

EMC 2015 Dresden WORKSHOPS & TUTORIALS

Abstracts for Final Program

MONDAY MORNING, AUGUST 17

Fundamentals of EMI/EMC

Sponsored by the Education and Student Activities Committee (ESAC)

Format: Full-day Tutorial -- WS1 and WS7

Chair: Arturo Mediano, UNIVERSITY OF ZARAGOZA, Zaragoza, Spain

Abstract

This tutorial is an overview of many of the major topics that need to be considered when designing an electronic product or system without EMI/EMC problems. The tutorial will present the foundational ideas, without complex math, so attendants could be able to successfully design, evaluate, diagnose, and solve EMI/EMC problems. Main objective is to introduce novel engineers to the fundamentals of this complex subject and to attract experienced designers to a review of the basics.

Topics included in the tutorial include emissions (both radiated and conducted), printed circuit boards (PCB), grounding, shielding, cables, filters and testing fundamentals.

Speakers and Topics

8:30 – 8:40 Introduction

Arturo Mediano, University of Zaragoza, Zaragoza, SPAIN

Welcome and presentation. Tutorial outline.

8:40 – 10:00 Radiated Emissions

Lee Hill, Silent Solutions LLC, Amherst, NH, USA

A concise introduction to the generation of radiated emissions from electronic products, and the consequences of how we measure them. A discussion of the four noise paths.

Practical discussion, definition, and hardware demonstrations of near-field and far-fields common-mode current and dipole antennas. A brief discussion of some common causes of excessive radiated emissions.

10:00 – 10:30 BREAK

10:30 – 11:15 Conducted Emissions

Lee Hill, Silent Solutions LLC, Amherst, NH, USA

A discussion of how and why we measure conducted emissions. How to visualize differential-mode and common-mode noise currents as they travel through the artificial mains network. The principles behind separation of modes and how to make a practical diagnosis of the dominant mode at a given frequency. A discussion of some common causes of excessive differential- and common-mode conducted emissions failures, as well as some typical design and filter solutions.

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11:15 – 12:00 PCB Layout for EMC Compliance

Bruce Archambeault, PhD, Missouri University of Science & Technology, Four Oaks, NC; Systems & Technology Group, IBM Corporation, RTP, NC; Archambeault EMI/EMC Enterprises, Four Oaks, NC

Good layout practices can make a huge difference in the PCB EMC performance. This talk will discuss some of the most important considerations.

Modeling of EMC Problems Using CONCEPT-II

Format: Half-day Workshop -- WS2

Chair: Christian Schuster, Technische Universität Hamburg-Harburg, Hamburg, Germany

Co-chair: Heinz-D. Brüns, Technische Universität Hamburg-Harburg, Hamburg, Germany

Abstract

CONCEPT-II is a method of moments (MoM) solver based on a frequency domain formulation for the treatment of metallic and dielectric objects. The code is under continuous development at the Institute of Electromagnetic Theory at TUHH and free of charge for academic institutions and non-commercial applications. The workshop is intended to introduce the solver to the wider EMC community and instruct people on how to solve EMC problems using MoM. After a short overview of the code features a number of current CONCEPT-II users will report on how they apply the code to their EMC issues and what difficulties they met in doing so. A broad range of EMC topics will be covered along the way including highly resonant cavities, electromagnetic field coupling, impact of direct and indirect lightning strikes, radar cross section computations, evaluation of shielding effectiveness, low frequency problems in power circuits, and antenna modeling for magnetic resonance imaging. The workshop will be of high value for anyone looking for numerical solutions of challenging EMC problems and will encourage them to use a method of moments based tool. It will be specifically useful for EMC experts from universities and public research institutions that are interested in the application of a software tool that can handle a wide range of EMC problems – for free.

Planned Speakers and Topics

Modeling of EMC problems using CONCEPT-II

H.-D. Brüns, Technische Universität Hamburg-Harburg, Institute of Electromagnetic Theory

Efficient simulation of the stochastic electromagnetic field coupling into transmission line structures using the method of moments"

M. Magdowski, R. Vick, Otto-von-Guericke-Universität Magdeburg, Electromagnetic Compatibility Lab

Analysis of a hybrid broadband reverberation chamber antenna

M. P. Robinson, I. D. Flintoft, G. Esposito, A. C. Marvin, L. Dawson, J. F. Dawson, University of York, UK

Simulation of Lightning Strikes to the Peissenberg Tower using the Computer Code CONCEPT II

F. Heidler, M. Manhardt, K. Stimper, Universität der Bundeswehr München

Radar Cross Section Analysis of Aircraft using CONCEPT-II

A. Schröder, Institute of Applied Physics, University of Bern

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Effects of radomes on antenna radiation

J. Lansink Rotgerink, J.J van Es, J. Verpoorte. National Aerospace Laboratory NLR, Avionics Technology department

Calculation of shielding effectiveness of wires and avionics boxes

H. Schippers, J. Verpoorte, J. Lansink Rotgerink, National Aerospace Laboratory NLR, Avionics Technology department

Calibration Procedures for Radiation Model Creation based on Near Field Measurements

D. Rinas, Zongyi Chen, S. Frei, Technische Universität Dortmund, On-Board Systems Lab

Stochastical EMC Simulations for the Investigation of Real Cable Layouts

D. Hamann, M.-B. Konerding, H. Garbe, Leibniz Universität Hannover, Institute of Electrical Engineering and Measurement

Lightning Protection of Aircraft Systems Installed inside Composite Nose: Principal Analysis

D. Rutile*, J. Kučera**, Z. Raida*, Zdeněk Řezníček**, *: Department of Radio Electronic, Brno University of technology, Brno, Czech Republic, **: Evektor, spol. s r.o., Kunovice, Czech Republic

Efficient Antenna Modelling by Using Multiport Moment Methods for Magnetic Resonance Imaging Coils

C. Findekle, Philips Research Europe-Hamburg, Tomographic Imaging Department

Simulation of the Radiation of Large High Voltage Applications in the Frequency Range up to 10 MHz"

G. Seibert, M. Meeh, Siemens, Erlangen, Germany

Application of Reverberation Chambers

Format: Half-day Tutorial -- WS3

Chair: Vignesh Rajamani, Oklahoma State University, Stillwater, Oklahoma, USA

Abstract

This 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.

This half-day tutorial provides a brief overview of Reverb Chamber (RC) theory, followed by recent applications of RCs. The tutorial material will be updated to reflect recent research results and implications. The format will be a conference presentation style (lecture) followed by questions moderated by the chairman. It is designed for both academics and people from industry who will be involved in radiated emission or immunity testing of commercial or military systems using reverberation chambers and will be valuable to personnel evaluating the use of reverberation chambers as a complement to or replacement for other types of radiated test facilities and for personnel who are trying to use statistical methods to characterize the electromagnetic environments.

