FINAL PROGRAM

2024 IEEE INTERNATIONAL SYMPOSIUM ON

AUGUST 5 - 9

EMC+SIPI

2024

PHOENIX, ARIZONA

ELECTROMAGNETIC COMPATIBILITY, SIGNAL & POWER INTEGRITY

KEYNOTE SPEAKER

Ed Godshalk

Ph.D., IEEE Fellow

EXHIBIT HALL

TECHNICAL PROGRAM DETAILS

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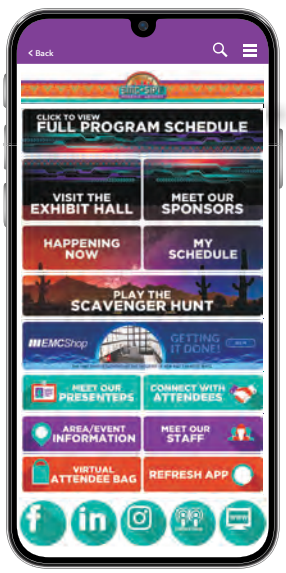
Tap the event icon to launch your event's app.

2. Login to the App:

Tap **Create Account** and enter the event code emailed to the attendees. The event code will also be on signs at the Symposium.

3. App Tips:

Download the app before you go! Wi-Fi connection onsite can affect the functionality of the app. **Browse** the event information and create a personal schedule by tapping on the star next to presentation titles.



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CHAIR'S MESSAGE

WELCOME FROM VIGNESH RAJAMANI, THE 2024 EMC+SIPI GENERAL CHAIR

On behalf of the EMC Society, I am thrilled to invite you to join us in Phoenix, Arizona for the annual EMC+SIPI Symposium.

Without the hard work and the dedication of the Symposium committee, we could not have put together a stellar technical and social program that each attendee will be able to enjoy.

Just like the previous years, the Symposium features technical sessions, workshops and tutorials, technical, standard and working group meetings, experiments and demonstrations, "Ask the Expert" panels, an extensive technical exhibition in addition to the social events that serve as a catalyst for collaboration and networking.

The flagship offering like the Clayton R. Paul Global University program is offered again in Phoenix and in addition to that I am very happy to introduce the inaugural Global SIPI University. This course aims at bridging the existing gap that engineers face with SI and PI related topics. Such courses are only offered at a few academic institutions and research laboratories in the US and worldwide, and we are striving to establish it as a staple at our annual Symposium.

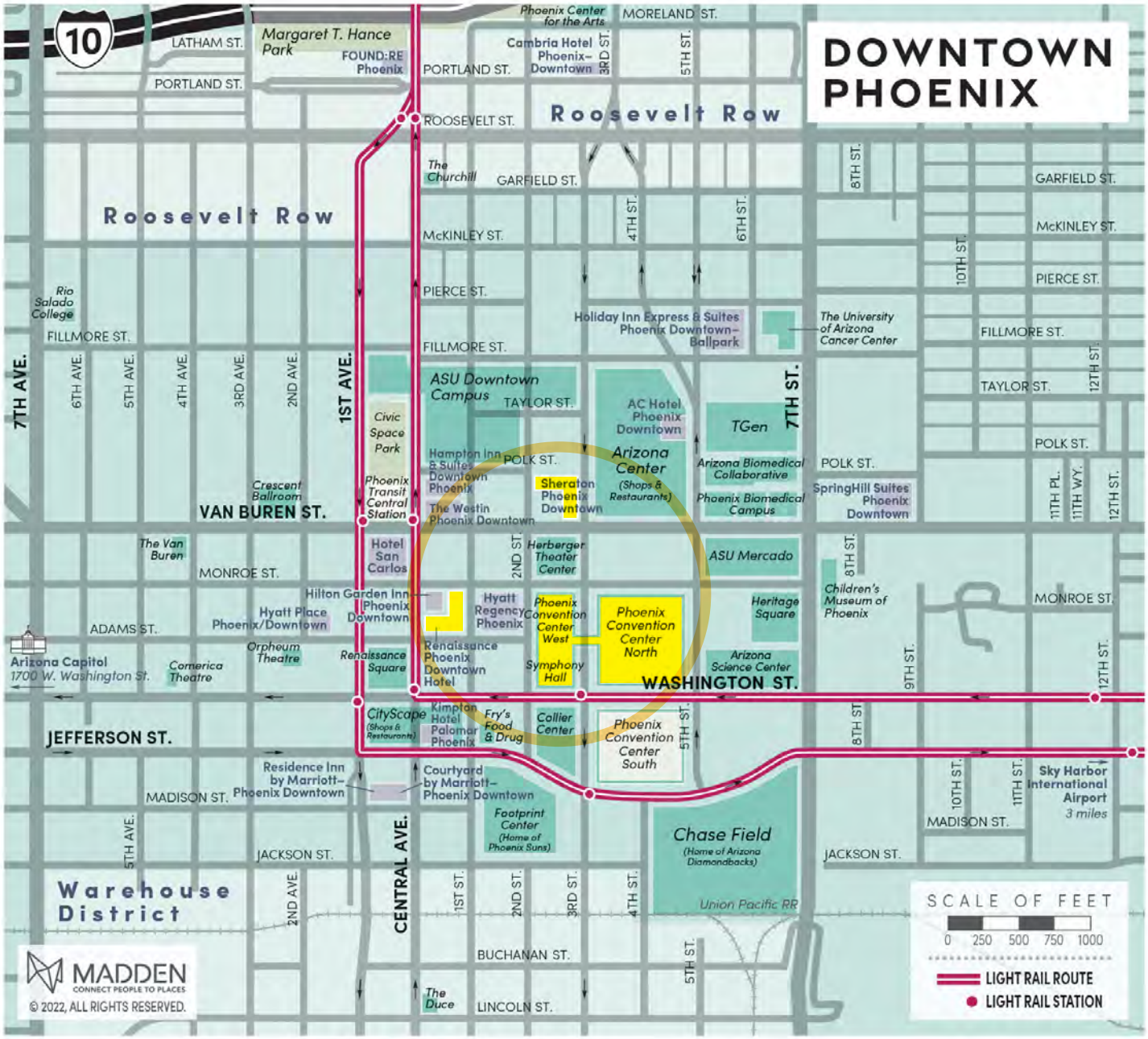
Regarding the social programs, the Welcome Reception will be held on the exhibit floor just like last year giving attendees extra time to look around the exhibit hall and interact with the exhibitors about their products and service offerings. The Gala will be held on Wednesday evening and this year, we will be celebrating Oktoberfest in Phoenix! Sponsor Rohde & Schwarz has many surprises in store for this festive event!

Situated in downtown Phoenix, the Phoenix Convention Center offers modern amenities and a contemporary architectural style. Within walking distance, visitors can discover a diverse array of hotels, dining establishments, and entertainment options, creating a convenient and enjoyable experience. From cultural attractions like the Phoenix Art Museum to shopping at the Arizona Center Mall, the surrounding area complements the convention center, providing a well-rounded destination for attendees. The Arizona Science Center, the Children's Museum of Phoenix, and the Rosson House are all 5 minutes or less to walk from the Convention Center.

In summary, I am really looking forward to a packed week to reconnect with some old friends and new acquaintances. As I mentioned earlier in this message, none of this would be possible without the dedicated staff and volunteers that serve as committee members, and I am indebted and privileged to work with such a wonderful group of people.

Vignesh Rajamani
General Chair, 2024 IEEE International Symposium on Electromagnetic Compatibility, Signal & Power Integrity (EMC+SIPI).

DOWNTOWN PHOENIX MAP



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VIEW THE LIGHT RAIL MAP

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- Boarding pass kiosks
- Pet parks
- Early bag check for travelers flying Southwest or American
- Cell phone waiting lot for those waiting to pick up passengers

VIEW THE PHOENIX SKY TRAIN WEBSITE

MEETING ROOMS MAP

NORTH BUILDING | 100 LEVEL

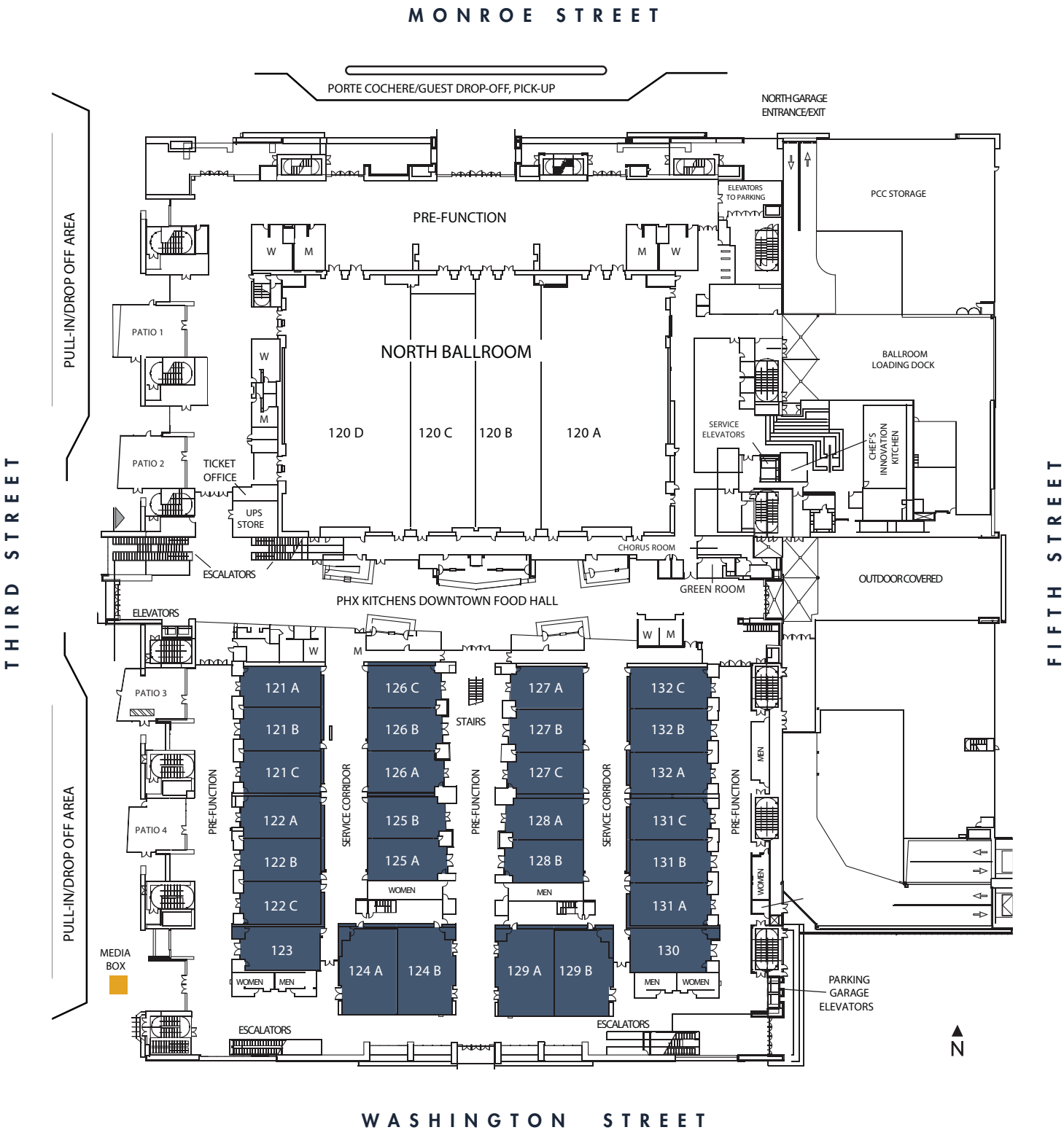
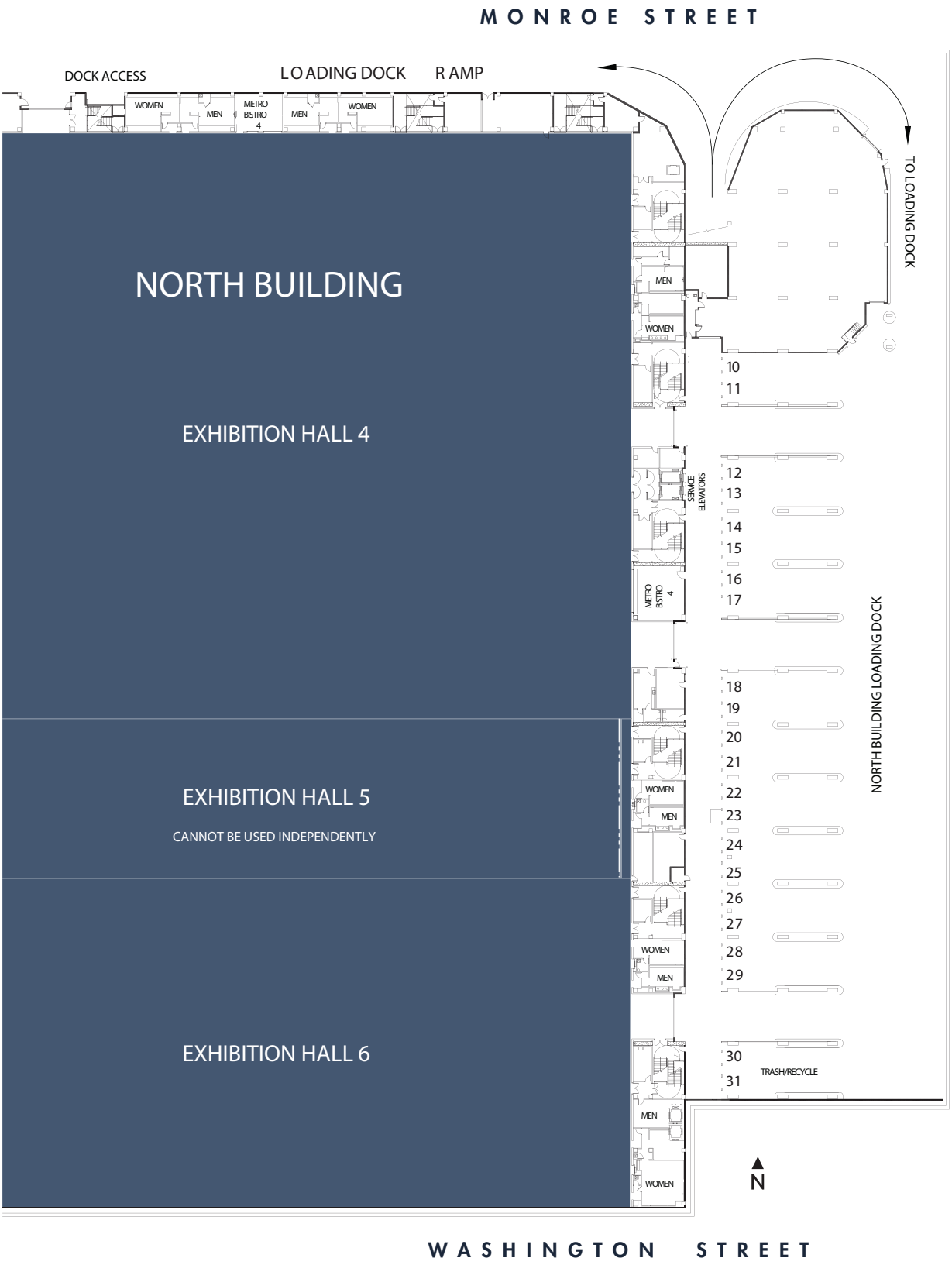


