM
Antenna Developed for Site Validation of EMI Measurements in the GHz Band
A. Maeda; and J. Kawano, — VCCI Council, Tokyo, Japan; C. Miyazaki, Mitsubishi Electric Corporation, Kamakura, Kanagawa-pref, Japan; S. Kobayashi; and K. Tanakajima, — Intertek Japan, Kamisu-shi, Japan

We developed a shortened dipole antenna for the measurement of site attenuation in the frequency range between one and six GHz, which used three sets of the elements in the frequency ranges of 1 to 2 GHz, 2 to 4 GHz, and 4 to 6 GHz. The site attenuation of the full-anechoic chamber was measured by these antennas. The result was satisfactory and indicated that the chamber space can be regarded as free space.

FR-AM-4 (T) EMC Issues in Hybrid and Electric-Propulsion Vehicles

Room 18C

Chair: Mark Steffka, General Motors and University of Michigan, Michigan, U.S.A.

Co-Chair: James Muccioli, Jastech EMC Consulting, LLC, Michigan, U.S.A.

The global shift towards the engineering of efficient and manufacturable electric drive vehicle propulsion systems will result in new challenges in meeting vehicle

EMC requirements in order to assure customer satisfaction, meet legal requirements, or support mission performance goals. Much of the existing methods to address EMC of motor drives (primarily conducted and radiated emissions) are based upon "legacy" low voltage components and systems. The high voltage (typically 300 to 600 volts) and high current (hundreds of amps peak demand) in vehicle propulsion systems will require new analysis approaches, test methods, and effective use of simulation/modeling. This tutorial will discuss the development of electric motors from "small scale" to large drive motors, the mechanical constraints of motor EMC compliance, systems integration methods of today, and possible solutions for the future.

8:30 AM - 9:15 AM
Modeling and Simulation of Powertrains for Electric and Hybrid Vehicles
M. P. Klingler, Peugeot Citroen Automobiles, Velizy-Villacoublay, France

This presentation focuses on a general overview of ways to model and simulate powertrains for electric and hybrid vehicles. The outline of the presentation is: the background, the automotive context, overview of different simulation tools commonly used, the general simulation approach, EMC analysis of an electric powertrain, a generic typical electric powertrain, EMC problems introduced by powertrains, specific EMC questions to address, modeling and simulating powertrains, components, (un-)shielded equipment near to chassis, chassis of the vehicle, cables and harnesses, interfacing between codes, summary, and conclusions.

9:15 AM - 10:00 AM
EMC System Engineering of the Hybrid Vehicle Electric Motor and Battery Pack
J. Muccioli; and D. Sanders, — Jastech EMC Consulting LLC, Farmington Hills, Michigan, U.S.A.

This presentation looks at the current and future EMC challenges of hybrid vehicle electric motors and battery packs. The focus will take a system engineering approach to identify requirements, design direction, and cost.

BREAK (10:00 AM – 10:30 AM)

10:30 AM - 11:15 AM
Evaluating Multi-Line EMI Filters for Common Mode & Differential Mode
D. Sanders; and J. Muccioli, — Jastech EMC Consulting LLC, Farmington Hills, Michigan, U.S.A.

This presentation will discuss how to identify the type of measurements and parameters needed to measure common and differential mode response of a multiple line EMI filter. Additionally, the methods discussed will look at an automotive low power example and then discuss the challenges in hybrid vehicles.

11:15 AM - 12:00 AM
Design, Engineering, and Manufacturing of Motors for Electric Vehicle Applications
M. A. Steffka, University of Michigan-Dearborn, Dearborn, Michigan, U.S.A.

This presentation will give an overview of design considerations, manufacturing techniques, and analysis of drive motors for electric vehicles.

FR-PM-1 (T) Application of Reverberation Chambers

Room 17A

Chair: Chuck Bunting, Oklahoma State University, Oklahoma, U.S.A.