Planned Speakers and Topics

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1. Introduction – Rationale for RC Testing and Overview of Reverberation Chamber Theory

Vignesh Rajamani and Chuck Bunting, Oklahoma State University (OSU), Stillwater, Oklahoma, USA

2. Multiple antenna stirring for reverberation chambers

Valter Mariani Primiani, Polytechnic University of Marche, Ancona, Italy.

3. Optimizing reverb chamber design for DO160 Cat G and L

Garth D'Abreu, ETS Lindgren, Cedar Park, Texas, USA

4. Measurement of Antenna Noise Temperature in a Reverberation Chamber

Andy Marvin, University of York, UK

5. Flexible Testing

Frank Leferink, University of Twente, The Netherlands

6. Use of Reverberation Chambers in Design and Verification of Highly Shielded Systems

Mats Backstrom, Technical Fellow, Electromagnetic Effects, Adj. Professor, Royal Institute of Technology (KTH), Saab Aeronautics, Sweden

Details of the first practical method for Risk-Managing EMC (i.e. achieving EMC for Functional Safety)

Sponsored by TC1

Format: Half-day Workshop -- WS4

Chair: Keith Armstrong, Cherry Clough Consultants Ltd, Brocton, Stafford, United Kingdom

Abstract

Where safety risks can be increased by the effects of EMI on electronic equipment, EMC must be risk-managed for the full lifetime of the equipment/system/installation concerned, and so must take into account all reasonably foreseeable aging, wear, corrosion, faults, use and misuse.

Overall risks of death from new projects are only acceptable at levels below 0.1% (1000ppm) per person per year, with most of the acceptable levels being set at or below 0.0001% (1ppm) per person per year. However, there are many possible contributors to this overall safety risk, and the proportion of the overall risk that is allocated to EMI causes is typically 1/10th of this, i.e. between a risk of death of 100ppm and 0.1ppm per person per year.

A consequence of the above is that no affordable time/cost of EMC immunity testing, at any test levels, can possibly provide the necessary design confidence required for compliance with the relevant safety risk management standards. Where the future EM environment is unknown (as it usually is), the traditional approach (e.g. as used by the military) is to use very rugged high-specification EM mitigation, designed to meet or exceed all possible environmental issues (shock, vibration, humidity, salt spray, temperature, EM disturbances, etc.). However, this 'big grey box' approach can be too large, heavy or costly for many modern safety critical systems, especially (for example) in road/air transportation, portable medical devices, mobile life-support equipment, etc.

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This tutorial also describes a new approach, first published in August 2013, which (unlike the 'big grey box' approach) adds little to size, weight and cost. These two approaches can also be used to help manage non-safety risks associated with the use of electronics, including financial risks, mission-critical risks, high-reliability, etc.

Planned Speakers and Topics

Increasing Importance of EMC for Functional Safety

Davy Pissoort, Assistant Professor KU Leuven – KULAB,
Research Group ReMI - Reliability in Mechatronics & ICT,
Oostende, Belgium

General overview of approaches: a) 'big grey box'; b) new method

Keith Armstrong, Cherry Clough Consultants Ltd, Brocton, Stafford, United Kingdom

Developments in all related IEC and IEEE standards

Keith Armstrong

Special challenges for medical EMC standard IEC 60601-1-2

Keith Armstrong

Discussions of the detailed Design Techniques and Measures for increasing resilience against EMI, using the new practical method

Keith Armstrong

Overall discussions, Q & A

Chaired by Davy Pissoort

Technical Summary and Conclusions

Keith Armstrong

Novel Absorber Applications

Format: Half-day Tutorial -- WS5

Co-chairs: Vincent Keyser, ETS-Lindgren, Cedar Park, Texas, USA,
Stéphane Blanc, Groupe UTAC Ceram
Janet O'Neil, ETS-Lindgren, Cedar Park, Texas, USA

Abstract

This tutorial will look at new applications and developments in the use of RF and EMC absorber. Examples of new applications beyond the traditional EMC measurements will be presented. A wide range of emerging topics will be discussed, which includes using the latest absorber techniques for retrofitting existing anechoic chambers, high power applications of absorber, absorber designs for wireless applications, and EMC absorber floor placement per the latest industry standards. It will also include a review of the nuances inherent in floor absorber placement as called out in the CISPR 16 chamber standards and the new ANSI C63.4-2014, which is scheduled to be referenced by the FCC. Presenters

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active in the ANSI C63 and CISPR standards committees will explain the nuances and changes and how these affect test results.

In recent years there has been an increased need for high power radiated measurements in an anechoic chamber. Since absorber works by transforming electromagnetic energy into thermal energy, there is a concern that in the presence of high fields the absorber can exceed threshold or ignition temperatures. An absorber engineer will provide insight on thermal behaviors of absorber under EM field illumination and tips on selecting the right absorber for a given application.

With the considerable advances in absorber technology over the past 20 years, users of older anechoic lined chambers are considering the possibility of replacing the existing absorber with new absorber. The goal is to increase overall chamber performance while keeping costs down in utilizing the existing chamber. However, a project of this scope must be approached cautiously to ensure predicted performance is achieved and construction costs are within budget. Tips and tools to consider for successful chamber retrofits based on experience will be provided.

The long established automotive industry has been experiencing a transition from the traditional immunity and emission measurements required for certification, to the increasing implementation of new tests commonly associated with measuring the performance of wireless devices and antennas. As the number of antennas on a vehicle continues to increase, standardized tests have been introduced to verify that vehicle operation is not affected by the on board communication. We will look at the recent trend for building a dual purpose chamber to satisfy EMC and wireless test requirements, as well as the impact on absorber design for a common use chamber.

Planned Speakers and Topics

The Increasing Need for Wireless Testing in the Automotive Industry – The Impact on Absorber Design and Test Antennas

Garth D’Abreu, ETS-Lindgren, Cedar Park, Texas, USA

Investigating Floor Absorber Placement Implications for Testing per CISPR 16

Drew Frana, IBM, Rochester, Minnesota, USA

Martin Wiles, ETS-Lindgren

Floor Absorber Placement Implications per the FCC’s Recently Referenced ANSI C63.4-2014 – Why the Increase in Absorber Floor Coverage?