EXHIBIT HALL MAP



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SCHEDULE AT A GLANCE

	MONDAY, AUGUST 5	TUESDAY, AUGUST 6	WEDNESDAY, AUGUST 7	THURSDAY, AUGUST 8	FRIDAY, AUGUST 9
6:30 AM				Team EMC Bike Ride	
8:30 AM	Workshops & Tutorials	Keynote	Workshops & Tutorials	Technical Sessions	Workshops & Tutorials
10:00 AM	Break	Break & Exhibits	Break & Exhibits	Break & Exhibits	Break
10:30 AM	Workshops & Tutorials	Technical Sessions	Workshops & Tutorials	Technical Sessions	Workshops & Tutorials
12:00 PM	Break / Chapter Chair Training Session	Break & Exhibits	Break & Exhibits / Past President's Luncheon	Awards Luncheon	Break
1:30 PM	Workshops & Tutorials	Technical Sessions	Youth Technical Program 1:00 -3:30PM / Workshops & Tutorials, Technical Sessions and Poster Session	Technical Sessions	Workshops & Tutorials
3:00 PM	Break & Exhibits	Break & Exhibits	Break & Exhibits	Break	Break
3:30 PM	Workshops & Tutorials	Technical Sessions	Workshops & Tutorials and Technical Sessions / Women in Engineering	Technical Sessions	Workshops & Tutorials
5:00 PM					
6:00 PM		Welcome Reception			
7:00 PM	EMC+SIPI Jeopardy! YP Event	"After the Welcome Reception" YP Event	Evening Gala		
10:00 PM					

Clayton R. Paul Global University: 8:00AM - 5:15PM

Clayton R. Paul Global University: 8:00AM - 5:15PM

Global SIPI University: 8:30AM - 5:30PM

Clayton R. Paul Global University

EXHIBIT HALL SCHEDULE

EXHIBIT HOURS:

TUESDAY, AUGUST 6
Exhibits Open: 9:30 AM – 7:00 PM
Welcome Reception: 5:00 PM – 7:00 PM

WEDNESDAY, AUGUST 7
Exhibits Open: 10:00 AM – 5:00 PM

THURSDAY, AUGUST 8
Exhibits Open: 10:00 AM – 1:00 PM

PROMOTE EMC+SIPI 2024 ON YOUR SOCIAL CHANNELS!

We've created this content for your convenience to promote the 2024 EMC+SIPI Symposium via social media

Use our logos and sample text to promote visitors to your booth, attendance at your presentation, or simply your brilliance in attending the world's premier gathering of EMC and SIPI professionals!

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GENERAL INFORMATION

BRINGING COMPATIBILITY TO ENGINEERING INNOVATIONS SINCE 1957

The IEEE EMC Society has been at the pivot point of engineering technology for over a half-century. With a long history of developments in Electromagnetic Compatibility and Electromagnetic Environmental Effects, the Society brings sharp focus to methods and practices for proper performance of energy, electrical, communications, information technology and wireless systems. The Society promotes information sharing through regional chapters and international symposia. Collaboration across the research, design, test, regulatory and media industries has helped shape the world as we know it.

LEADING EDGE INFO

- EMC Measurements
- Signal & Power Integrity
- EMI Control
- EMC Management
- Low Frequency EMC
- Computational Electromagnetics
- High Power Electromagnetics
- Electromagnetic Environments
- Smart Grid EMC
- Regulatory Requirements for EMC, ESD, EMI, and SIPI

... AND MORE!

MEET THE STAFF

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Taylor Jacobi


Jenn Butler

TECHNICAL CHAIR'S MESSAGE

WELCOME FROM CHUCK BUNTING, THE 2024 TECHNICAL PROGRAM COMMITTEE CHAIR

WELCOME!

On behalf of the Technical Program Committee, welcome to the 2024 IEEE International Symposium on Electromagnetic Compatibility, Signal & Power Integrity (EMC+SIPI). I hope to meet you during this exciting week full of discussions, where we can share insights, ask questions, learn from the experts and innovators, as well as see new products.

The 2024 IEEE International Symposium on EMC and Signal & Power Integrity (EMC+SIPI) will be held in Phoenix, Arizona for the first time.

I encourage you to attend one of the many special sessions or traditional paper sessions – there is a lot to learn in the late-breaking developments of our colleagues. Attend and be challenged! If you're seeking in-depth discussions on a specific topic, consider participating in either a workshop or a tutorial. Tutorials typically involve one-directional communication directed at the audience, providing comprehensive information and guidance. In comparison, workshops offer a more interactive experience, fostering discussions and active engagement among participants. The popular experiments and demonstrations program provide hands-on learning opportunities to complement the technical presentations. These presentations often vividly demonstrate what makes the EMC/SIPI area so fascinating and always provoke new thoughts about our cool vocation. Stick around and discuss with the presenters and colleagues, and then reproduce the experiment or demonstrations to show your colleagues when you get back home. The "Ask the Expert" panel sessions will give another dimension to the Symposium where you can hear experts each respond to challenges that are happening in your industry or area. See the program for the details.

"Standards Week" is a combination of talks, tutorials, workshops, panel sessions, and demonstrations to update the engineering community about new developments in International EMC and Signal Integrity/Power Integrity (SIPI) standards. Standards Week includes a collection of what is going on in standards bodies, such as in the IC, CISPR, ANSI C63, etc. and what will affect us in the coming years. You can also attend one of the many standards committee meetings and/or working group meetings during the Symposium week to learn more about the standards process, and how you can get involved. These meetings are open to all interested in EMC and SIPI standards. Step up and serve your community and share your expertise!

Our Clayton R. Paul Global EMC University (CRPGU) features an overview of fundamental topics presented by expert instructors from universities and industries from around the globe. The Global University is larger and more extensive than ever before and will provide an excellent knowledge boost for everyone who already possesses a basic knowledge in the field of EMC and SIPI.

This extensive program will provide something for everyone. I hope you use this opportunity to catch up with old friends and make new ones.

Chuck Bunting
Technical Program Committee Chair, 2024 IEEE International Symposium on Electromagnetic Compatibility, Signal & Power Integrity (EMC+SIPI).

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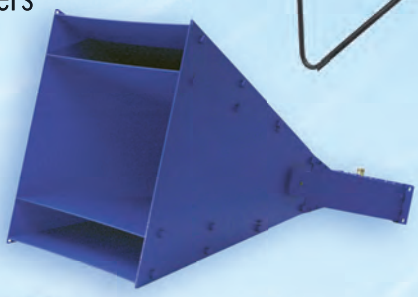

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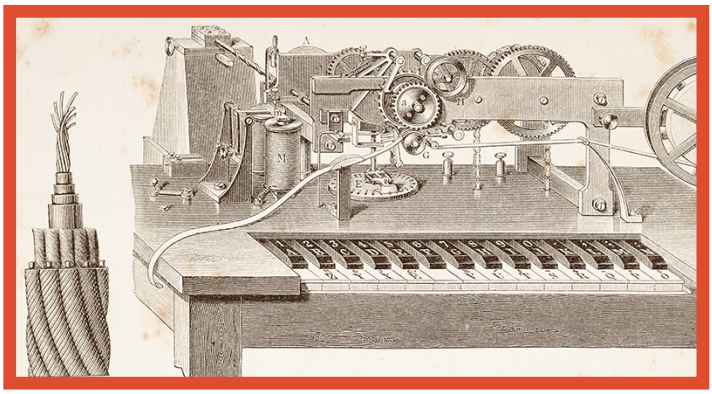
KEYNOTE PRESENTATION

TUESDAY, AUGUST 6, 2024 • 8:30 – 9:30 AM • ROOM: 120A

THE STORY OF THE TRANSATLANTIC TELEGRAPH AND THE WORLD'S FIRST INTERNET



Electrical telegraphy can be considered to be the first example of electrical engineering. Electrical telegraphs were point-to-point text messaging systems that were first used around 1840. This presentation traces the formative years of electrical engineering and the evolution of transmission line engineering that enabled a global communications network over **180** years ago! The story begins with the invention of the "Victorian internet", the telegraph, generally regarded as the first practical use of electronics. This is followed by transatlantic telegraph cable in **1858**, which some historians equate as the 19th century equivalent of landing a man on the moon. These were a catalyst for technologies such as improved battery design, insulated wire, coaxial cable, modulation schemes, and using the earth as a conductor. The transatlantic cable taught engineers the concept of the RC time constant **while educating them on threats to undersea cables such as sharks, whales, sawfish, and species of shipworm.**

The presentation includes results of a replica of the original system that illustrates the data rate problem. Many great minds of the 19th century (**Samuel Morse, Hans Christian Orsted, Joseph Henry, Carl Friedrich Gauss, and many others**) worked to understand and solve this problem, resulting in the telegrapher's equations that enabled high-speed communication and long-distance telephone service. The culmination is the modern transoceanic fiber optic cable, which forms the backbone of the global communications network. **Presently 99% of the data traffic that is crossing oceans is carried by undersea cables. The total carrying capacity of a submarine cable is in the terabits per second range while satellites typically offer only 1 gigabit per second capability.**

PRESENTED BY: Ed Godshalk, *Ph.D., IEEE Fellow*

Ed has been an Electrical Engineer for over 40 years and worked at several startups, Tektronix and Maxim Integrated. While at Cascade Microtech (1989-94), he invented the world's first waveguide input wafer probe and later the Air Coplanar Probe (ACP), which has been widely imitated. During his 22 years at Maxim, from which he retired in 2019, he created the Electromagnetics Group. He is presently working with FJ Scaler on Coherent Optical Subassembly (COSA) development for high-speed optical communications. He has over a dozen issued patents.

In 2020 he was elevated to the grade of Fellow by the Institute of Electrical and Electronic Engineers (IEEE) "For the development of microwave on-wafer probing and measurement techniques" which helped to enable microwave integrated circuits for commercial use.

Ed finds great pleasure in mentoring students and helping them achieve success in engineering and life. Helping students understand the origin of technical ideas is important to him, since this helps them to have a deeper understanding of engineering.

He also restores vintage sports cars and enjoys backcountry skiing and being in the mountains. In his younger days he organized an expedition that successfully climbed Denali, the tallest peak in North America (20,310'). He also climbed Kilimanjaro (19,341') in Africa, and numerous other peaks in North America.

MONDAY, AUGUST 5

SCHEDULE AT A GLANCE

ROOM	125AB	127A	127B	127C	128A	128B	129A
8:30 AM	TUTORIAL WT01 Henry W. Ott Fundamentals of Electromagnetic Compatibility	TUTORIAL WT03 Electromagnetic Wave Information Security to Enhance the Reliability of the Infrastructure as the Foundation of Society	TUTORIAL WT02 Military EMC Tutorial	WORKSHOP WT04 Wide Bandgap (WBG) Power Electronics EMI and Solutions	WORKSHOP WT05 Understanding EMC Regulations and Standards	TUTORIAL WT06 American National Standards Committee C63 - Electromagnetic Compatibility - Update on Latest C63 Standards	TUTORIAL WT07 Today's Automotive EMC/RF Testing: Is it Enough?
10:00 AM	REFRESHMENT BREAK						
10:30 AM			S		S	S	
12:00 PM	LUNCH BREAK						
1:30 PM		TUTORIAL WT08 Basic EMC Measurements		WORKSHOP WT09 Modeling of Cables, Connectors, Shielding and Harnesses	WORKSHOP WT10 Smart Grid and EMC Issues	TUTORIAL WT11 EMC Tests Passed, but EMI Can Still Cause Functional Safety Risks. EM Resilience is Needed	WORKSHOP WT12 Automotive EMC - Electric Vehicle - Measurement and Simulation
3:00 PM	REFRESHMENT BREAK						
3:30 PM				S			
5:00 PM							
5:30 PM							

ADDITIONAL STANDARDS SESSIONS, WORKING GROUPS AND TECHNICAL COMMITTEES
For Collateral Meetings, please see page 141

EMC+SIPI JEOPARDY! YP EVENT

The Arrogant Butcher - 2. E. Jefferson #150, Phoenix, Az 85004
6:00 - 10:00 PM (Pre-Registration Required)

SPEAKERS BREAKFAST

Phoenix Convention Center - 126ABC: 7:00 - 8:30 AM
(Breakfast Only on the Day of Presentation)

REGISTRATION/INFO DESK

7:00 AM - 5:00 PM

COMPANION SUITE

(Pre-Registration Required)
Sheraton Phoenix Downtown - North Mountain
Monday - Thursday: 7:00 - 10:00 AM

S STANDARDS WEEK SESSIONS

Join us for this special track on current and emerging International EMC and SIPI Standards! Attend open Working Group meetings with opportunities to contribute and ask questions.

MONDAY, AUGUST 5

WT01 TUTORIAL

HENRY W. OTT FUNDAMENTALS OF ELECTROMAGNETIC COMPATIBILITY

8:30AM - 5:30PM

Room: 125AB

Co-Chairs:

John McCloskey, *NASA, College Park, MD, USA*

Jen Dimov, *NASA, Greenbelt, MD, USA*

This tutorial is an overview of many of the major topics that need to be considered when designing an electronic product or system to meet signal and power integrity (SIPI) and electromagnetic compatibility (EMC) requirements. The tutorial will present the foundational ideas from physics and mathematics and will demonstrate the engineering approaches to help the attendees to successfully design, evaluate, diagnose, and/or solve EMI problems. The main objective of this tutorial is to provide a learning opportunity for those that are new to EMC as well as provide a review of the basics to those who already have some experience in this area.