This half-day tutorial will provide an introduction to recent applications of reverberation chambers. It is intended to provide EMC engineers who are interested in applying reverberation chambers to various measurement issues and the extension of reverberation chambers to solve a variety of EMC problems. The tutorial will also provide a brief overview of RC theory, followed by recent applications of RC's. The format will be a conference presentation style (lecture) followed by questions moderated by the chairman.

1:30 PM - 2:00 PM
Introduction - Rationale for RC Testing
V. Rajamani, Oklahoma State University, Stillwater, OK, U.S.A.; G. J. Freyer, Consultant, Monument, CO, U.S.A.; and C. F. Bunting, Oklahoma State University, Stillwater, OK, U.S.A.

This presentation will cover the importance of EMC testing in reverberation chambers, and will clearly bring out the advantages and disadvantages of this type of testing and also suggest some applications.

2:00 PM - 2:30 PM
EM Characterization of Environments - Using RC Techniques
V. Rajamani; and C. F. Bunting, — Oklahoma State University, Stillwater, OK, U.S.A.; and G. J. Freyer, Consultant, Monument, CO, U.S.A.

This presentation will point out how reverberation chamber theory and techniques can be used to characterize different EM environments.

2:30 PM - 3:00 PM
Overview of Reverberation Chamber Theory
C. Bunting, Oklahoma State University, Stillwater, OK, U.S.A.; G. Freyer, Consultant, Monument, CO, U.S.A.; and V. Rajamani, Oklahoma State University, Stillwater, OK, U.S.A.

This presentation will cover basic RC theory including EM theory, modal characteristics, electromagnetic environments, and statistical characteristics.

BREAK (3:00 PM – 3:30 PM)

3:30 PM - 4:00 PM
Wireless Channel Modeling and Simulation in a Reverberation Chamber
J. M. Ladbury; G. H. Koepke; C. L. Holloway; and K. Remley, — National Institute of Standards and Technology, Boulder, Colorado, U.S.A.

We present some of our recent results related to modeling and simulating arbitrary wireless environments. We have measured and evaluated the several different types of wireless environments, including factories, urban environments, apartments, and office buildings. We have demonstrated the ability to simulate various wireless characteristics, including the relative strengths of direct and multipath signals (ricean K factor), and also rf delay spread.

4:00 PM - 4:30 PM
Probe Calibration and Antenna Evaluation in a Reverberation Chamber
J. M. Ladbury; G. H. Koepke; and C. L. Holloway, — National Institute of Standards and Technology, Boulder, Colorado, U.S.A.
We present some of our results relating to calibration of electromagnetic field probes in a reverberation chamber. We found that accurate measurements are possible in a reverberation chamber, but there are a number of issues that complicate the evaluation. These include EMI sensitivity of probes, transient responses of probes, and antenna efficiency effects.

FR-PM-2 (T) Commercial Off-the-Shelf (COTS) E3 Risk Assessment Process

Room 17B

Chair: Mark Johnson, Naval Sea Systems Command, Washington DC, U.S.A.

This DoD COTS E3 Risk Assessment tutorial will describe the process that the DoD uses to develop an assessment of the EMC risk associated with using commercial items in military applications. The goal of this tutorial will be to establish a dialogue with the commercial technical EMC community on the validity, pros, cons, and pitfalls of such a risk assessment process. The session may be of particular interest to symposium attendees that develop and integrate large communications-electronics (CE) equipment for the U.S. DoD.

The current DoD acquisition trend toward capabilities-based solutions (vice use of MIL SPECs or specific performance) and ongoing budget and schedule pressures have led to an increased use of commercial equipment and systems that create some of today's operational problems in the DoD Electromagnetic Environmental Effects (E3) and Spectrum Management communities.

The objectives of this tutorial are to:
- Describe the risk minimization process to evaluate COTS, based on vendor commercial EMI qualification test results against military E3/SM requirements.
- Draw comparisons to the military EME from commercial EMI standards.
- Provide a forum to share COTS E3 technical information such as design requirements, test methodologies, operational issues, and acquisition concerns.