Donald N. Heirman, Don HEIRMAN Consultants, Lincroft, New Jersey USA

Retrofitting an Existing Chamber with New Absorber – Tips and Techniques to Ensure a Successful Project

Stéphane Blanc, Groupe UTAC Ceram, Linas-Montlhéry, France

Absorber Requirements Comparison for Different Procedures of Anechoic Chamber Test Site Validation, including ETSI

Anders Mynster, DELTA, Denmark

RF Absorbers for High and Medium Power Applications

Zhong Chen, ETS-Lindgren, Cedar Park, Texas, USA

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New challenges and techniques in shielding against Electromagnetic Interference

Format: Half-day Tutorial -- WS6

Chair: Jorge Victoria Ahuir, Würth Elektronik eiSos GmbH, Waldenburg, Germany

Co-Chairs: Bernd Deutschmann, Graz University of Technology, Austria;

Peter Reiser, Visteon Electronics Germany GmbH, Karlsruhe, Germany

Abstract

Shielding is not only about “gasketing” seams and calculating apertures. With the wide spread of wireless technologies through higher and lower frequencies, the continuous miniaturization of electronic devices and the development of powerful EMC measurement and simulation tools, EMC shielding is more useful and more challenging than ever. Therefore engineers need today new knowledge, skills, materials and techniques to prevent/solve their electromagnetic interferences.

This half day tutorial will provide an updated, innovative and practical overview to EMI shielding challenges, including practical demonstrations with real examples, measurements and simulations.

Planned speakers and topics

IC shielding with soft magnetics

Bernd Deutschmann, Teknisches Universität Graz, Austria

NFC/RFID selective shielding

Jorge Victoria, Würth Elektronik eiSos GmbH, Waldenburg, Germany

Shielding in Wireless Power applications

Jorge Victoria, Würth Elektronik eiSos GmbH, Waldenburg, Germany

New challenges and techniques in EMC Shielding

Peter Reiser, Visteon Electronics Germany GmbH, Karlsruhe, Germany

MONDAY AFTERNOON, AUGUST 17

Fundamentals of EMC

Sponsored by ESAC

Format: Full-day Tutorial -- WS1 and WS7

Chair: Prof. Arturo Mediano, UNIVERSITY OF ZARAGOZA, Zaragoza, Spain

Speakers and topics

2:00 – 2:45 Grounding

Todd Hubing, Department of Electrical and Computer Engineering, Clemson University, Clemson, SC

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Proper ground is an essential aspect of design for EMC compliance. This presentation covers fundamental ground concepts and emphasizes the importance of differentiating functional grounds from functional current returns. A ground serves as a local voltage reference, while a current return provides a path for signal and power currents to return to their source. The concepts of proper ground structures and ground conductors are defined. Design rules for current returns are developed and compared to the rules for effective ground design.

2:45 – 3:30 Shielding

Andrew Marvin, York EMC Services, York, United Kingdom

This presentation describes the basic principles of Electromagnetic screening.

3:30 – 4:00 BREAK

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4:00 – 4:45 Cables

Todd Hubing, Department of Electrical and Computer Engineering, Clemson University, Clemson, SC

Choosing the right cable for a given application is an important part of designing for EMC compliance. This presentation reviews various cable parameters such as impedance, imbalance, and attenuation that have an impact on EMC and signal integrity. It also discusses important properties of cable construction such as mechanical stiffness, chemical composition and cost. Cable shielding and connector options are reviewed, as well as methods for evaluating the effectiveness of cable and connector shields.

4:45 – 5:30 Filters for EMI-EMC

Arturo Mediano, Prof., Electronics Engineering, University of Zaragoza, Zaragoza, Spain

This topic will cover a review of the fundamentals of EMI/EMC filters including a basic classification and the review of usual topologies. Common components will be considered: capacitors, ferrites, three terminal capacitors, feed-through capacitors, and mains filters. How to evaluate a filter. How to destroy a filter. Key points for success.

Computational Electromagnetics and Multiphysics Methods for Characterizing Complex EMC/EMI Effects

Format: Half-day Workshop -- WS8

Co-chair: Wen-Yan Yin, Zhejiang University, Hangzhou, China

Christian Schuster, Technische Universität Hamburg- Harburg, Germany

Abstract

Numerical modeling for EMC/EMI problems remains a challenging task even with nowadays computational resources and off-the-shelf software tools. This workshop hosts a series of speakers that have made recent contributions to the field of computational electromagnetics and multiphysics methods applied to problems relevant to the EMC community. The presentations will give both a review of the state of the art in the respective fields and show recent progress. Topics that will be addressed include general computational electromagnetic and multiphysics methods, numerical efficiency, numerical accuracy, handling of complex problems, validation of simulation results, proper choice of methods, and application of numerical methods to EMC/EMI problems. The workshop is intended both for researchers active in numerical modeling and practitioners from the EMC community that want to learn about novel methods.

Planned Speakers and Topics

Finite-Difference Based Time-Domain Modeling for EMC/EMI Applications

Zhizhang Chen, Dalhousie University, Halifax, Nova Scotia, Canada

High Performance Computing Method for Fast Simulating Complex Electromagnetic Environment Effects

Zhou Haijing,

Institute of Applied Physics and Computational Mathematics, Beijing, China

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From Computational Electromagnetics to Multiphysics Methods for Characterizing High-power EMC/EMI Effects

Wen-Yan Yin, Zhejiang University, Hangzhou, China

Solving Highly Resonant Structures Using a Fast Direct H Matrix Solver in the Method of Moments

Alexander Vogt, Technische Universität Hamburg- Harburg, Germany

Using the Contour Integral Method for Solving Large EMC Problems on Printed Circuit Boards

Christian Schuster, Technische Universität Hamburg- Harburg, Germany

Recent Advancements in Partial Element Equivalent Circuit (PEEC) Modeling

Giulio Antonini, University of L'Aquila, Italy

Power Distribution Design on PCBs for Effective EMI Control

Sponsored by TC10

Format: Half-day Tutorial -- WS9

Sponsor: EMC Society TC 10

Co-Chairs: Bruce Archambeault, Missouri University of Science & Technology, Archambeault EMI Enterprises, Four Oaks, NC, USA
James Drewniak, Missouri University of Science & Technology, Rolla, MO, USA

Abstract

This tutorial will focus on good Power Distribution Network (PDN) design to control EMI on Printed Circuit Boards (PCBs). Topics include how to develop realistic target impedance for the PDN, pre-layout and post layout analysis, as well as a number of case studies to show the best design approaches to minimize EMI noise between the power/ground-reference planes. Decoupling capacitor placement, relative positions of the capacitors, and capacitance values will all be considered for the optimum design. Understanding the limitations of the capacitors due to connection inductance, position, and power plane depth in the PCB stack up are vital to the overall optimization of the EMI performance of the PDN.