PLANNED SPEAKERS & TOPICS

Electric Fields, Magnetic Fields, and Maxwell's Equations
John C. McCloskey
NASA's Goddard Space Flight Center, USA

Inductance and Capacitance
Bruce Archambeault[1,2]
[1]*Missouri University of Science and Technology, USA;* [2]*IBM, USA*

Crosstalk
Eric Bogatin
University of Colorado Boulder, USA

Transmission Lines and Basic Signal Integrity
Xiaoning Ye
Intel Corporation, USA

PCB Decoupling
Chulsoon Hwang, James Drewniak
Missouri University of Science and Technology, USA

Grounding
Todd Hubing
LearnEMC, USA

Mitigation Strategies
Frank Leferink, Niek Moonen
Universiteit Twente, Netherlands

Conducted Emissions
Lee Hill[1, 2, 3]
[1]*SILENT Solutions LLC & GmbH, USA;* [2]*Worcester Polytechnic Institute, USA;* [3]*University of Oxford, United Kingdom*

Radiated Emissions
Cheung-Wei Lam, *Apple Inc., USA*
Lee Hill, *SILENT Solutions LLC & GmbH, USA*

WT02
TUTORIAL

MILITARY EMC TUTORIAL

8:30AM - 5:00PM
Room: 127B
Sponsored by TC-3

STANDARDS WEEK

Co-Chairs:
Robert Davis, *Lockheed Martin (Retired), Syracuse, NY USA*
Carl Hager, *NSWC Dahlgren, Dahlgren, VA, USA*

The objective of this tutorial is to enhance our attendees' knowledge and understanding of key aspects of Military EMC that will help them in the performance of their jobs.

The tutorial will cover a broad range of Military EMC topics. The morning tutorial presentations will start with four talks updating the audience on the status and changes to MIL-STD-461, DoD E3 & Spectrum Directives/Instructions and Standards, Military HDBK-240 and NATO AECTP 250 & 500. This will be followed by a review of MIL-STD-464D Near Strike Lightning E-Field requirements, a discussion on the US Navy's HEMP E1 Test Range's existing and future operations and a talk on Surveying EMR Hazards on Army and Civilian vehicles.

The afternoon's tutorial presentations include a collaborative talk on ESD Indirect Effects on non-metallic ordnance, a presentation on EMI, N-EMP, L-EMP and TEMPEST Zoning and a discussion on the rising electromagnetic threat to military operations caused by civilian infrastructure. A Review of Spectrum Efficiency Solutions and Antenna Design Considerations for Efficient Spectrum and a discussion on Filters for Military EMC Applications, are also included in the afternoon presentations. The tutorial will conclude with a "Panel Discussion" with experts having a diverse background in Military EMC from the United States, Canada, Sweden, and the Netherlands.

PLANNED SPEAKERS & TOPICS

DoD E3 and Spectrum Directives and MIL-STD Update
Mark Waller
US Army Redstone Test Center, USA

MIL-STD-461 Updates and Status
Finbarr M. OConnor
Huntington Ingalls Industries, USA

Electromagnetic Environmental Effects to Ordnance Guide MIL-HDBK-240
Mark Waller
US Army Redstone Test Center, USA

NATO Electrical and Electromagnetic Environmental Conditions AECTP 250 and Electromagnetic Environmental Effects Tests and Verification Methods AECTP 500 New Editions
Antonius J. van Bladel[1,2]
[1]*Dutch Ministry of Defence, Netherlands;*
[2]*NATO E3 Action Team*

Review of Near Strike Lightning Electric Field Requirements in MIL-STD-464D
Tiffany Morisak
NAVAIR, USA

HEMP (E1) Test and Evaluation Facilities for Aircraft
John Howson IV
NAVAIR Patuxent Naval Air Station, USA

Helicopter-Borne Electrostatic Discharge (HESD) to Ordnance and Indirect Effects
Phillip Melton, Jeffrey Clark
NAVSEA Warfare Centers Indian Head, USA

EMI, N-EMP, L-EMP and TEMPEST Zoning: Differences and Commonalities
Frank Leferink
Thales Netherlands, Netherlands

Real-World Electromagnetic Radiation (EMR) Hazard Mitigations for Army and Civilian Vehicles
Robert Tarrant
US Army Aberdeen Test Center, USA

The Rising Electromagnetic Threat to Military Operations Caused by Civilian Infrastructure
Petter Gärdin
Swedish Armed Forces, Sweden

Review of Spectrum Efficiency Solutions and Antenna Design Considerations for Efficient Spectrum Usage
Sarah Seguin
Aerospace Corporation, USA

EMC Filters for Military Applications
Randy J. Jost
Utah State University, USA

MONDAY, AUGUST 5

WT03 TUTORIAL

ELECTROMAGNETIC WAVE INFORMATION SECURITY TO ENHANCE THE RELIABILITY OF THE INFORMATION INFRASTRUCTURE AS THE FOUNDATION OF SOCIETY

8:30AM - 12:00PM

Room: 127A

Sponsored by TC-5

Chair:
Yuichi Hayashi, *Nara Sentan Kagaku Gijutsu Daigakuin Daigaku Joho Kagaku Kenkyuka, Ikoma, Japan*

Co-Chair:
William Radasky, *Metatech Corporation, Goleta, CA, USA*

Nowadays, where valuable information such as personal data, health records, financial details, and even intellectual property, including AI learning models, are handled over networks, ensuring the security of information systems that support these network infrastructures has become one of the most critical social issues. It is desirable to appropriately secure information systems at various layers, including applications and networks. However, the security of the hardware, which is the foundation of trust in these systems, is especially crucial. Furthermore, among hardware security concerns, electromagnetic wave-based attacks are one of priority because they can degrade security without leaving evidence. Therefore, this tutorial session will focus on hardware security related to electromagnetic waves, introducing the latest research trends in threats and countermeasures. Additionally, for those not well-versed in hardware security, we will provide the fundamental knowledge necessary to understand this tutorial.

PLANNED SPEAKERS & TOPICS

Introduction to Electromagnetic Wave Information Security to Enhance the Reliability of the Information Infrastructure
Yuichi Hayashi
NAIST, Japan

Inaudible Attack on Smart Speakers using IEMI
Chulsoon Hwang
Missouri University of Science and Technology, USA

Review of Research Trend on Side Channel Leakage Simulation Method of Cryptographic Modules
Kengo Iokibe
Okayama University, Japan

Backscattered Side-Channel Attacks and Countermeasures
Shahin Tajik
Worcester Polytechnic Institute, USA

IEMI Attack against PDN of RO based TRNG
Youngwoo Kim
Sejong University, Korea

WT04
TUTORIAL

WIDE BANDGAP (WBG) POWER ELECTRONICS EMI AND SOLUTIONS

8:30AM - 12:00PM

Room: 127C

Sponsored by SC-5

Chair:
Shuo Wang, *University of Florida, Gainesville, FL, USA*

Wide bandgap (WBG) power semiconductors, such as SiC MOSFETs and GaN HEMTs, have higher switching speed and lower conduction power loss compared to conventional Si power semiconductor devices like IGBTs and MOSFETs. They are becoming more popular in modern power electronics applications, such as renewable energy, HVDC, aerospace, and power grid support because they can achieve higher energy efficiency with higher power densities. They are expected to replace conventional Si power devices in the future. However, their high switching frequencies and speeds cause high electromagnetic interference (EMI), which results in extra components for EMI filtering. This cancels the benefits of WBG devices. It is, therefore, important to investigate the EMI characteristics of WBG power electronics and the solutions to reduce the EMI without sacrificing performance, power density, and efficiency. Co-sponsored with IEEE Power Electronics Society, this workshop will focus on the recent advances in modeling, measurement, and suppression of EMI for WBG power electronics systems. The presenters will deliver the workshop based on their most recent research. The workshop is useful for all engineers and researchers in power electronics EMI and government employees related to the topic.

PLANNED SPEAKERS & TOPICS

A History of Silicon Carbide (SiC) Wide Bandgap (WBG) Advancement through Power Electronic Building Blocks (PEBB) and Implications for the Future
Lynn J. Petersen
Office of Naval Research, USA

Radiated EMI of WBG Power Electronics Systems
Shuo Wang
University of Florida, USA

Gate Driver Design with Improved Near-Field Noise Immunity for Medium-Voltage High-Power SiC-Based Converters
Dushan Boroyevich, He Song
Virginia Polytechnic Institute, USA

Common Mode Electromagnetic Interferences in Power Electronics Network
Seungdeog Choi
Mississippi State University, USA

Scalability of EMC Design and Approach Toward High Power and High-Frequency Power Electronics Systems
Dong Dong
Virginia Polytechnic Institute and State University, USA

High Frequency Side Effect Modeling and Mitigation in WBG based Mobile Grid
Fang Luo
Stony Brook University, USA

EMI Propagation Study in a 10 kV SiC MOSFET based Power Electronics Building Block (PEBB)
Ashkan Barzkar, Rolando Burgos, Dong Dong, Dushan Boroyevich
Virginia Polytechnic Institute and State University, USA

Workshop Panel Discussion
Shuo Wang
University of Florida, USA

MONDAY, AUGUST 5

WT05
TUTORIAL

UNDERSTANDING EMC REGULATIONS AND STANDARDS

8:30AM - 12:00PM
Room: 128A
Sponsored by IEEE SACCom

STANDARDS WEEK

Chair:
Henry Benitez, *ElectroMagnetic Investigations, Beaverton, OR, USA*

The session will include presentations from representatives for the FCC, FDA, NIST, former TCB Chair, CISPR Committees and test lab Accreditation Body.

The session will present some background into the history of EMC and the evolution resulting in the need for EMC regulations and standards. An overview of the IEC process for the development of EMC standards will be provided. The speakers will form a panel for questions and answers at the end of the session.

PLANNED SPEAKERS & TOPICS

Introduction to Standards and Regulations
Henry Benitez
ElectroMagnetic Investigations, LLC, USA

USA FCC Overview
William Hurst
ANAB Technical Assessor, USA

TCB Overview of FCC Testing Development
William H. Graff
TCB Council, USA

Success of Mutual Recognition Agreements
Nathalie Rioux
National Institute of Standards and Technology, USA

FDA
Yasaman Ardeshirpour
US Food and Drug Administration, USA

Role of Accreditation Bodies
Megan McConnell
A2LA, USA

CISPR H and CISPR A
Andy Griffin
Cisco Systems Inc., USA

CISPR SCI, CISPR 32 and CISPR 35
Ghery S. Pettit
Pettit EMC Consulting LLC, USA

Automotive Standards Development by CISPR/D
Review of CISPR 12, CISPR 36, and CISPR 25
Craig Fanning
Elite Electronic Engineering, Inc., USA

Panel Discussion

WT06
TUTORIAL

AMERICAN NATIONAL STANDARDS COMMITTEE C63 – ELECTROMAGNETIC COMPATIBILITY – UPDATE ON LATEST C63

STANDARDS WEEK

8:30AM - 12:00PM
Room: 128B
Sponsored by TC-1

Chair:
Daniel Hoolihan, *Hoolihan EMC Consulting, Lindstrom, MN, USA*

This tutorial will introduce the ANSC C63-EMC (C63 Committee) to conference attendees and highlight the latest status of key C63 Standards. Many C63 standards are Incorporated by Reference (IBR) by the United States Federal Communications Commission (FCC) and are mandatory for measuring electronic products for compliance with FCC Rules. A similar number of C63 standards are also used by Canada for showing compliance to their Regulations.

PLANNED SPEAKERS & TOPICS

Draft ANSI C63.4:202? A Review
Andy Griffin
Cisco Systems, USA

Draft Standard ANSI C63.25.3
Nicholas Abbondante
Intertek USA Inc., USA

Overview of C63.26 – American National Standard for Compliance Testing of Transmitters used in Licensed Radio Services
William Elliott
TUV SUD America, USA

ANSI C63.9 Standard Update
Jeff Evans
Consultant, USA

Far-Field Measurement Distance White Paper
Pelin Salem
Cisco Systems Inc., USA

ARIZONA FUN FACT — INTRODUCTION TO THE 5 C'S OF ARIZONA

Arizona is a state that is rich in resources which we call the five C's:

COPPER • COTTON • CITRUS • CATTLE • CLIMATE

Since 1910, the state has been the nation's leading source of copper, still producing 68% of the nation's copper today. The Arizona Pima Indians have been growing their luxury Pima cotton variety in this state since the early 1800's and in cooperation with the USDA developed Supima Cotton, which rivals Egyptian cotton in quality, is used as a replacement for silk, and is grown exclusively in the United States.

Arizona's citrus industry predates statehood by decades. The sun and soil are perfect for growing oranges, tangerines, lemons and grapefruit. Yuma County, AZ holds the title of winter lettuce capital of the world for their long growing season, rich soil, and endless sun.

Cattle ranching in Arizona has been a mainstay since the Spanish introduced cattle to the area in the 1600's. The federal government manages about 11.5 million acres of rangeland in Arizona which may be leased for livestock grazing and the state is home to over 900,000 head of cattle.

And of course, you can't talk about Arizona without mentioning the climate. The warm climate with mild winters and hot summers makes it an ideal place for outdoor activities.

WT07
TUTORIAL

TODAY'S AUTOMOTIVE EMC/RF TESTING: IS IT ENOUGH?

8:30AM - 12:00PM
Room: 129A

Co-Chairs:
Garth D'Abreu, *ETS-Lindgren, Cedar Park, TX, USA*
Craig Fanning, *Elite Electronic Engineering, Inc., Downers Grove, IL, USA*

The automotive industry has been progressing at a rapid pace with the development and adoption of electric propulsion and advanced driver assistance (ADA) related systems. As a result, many new developments fall outside the scope or definitions described in the currently published automotive standards. In most cases, an interpretation of the intent of a standard is sufficient but in others, amendments or new standards are required. With the introduction of new systems, automotive industry manufacturers face new challenges related to EMC, RF, and wireless performance. These extend from the design of ICs and antennas, through to components, subsystems, and full vehicles.

This tutorial will cover a broad range of topics addressing the design of vehicle components and subsystems related to communications, propulsion, and other elements. We will discuss traditional component design (which in the new paradigm presents challenging EMC problems), the design of high speed vehicle networks to mitigate signal integrity issues, and review some of the short comings of existing standards. We'll address the critical impact a vehicle structure can have on antenna design and communication performance. In conclusion, in lockstep with the rapid improvements in automotive technology, we'll review today's test environments to validate that automotive components and vehicles successfully perform as intended. Our speakers represent industry and academia with extensive experience in automotive EMC/RF/Wireless design and test. Several speakers are active technical contributors to the international standards committees, such as the ISO, SAE, and CISPR D automotive committees.