1:30 PM - 2:00 PM
COTS and the DoD Acquisition Process
M. Z. Grenis, DISA, Annapolis, Maryland, U.S.A.

This presentation will provide an overview of the E3 and spectrum supportability issues associated with the use of commercial and non developmental items (CI/NDI) for military applications. Electromagnetic compatibility concerns must be addressed for this growing class of equipment. A thorough evaluation of the application of CI/NDI equipment and the intended operational electromagnetic (EM) environment is more critical now as its use proliferates on military platforms. The major emphasis of this course of action will help ensure the evaluation and selection of EM compatible CI/NDI equipment deemed capable of filling military operational requirements with little or no modification.

2:00 PM - 2:30 PM
DoD Commercial off-the-Shelf (COTS) Equipment E3 Risk Assessment Process
B. Farmer; and P. Marti, — EMC Management Concepts, Sterling, Virginia, U.S.A.

This DoD COTS E3 Risk Assessment presentation will describe the proposed process that the DoD use to assess the EMC risk associated with using commercial items in military applications. The goal of the presentation is to establish a dialogue with the commercial technical EMC community on the validity, pros, cons, and pitfalls of such a risk assessment process.

2:30 PM - 3:00 PM
A Comparison of Commercial Standards to MIL-STD-461
P. Marti, EMC Management Concepts, Sterling, Virginia, U.S.A.

This presentation will give a comparison of EU commercial standards to US military standards. The purpose is to present several comparisons, similarities, and guidance in trying minimize the amount of testing of COTS products that would be used by the military. It will also give recommendations as to how to perform a

meaningful comparison and a lot of the pitfalls of risk analysis.

BREAK (3:00 PM – 3:30 PM)

3:30 PM - 4:00 PM
Wireless Electromagnetic Environmental Effects/Spectrum Challenges
D. M. Johnson, Naval Sea Systems Command, Washington Navy Yard, D.C., U.S.A.

This tutorial will discuss the E3/Spectrum challenges of wireless technology use aboard Navy platforms. DoD platforms such as Navy ships pose significant challenges both from the perspective of potential to cause EMI to wireless technologies, and from the perspective of causing interference to critical DoD equipment on those platforms. Navy experience and solutions to these challenges will be discussed.

4:00 PM - 4:30 PM
Shipboard Wireless Installation Issues/Test Results
D. R. Hilton; D. Southworth; and C. Dilay, — SSC Pacific, San Diego, California, U.S.A.

This presentation will describe installation issues related to wireless installation on board Navy ships, including space to space coupling and emission control limitations. This presentation will include a discussion on the reverberant nature of shipboard spaces and the effect on wireless access points. Included will be test results for both coupling and emission control tests completed on board USS GEORGE H.W. BUSH (CVN 77) and USS BONHOMME RICHARD (LHD 6).

FR-PM-3 (T) Fundamentals of Signal Integrity

Room 18B

Chair: Prof. Tzong-Lin Wu, National Taiwan University, Taiwan
Co-Chair: Prof. James Drewniak, Missouri University of Science and Technology, Missouri, U.S.A.

The focus of this tutorial will be on the fundamental modeling and design concepts of signal and power integrity (SI and PI) for high-speed circuit systems. Several important topics will be highlighted, including the models of the active devices for SI and PI simulation, modeling and analysis of the high-speed signal link path in PCB and packages, jitter in high-speed signals, modeling and design for the power distribution network, and the measurement techniques for SI.

1:30 PM - 2:15 PM
High-Speed Signal Link Path and Jitter: Models and Analysis
J. Fan, Missouri University of Science and Technology, Rolla, Missouri, U.S.A.

This talk will cover the fundamentals of high-speed signal link-path analysis, jitter components and decomposition, link-path modeling, and design.

2:15 PM - 3:00 PM
Measurements for Signal Integrity
V. Ricchiuti, Technolabs, L'Aquila, Italy

This talk will describe some techniques for measuring the quality of digital signals on board.