Planned Speakers and Topics

Power Integrity by Design using Physics-Based Models – Multilayer PCBs

James Drewniak, Missouri University of Science & Technology, Rolla, MO, USA

Target Impedance and Transient Voltage Ripple Estimation

Jun Fan, Missouri University of Science & Technology, Rolla, MO, USA

The Effect of Power Plane Depth in the PCB Stackup and Dielectric Thickness on PDN Performance

Sam Connor, IBM, Research Triangle Park, NC, USA

PCB Effects for Power Integrity

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Bruce Archambeault, PhD, Missouri University of Science & Technology, Archambeault EMI Enterprises,
Four Oaks, NC, USA

Calibration of EMC Test Facilities and Measurement Instrumentation

Format: Half-day Tutorial -- WS10

Chair Doug Kramer, ETS-Lindgren, douglas.kramer@ets-lindgren.com

Co-Chair Thomas Kleine-Ostmann, Physikalisch-Technische Bundesanstalt (PTB)

Abstract

This tutorial will present detailed information about the state of the art in calibration of EMC measurement equipment and test facilities required by many current international standards. Specific requirements and nuances that can challenge even the most experienced EMC practitioner will be discussed, and methods for practical implementation for real-world application will be shared with attendees. Speakers will include experts who are actively involved in using, writing and maintaining the standards in which the requirements are established.

All new material will be presented, representing activity within the related standards committees, including CISPR, ISO, ANSI ASC C63® and IEEE. This tutorial will take a novel approach to equipment and facility calibration by delving into implementation of specific characteristics and requirements, as opposed to a general treatment of calibration.

Calibration issues related to a variety of test facilities and measurement equipment and the associated standards will be included; test sites used for antenna calibration and reference test sites, per revision being developed for CISPR 16-1-5 and future CISPR 16-1-6. Clarification will be provided about distinguishing LISNs and AMNs separately, since many engineers and technicians use these terms interchangeably. Attendees can expect to improve their understanding of both the background of the latest requirements for calibration of EMC measurement equipment and facilities and practical aspects of performing or specifying the required calibrations.

Confirmed topics and speakers

Calibration of Field Probes for EMC Measurements

Thomas Kleine-Ostmann, Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

Introduction to Calibration Methods: Calibration of LISNs and Current Probes for EMC Testing

Doug Kramer, ETS-Lindgren, Cedar Park, TX

Electromagnetic Field Probe Calibrations and Antenna Efficiency Measurements Utilizing Reverberation Chambers

Dennis Lewis, The Boeing Company, Seattle, WA, USA

Time Domain sVSWR method for EMC radiated emission test sites > 1 GHz

Zhong Chen, ETS-Lindgren, Cedar Park, Texas, USA

An Overview of EMI Compliance Receiver Calibration

Mark Terrien, Keysight Technologies, Santa Rosa, CA, USA

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Is traceable calibration of EMC pulse generators possible?

Anders Bergman, SP Technical Research Institute of Sweden, Borås, Sweden

Antenna Calibration and Site Validation for Radiated Emissions above 1GHz (CISPR 16-1-4, 16-1-5, 16-1-6)

By Martin Wiles, ETS-Lindgren, Stevenage, England, UK

COST IC 1407 “ACCREDIT” workshop: EMI challenges in future complex multi-functional (digital) Systems

Sponsored by COST IC 1407

Format: Half-day Tutorial -- WS11

Chair: Dave Thomas, The University of Nottingham

Abstract

The growth of Internet-enabled smart infrastructures underpinning virtually every sector of economic and social life requires complex, high performance and highly integrated miniature electronic systems. The electromagnetic interference will increase with the anticipated increase of clock speeds, frequency of operation and circuit density. Immunity levels will also decrease due to lower supply voltages and lower signal power levels. Traditionally, the potential EMI sources were assessed in the frequency domain assuming static emissions. This is not valid for multifunctional devices with many operating modes. New approaches that fully account for time dependence and uncertainty are needed.

The tutorial will present some state-of-the-art, unconventional methods and instruments in the realm of EMI prediction and assessment and will speculate on the challenges lying ahead and the feasible manners to approach them.

Planned Speakers and Topics

The characterization and propagation of stochastic fields from printed circuit boards

D. Thomas, The University of Nottingham, United Kingdom

Multipole-Based Macro-models for EMC and EMI System Analysis

Bart Boesman, KU Leuven, Belgium A.T. de Hoop, I.E. Lager, Delft University of Technology, the Netherlands

Parametric Identification of Stochastic EMI Sources Based on Near-Field Measurements

Y. Kuznetsov, A. Baev, and A. Gorbunova (Moscow Aviation Institute, Russia)

Challenges in near field scanning real world electronic modules

A. P. Mynster, DELTA – Danish electronics, lights and acoustics, Denmark

Smart Grid EMC Update

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Sponsored by SC1

Format: Half-day Tutorial -- WS12

Chair: Donald N. Heirman, Don HEIRMAN Consultants, Lincroft, New Jersey, USA

Abstract

Smart Grid EMC is so pervasive that almost all that are involved in devices and systems that are part of the Smart Grid will need to see the bigger picture of the acceptance of EMC considerations. The primary issue involves the immunity of products that are connected to the power grid. This tutorial will provide the status of several Smart Grid key organizations and activities on the need for EMC considerations, especially in the frequency range 2 kHz to 150 kHz. There continues to be a need for strong recommendations that EMC must be considered to ensure the proper operation of SG devices in the electromagnetic environment where they will be installed. The speakers are all involved in EMC aspects of the Smart Grid and are willing to answer questions on their presentations at the end of the presentations.

Planned speakers and topics

NIST Smart Grid, SG Interoperability Panel (SGIP) 2.0 and the EM Interoperability Issues Working Group Activities

Donald N. Heirman, Don HEIRMAN Consultants, Lincroft, New Jersey USA

Low Frequency EMC Challenges in the Frequency Range 2 kHz to 150 kHz

Jan Meyer, Technische Universitat Dresden, Institute of Electrical Power Systems and High Voltage Engineering, Dresden, Germany

Immunity for Power Station and Substation Environments

William Radasky, Metatech Corporation, Goleta, California, USA

TUESDAY AFTERNOON, AUGUST 18

Basic EMC Measurements

Sponsored by TC2

Format: Half-day Tutorial -- WS13

Chair: Donald N. Heirman, Don HEIRMAN Consultants, Lincroft, New Jersey

Abstract

This tutorial will provide information on aspects beyond the test procedure needed in performing EMC tests by competent test labs. Included will be a discussion on the application of measurement uncertainty, measurement instrumentation and its calibration, and what constitutes an acceptable test laboratory. In addition, the standards processes for both the IEEE and the International Electrotechnical Commission (IEC) will be discussed followed by a review of selected IEEE EMC Society measurement standards needing participation to complete. Where appropriate, attendees will be asked questions as to what they learned and have an opportunity for extended questioning of the speakers' subjects at the end of the session.