PLANNED SPEAKERS & TOPICS

Design Considerations of Automotive High Speed In-Vehicle Network Links from PCB to PCB
Sergej Bub1, Andreas Hardock[1], Rich Boyer[2]
[1]*Nexperia, USA;* [2]*Aptiv Plc, Ireland*

Common Design Practices in Automotive Component/ Sub-System Integration and Their Negative Impact to EMC
Ronald Missier
Ford Motor Company, USA

Amperes of Current at 100 kHz: Bulk Current Injection Measurement Artifact or Radiated EM Disturbance Reality?
Patrick DeRoy
Analog Devices Inc., USA

Challenges in Automotive Antenna Design and Testing
Daniel Aloi
Oakland University, USA

Expanding Options for EMC Testing of Automotive Components and Full Vehicles
Garth D'Abreu
ETS-Lindgren, USA

WT08
TUTORIAL

BASIC EMC MEASUREMENTS

1:30PM - 5:00PM

Room: 127A

Sponsored by TC-2

Chair:
Monrad Monsen, *Oracle, Broomfield, CO, USA*

There continues to be those entering the EMC field who are performing measurement activity for both emissions and immunity. In addition, there are practitioners who want to get a second opinion to support what they are doing. They are all at least familiar with basic EMC immunity measurements methods that cover a wide range of electromagnetic phenomena. This tutorial will cover both emissions and immunity by highlighting the latest amendment to a major multimedia emissions standard and a selection of immunity testing standards for transients that are more difficult to implement. The transient discussion will also delve into signals that are high power in a very short time. Also included: a description of emission and immunity test sites, the sites that are becoming popular and their validation requirements, as well as an overview of test setups in these facilities. Where appropriate and if time permits, attendees will be asked questions as to what they have learned and will be given an opportunity to question the speakers at a panel discussion at the end of the session.

PLANNED SPEAKERS & TOPICS

Use of Basic Measurement Facilities, Methods and Associated
Ghery Pettit
Pettit EMC Consulting, USA

CISPR 32 Emissions Testing
Ghery Pettit
Pettit EMC Consulting, USA

Performing Immunity Testing to Transient Signals
Tom Braxton
IEEE Life Senior Member, USA

Continuous Wave Immunity
Ross Carlton
Gibbs and Cox Inc, USA

High Power Electromagnetics Test Facilities and Measurement Methods
William A. Radasky
Metatech Corporation, USA

Photo by Patrick Andre

MONDAY, AUGUST 5

WT09 WORKSHOP

MODELING OF CABLES, CONNECTORS, SHIELDING AND HARNESSES

1:30PM - 5:00PM

Room: 127C

Sponsored by TC-4

STANDARDS WEEK

Chair:
Charles Jullien, *Safran Electrical & Power, Blagnac, France*

Co-Chair:
Huadong Li, *Molex LLC, Naperville, IL, USA*

This workshop will give a general introduction to modelling of cable construction, termination and grounding for product EMC, present some numerical testing methods for cable and connector shielding, introduce some methods for cable and connector EMC modelling and analysis, demonstrate some examples on EMC simulation and design for cables and connectors. Indeed with the advent of electric transport and the generalization of electronic equipment throughout the world, the transport of energy and information has become a major issue. The multiplication of cabling networks is also a source of propagation of system disturbances. Mastery of EMC within cables requires knowledge of couplings and the ability to predict these couplings using simulation tools. Whether at the level of connectors, cables, shielding, each brick must be known to evaluate the protection solutions at the harness level and then subsequently integrated into its higher-rank system environment. This workshop will provide an update on knowledge and work in the community.

The workshop is divided into topics as: High-resolution FDTD Modeling of Braided Wire Shields for the Extraction of Transfer Impedance, Modeling of transfer impedance characterization bench up to 9GHz, Measurands of Cable and Connector Shielding Effectiveness and Their Applications, Radiation Losses and Crosstalk on Shielded Transmission LInes, Precision RF CCAs for simulation and measurement, Magnetic modelling.

The workshop will help the audience to properly test and design cables, connectors and their assemblies for product EMC.

PLANNED SPEAKERS & TOPICS

FDTD Modeling of Braided Wire Shields for the Extraction of Transfer Impedance
Griffin Kowash
Electro Magnetic Applications, Inc., USA

Modeling of Transfer Impedance Characterization Bench Up to 9GHz
Charles Jullien, Thomas Colleter, Danica Cvetkovic
Safran Electrical and Power, France

Shielding Effectiveness Measurands of Cables, Connectors, and Their Assemblies
Huadong Li
Molex LLC, USA

Radiation Losses and Crosstalk on Shielded Transmission Lines
Paul Bremner, Weitao Dai
Robust Physics, USA

Parallel Plate Transmission Line for EMC
Gary Biddle
Sametec, USA

Simulations and Measurements of Shielding Effectiveness of Connectors in Low Intensity Magnetic Fields
Eugene Mayevksiy
TE Connectivity, USA

Shielding Effectiveness Measurements of Cables with GTEM Cell
Furkan Şahin, Sander Bronckers, Anne Roc'h
Technische Universiteit Eindhoven, Netherlands

WT10 WORKSHOP

SMART GRID AND EMC ISSUES

1:30PM - 5:00PM

Room: 128A

Sponsored by SC-1

Chair:
Michael McInerney, *Consultant, Champaign, IL, USA*

Co-Chair:
William Radasky, *Metatech Corporation, Goleta, CA, USA*

Smart Grids (as used in electric power systems) are an important topic worldwide. Smart Grid applications continue to increase, as do EMC issues with components, equipment, and standards. The workshop will begin with a review of the activities of the IEEE EMC Special Committee 1 (SC 1) which coordinates Smart Grid EMC activity within the IEEE EMC Society. Then a short presentation on residential solar power applications and interconnection with the local electrical power provider will be given.

The workshop will continue with a presentation on internal EMC issues in the low voltage grid when prosumers dominate network connections. Prosumers have a different interaction with the distribution network in comparison with traditional producers and consumers. They have a bi-directional power exchange with the grid, meaning they receive from as well as deliver electricity to the network. Under ideal sunlight and wind conditions the substantial current fed into the grid from prosumer generation installations causes an increase in voltage above acceptable levels, which consequently leads to the disconnection of prosumers' installations. This situation can be treated as a very interesting case of EMC, where mass usage of devices in an electromagnetic environment causes such a change in this environment that the operation of devices becomes impossible. In the tutorial, experimental results registered by the AMI system (Advanced Metering Infrastructure) of the distribution system operator, which includes over 200,000 smart energy meters, will be presented. Methods for utilizing the existing network infrastructure and machine learning techniques to reduce the instances of prosumer disconnection and increase the absorption of energy from renewable sources will also be presented.

The workshop will conclude with two presentations on standards that address EMC issues in Smart Grids. Both existing standards and standards under development will be included. For example, three of four IEEE standards that address EMC testing requirements for smart grid equipment and components are now either completed or nearly complete. A review of the activities of the of the Smart Grid EMC working group in the United States (Smart Electric Power Alliance – SEPA). These activities focus on Smart Grid devices that are exposed to the electromagnetic environment that the grid traverses and where it terminates.

PLANNED SPEAKERS & TOPICS

Introduction to the IEEE EMC Society Special Committee 1 (SC 1) and Residential Solar, Real-World Examples
Michael McInerney
Mac and Ernie, USA

SEPA (Smart Electric Power Alliance) Electromagnetic Interoperability Issues Sub-Group (EMIISG) – Its History, Accomplishments and Status
William Radasky
Metatech Corporation, USA

Internal EMC Issues in Low Voltage Grid with Significant Share of Prosumers
Robert Smolenski
University of Zielona Gora, Poland

IEEE Standards Update: Four Revised EMC Standards for Utility Controls Testing
Jerry Ramie
ARC Technical Resources, USA

MONDAY, AUGUST 5

WT11 WORKSHOP

EMC TESTS PASSED, BUT EMI CAN STILL CAUSE FUNCTIONAL SAFETY RISKS. EM RESILIENCE IS NEEDED

1:30PM - 5:00PM

Room: 128B

Sponsored by TC-1

Chair:
Martin Armstrong, *Cherry Clough Consultants Ltd, Stafford, United Kingdom*

Co-Chair:
Davy Pissoort, *Katholieke Universiteit Leuven, Bruges, Belgium*

Rapid developments in electronics now means that safe-enough operation of most products, applications, systems and networks relies on managing the risks that can be caused by errors, malfunctions or failures in programmable digital systems.

Unfortunately: i) They have too many possible digital states to be thoroughly tested, even once ii) They are non-linear, so we can't interpolate between tested states. E.g., even if 99% of their digital states had passed safety tests, we can't assume that their untested states would be safe. iii) Their inherent unpredictability means they cannot be shown to be safe enough by any practical test program.

EMI is continually being made more likely by the very rapid deployment of 'noisy' electronic technologies, including power conversion, wireless power transfer, and wireless datacoms There is also very rapid deployment of Machine Learning (ML) and Artificial Intelligence (AI), in the operational control of aircraft, automobiles, trains, aircraft, ships, spacecraft, mining, healthcare, surgery, agriculture, industrial manufacturing, process control, public utilities, etc.

PLANNED SPEAKERS & TOPICS

Managing the Risks that EMI Can Cause – An Introduction
Keith Armstrong
Cherry Clough Consultants Ltd, United Kingdom

Managing the Risks that EMI Can Cause – Details of T&Ms
Keith Armstrong
Cherry Clough Consultants Ltd, United Kingdom

Ongoing and Future Research in EM Resilience
D. Pissoort
Katholieke Universiteit Leuven, Belgium

ARIZONA FUN FACT A DEEPER DIVE INTO COPPER

Copper is one of the most sought-after and prevalent resources in Arizona, and there is no question why it is one of the 5 C's. Copper found throughout the state was used by native Americans for tools, weapons, jewelry, and painting, but it later became a significant source of power. The dome of the State Capital is even covered in 2,500 pounds of copper.

Copper in Morenci, AZ was first discovered in 1863 during the civil war by General James Carleton and 1st Infantry California Volunteers. According to AZCentral, "Morenci was the fifth largest copper producer in the world, producing 550,000 tons of copper during 2016," (Nothaft, 2017). They remain the 5th largest copper producer in the world and the largest mine in North America.

Since 1910, the state has been the nation's leading source of copper, still producing 68% of the nation's copper today.

WT12 WORKSHOP

AUTOMOTIVE EMC – ELECTRIC VEHICLE – MEASUREMENT AND SIMULATION

1:30PM - 5:00PM

Room: 129A

Chair:
Martin Wiles, *MVG World, Haydock, United Kingdom*
Co-Chair:
Paul Duxbury, *MVG - Microwave Vision Group, Haydock, United Kingdom*

This workshop focuses on EMC for Electric Vehicles (EVs) by looking at Simulation and Measurement aspects from the industry.

From a measurement perspective: Regulatory requirements in EMC Standards mean that manufacturers must test EV equipment to EMC including motors, chargers and batteries. Details of the tests and how they are practically implemented into EMC anechoic chambers will be discussed.

From a simulation perspective: It is well known that correlation between table and vehicle tests can differ significantly, and we will go through the different steps of the modelling and simulation of CE tests of EV on-board powertrain chargers to compare results on table/ vehicle. Many different parameters are usually involved in the performance of HV shielded links of EVs, such as those between HV batteries, DC/DC converters, on-board chargers, inverters, and electric motors. We will address the importance of considering the aging of HV connectors. High currents serve as the source to many industry challenges in electronics. For the electric powertrains of EVs, the specifics range from magnetic field exposure and emissions standards to the compliance of EMC regulations for the full vehicle. Electrical characterization of the power electronics of an EV have increasingly been pushed towards simulation, where countless design iterations can be investigated on the individual component level, all the way towards a full vehicle. Automotive OEMs want to perform system level simulations with EVs on early stages of development. Methodology will be presented on how to generate models of HV devices and especially filters based on measurement reports that can be used in system level simulation in the car model.

Finally, numerical simulations will be presented for EMC problems related to eMobility, e.g. radiation, crosstalk at cable harnesses, emissions from electrical power trains. A digital twin for vehicle immunity tests is also presented to better understand the different exposure situations of EMC tests on a component at vehicle level. Simulation of CISPR test standards will also be presented.