BREAK (3:00 PM – 3:30 PM)

3:30 PM - 4:15 PM
Fundamental of Power Distribution Networks and Power Integrity Design
T. Wu, National Taiwan University, Taipei, Taiwan

With the trend of fast edge rates, high operation frequencies, and low voltage in high-speed or high-frequency circuits, power/ground noise caused by simultaneously switching currents has become one of the major concerns for high-speed or mixed-signal circuit designs. In this talk, the fundamental concept for the power integrity (PI) design is first introduced, including the power distribution network (PDN) and its impedance, the mechanism of the power noise, and the design issues caused by the power noise. Several commercial solutions to suppress the noise, such as SMT capacitors, embedded capacitors, and on-chip capacitors, will be presented. Recently, electromagnetic band gap (EBG) structures are proposed to be an alternative approach for power noise suppression. Several novel EBG structures with efficient noise suppression capability will also be demonstrated in this talk.

4:15 PM - 5:00 PM
Block-by-Block Link-Path Analysis and Design with Physics-Based Models
J. Drewniak, Missouri University of Science and Technology, Rolla, Missouri, U.S.A.

This talk will give a block by block analysis of SI.

FR-PM-4 (W) Wireless Propagation Measurements and Analysis of Electrically Very Large Structures

Room 18C

Chair: Perry Wilson, National Institute of Standards and Technology, Colorado, U.S.A.
Co-Chair: Dennis Lewis, The Boeing Company, Washington, U.S.A.

With the proliferation of wireless electronic devices such as RFID, WLAN, In-flight Entertainment (IFE), and Personal Electronic Devices (PED), it is important to understand how they interact with their environment and with other devices and systems. This workshop will address the measurement and evaluation of radio wave

propagation inside large structures such as buildings, ships, and aircraft.

1:30 PM - 2:15 PM
Random Walk Technique: Measuring EME in Below-Deck Complex Cavities
G. Tait; and M. Slocum, — Naval Surface Warfare Center, Dahlgren, Virginia, U.S.A.

An efficient and accurate “walk-around” technique is presented for making on-site measurements of the electromagnetic environment in closed, reflective spaces, such as aboard ships and aircraft. To assess the potentially disruptive or harmful effects to electronics equipment or ordnance from accumulated RF emissions, these reverberant spaces are characterized as overmoded complex cavities, and a statistical analysis is exercised to obtain important information about maximum and average power densities and their associated uncertainties. This new technique utilizes lightweight and portable test equipment, and is particularly well suited for measurements in field-operational spaces, where the use of more conventional techniques has proven to be very difficult due to severe constraints on time, working volume, equipment size and weight, and test costs. The efficiency and accuracy of the walk-around technique are demonstrated in this work. In addition, the walk-around technique is extended to applications involving coupled-cavity RF propagation and emissions control from apertures and hatches.

2:15 PM - 3:00 PM
Measurements of Wireless Propagation in a Large Factory and Implications for Wireless Connectivity in Robots
K. A. Remley, NIST, Boulder, Colorado, U.S.A.

We will describe measurements of radio-wave propagation characteristics in the highly reflective environment of an automotive manufacturing facility. Our measurements provide an understanding of existing background ambient signals, as well as multipath characteristics such as decay time, directionality, and structure. We replicated the power delay profile from measurements made in three different automotive manufacturing facilities in a reverberation chamber, and we will discuss how this facility can be used for testing wireless devices such as robots on the factory floor.

BREAK (3:00 PM – 3:30 PM)

3:30 PM - 4:15 PM
Propagation and Detection of Signals Before, During, and After the Collapse of Large Structures
C. L. Holloway, NIST, Boulder, Colorado, U.S.A.

In this presentation, we will present radio propagation data for the coupling of signals into and out of large building structures.

4:15 PM - 5:00 PM
Advancements in RF Propagation Measurements and Analysis of Large Aircraft
N. T. Horton, The Boeing Company, Seattle, Washington, U.S.A.