Planned Speakers and Topics

IEEE EMC Society and the International Electrotechnical Commission (IEC) Standardization Processes

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Donald N. Heirman, Don HEIRMAN Consultants, Lincroft, New Jersey, USA
Alistair Duffy, De Montfort University, England

Measurement instrumentation and calibration (CISPR Measuring Receiver)

Jens Medler, Rohde & Schwarz, Munich, Germany

Tips on Selecting a Quality Test lab

Dan Hoolihan, Hoolihan EMC Consulting, Lindstrom, Minnesota, USA

Measurement Uncertainty--CISPR 16-4-2

Manfred Stecher, Rohde & Schwarz, retired, Munsing/Ammerland, Germany

WEDNESDAY MORNING, AUGUST 19

Unmanned Aircraft Systems – EMC and Applications

Sponsored by SC6

Format: Half-day Tutorial -- WS14

Chairs: Frank Sabath, Bundeswehr Research Institute for Protective Technologies
and NBC-Protection, Munster, Germany
Thorsten Schrader, Physikalisch-Technische Bundesanstalt (PTB),
Braunschweig, Germany

Abstract

This workshop will discuss challenges which are associated with application of unmanned aircraft systems (UAS) in hazardous environment, including EMC aspects, hardening to high-power electromagnetic fields and flight management systems.

UAS are one of the most advancing platforms used for many applications in EMC, industrial inspection, scientific research and measurements, and disaster control and emergency management. With the advent of these systems secure operation of single or multiple flying systems may become an issue. Novel flight management systems, personal safety, EMC requirements and applications will be discussed.

Planned Speakers and Topics

WERAN - Interaction of Wind Turbines with Terrestrial Navigation Systems and Radar

Thorsten Schrader, Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany, *Jochen Bredemeyer*, Flight Calibration Services FCS GmbH, Braunschweig, Germany, *Christoph Stupperich*, steep GmbH, Bonn, Germany, and *Heyno Garbe*, Leibniz Universität Hannover, Hannover, Germany

UAV-based Measurement Platform for Precision Electromagnetic Field Measurements

Thorsten Schrader, *Marius Mihalachi*, *Jan Rohde*, *Thomas Kleine-Ostmann*, Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany

Security and averting of danger from and for UAVs – necessity of robust flight management systems and sensors

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Christian Kaiser, COPTING GmbH, Braunschweig, Germany

Detection and Tracking of Micro Aerial Vehicles (MAVs)

Michael Caris, Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR, Wachtberg, Germany

Define and Test Electromagnetic Immunity of UAS for First Responders

Christian Adami, Sebastian Chmel, Michael Jöster, Thorsten Pusch, and Michael Suhrke, Fraunhofer Institute for Technological Trend Analysis (INT), Euskirchen, Germany

A brief Introduction on the Susceptibility of UAS against HPEM Threats

Stefan Potthast, Bundeswehr Research Institute for Protective Technologies and NBC-Protection (WIS), Munster, Germany

WEDNESDAY AFTERNOON, AUGUST 19

EMC issues related to power system technical performance

Sponsored by TC7

Format: Half-day Tutorial -- WS15

Chair: Chair: Dave Thomas, The University of Nottingham

Abstract

The increasing use of internet enabled equipment and high performance power converters in power networks is making EMC in the power system environment more critical. It is also becoming important that engineers are aware of all the activities going on in the world associated with EMC to avoid conflict or gridlock in the development of new infrastructures. CIGRE has had a long tradition of working in the area of EMC in power systems and this workshop is aimed at informing the EMC community on the strength and breadth of this work to forge new liaisons and collaborations for the future.

Planned Speakers and Topics

Introduction to CIGRE

William Radasky, Metatech Corporation, Goleta, California, USA

WG C4.32 Understanding of the Geomagnetic Storm Environment for High Voltage Power Grids

William Radasky, Metatech Corporation, Goleta, California, USA

WG C4.30 EMC in Wind Energy Systems

WH Siew, University of Strathclyde

CIGRE WG C4.31 EMC between Communication Circuits and Power Systems

Dave Thomas, University of Nottingham

THURSDAY MORNING, AUGUST 20

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Nanotechnology applied to EMC

Sponsored by TC11

Format: Half-day Tutorial -- WS16

Chair: Alessio Tamburrano, Sapienza University of Rome, Rome, Italy

Abstract

Nanotechnology is the engineering of functional systems at the molecular and atomic scale and represents a technological revolution that is shaking scientific academia, industries and almost all areas of society. Nanotechnology has the potential to develop many novel materials and devices with a vast range of applications. Over the last ten years several studies have been focused on carbon nanotubes, graphene nanoribbons, nanostructured multifunctional materials and single/ multi-phase composites filled with nanoparticles. The outstanding performance and capabilities of these novel materials have demonstrated a great impact in different EMC applications: signal integrity of electrical nano-interconnects and nano-vias for high speed electronics, multifunctional electromagnetic shields, lightweight and high performance radar absorbing materials, just to mention some examples. The Tutorial is intended to introduce EMC engineers and researchers to nanoscience and nanotechnology showing how fundamental EMC topics (like measurements, transmission line, shielding and protection) should be “revisited” at nanoscale. It will present new materials, devices and processes for EMC applications, with particular attention to theoretical modelling approaches, simulation methods and experimental characterization techniques.

The Tutorial will provide participants with opportunities for professional development and the chance to gain a better understanding of nanotechnology and its implications in EMC issues. The Tutorial will contribute to the development of a debate on the state-of-art as well as on future research possibilities.

Planned Speakers and Topics

Introduction to Nano-EMC

Alessio Tamburrano, Sapienza University of Rome, Rome, Italy

Modeling and Shielding Performances of Graphene-Based Multilayer Screens

M. D’Amore, Sapienza University of Rome, Rome, Italy

Graphene-polymer nanocomposites for radar absorbing materials

M. S. Sarto, Sapienza University of Rome, Rome, Italy

FRIDAY MORNING, AUGUST 21

Automotive EMC

Sponsored by TC2

Format: Full-day Workshop -- WS18

Chair: Marco Klingler, Peugeot Citroën Automobiles, Vélizy-Villacoublay, France

Abstract

Automotive electric / electronic systems are endlessly growing in complexity with a permanent constraint of a constant or reduced time-to-market. Therefore, there is a strong need to constantly

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improve the efficiency of the EMC related tasks throughout the entire development process, starting from the design phase until the full-vehicle validation phase. This workshop intends to present an overview of the most recent industrial advances in the field of automotive EMC design, modeling and simulation as well as in the field of automotive standards, testing and measurements. The presentations in this workshop will cover EMC issues at system, sub-system, equipment and component levels. In particular, topics addressed by the speakers will include hybrid power-train systems EMC analysis, antenna implementation, equipment design, printed-circuit-board optimization, and electric/electronic component characterization.