PLANNED SPEAKERS & TOPICS

EMC and eMobility
Martin Wiles, Paul Duxbury
MVG World, United Kingdom

Modeling of Conducted Emission Tests of EV On-Board Powertrain Chargers on Table and on Vehicle – Discussions on the Correlation between Test Results
Marco Klingler[1], Abdelhak Benali[2], Jérôme Mollet[2]
[1]EMC Consultant, France; [2]Dassault Systèmes, France

Effect of Aging on the Transfer Impedance of Shielded Connectors and Their Impact on Different EV HV Shielded Cable Arrangements
Marco Klingler
EMC Consultant, France

Holistic EMC Simulations for Power Electronics in Electric Vehicles
Tyler Dodge
Dassault Systèmes, USA

Optimizing Filter Parameters for High Voltage Power Systems with CISPR-25 Measurements
Roman Jobava
EMCoS LLC, Georgia

Advanced EMC Simulations for eMobility
C.J. Reddy
Altair, USA

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TUESDAY, AUGUST 6

SCHEDULE AT A GLANCE

ROOM	125AB	127B	127C	128A	128B
8:30 AM 9:30 AM	Keynote Presentation: The Story of the Transatlantic Telegraph and the World's First Internet Room 120A				
10:00 AM	REFRESHMENT BREAK				
11:00 AM	SPECIAL SESSION SS01_1 Machine Learning Aided SI, PI, EMC and EMI Session	TECHNICAL PAPERS TC2_1 EMC Measurements for PCBs and Memory Components	TECHNICAL PAPERS TC9_1 Modeling Techniques for Radiation	TECHNICAL PAPERS TC10_12 High-Speed Interconnects and Noise Coupling	TECHNICAL PAPERS TC10_S1 Crosstalk, Jitter, Noise Coupling, BER Analysis #1
12:00 PM	LUNCH BREAK				
1:30 PM		TECHNICAL PAPERS TC2_2 EMC Measurements for Wireless Communications, Pulsed Interference and Transistors	TECHNICAL PAPERS TC9_2 Computational EM	TECHNICAL PAPERS TC10_13 Power Distribution Networks & Decoupling #1	TECHNICAL PAPERS TC10_2 Material Characterization for SI
3:00 PM	REFRESHMENT BREAK				
3:30 PM 4:30 PM		TECHNICAL PAPERS TC2_3 EMC Measurements – Probes	TECHNICAL PAPERS TC9_3 Multi-Physics Modeling	TECHNICAL PAPERS TC8&TC2 Aerospace EMC and Shielding	TECHNICAL PAPERS TC10_3 Simulation and Modeling Techniques #1
5:00 PM					
	CLAYTON R. PAUL GLOBAL UNIVERSITY: 8:00 AM - 5:15 PM, 124A (Pre-Registration Required)				
	EXHIBIT HALL HOURS Grand Opening Ribbon Cutting at 9:30 AM EXHIBITS OPEN: 9:30 AM – 7:00 PM EXPERIMENTS & DEMOS: 10:00 AM - 12:30 PM, 2:00 - 4:00 PM ASK THE EXPERTS PANELS: 10:00 - 11:30 AM, 2:00 - 3:30 PM				
	ADDITIONAL STANDARDS SESSIONS, WORKING GROUPS AND TECHNICAL COMMITTEES For Collateral Meetings, see page 141				

SENIOR MEMBER AND FELLOW EVALUATION EVENT
Phoenix Convention Center - 126ABC
Senior Member Discussion: 2:30 - 3:30 PM • Fellow Member Discussion: 3:30 - 4:00 PM

WELCOME RECEPTION IN THE EXHIBIT HALL: 5:00 - 7:00 PM

"AFTER THE WELCOME RECEPTION" YP EVENT: Huss Brewing Downtown PHX Brewpub
225 E Monroe St, Phoenix, AZ 85004, 5:00 - 7:00 PM (Pre-Registration Required)

SPEAKERS BREAKFAST
Phoenix Convention Center - 126ABC: 7:00 - 8:30 AM (Breakfast Only on the Day of Presentation)

REGISTRATION/INFO DESK: 7:30 AM - 5:00 PM

COMPANION SUITE: Sheraton Phoenix Downtown - North Mountain
Monday - Thursday: 7:00 - 10:00 AM (Pre-Registration Required)

CLAYTON R. PAUL GLOBAL UNIVERSITY

ADVANCE YOUR EMC KNOWLEDGE AND CAREER WITH IN-DEPTH CLASSES ON EMC AT THE IEEE EMC SOCIETY'S PREMIER EDUCATIONAL EVENT.

TUESDAY, WEDNESDAY & THURSDAY • ROOM: 124A

Chair: Arturo Mediano, *Professor, I3A, University of Zaragoza*

The topics for this year's Global University are those that have been proven to be valuable to participants in previous Symposia. The event for this year will provide the attendees with a great learning experience, due to the ability for interaction between instructors and attendees, as well as providing networking among attendees.

This year's Global University will truly be an event that honors Dr. Paul's efforts and dedication to the EMC Society as well as
maintains his high standards in providing EMC educational opportunities!

Attendees may qualify for IEEE professional development hours (PDH) and continuing education units (CEU) certificates. Course size is limited and will be filled on first-come, first-served basis.

PLEASE NOTE: The Clayton R. Paul Global University course content is intended for engineers who have been working in EMC and/or SIPI for several years and wish to be able to deepen their understanding. It is suggested that those who would like to attend will have already participated in the "Fundamentals Tutorial" held on Monday during the annual IEEE EMC Society Symposium week.

RATE:

$400

Photo by Richard Georgerian

Read the instructor bios and presentation abstracts:
www.emc2024.org/programs/technical-programs/global-university

SPEAKERS AND TOPICS

The course begins with a short introduction followed by ten presentations that are designed to encourage attendees' questions. Attendees will have opportunities for discussions with the instructors.

SIGNAL SPECTRA
Dr. Flavia Grassi
Professor, Politecnico Milano

NON-IDEAL BEHAVIOR OF COMPONENTS
Dr. Anne Roc'h
Assistant Professor,
Eindhoven University of Technology

RADIATED EMISSIONS
Mr. Lee Hill
MSEE, Missouri University of Science & Technology
Founding Partner, SILENT Solutions LLC & GmbH
Adjunct Faculty, Worcester Polytechnic Institute (WPI)
Associate Tutor, University of Oxford

CONDUCTED EMISSIONS
Dr. Arturo Mediano
Professor, I3A, University of Zaragoza
Founder The HF Magic Lab
IEEE Senior Member. Chair EMC-S Spain Chapter.
Past Chair MTT-S MTT-17 Committee.

ELECTROSTATIC DISCHARGE (ESD)
Dr. Todd Hubing
Professor Emeritus, Clemson University
IEEE Fellow, ACES Fellow
Past President, IEEE EMC Society

PCB DESIGN FOR EMC
Dr. Bruce Archambeault
Adjunct Professor,
Missouri University of Science & Technology
IBM Distinguished Engineer Emeritus
Principal, Archambeault EMI/EMC Enterprises
IEEE Fellow, Past President, IEEE EMC Society

SHIELDING
Dr. Frank Leferink
Professor, University of Twente
Technical Authority, THALES Nederland
IEEE Fellow

SIGNAL INTEGRITY
John Golding
Mr. John Golding
Sr. Applications Engineer Consultant
Siemens EDA

CROSSTALK
Dr. Daryl G. Beetner
Professor, Missouri University of Science & Technology
Director, Missouri S&T Electromagnetic Compatibility Laboratory
Director, NSF Center for Electromagnetic Compatibility

POWER INTEGRITY
Dan Chirpich
MSEE at University of Kansas
Principal Engineer, AppliedLogix, LLC.
Signal and Power Integrity Lead

DATE & TIME	TITLE	LECTURER
TUES, AUG 6 • 8:00-10:00AM	Signal Spectra	**Dr. Flavia Grassi** *(Politecnico Milano)*
TUES, AUG 6 • 10:30AM-12:00PM	Non-Ideal Behavior of Components	**Dr. Anne Roc'h** *(Eindhoven University of Technology)*
TUES, AUG 6 • 1:00-3:00PM	Radiated Emissions	**Lee Hill** *(SILENT Solutions LLC & GmbH)*
TUES, AUG 6 • 3:30-5:15PM	Conducted Emissions	**Prof. Dr. Arturo Mediano** *(University of Zaragoza)*
WED, AUG 7 • 8:00-10:00AM	Electrostatic Discharge	**Dr. Todd Hubing** *(Clemson University)*
WED, AUG 7 • 10:30AM-12:00PM	PCB Design for EMC	**Dr. Bruce Archambeault** *(Missouri University of Science & Technology)*
WED, AUG 7 • 1:00-3:00PM	Shielding	**Dr. Frank Leferink** *(University of Twente)*
WED, AUG 7 • 3:30-5:15PM	Crosstalk	**Dr. Daryl G. Beetner** *(Missouri University of Science & Technology)*
THUR, AUG 8 • 8:00-10:00AM	Signal Integrity	**John Golding** *(Siemens EDA)*
THUR, AUG 8 • 10:30AM-12:00PM	Power Integrity	**Dan Chirpich** *(AppliedLogix, LLC)*

*Attendees participating in Clayton R. Paul Global University must attend all 20 hours of the instruction to receive a participation certificate. Other Symposium sessions and activities can be attended outside of these hours.

TUESDAY, AUGUST 6

ATE-1
ASK THE EXPERTS
PANEL DISCUSSION

AUTOMOTIVE HYBRID, ELECTRIC AND AUTONOMOUS – ADDRESSING THE COMPLEXITY OF MODERN VEHICLES

10:00AM - 11:30AM

Room: Exhibit Hall

Organizer:
Janet O'Neil, *ETS-Lindgren*

Today's complex vehicle platforms include propulsion, entertainment and safety related systems all having to function reliably without impacting safety or the legacy communications infrastructure. The increased interest in autonomous vehicles is also driving the need for more sophisticated automotive EMC design and test scenarios, such as those addressing EMC, sensors (including radar) and wireless considerations. This impacts both component level and full-vehicle level emissions and immunity

Our Automotive "Ask the Experts" panelists represent a diversity of automotive related organizations, including full vehicle manufacturers, an integrated circuit (IC) test specialist, members of the ISO/CISPR D Automotive EMC Committees, an automotive test chamber and instrumentation manufacturer, and a commercial automotive EMC test lab. These experts will share their knowledge on current and future automotive EMC design and test considerations. Bring your questions or simply listen and learn.

PLANNED PANELISTS INCLUDE:

Bob Mitchell, *TUV Rheinland, Littleton, MA, USA*

Garth D'Abreu, *ETS-Lindgren, Cedar Park, TX, USA*

Keith Frazier, *Ford Motor Company, Dearborn, MI, USA*

Jens Medler, *Rohde & Schwarz, Munich, Germany*

Cheyne Scoby, *Rivian Automotive, Long Beach, CA, USA*

Rich Boyer, *Aptiv, Warren, OH, USA*

EXHIBIT HOURS:

TUESDAY, AUGUST 6
Exhibits Open: 9:30 AM – 7:00 PM
Welcome Reception: 5:00 PM – 7:00 PM

WEDNESDAY, AUGUST 7
Exhibits Open: 10:00 AM – 5:00 PM

THURSDAY, AUGUST 8
Exhibits Open: 10:00 AM – 1:00 PM

Learn more about the EMC+SIPI 2024 Exhibit Hall on Pages 152

TUESDAY, AUGUST 6

ED01
EXPERIMENT DEMONSTRATION

CRACKING THE SHIELD: NOISE SUPPRESSION SHEETS (NSS) AND BOARD LEVEL SHIELDING (BLS) FOR YOUR PCB

10:00AM - 12:00PM

Room: Exhibit Hall - E&D Booth 1

Knowing which Noise Suppression Sheets has to be selected for your application in electromagnetic compatibility (EMC) and signal integrity, can be a tricky matter. Join our session for studying in focus on NSS, examining their composition, magnetic characteristics, the effect of different thicknesses. We will also provide a practical insights into the integration shielding solution for improving the board level shielding from your application with shielding cans or shielding cabinets, discussing the trade-offs between possible solutions.

Don't miss our session where we unveil the cutting-edge wonders of **Noise Suppression Sheet** and **Board Level Shielding.**

PRESENTERS

Victor Martinez Garcia[1], Jared Quenzer[2]
[1]Wurth Elektronik, Germany; [2]Würth Elektronik, USA

ED02
EXPERIMENT DEMONSTRATION

BULK CURRENT INJECTION TECHNICAL DEMONSTRATION

10:00AM - 12:00PM

Room: Exhibit Hall - E&D Booth 2

The purpose of this demonstration titled "BCI Demo" is to show how to calculate and a achieve test levels with a BCI system for ISO 11451, MIL-STD-461G, and IEC 61000-4-6 test standards. We will work backwards given a test level, known transfer impedance from industry probes and equipment and then follow good practices to size generators and amplifiers accordingly (following an 80% rule).

The ease of setting up a test like this when there is a fully automated software that can control all instrumentation will also be highlighted during this demo. The goal is to see how close we can get to the reach measurements given the constraints we operate under.

PRESENTERS

Sean R. Lynch
Rohde & Schwarz, USA

TUESDAY, AUGUST 6

ED03
EXPERIMENT DEMONSTRATION

USING LOW COST SOFTWARE DEFINED RADIO (SDR) FOR EMC INVESTIGATIONS

10:00AM - 12:00PM

Room: Exhibit Hall - E&D Booth 3

Karen Burnham will demonstrate how different SDRs, costing between $20 - 200, can be used for EMC purposes. In particular, she will demonstrate using SDR dongles in combination with antennas and/or current probes to get a sense of the EM/RF environment in a particular area and potential trouble spots.

PRESENTERS

Karen Burnham
Electro Magnetic Applications, Inc., USA

ED04
EXPERIMENT DEMONSTRATION

UNVEILING TIME DOMAIN GATING: ENHANCING CONTROL AND VERSATILITY WITH A NEWLY DEVELOPED LIBRARY

10:00AM - 12:00PM

Room: Exhibit Hall - E&D Booth 4

Time domain gating is a well-known technique for isolating responses in reflective environments, commonly integrated into commercial vector network analyzers (VNAs). However, users often have limited options for further processing once data is downloaded from a VNA. To address this, a gating library has been developed which provides greater flexibility to users. This library can easily integrate with popular programming languages such as Matlab, Python, and C. Gated results often suffer from "band edge effects" due to limited measurement bandwidth. To mitigate this, the library incorporates standard edge treatment techniques and introduces a new Spectrum Extension Edgeless Gating (SEEG) method, significantly reducing edge effects compared to conventional methods. In addition, the library is not limited to time domain applications, but also performs well in spatial and spectrum analyses, such as image processing and antenna spectrum analyses. During demonstrations, real-time gating of antenna responses will be showcased, with parameters adjusted via Matlab script. Additionally, outputs from conventional edge renormalization and SEEG techniques will be compared to highlight the latter's superiority in edge treatment. Furthermore, spectrum mode filtering for antenna extrapolation will be demonstrated, showing the library's versatility beyond time-domain applications, utilizing data from the Boeing Dual Robotic Antenna Measurement System (DRAMS) for real-time gating in the angular spectrum domain.

PRESENTERS

Yibo Wang[1], Andrew Shyne[2]
[1]ETS-Lindgren, USA, [2]The Boeing Company, USA

SS01 SPECIAL SESSION

MACHINE LEARNING AIDED SI, PI, EMC AND EMI SESSION

10:30AM - 5:00PM

Room: 125AB

Sponsored by SC-3

SESSION #1:
Co-Chairs:
Lijun Jiang, *Missouri University of Science and Technology, Rolla, MO, USA*
Sourajeet Roy, *Indian Institute of Technology Roorkee, Roorkee, India*

SESSION #2:
Co-Chairs:
Alistair Duffy, *De Montfort University, Loughborough, United Kingdom*
Hanzhi Ma, *Zhejiang University, Hangzhou, China*

SESSION #3:
Co-Chairs:
Jianfeng Zheng, *University of Houston, Houston, TX, USA*
Matteo Cocchini, *International Business Machines Corp, New York, NY, USA*
Mohamed Kheir, *SDU, Syddansk Universitet, Odense, Syddanmark, DK, academic, Sonderborg, Denmark*

Machine learning is having a profound effect Machine learning is having a profound effect on the landscape of every technology domain, including signal integrity, power integrity, EMC, and EMI engineering. This special session will present the state-of-the-art in our IEEE Society. It will focus on the paradigm shift of using machine learning to generate innovations in a way that's differentiate to traditional design and analysis approaches. The session will aim to draw deeper analysis and facilitate open discussions about the pros and cons of machine learning in EMC/EMI, SI and PI.