With the proliferation of external electromagnetic threats and wireless electronic equipment internal to aircraft, it is important to understand how radio frequency (RF) energy from these sources penetrates and propagates within aircraft structure. Incorporation of recent advancements in test methodology and measurement equipment has led to an overall improvement in RF test capabilities by improving measurement quality and reducing test time. This presentation will provide an overview of recent, current, and future development work pursued by Boeing regarding test and measurement capabilities relative to RF propagation in and around aircraft for the purpose of shielding assessment and wireless systems implementation.

FR-PM-5 (T) Advances in Site Validation Techniques and Related Measurement Activity above 1 GHz

Room 19A

Chair: Dr. Vince Rodriguez, ETS-Lindgren, Texas, U.S.A.

For some time now, the American National Standards Institute (ANSI) Accredited Subcommittee (ASC) C63® (Electromagnetic Compatibility) has had a working group tasked with developing new procedures for validating EMC radiated emission 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 such 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. Presentations will address EUT test setup, selection of a test facility, test instrumentation, antennas, exercising of the EUT, and other challenges in product compliance testing above 1 GHz.

1:30 PM - 2:00 PM
Absorber Placement to Achieve “Free-Space” Test Conditions
W. J. Schaefer, Cisco Systems, San Jose, California, U.S.A.

A test method will be described that allows proper placement of floor absorbers based on time domain measurements using a Vector Network Analyzer.

2:00 PM - 2:30 PM
Introduction to Antennas above 1 GHz
V. Rodriguez, ETS-Lindgren, Cedar Park, Texas, U.S.A.

This presentation will look at some of the important issues that affect antennas at frequencies above 1 GHz.

2:30 PM - 3:00 PM
High-Resolution Site Attenuation Measurements using Ordinary EMC Antennas
R. T. Johnk; and J. D. Ewan, — Institute for Telecommunication Sciences (NTIA/ITS), Boulder, Colorado, U.S.A.

This talk will present a methodology for performing high-resolution time-domain site attenuation measurements using ordinary EMC antennas. This talk will feature both numerically modeled and real-world measurements. The material presented will be of interest to those folks who need to evaluate their EMC test sites.

BREAK (3:00 PM – 3:30 PM)

3:30 PM - 4:00 PM
Twenty First Century EMI Detectors: CISPR-Average and RMS-Average
J. Young, Rohde & Schwarz, Columbia, Maryland, U.S.A.

This presentation will cover the background and use of two new CISPR detectors: the RMS-Average and the CISPR defined Average. RMS-Ave and CISPR-Ave are defined for use above 1 GHz as well as the more traditional CISPR bands below 1 GHz. The presentation will focus on modern digital modulations that drove their development, weighting characteristics, phase in dates, and product categories where each detector is mandatory. The presentation will also compare and contrast the new CISPR detectors to linear average and QuasiPeak detectors found on traditional EMC instruments.

4:00 PM - 4:30 PM
Comparison of VSWR and TDR Methods for Chamber Validation Above 1 GHz
T. O'Shea, Northwest EMC, Inc., Brooklyn Park, Minnesota, U.S.A.

The latest version of CISPR 22 requires site validation above 1 GHz. The VSWR method is specified, but the TDR method provides a lot more information. How do the two methods compare? Can the data from either method be used in determining compliance? Several test sites were measured using both methods and the results of these methods will be discussed.

4:30 PM - 5:00 PM
Site Qualification 1 GHz: A Comparison of Intrinsic Uncertainty of the CISPR Site VSWR and ANSI Time Domain Methods
M. J. Windler, Underwriters Laboratories, Northbrook, Illinois, U.S.A.

Test methods, assets, and personnel all effect the repeatability and uncertainty of measurements. This presentation will compare and contrast site VSWR and time domain reflectometry tests with respect to uncertainty and repeatability. Key issues highlighted will include positioning of signal sources, variability of pattern, operator contributions, and instrumentation.