Planned Speakers and Topics

08:30 – 09:00

Overview and Challenges in Automotive EMC Standardization and Regulation

Ariel Lecca

PSA Peugeot-Citroën, Vélizy-Villacoublay, France

09:00 – 09:30

System Level EMC Simulations of an Automotive Radiated Immunity Configuration

Anna Gheonjian¹, Irina Oganezova¹, Moncef Kadi², Xavier Bunlon³

¹ EM Consulting and Software, EMCos Ltd., Tbilisi, Georgia

² IRSEEM / ESIGELEC, Rouen, France

³ Renault S.A.S., Guyancourt, France

09:30 – 10:00

Advanced methods for the simulation of immunity behaviour of a car body in the frequency domain or time domain

Markus Laudien, Frédéric Bocquet

ANSYS, France

10:30 – 11:00

1 Gbps on Unshielded Wiring Harnesses in an Automotive Environment

Todd H. Hubing

Clemson University, Clemson, SC, USA

11:00 – 11:30

Calculation of RF Interference from Coupled Shielded Hybrid Cables utilizing Current Probe Measurements

Peter Hahne¹, Martin Aidam², Andreas Ludwig², Xiaofeng Pan², Markus Schick³

¹ Ingenieurbüro Dr. Peter Hahne, Bad König, Germany

² Daimler AG, Germany

³ Altair Engineering GmbH, Germany

11:30 – 12:00

EMC Analysis of Shielded Cables and Connectors for Power Transmission in Electric and Hybrid Electric Vehicle

Stephan Frei, Abid Mushtaq

TU Dortmund University, Germany

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Working EMC Engineer Skills

Sponsored by TC1

Format: Full-day Tutorial -- **AM: WS19**, PM: WS24

Chair: Kimball Williams, USA

Abstract

Explore some of the more critical aspects of working as an EMC engineer that are of a non-technical nature. These skills are not taught in any engineering curricula but, can be critical to building a successful engineering career. In the AM and PM sessions leadership of the EMC Society will discuss seven of these factors that can make the difference between career success and the unfortunate alternative.

Planned Speakers and Topics (AM Session: WS19)

Introduction: (The 'Soft Skills', who needs them?)

Kimball Williams, Dearborn, Michigan, USA

Fundamentals of Leadership

Elya Joffe, Electromagnetic Solutions, Ltd., Tel Aviv, Israel

Human Factors in Advancing Your Engineering Career

Bob Hofmann, Hofmann Engineering, Chicago, Illinois, USA

Writing a Transactions Paper

John Norgard, NASA Johnson Space Center; Houston, TX, United States

Effective Meetings

Elya Joffe, Electromagnetic Solutions, Ltd., Tel Aviv, Israel

Measurement Uncertainty – Challenges and Solutions

Format: Half-day Tutorial -- WS20

Co-chairs: Doug Kramer, ETS-Lindgren, Cedar Park, Texas USA

Carlo Carobbi, University of Florence, Italy

Janet O'Neil, ETS-Lindgren, Cedar Park, Texas, USA

Abstract

In the near future, the evaluation of Measurement Uncertainty (MU) won't be the same as we have known since the first edition of the Guide to Uncertainty in Measurement (GUM) was published in 1993. Some important changes are indeed expected in the second edition of the GUM, tentatively scheduled for publication in 2016. Such changes are mainly required in order to make the GUM consistent with its supplements and address the very fundamental idea of probability. The scope of the presentation by Prof. Carobbi, in particular, will show how the new concepts will practically affect evaluation of MU.

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There has been an increasing need for accredited calibration test services in the commercial EMC, military and aerospace test communities. Part of the accreditation process based on ISO 17025 is the determination of measurement uncertainty – a requirement that is often misunderstood or misinterpreted. This tutorial will provide an overview and discussion of measurement uncertainty to further the knowledge of this subject in the international EMC testing community.

One of the goals of the tutorial is to address head on the fact that the majority of people new to measurement uncertainty are intimidated and overwhelmed. Tips and tools will be provided to make those associated with measurement uncertainty educated and comfortable moving forward in this area.

This tutorial brings together a number of different viewpoints on measurement uncertainty in order to provide a well-rounded discussion of the topic.

Planned Speakers and Topics

Everyday, Practical Tools for Measurement Uncertainty Evaluation in a Lab Environment

Dennis Lewis, The Boeing Company, Seattle, WA, USA,

The New, Second Edition of the Guide to Measurement Uncertainty (GUM 2016) – How the Evaluation of MU Will Evolve in the Future

Carlo F. M. Carobbi, University of Florence, Italy and member of the Joint Task Force between IEC TC 77 and CISPR on Measurement Uncertainty

Antenna Calibration Uncertainty Evaluation Using Measurement Model and Monte Carlo Method

Zhong Chen, ETS-Lindgren, Cedar Park, TX, USA,

Application of Test Instrumentation Uncertainty Data for Practical EMC Testing and Test Reports

Per Thåstrup Jensen, DELTA, Denmark and member of IEC SC77B/WG10

IEC HPEM Standardization Update

Sponsored by TC5

Format: Half-day Tutorial -- WS21

Chair: William Radasky, Metatech Corporation, Goleta, California, USA

Abstract

High power electromagnetic transients are in the news seemingly every day including the threats of high-altitude electromagnetic pulse (HEMP) produced by nuclear weapons detonated in space and high-tech electromagnetic weapons that can cause intentional electromagnetic interference (IEMI).

Unfortunately there is a lot of misinformation in the Press, and this tutorial will clarify the terms and the waveforms of interest. IEC SC 77C has been working since 1992 standardizing these environments and their coupling to cables and equipment, developing test methods for cables and equipment, and developing different protection methods for new and existing facilities that need to be protected from these threats. These main three aspects of the completed work will be reviewed for the attendees. In addition the work underway in the IEC today and the accomplishments of other organizations in this field will be reviewed. The scheduled speakers have been involved in this work for many years as officers and participants in the work of IEC SC 77C and will be able to answer all questions that may arise from their presentations.