10:30AM
Imitation Learning-Based Fast Optimization of SSD Interface for PCIe 6.0 Considering Signal Integrity
Seonguk Choi[1], Jihun Kim[1], Taein Shin[1], Jungmin Ahn[1], Keunwoo Kim[2], Keeyoung Son[3], Joonsang Park[1], Jinwook Song[4], Kyungsuk Kim[4], Sunghoon Chun[4], Joungho Kim[2]
[1]*Korea Advanced Institute of Science and Technology, Korea;* [2]*Samsung Electronics, Korea*
EMC BEST PAPER FINALIST
ABSTRACT: In this paper, we propose an genetic algorithm (GA)-based imitation learning (IL) for fast optimization method of interface in the Peripheral Component Interconnect Express (PCIe) 6.0 system using Pulse Amplitude Modulation (PAM4) signaling. PCIe is the main interface standard for connection between CPU and GPU or solid-state drive (SSD) with a high data rate. However, issues related to signal integrity (SI) become severe as the data rate per lane has increased with each generation. Therefore, optimizing both the PCIe channel and equalizer is required. The proposed method trains the policy network to obtain immediately the optimal design of the channel and equalizer by using the imitation learning method. Based on the high-quality data obtained from the GA, the policy network learns the expert trajectories. Furthermore, the training process is implemented in several host systems. Hence, the trained policy network has reusability for an arbitrary electrical characteristic of the host systems. For verification, the proposed method is applied to the E1.L SSD interface design task. As a result, the superiority of the proposed method is validated by comparing conventional optimization algorithms in terms of optimal performance and computational time.

11:00AM
High-Speed Link Transient Simulation based on Simple Recurrent Unit Method
Hanzhi Ma, Jiarui Qiu, Ling Zhang, Da Li, ErPing Li
Zhejiang University, China
ABSTRACT: Time-domain transient simulation is a crucial signal integrity modeling technique in high-speed link design. Recurrent Neural Network (RNN), a commonly used machine learning method for high-speed link transient simulation, faces a limitation in parallel operation during computation. This constraint presents challenges when analyzing high-speed links with long input bit patterns. In this paper, we introduce an effective and accurate transient simulation approach that utilizes the Simple Recurrent Unit (SRU) for assessing signal integrity in high-speed links. Applied to a nonlinear high-speed link example, the SRU model demonstrates both a faster training and improved accuracy in predicting output signals compared to the conventional RNN model.

TUESDAY, AUGUST 6

11:30AM

High-Speed Channel Simulator using Neural Language Models

Hyunwook Park[1], Yifan Ding[1], Ling Zhang[2], Natalia Bondarenko[3], Hanqin Ye[3], Brice Achkir[3], Chulsoon Hwang[1]
[1]Missouri University of Science and Technology, USA; [2]Zhejiang University, China; [3]Cisco Systems Inc., USA

ABSTRACT: In this paper, high-speed channel simulators using neural language models are proposed. Given the input sequence of geometry design parameters of differential channels, the proposed channel simulator predicts SI characteristic sequences such as insertion loss (IL) and far-end crosstalk (FEXT). Sequence-to-sequence (seq2seq) networks using a recurrent neural network (RNN) and a long short-term memory (LSTM) are utilized for the estimator. Moreover, a transformer network which is a recent neural engine of large language models (LLMs) is introduced for the first time. Compared to seq2seq networks, the transformer network-based simulator can achieve shorter computing time due to its parallel computation called an attention. The accuracy and training time of seq2seq and transformer networks are validated and compared. As a result, all the proposed simulators show ~1% error rates for both the IL and FEXT. However, for the training time, the transformer network achieves 75%–83% reduction compared to seq2seq networks.

1:30PM

A Hybrid Algorithm to Dual Sparse Sampling Measurement in Time-Resolved Electromagnetic Near-Field Scanning

Yanming Zhang[1], Shichang Gao[1], Lijun Jiang[2]
[1]The Chinese University of Hong Kong, China; [2]Missouri University of Science and Technology, USA

ABSTRACT: Time-resolved electromagnetic near-field scanning is vital for antenna measurement and addressing complex electromagnetic interference and compatibility issues. However, the swift acquisition of high-resolution spatiotemporal data remains challenging due to physical constraints, such as moving the probe position and allowing sufficient time for sampling. This paper introduces a novel hybrid approach that combines Kriging for sparse spatial measurement, compressed sensing (CS) for sparse temporal sampling, and dynamic mode decomposition (DMD) for a comprehensive analysis of dual-sparse sampling electromagnetic near-field data. CS optimizes sparse sampling in the time domain, capitalizing on the inherent sparsity within electromagnetic radiated signals, resulting in reliable representation of time-domain signals and reducing the required time samples. Latin hypercube sampling guides the probe position, facilitating sparse measurement in the space domain. DMD extracts meaningful insights from the resulting sparse spatiotemporal data, producing sparse dynamic modes and temporal evolution information. Subsequently, Kriging is employed to infer missing spatial measurements for each sparse dynamic mode. Finally, the entire spatiotemporal signals are reconstructed based on interpolated dynamic modes and temporal evolution information. Validation of the proposed method is demonstrated with an example using crossed dipole antennas as the device under test. The Kriging-CS-DMD framework effectively reconstructs electromagnetic fields with precision while concurrently reducing the measurement workload in both the time and space domains. This methodology holds promise for various applications, including space-time-modulated electronic devices.

2:00PM

Machine Learning Model for a Trace Referenced to Meshed Ground Planes

Jiyue Zhu, Xiaoyan Xiong, Gang Kang, Karthikeyan Mahadevan
Cadence Design Systems Inc., USA

ABSTRACT: Transmission lines (TL) with meshed ground planes have been widely used in Flexible Printed Circuit Boards (FPCB) because of its physical flexibility and weight. Unfortunately, the introduction of the meshed ground plane increases the complexity of modeling for the signal integrity of TL, which is beyond the capability of TL theories and 2D numerical methods. Although 3D full wave methods can characterize the electric properties accurately, it costs time and computation resources heavily. In this paper, we propose a machine learning model to calculate the inductance and capacitance per unit length (PUL) of TL with meshed ground planes. In this model, multiple physical parameters which can affect the characteristic impedance are taken into account. Simulation samples are obtained using 3D full wave simulations as training and testing data. The testing results show that predictions of the machine learning model are in good agreement with the results of 3D full wave simulations.

2:30PM

Efficient Distribution-Based Process Corner Identification using Machine Learning

Andrew Page, Matteo Cocchini, Zhaoqing Chen
IBM Corp., USA

ABSTRACT: This paper presents a novel method of open-area wire corner modeling for high-speed PCB's based on the statistics of transmission line performance calculated using a pair of neural network surrogate models. This approach requires significantly less data than a polynomial interpolation surrogate model or a brute-force sweep, the two predominant alternatives. This reduction in overhead allows the same problems to be solved in a fraction of the time and allows introduction of more complexity into corner model extraction. It is demonstrated for a differential stripline embedded in a low-loss material giving a 10-D design space, showing a 5x speedup over the previous methods while exhibiting excellent accuracy and providing statistical information. Correlation between a live training metric and ground-truth model performance is examined in a convergence study.

TUESDAY, AUGUST 6

3:30PM

Active Machine Learning for Automatic High-Frequency EMI Source Localization

Jinghai Guo[1,2], Ling Zhang[1], Xin Yan[3], Hanzhi Ma[3], Da Li[3], ErPing Li[1]
[1]Zhejiang University, China; [2]National Key Laboratory of Intense Pulsed Radiation Simulation and Effect, China; [3]Missouri University of Science and Technology, USA

ABSTRACT: This paper proposes a sparse emission source microscopy (ESM) technique based on active machine learning to localize high-frequency electromagnetic interference (EMI) sources. The proposed method, which combines the query-by-committee (QBC) algorithm and a newly proposed entropy feedback (EF) technique, can significantly improve the efficiency of high-frequency EMI source location by reducing the number of scanning points. The results of simulation and measurement examples show that the proposed method is much more time-efficient compared with the full sampling method. Also, the method demonstrates a noticeable advantage over the uniform sampling and random sampling approaches, and has higher accuracy of EMI source location with the same number of sparse scanning samples.

4:00PM

A Fast Metalearning Algorithm for Neural Network Enabled Uncertainty Quantification of Graphene based Interconnects with Passive Shielding

Asha Kumari Jakhar, Dyuti Basu, Km Dimple, Surila Guglani, Avirup Dasgupta, Sourajeet Roy
Indian Institute of Technology Roorkee, India

EMC BEST PAPER FINALIST AND BEST STUDENT PAPER SEMI-FINALIST

ABSTRACT: Inserting passive shield lines in between the active and victim conductors has become a standard approach for mitigating the crosstalk effects in multi-walled carbon nanotube (MWCNT) and multilayer graphene nanoribbon (MLGNR) interconnect networks. However, the insertion of the shield lines augments the number of conductors of the network, thereby making the training of artificial neural network (ANN) surrogate models of such networks from SPICE simulations a time-consuming process. In this paper, this problem is addressed using a novel multistage metalearning algorithm. In the proposed algorithm, an additional ANN is trained using data extracted from SPICE simulations of the network where the active and victim lines are represented using the rigorous multiconductor circuit (MCC) model and the shield lines are represented using the compact but approximate equivalent single conductor (ESC) model. Finally, the metadata extracted from this additional ANN is leveraged to achieve higher training efficiency not possible using standard metalearning algorithms. Validation examples of MWCNT and MLGNR interconnect networks at 7-nm technology node are presented in this paper.

4:30PM

Graph Convolutional Neural Network Assisted Genetic Algorithm for PDN Decap Optimization

Haran Manoharan[1], Jack Juang[1], Ling Zhang[3], Hanfeng Wang[2], Jingnan Pan[2], Kelvin Qiu[2], Xu Gao[2], Chulsoon Hwang[1]
[1]Missouri University of Science and Technology, USA; [2]Google LLC, USA; [3]Zhejiang University, China

SIPI BEST STUDENT PAPER SEMI-FINALIST

ABSTRACT: This paper proposes a hybrid algorithm combining reinforcement learning (RL) and a genetic algorithm (GA) for PDN decap optimization. The trained RL agent uses a graph convolutional neural network as a policy network and predicts the decap solution for a given PDN impedance and target impedance, which is seeded as an initial population to the GA. The trained RL agent is scalable regarding the number of decap ports. The main goal is to save computation time and find the near global minimum or global minimum. Generalization of the algorithm to different decap libraries is achieved through transfer learning, eventually reducing the training time of the RL agent. The proposed algorithm finds a decap solution satisfying target impedance twice as fast compared with genetic algorithms.

BEST STUDENT PAPER CONTEST

The Best Student Paper Contest recognizes and celebrates outstanding research contributions from students. The contest seeks to identify and reward innovative, high-quality research papers that demonstrate exceptional insight, originality, and academic rigor. Submissions are evaluated by a panel of experts from diverse academic fields, and winners receive a prestigious award during the award luncheon. Finalists will be invited to pitch their work during the Young Professional event, and present a poster during the conference as part of the final evaluation steps. This contest aims to encourage and support the next generation of researchers and scholars, fostering a culture of academic excellence and intellectual growth.

Join us to support our students and learn more about their outstanding Technical Papers!

Tuesday, August 6
in the Exhibit Hall
2:45 - 3:45 PM

TUESDAY, AUGUST 6

TC2-1 TECHNICAL PAPERS

EMC MEASUREMENTS FOR PCBS AND MEMORY COMPONENTS

10:30AM - 12:00PM

Room: 127B

Sponsored by TC-2

Chair:
Ghery Pettit, *Pettit EMC Consulting, Olympia, WA, USA*

Co-Chair:
Ahalya Srikanth, *Ford Motor Company, Lasalle, ON, Canada*

PLANNED SPEAKERS & TOPICS

10:30AM

Octal-Input Zero-Span-Mode Analyzer using FPGA Boards

Satoru Hatsukade[1], Keiji Wada[2]
[1]Railway Technical Research Institute, Japan; [2]Tokyo Metropolitan University, Japan

ABSTRACT: Measuring leakage currents in the rolling stock is crucial to avoid electromagnetic interference (EMI). Particularly, tackling common-mode current paths at a given signal frequency at several locations simultaneously is essential because railway signaling equipment uses electromagnetic waves below 10 MHz to detect trains and for vehicle-to-ground communications. This paper presents a measurement instrument that can simultaneously record eight inputs in zero-span mode using two low-cost field-programmable gate array boards.

11:00AM

Reactive Magnetic Near-Field to Far-Field Transformation based on Plane Wave Spectrum at PCB Level

Dong-Hao Han, Ming-Jie Pang, Xing-Chang Wei
Zhejiang University, China

EMC BEST STUDENT PAPER SEMI-FINALIST

ABSTRACT: This paper proposes a reactive magnetic near-field to far-field transformation method based on plane wave spectrum (PWS), aiming at electromagnetic radiation emission (RE) assessment at printed circuit board (PCB) level. Different from the antenna near-field measurement, the scanning plane is usually located in close vicinity of the device under test (DUT) in electromagnetic interference (EMI) near-field measurement, within the reactive region where evanescent waves are dominant. Additionally, in consideration of the presence of a ground plane on PCB, the tangential reactive electric near-field is minor, thus making it more common to measure the tangential reactive magnetic near-field. This further increases the difficulty of predicting far-field, which is commonly characterized by and . In this paper, the formula for magnetic near-field to far-field transformation is derived. Compared with the traditional dipole source reconstruction method, the proposed method eliminates the need for any intermediate steps and showcases an enhanced precision in predicting the far field of different examples. Additionally, the proposed method exhibits stronger robustness against noise interference, even in scenarios where the signal-to-noise (SNR) ratio is as low as 0 dB. Subsequently, numerical and experimental examples corroborate the effectiveness of the proposed mothed for reactive magnetic near-field to far-field transformation.

11:30AM

Designing Spectrum Analyzer Measurements for EMI Analysis of Memory Components

Praveen Gurrala, Todd Elson
Micron Technology Inc., USA

ABSTRACT: Spectrum analyzers are widely used for peak emission power measurements in electromagnetic interference applications. For wideband input signals, the measured amplitudes must be corrected to account for the attenuating effect of small resolution bandwidths (RBW). We develop an analytical relationship between the peak amplitude and the RBW for bursty input signals of the type typically associated with DRAM memory operation and demonstrate its validity in emissions measurements. We also propose a method to improve the signal-to-noise ratio by repeating the test pattern periodically.