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Planned Speakers and Topics

Description of the HEMP and IEMI Scenarios and the Resulting Electromagnetic Waveforms

William Radasky, Metatech Corporation, Goleta, California, USA

Richard Hoad, QinetiQ Group plc, Farnborough, UK

Description of Test Methods to Reproduce HEMP and IEMI Environment Waveforms in Order to Test Protective Devices, Equipment and Systems

Richard Hoad, QinetiQ Group plc, Farnborough, UK

William Radasky, Metatech Corporation, Goleta, California, USA

Description of Methods to Protect Against HEMP and IEMI

Richard Hoad, QinetiQ Group plc, Farnborough, UK

William Radasky, Metatech Corporation, Goleta, California, USA

Description of Standards Under Development in the IEC and a Review of the Standardization Work Accomplished and Underway in the ITU-T, the IEEE EMC Society and Cigré SC C4

William Radasky, Metatech Corporation, Goleta, California, USA

Richard Hoad, QinetiQ Group plc, Farnborough, UK

Assessment and Approvals for Wireless Module Technology

Format: Short Workshop -- WS22.1

Chair: Michael Derby, American Certification Body, Hampshire, England, UK

Abstract

An overview of the process for assessing or installing wireless transmitter, receiver and transceiver modules in the USA, Canada, Europe and Japan.

The presentation will include an explanation of the process for authorizing the wireless module for regulatory compliance and also for installing a module into other host equipment.

There is a growing industry for pre-approved radio modules, supplied to the market as a product for incorporation into other host devices. The processes for authorizing these modules can vary greatly between the geographical regions covered in this presentation. In addition, the requirements and responsibilities placed on the installer of the pre-assessed module vary.

The presentation will clarify the requirements and differences for each of the regions covered.

This presentation is important to manufacturers of wireless module devices and also to manufacturers of equipment which integrate wireless modules. This presentation is also of interest to test labs and anyone involved in the regulatory compliance process for wireless modules or equipment incorporating modules; such as the M2M industry.

Planned Speaker and Topic

Modular Approvals and Module Integration

Michael Derby, American Certification Body, Hampshire, England, UK

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Regulatory Requirements for Wireless Systems

Format: Short Workshop -- WS22.2

Chair: Mike Violette, Washington Laboratories and American Certification Body, McLean, Virginia, USA

Abstract

An overview of the regulatory requirements for authorizing wireless devices in the USA, Canada, Europe and Japan. An explanation of the compliance routes applicable for different types of device and the testing requirements facing the product manufacturer and test lab.

Devices can typically be separated into categories or types, such as licensed transmitters and unlicensed transmitters. There also exists a mixture of compliance routes, such as certification, verification or declaration of conformity. In addition, each geographical region has its own testing and compliance process. The presentation will clarify the requirements and differences for each of the regions covered.

This presentation is important for wireless product manufacturers and anyone involved in the regulatory compliance process for wireless transmitters, receivers and receivers.

Planned Speakers and Topics

Regulatory Requirements for Wireless Systems

Mike Violette, Washington Laboratories and American Certification Body, McLean, Virginia, USA

FRIDAY AFTERNOON, AUGUST 21

Basic Automotive EMC

Sponsored by TC2

Format: Full-day Workshop -- WS23

Chair: Marco Klingler, Peugeot Citroën Automobiles

See WS18 for description

Planned Speakers and Topics

14:00 – 14:30

EMC Simulation of a Variable Frequency Drive

Andreas Barchanski

CST AG, Darmstadt, Germany

14:30 – 15:00

Prediction of Radiated Emission Levels for Automotive Products using EM Simulations

Reddy V. Sreenivasulu, Jan Hansen, Peter Kralicek, Kranti Kumar

Robert Bosch GmbH, Germany

15:00 – 15:30

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Complexities of Resonance Influences on Automotive Sensor and Signal Lines

Jean-Roger K. Kuvedu-Libla

Delphi Electronics & Safety, Bascharage, Luxembourg

16:00 – 16:30

EMI Characterization of DC Motors

Flavio Canavero, Riccardo Trincherio, Igor Stievano

Politecnico di Torino, Torino, Italy

16:30 – 17:00

Reverberation Chambers for Vehicle Testing

Martin Aidam

Daimler AG, Germany

17:00 – 17:30

Evolving Automotive EMC Testing

Garth D'Abreu, ETS-Lindgren, Cedar Park, Texas, USA

Working EMC Engineer Skills

Sponsored by TC1

Format: Full-day Tutorial – AM: WS19, **PM: WS24**

Chair: Kimball Williams, USA

See WS19 for description.

Planned Speakers and Topics (PM Session: WS24)

How to Give Effective Presentations

Bruce Archambeault, Missouri University of Science and Technology, Rolla, Missouri, USA and IBM, Research Triangle Park, North Carolina, USA

Networking Skills

Dan Hoolihan, Hoolihan EMC Consulting, Minneapolis, Minnesota, USA

EMC for Managers

Joanna Hill, EMC Consultant, JPHill LLC, Hazel Park, Michigan, USA

Debugging EMI Test Failures

Sponsored by TC4

Format: Half-day Workshop (WS25)

Chair: Ross M. Carlton, National Instruments, Austin, Texas, USA

Abstract

This workshop will explore the challenging area of troubleshooting failures encountered during EMC testing. The workshop will begin with a presentation on the challenges of managing and leading troubleshooting efforts. These challenges can be as difficult to overcome as the technical challenges

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involved unless they addressed early and consistently. The presentation will illuminate potential problem areas and provide insight on techniques that can be tailored to any design environment.

The focus of the remaining presentation will be on debugging radiated RF emissions test failures. We will begin with finding the failure during a compliance radiated RF emissions measurement at an internal or external EMC lab. The presentation will focus on techniques and tools, typical fixes, and other insights for troubleshooting radiated RF emission failures using a compliance test facility, such as an open area test site or semi-anechoic chamber, where the availability of the test facility is limited due to scheduling or cost.

We then move to troubleshooting the failure on a workbench or at a pre-compliance test facility. The presentations will focus on system and PCB level techniques, primarily using near field probes. Utilizing these measurements to debug the failure and gain confidence in the product performance prior to another compliance test will be discussed. Demonstrations using specialized test fixtures as well as real-world products will enhance the learning experience.

The Workshop will end with a panel of the presenters to provide an opportunity for attendees to both ask questions as well as contribute what they have learned from their own troubleshooting experiences.