TC9-1 TECHNICAL PAPERS

MODELING TECHNIQUES FOR RADIATION

10:30AM - 12:00PM

Room: 127C

Sponsored by TC-9

Chair:
Shubhankar Marathe, *Amazon Lab126, Santa Clara, CA, USA*

PLANNED SPEAKERS & TOPICS

10:30AM

Effects of the Asynchronous Differential Signals on Radiated Emissions
Jaehoon Kim
Altair Engineering Inc, USA
ABSTRACT: Asynchronous differential signals are studied in terms of how much their phase difference quantitatively contributes to electromagnetic noise radiated both from a PCB and a cable. A simulation setup, based on the CISPR 25 standard, is utilized to understand the EMI effect difference between the PCB and the cable. More importantly, it is estimated when the cable is closely coupled with the differential signal's clock frequencies and leads to the worst radiated emissions.

11:00AM

Impact of Different Voltage Source Models on Radiated Field and Incident Power Density within the Boundary Element Method Formalism
Anna Šušnjara Nejašmić, Dragan Poljak
Sveuciliste u Splitu Fakultet elektrotehnike strojarstva i University of Split, Croatia
ABSTRACT: This paper deals with the impact of different voltage source models on computed radiated electromagnetic (EM) field and incident power density (IPD) in the framework of boundary element method formalism. Quarter, half and full wavelength dipole antennas are placed in free space. Antenna current is obtained by solving the Pocklington's integrodifferential equation via Galerkin-Bubnov Indirect Boundary Element Method (GB-IBEM). Delta gap (DG) and magnetic frill (MF) are used as excitation source models. Frequency, distance, antenna radius and segment number are varied. Relative errors in current, EM field and IPD values are computed for MF source with respect to DG source. It is found that definition of antenna radius plays an important role in the difference between the results obtained with DG and MF sources. The relative error does not depend on frequency nor on distance from the antenna for EM field and IPD.

ARIZONA FUN FACT

COTTON IN ARIZONA

The Arizona Pima Indians have been growing their luxury Pima cotton variety in this state since the early 1800's – they use a technique so sophisticated that it rivals Egyptian Cotton in quality, and is used as a silk replacement.

In cooperation with the USDA, Supima brand cotton is grown exclusively in the United States and is used by countless U.S apparel companies.

TUESDAY, AUGUST 6

TC-10-12 TECHNICAL PAPERS

HIGH-SPEED INTERCONNECTS AND NOISE COUPLING

10:30AM - 12:00PM

Room: 128A

Sponsored by TC-10

Chair:
Hanfeng Wang, *Google Inc, Mountain View, CA, USA*

Co-Chair:
Chulsoon Hwang, *Missouri University of Science and Technology, Rolla, MO, USA*

PLANNED SPEAKERS & TOPICS

10:30AM

Vertical Interconnect Technology in Silicon, Package, and Printed Circuit Board (PCB) with Coaxial Structure

Junyong Park[1], Chaofeng Li[1], Eddie Mok[2], Joe Dickson[2], Joan Tourné[3], Donghyun Kim[1]

[1]Missouri University of Science and Technology, USA; [2]Wus Printed Circuit (Kunshan) Co., Ltd, USA; [3]NextGin Technology, Netherlands

ABSTRACT: This paper introduces vertical interconnect technology in silicon, package, and printed circuit board (PCB) levels with a coaxial structure, respectively. The coaxial structure has been known to be advantageous in terms of signal integrity (SI) compared to the non-coaxial structure. The coaxial structure is easy to control the characteristic impedance Z0 and robust to crosstalk. The silicon-level interconnect includes the wire bonding (WB) and through-silicon via (TSV) technology, the package-level interconnect includes an elastomer package test socket. The PCB-level interconnect includes the vias, and vertical conductive structure (VeCS). For each level, the non-coaxial and coaxial interconnects are compared with the measurement results in the frequency domain. In conclusion, this paper successfully shows the improvement of the coaxial structure at silicon, package, and PCB levels.

11:00AM

Channel Budget Assessment of ENRZ and PAM4

Francesco de Paulis[1], Sherman Shan Chen[2], Tim Wang-Lee[3], Luis Boluna[3], Mike Resso[3], Brandon Gore[4]

[1]University of L'Aquila, Italy; [2]Kandou Bus, United Kingdom; [3]Keysight Technologies, USA; [4]Samtec Corporation, USA

ABSTRACT: The development of future interconnect technology will involve the exploration of different modulation or channel encoding schemes. This abstract deals with a one-toone comparison between the PAM4 and Ensemble NRZ (ENRZ) to verify their performances based on the same data throughput of 224 Gbps. The maximum length (loss) reached without equalization is investigated, and the receiver equalization (CTLE and DFE) required by the PAM4 based channel will be derived to obtain comparable results with the ENRZ without equalization in terms of eye height and width.

11:30AM

Noise Reduction Technique to Meet Power Delivery Requirements for High Speed IPs

Haijin Zhang[1], Jinsong Hu[1], Xiao Hu[1], Qing Zhou[2]

[1]Intel Corporation, China; [2]Intel Corporation, USA

ABSTRACT: In multichip package (MCP) design, merging power rails is common to reduce costs. However, power noise often couples between different IPs via the power delivery network. High-speed IPs like PCIE gen5 require tight power noise control. This paper proposes an embedded low-pass filter in the package to attenuate high-frequency power noise coupling to high-speed IPs, reducing peak-to-peak noise on the power rail by 75%. Our approach is valuable for power design for high-speed IPs and MCPs.

TC10-S1 TECHNICAL PAPERS

CROSSTALK, JITTER, NOISE COUPLING, BER ANALYSIS #1

10:30AM - 12:00PM

Room: 128B

Sponsored by TC-10

Chair:
Jianmin Zhang, *Google Inc., Mountain View, CA, USA*

Co-Chair:
Francesco de Paulis, *University of L'Aquila, L'Aquila, Italy*

PLANNED SPEAKERS & TOPICS

10:30AM

Modeling of Ground-Bounce Induced Jitter for Rising Transition Edges in CMOS Inverters

Anuj Kumar, Jai Narayan Tripathi
Indian Institute of Technology Jodhpur, India

SIPI BEST STUDENT PAPER SEMI-FINALIST

ABSTRACT: An analytical modeling approach for ground-bounce noise (GBN) induced jitter in CMOS inverters for the rising transition edges at the output is presented in this paper. To estimate jitter at the inverter output, the device parameters of the transistors are used for a comprehensive analysis. A closed form expression for jitter is derived by establishing the input-output relationship of the CMOS inverter based on the different operating modes of the transistors. The proposed analytical method has been validated using several examples and for various process corners of 40 nm United Microelectronics Corporation (UMC) technology. The transient responses of the inverter with and without noise, as well as estimated jitter using the proposed method is closely matched with the results obtained from an SPICE based simulator.

11:00AM

Modeling of Power Distribution Network (PDN) Noise Coupling Induced Clock Phase Noise

Zhekun Peng[1], Junyong Park[1], Chaofeng Li[1], Joey Stecher[1], Srinivas Venkataraman[2], Xu Wang[2], Granthana Rangaswamy[2], DongHyun (Bill) Kim[1]
[1]Missouri University of Science and Technology, USA; [2]Meta Platforms Inc., USA

ABSTRACT: Phase noise analysis is important to clock design. Noise sources of spurs shown on the phase noise result are challenging to find out due to the unknown source locations and coupling mechanisms. Noise from power distribution network (PDN) is one of the most troublesome sources. A behavioral modeling methodology is proposed to simulate the clock phase noise induced by PDN noise coupling for two different mechanisms : PDN-to-clock additive coupling and PDN-to-PDN up-conversion modulation. The thermal noise and 1/f flicker noise are simplified to provide a straightforward view of spur level. The model can be applied to both single-ended clock and differential clock. The result of the model can be used to compare the power spectral density of the potential noise sources and provides hypothesis on the potential noise source together with layout change simulation. The potential root cause of the spurs is analyzed. The mitigation methodologies of the phase noise are proposed and evaluated in the specific case, presenting a 34 dB suppression to the spurs shown on a differential clock phase noise.

11:30AM

Modeling of Variability-Aware Supply-Induced Jitter in VMD Circuit Driving Long Transmission Lines

Vinod Kumar Verma, Bhavani Sankar Challa, Jai Narayan Tripathi
Indian Institute of Technology Jodhpur, India

ABSTRACT: This paper discusses the impact of variations in device parameters on power supply-induced jitter for a voltage-mode driver circuit driving long transmission lines. It aims to provide a comprehensive study on variability-aware modeling of power supply-induced jitter. Semi-analytical expressions are derived to estimate jitter, considering both power supply noise and variability issues. The mathematical expressions are validated by comparing the results obtained from the analytical approach with those obtained from the EDA simulations. Compared to the EDA simulator, the suggested method offers a notable speedup in jitter estimation.

TUESDAY, AUGUST 6

TC-2-2 TECHNICAL PAPERS

EMC MEASUREMENTS FOR WIRELESS COMMUNICATIONS, PULSED INTERFERENCE AND TRANSISTORS

1:30PM - 3:00PM

Room: 127B

Sponsored by TC-2

Chair:

Tom Braxton, *Elite Electronic Engineering Inc, Bolingbrook, IL, USA*

PLANNED SPEAKERS & TOPICS

1:30PM

Assessing Time-Scale-Dependent Interference Vulnerabilities in Wireless Communications

Michelle Pirrone[1,2], Jordan Bernhardt[1], Adam Wunderlich[1]

[1]National Institute of Standards and Technology, USA; [2]University of Colorado Boulder, USA

EMC BEST STUDENT PAPER SEMI-FINALIST

ABSTRACT: We demonstrate a general-purpose approach to evaluate interference immunity at the source (data payload origin) of a `closed-box' wireless communication system over different time-scales. Specifically, using a consumer off-the-shelf point-to-point microwave link operating in the unlicensed U-NII-5 6GHz band as the victim system, we assess the impact of injected pulse-modulated noise with various signal periods at the source of a communication link. Observed distributions of link throughput show performance degradation and multimodal behaviors that are problematic for critical applications where a minimum data throughput is desired or required to maintain a given quality of service. Particularly, impacts from pulse-modulated noise are observed to induce greater link degradation as compared to constant additive white Gaussian noise with the same average power, highlighting the need to re-evaluate current EMC test methods that use constant AWGN as a benchmark interference signal.

2:00PM

Cage-in-Cage Test Setup for Discontinuous Radiated Emissions from GaN Transistors in the Gigahertz Frequency Range

Krzysztof Sieczkarek, Bartłomiej Nagórny, Adam Maćkowiak, Tomasz Warzyński, Michał Rokossowski, Radosław Szczepański

Łukasiewicz Research Network - Poznan Institute of Technology, Poland

ABSTRACT: The article presents a method for measuring unwanted radio frequency emissions in the frequency range 30 MHz to (at least) 6 GHz coming from new types of transistors based on gallium nitride (GaN). A test set-up based on dedicated Faraday cage was designed to extract emissions passing only through the transistor housing. Secondary screening was achieved through the use of an anechoic chamber and fast broadband spectrum measurement was performed using a real-time EMI receiver.

2:30PM

A Device for the Detection of HPEM Interference based on an LPDA Antenna with Nonlinear Load

R. Michels[1], M. Schaarschmidt[2], S. Fisahn[2], F. Gronwald[1]

[1]Universitat Siegen, Germany; [2]Bundeswehr Research Institute for Protective Technologies and CBRN Protection, Germany

ABSTRACT: Antenna structures with nonlinear loads that are exposed to electromagnetic illumination may show responses that are difficult to predict. A remarkable effect can be observed if a diode is chosen as nonlinear load. In this case, the rectifying property of the diode can lead to an energy storage effect that appears as a rather long lasting voltage at the antenna port. Besides the fact that this energy storage effect might be a major issue regarding EMC it is also possible to use it for the detection of high power electromagnetic (HPEM) pulses without requiring advanced high frequency equipment. In this contribution it will be shown that the broadband characteristics of a common log-periodic dipole antenna (LPDA) combined with a nonlinear energy storage effect can be utilized to develop an efficient low-cost HPEM pulse detector.

TC9-2 TECHNICAL PAPERS

COMPUTATIONAL EM

1:30PM - 3:00PM

Room: 127C

Sponsored by TC-9

Chair:
Shaohui Yong, *Missouri University of Science and Technology, San Jose, CA, USA*

PLANNED SPEAKERS & TOPICS

1:30PM

Efficient Crosstalk Evaluations for Electric Vehicles using FDTD and Transmission Line Simulations
Kyle Elsasser, Karen Burnham
Electro Magnetic Applications, Inc., USA
ABSTRACT: In electric vehicle (EV) architectures, a significant risk to electromagnetic self-compatibility is crosstalk between high voltage (HV) cables and low voltage (LV) signal lines such as the Controller Area Network (CAN) bus. Switching noise resulting from inverter or DC/DC conversion operations can be carried on HV lines and then couple into sensitive LV lines via a radiative crosstalk mechanism. When these threats are identified in advance, computational electromagnetic (CEM) modeling and simulation can be used to rapidly iterate through different design mitigations to arrive at a practical and cost-effective solution to ensure self-compatibility between the HV and LV systems. This paper presents a case study where this approach was used to improve the design of an EV mobile charging trailer to prevent likely threats to the CAN network.

2:00PM

3D Full Wave Finite Element Method for Advanced IC Pattern-Dependent Effects Analysis
Baolong Li, Lei Yue
Cadence Design Systems Inc., USA
ABSTRACT: During the sub-nanometer IC manufacturing process, the physical width, thickness, and sheet resistance of a wire generally depend on the surrounding wiring, called Pattern-Dependent Effects. The Pattern-Dependent effects can change resistance and capacitance values by up to 50%, so it is important to account for them in simulation and modeling. Luckily, some RFIC EM simulation software offered solutions in the past, but they are not 3D full-wave algorithms. This paper will describe the challenges of FEM for such type of problem and introduce a hybrid electromagnetic algorithm to solve this effect and verify the effectiveness of this approach with a simple transmission line example.