Planned Speakers and Topics

14:00 – 14:05

Introduction

Ross M. Carlton, National Instruments, Austin, Texas, USA

14:05 – 14:50

Leading and Managing EMI Troubleshooting

John G. Kraemer, Rockwell Collins, Cedar Rapids, Iowa, USA

14:50 – 15:30

Troubleshooting Radiated Emissions Failures at the EMC Lab

Ross M. Carlton, National Instruments, Austin, Texas, USA

16:00 – 16:30

Fast, Low-Cost Near-Field Benchtop Debugging Techniques

Keith Armstrong, Cherry Clough Consultants Ltd., Brocton, Stafford, UK

16:30 – 17:00

Real Examples of Debugging EMC Test Failures at the PCB Level

Arturo Mediano, University of Zaragoza, Zaragoza, Spain

17:00 – 17:30

Panel Session

All Presenters

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Workshop on IEMI Effects on Critical Infrastructures: The European project STRUCTURES

Format: Half-day Workshop -- WS26

Chair: Marco Righero, *Istituto Superiore Mario Boella, Torino, Italy*

Abstract

Security and quality of life in industrialized countries depend on continuous and coordinated performance of a set of infrastructures (energy systems, ICT systems, transportation, etc.) which can be therefore defined as critical infrastructures (CIs). STRUCTURES—Strategies for The impROvement of critical infrastrUCTure Resilience to Electromagnetic attackS—aims at analysing possible effects of electromagnetic (e.m.) attacks and, in particular, of intentional e.m. interference (IEMI) on such CIs, at assessing their impact for our defence and economic security, at identifying innovative awareness and protection strategies and at providing a picture for the policy makers on the possible consequences of an electromagnetic attack.

The project started on the 1st of July 2012 and will be near its conclusion for EMC 2015 in Dresden.

The workshop, featuring speakers from the involved partners, will give an account of the challenges faced by the consortium, will describe the techniques used to manage the different problems, and will present the outcomes of three years of investigations.

Planned Speakers and Topics

1. General introduction

Aldo Bonsignore, *Ingegneria Dei Sistemi, Roma, Italy*

2. The beginning of the project and some review

Benjamin Menssen, *Leibniz Universität Hannover, Hannover, Germany;*

Kai Rathjen, *Helmuth-Schmidt, Universität Hamburg, Germany*

3. Experimental Characterization of Critical Systems and Components

Nicolas Mora, *Swiss Federal Institute of Technology (EPFL), Lausanne, Switzerland*

Michael Camp, *Rheinmetall Waffe Munition GmbH, Unterluess, Germany*

4. Numerical analysis

Mario Antonelli, *Ingegneria Dei Sistemi, Roma, Italy*

Simon Runke, *Bergische Universität Wuppertal, Wuppertal, Germany*

5. Protection strategies

Marcos Rubinstein, *University of Applied Science and Arts Western Switzerland (HES-SO),*

Yverdon-les-bains, Switzerland

6. IEMI detection systems: A low cost IEMI detector

John Dawson, *University of York, York, U.K.*

Werner Hirschi, *Montena technology sa, Rossens, Switzerland*

7. Guidelines & Methodologies for risk assessment and mitigation of IEMI

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Frank Leferink, *University of Twente, Enschede, and THALES, Hengelo, The Netherlands*

Francesca De Simio, *Università Campus Bio-Medico di Roma, Roma, Italy*

ESD: Data Center ESD occurrence rate, ESD to Displays and Integrated ESD PCB IC Co-design

Format: Half-day Tutorial -- WS27

Co-chair: David Pommerenke, Missouri University of Science and Technology, Rolla, Missouri

Harald Gossner, Intel, Neubiberg, Germany

Abstract

Data centers can save energy by using outside air for cooling. However, the energy saving is strongly reduced if moisture needs to be added to the air to avoid operating the data center at low humidity, such as 25% or 8%. In proposing a wider operating range of air intake relative humidity concern was raised that the ESD induced failure rate may increase to an unacceptable level. In a larger study the effect of humidity on ESD charge voltages and discharge currents was investigated. The flooring / shoe combination was varied for humidities from 8% to 45% between 5C and 38C. Further, charge creation by sitting up from a chair or removing a garment was included and charge creation by cable handling. The data set is analyzed by its maximal voltages, walking voltages and methods are shown to extrapolate the probability to higher voltage levels. It is concluded that the ESD induced failure rate will only increase by a factor of about 2-3 if the humidity is reduced from 25% to 8% for the worst case floor/ shoe combination investigated. However, the risk of damaging voltage caused by other user action, such as sitting up from a chair is significant. Countermeasures such as conductive floors and shoes nearly illuminate any risk if the data center's equipment is ESD robust by IEC 61000-4-2 test standard at 4kV contact mode and 8kV air discharge.

ESD to displays can damage or upset the display. Throughout the cell phone, tablet and laptop industry this is a serious problem as possible user interface innovations are delayed by failing ESD robustness. This part of the workshop address ESD to displays by analyzing the test methods derived from the IEC 61000-4-2 standard showing that the "display down" test scenario is very severe and may not reflect any user scenario. Further it is shown that sparkles discharges to the glass area introduce large surface charges having sub-nanosecond rise times and many Ampere of current. Although no spark is visible damage and upset errors are common. The tutorial will explain test methods, simulation methods and how to visualize the charge distribution on the surface.

Efficient ESD design for system level ESD can only be achieved if board and device level protection circuitry match to each other. Purpose of this tutorial is to provide an understanding of board/ IC interaction under IEC 61000-4-2 testing conditions and to discuss useful design strategies supported by appropriate tools. This is meant to be beneficial both for ESD engineers of ICs and board designers responsible for EMC/ESD compliant design of the system. While it has clearly been pointed out that even elevated IC level HBM targets are insufficient for achieving the required IEC 61000-4-2 ESD level, more attention has to be put to the detailed turn-on and clamping behavior of IC level and board level ESD protection components. High current characterization of board protection and IO circuit by TLP is a first step. This enables the board designer to assess the behavior of IC pins and select appropriate board protection elements. A first time right design optimization will be explained which based on high current models of board components and IC IOs and the numerical simulation of the protection network under

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ESD conditions. Various test methods are available to evaluate the efficiency of implemented protection on board level quantitatively.

The course is divided into two parts, where one focuses on the general overview of failure mechanism and the protection design against hard fails, while the second one addresses soft fails and the typical ESD/EMC design strategies to protect against these. Also strategies for soft error root cause analysis are discussed. Methods for the characterization of ICs and PCBs responses to ESD induced soft errors by conducted and field coupling are shown.

Planned Speakers and Topics

Integrated ESD PCB IC Codesign

Harald Gossner, Intel, Neubiberg, Germany

ESD: Data center ESD occurrence rate and ESD to Displays

David Pommerenke, Missouri University of Science and Technology, Rolla, Missouri, USA