2:30PM

A Modal Network Representation of Complex Electrical Structures Suitable for an Overall EMC System Analysis
Hannes Schreiber, Marco Leone
Otto von Guericke Universitat Magdeburg, Germany
ABSTRACT: A novel efficient and versatile method for the modeling of electrical structures by an equivalent modal network is presented. Based on a modal full-wave solution, the network model can fully represent the system behavior and thus provides very good matches with conventional full-wave simulation even for complex examples. In contrast to black-box models, the presented approach provides physical insight into the system due to its modal description. This enables EMC analysis and optimization of the overall system by network simulation. The validity of the method is demonstrated by a computational example referring to an extensive Method-of-Moments full-wave solution.

TUESDAY, AUGUST 6

TC10-13 TECHNICAL PAPERS

POWER DISTRIBUTION NETWORKS AND DECOUPLING #1

1:30PM - 3:00PM

Room: 128A

Sponsored by TC-10

Chair:
Kinger Cai, *Intel Corporation, San Jose, CA, USA*

Co-Chair:
Jingook Kim, *Ulsan National Institute of Science and Technology (UNIST), Ulsan, Korea (the Republic of)*

PLANNED SPEAKERS & TOPICS

1:30PM

Innovatiave Decoupling Capacitor Solutions for Power Delivery Improvement on Advanced FPGA Packages
Wei Liu, Guang Chen, Jenny Xiaohong Jiang, Ed Milligan
Intel Corporation, USA

ABSTRACT:
In this paper, the innovative on-package decoupling capacitor (OPD) technique is presented for power delivery network (PDN) design optimizations with next generation Field- Programmable Gate Array (FPGA) for intensive power consumption usage. The paper introduces general on-package decoupling capacitor techniques, compares discrete multi-layer ceramic capacitors with deep trench capacitors, and demonstrates the advantage of deep trench capacitor (DTC) application in optimizing voltage noise in power delivery network. With the proposed DTC methodology, the voltage supply 1st droop at the package C4 bump can be reduced by 5mV in one example compared with MLCC (multi-layer ceramic capacitors) to reach design specifications. An accurate noise simulation methodology and package routing optimization strategy in noise optimization are essential to an efficient system evaluation and demonstrated in this paper.

2:00PM

Experimental Study of PCB Vibration Induced by MLCC Assembly Orientation and Process Variations
Yifan Ding[1], Ming-Feng Xue[2], Jianmin Zhang[2], Xin Hua[2], Benjamin Leung[2], Eric A. MacIntosh[2], Chulsoon Hwang[1]
[1]Missouri University of Science and Technology, USA; [2]Google Inc., USA

SIPI BEST STUDENT PAPER SEMI-FINALIST

ABSTRACT:
The piezoelectric effect will cause the multilayer ceramic capacitor (MLCC) to deform in several directions. When it is soldered to the printed circuit board (PCB) and powered on, these deformations will exert a certain force on the PCB, causing the PCB to vibrate and emit acoustic noise at a certain frequency. Determining the dominant deformation direction that MLCC can affect the PCB is relevant and important for efficiently extracting the equivalent source of noise. This paper provides a method to determine the dominant deformation direction produced by MLCC, explores it through experimental measurement results, and finally provides a conclusion to the investigation.

2:30PM

Novel Interdigital Capacitor-Type Power Distribution Network Design for Power Noise Suppression in Redistribution Layer Interposer
Haojie Wu[1], Xinglin Sun[2], Keeyoung Son[2], Jonghyun Hong[2], Yin Sun[3], Joungho Kim[2]
[1]Zhejiang University, China; [2]Korea Advanced Institute of Science and Technology, Korea; [3]Ningbo Detool Technology Co. Ltd, China

SIPI BEST PAPER FINALIST

ABSTRACT: The interposer-based high bandwidth memory-graphic processing unit (HBM-GPU) module plays the key role for high-performance computing (HPC) with ultra high data bandwidth. Among different interposer structures, redistribution layer (RDL) interposer has exhibited outstanding signal integrity performance due to its low dielectric constant (Dk) substrate. However, the low-loss characteristic results in compromised power integrity performance and increased coupling of power noise. Conventional methods that center on the placement of decoupling capacitors and filter-type structures cannot be effectively implemented on the RDL interposer due to its passive characteristic and limited routing space. In contrast to these methods, our focus is on designing the RDL interposer structure itself. In this paper, we proposed a novel power distribution work (PDN) design featuring an interdigital capacitor (IDC)-type structure and a hybrid-substrate layer stack, obtaining a larger on-interposer capacitor. We conducted simulations and analyses to investigate the impact of the proposed PDN structural parameters on the PDN impedance profile. Finally, we validated the effectiveness of the proposed IDC-type PDN in improving the PDN impedance and achieving superior noise attenuation by comparing it with the conventional mesh-type PDN.

TC10-2 TECHNICAL PAPERS

MATERIAL CHARACTERIZATION FOR SI

1:30PM - 3:00PM

Room: 128B

Sponsored by TC-10

Chair:
Tao Wang, *Amazon Lab126*

Co-Chair:
Wei Zhang, *Marvell, Santa Clara, CA*

PLANNED SPEAKERS & TOPICS

1:30PM

DK and DF Characterization of Low-Loss Dielectric Liquid by Cylindrical Cavity Resonator

Chaofeng Li[1], Seyedmehdi Mousavi[1], Reza Asadi[1], Seyedmostafa Mousavi[1], Reza Vahdani[1], Xiaoning Ye[2], Kai Wang[2], DongHyun Kim[1]
[1]Missouri University of Science and Technology, USA; [2]Intel Corporation, USA

ABSTRACT:
A novel cylindrical cavity resonator-based measurement method was developed to characterize the dielectric property of the low-loss dielectric liquid in the paper. The proposed method can be used to accurately measure the dielectric constant (Dk) and the loss tangent (Df) of the low-loss coolant for signal integrity analysis. The cylindrical cavity resonator works at tangential magnetic (TM010) mode is used in the paper to demonstrate the proposed method. A cylindrical cavity resonator apparatus was designed and investigated using full-wave simulations at first. The relative error of Dk and Df extractions based on the designed apparatus are less than 1% and 5% from simulation results, respectively. In addition, the designed apparatus was manufactured to verify the proposed method through measurements. Measurements demonstrate the high accuracy and repeatability of the proposed method for low-loss dielectric liquid characterization. The measurement uncertainty for Dk could be less than 1%.

2:00PM

Design of the TM_{010} Mode Cylindrical Cavity Resonator for PCB Dielectric Characterization

Reza Asadi[1], Chaofeng Li[1], Seyedmostafa Mousavi[1], Seyed Moastafa Mousavi[1], Reza Vahdani[1], Xiaoning Ye[2], DongHyun Kim[1]
[1]Missouri University of Science and Technology, USA; [2]Intel Corporation, USA

ABSTRACT: This paper presents the study of the TM010 mode cylindrical resonator, which can be used for printed circuit board (PCB) material properties extraction, e.g., the dielectric constant (Dk) and the loss tangent (Df) extraction. The theoretical formulas of the resonance frequency and Q-factor of the resonator are presented. In real measurement, the TM010 mode cylindrical cavity resonator needs to be excited by the probe. The study emphasizes the impact of probe orientation, location, and field distribution on the accuracy of material property extraction. The relationship between cavity dimensions and resonance frequency is explored, highlighting the influence of cavity radius and height on material property characterization. Visual representations and simulations illustrate the significance of these dimensions in accurately determining Dk and Df. The paper also compares the efficiency of electric- (E-) and magnetic- (H-) probe feeding methods through full-wave simulations. Results indicate that the E probe exhibits superior accuracy, with relative errors below 0.2% for Dk and less than 2.2% for Df, while the H probe shows a relative error of 0.1% for Dk and 8% for Df. The presented analysis can help the development and the manufacture of the cavity resonator method, for characterizing the PCB material.

2:30PM

Analytical Modeling of Partially-Filled TM_{010}-Mode Dielectric Resonator for Accurate DK and DF Extraction

Mehdi Mousavi[1], Chaofeng Li[1], Reza Asadi[1], Seyedmostafa Mousavi[1], Reza Vahdani[1], Xiaoning Ye[2], Mina Esmaeelpour[1], DongHyun Kim[1]
[1]Missouri University of Science and Technology, USA; [2]Intel Corporation, USA

ABSTRACT: In high-speed printed circuit board (PCB) modeling, the accurate determination of the dielectric constant (DK) and dissipation factor (DF) is crucial for signal integrity analysis at design stage. This paper introduces an analytical approach using a partially filled TM010-mode dielectric resonator, an effective tool for DK and DF extraction of PCB material. We begin by discussing the theoretical underpinnings of TM010-mode dielectric resonators and their applicability in measuring the DK and DF of the material under test. A mathematical model is then presented, linking the resonant characteristics directly to the DK and DF of the dielectric material. The validity of this model is established through comprehensive simulations results, highlighting its precision in determining DK and DF values. Our research not only underscores the practicality of TM010-mode dielectric resonators in PCB design but also offers a robust analytical framework for advance electronic material analysis in high-speed applications.

TUESDAY, AUGUST 6

ATE-3
ASK THE EXPERTS
PANEL DISCUSSION

MODERN SOLUTIONS TO THE INCREASING DEMAND FOR SMALLER, HIGHER PERFORMANCE PCB/IC/CHIP PACKAGES

2:00PM - 3:30PM

Room: Exhibit Hall

Organizer:
Anil Kumar, *Principal Engineer, Intel*

This panel will focus on "Modern Solutions to the Increasing Demand for Smaller, Higher Performance PCB/IC/Chip Packages." As the demand for smaller and higher performing electronic devices continues to grow, it presents unique challenges for Electromagnetic Compatibility (EMC), Signal Integrity (SI) and Power Integrity (PI) engineers.

The panel will explore the complexities and advancements in PCB/IC/Chip packages that enable smaller form factors while maintaining high performance. Our esteemed panelists, who are experts in the field, will share their insights and experiences in addressing these challenges.

Join us as we delve into topics such as miniaturization techniques, advanced packaging technologies, design considerations, and simulation and test methodologies. Discover the latest trends and innovative solutions that are revolutionizing the industry. Don't miss this opportunity to engage with industry leaders, gain valuable knowledge, and network with professionals in the field. Whether you have burning questions or simply want to expand your understanding, this panel is a must-attend event for anyone involved in EMC and SI/PI for PCB/IC/Chip packages.

PLANNED PANELISTS INCLUDE:

Harry Skinner, *Intel, OR, USA*

Kendall Hiles, *Siemens Digital Industries Software, NC, USA*

Lijun Jiang, *Missouri University of Science and Technology, MO, USA*

Ken Willis, *Cadence, CA, USA*

ED05
EXPERIMENT DEMONSTRATION

COMMON MODE – WHERE DOES IT COME FROM AND HOW CAN IT GO AWAY?

2:00PM - 4:00PM

Room: Exhibit Hall - E&D Booth 1

We hear about common mode currents. The question becomes how are they generated, and why are they a problem? If they exist in a product, how do we control it? What works and what does not work? Through both teaching and demonstration, Mr. Andre will demonstrate each of these points.

PRESENTERS

Patrick G. Andre
Andre Consulting, Inc., USA

ED06
EXPERIMENT DEMONSTRATION

VISUALIZATION OF LOW FREQUENCY EMI USING A SMARTPHONE

2:00PM - 4:00PM

Room: Exhibit Hall - E&D Booth 2

We will be demonstrating an application where we use a smartphone to map low frequency EMI. Data is captured through a magnetic sensor connected to the headphone jack and onboard GPS sensors. This data is then fused to provide a map of low frequency EMI up to 16 kHz. The map is dynamic and interactive, allowing one to view a heatmap of EMI or interrogate the EMI spectrum at a given point.

PRESENTERS

Kevin Claytor
Johns Hopkins University Applied Physics Laboratory, Johns Hopkins University Applied Physics Laboratory, Laurel, MD, US, academic/physics, USA

ARIZONA FUN FACT CITRUS IN ARIZONA

Arizona is one of the five citrus-producing states in the United States, dating back to 1887 when the first orange grove was planted near Camelback Mountain. Arizona Highways Magazine explains, "In 1935, more than 1.2 million boxes of grapefruits were produced in the state, and according to the U.S. Department of Agriculture, grapefruits reigned supreme until about 1942," (Ritchie). Water constraints have reduced Arizona's capacity for growing Citrus as a state, but citrus trees will always adorn houses and neighborhoods throughout the valley. It is a reminder of winter harvest and remains a staple in cocktails and recipes.

TUESDAY, AUGUST 6

ED07
EXPERIMENT DEMONSTRATION

THE CHALLENGE OF MEASURING A 40 UOHM (2000 AMP) PDN WITH A 2-PORT PROBE

2:00PM - 4:00PM

Room: Exhibit Hall - E&D Booth 3

The assessment of PDN impedance has become a well-published mantra. However, designing a power distribution network (PDN) for a scalable 2000 Amp power supply presents numerous challenges, one of which is measurement of the 2000A PDN.

Most of us are aware of the ground loop in the 2-port measurement. Most of us are also aware that we need to introduce a ground loop isolator to correct the error. If not, we've published plenty on the subject. But how much CMRR do you need to add? How does the use of a probe impact this requirement? The goal of this presentation is to demonstrate how one can effectively measure a 2000 Amp PDN or 40 uOhm using various VNAs. In addition to proving the need for CMRR rejection, discussion on how to calculate the minimum CMRR with a PDN impedance measurement using a 2-port probe will be shown. Lastly, it will be shown that it is possible to measure a sub-40 Qff impedance using a 2-port probe, when using an isolator that has sufficient CMRR.

PRESENTERS

Steve Sandler
California Miramar University, USA

Benjamin Dannan
Signal Edge Solutions

ED08
EXPERIMENT DEMONSTRATION

WI-FI 6E/7: AMAZING NEW FRONTIERS AND CHALLENGES ... EXPERIMENT/DEMONSTRATION

2:00PM - 4:00PM

Room: Exhibit Hall - E&D Booth 4

Wireless connectivity has had such an impact on how we conduct our daily lives. With the wires removed, suddenly we are able to be connected to almost anyone, anywhere and anytime. According to a report released by IDC Research, 3.8 billion Wi-Fi devices were forecasted to be shipped in 2023. Over the last few years, the number and complexity of the Wi-Fi standards has grown. The U.S. opened up the 6 GHz band while the EU opened up about half of the 6 GHz bands for Wi-Fi 6E, and now Wi-Fi 7. Although the Wi-Fi 7 standard has yet to be formally adopted, manufacturers have released Wi-Fi 7 products already. Each new standard offers more.. more bandwidth, more data transfer, more capability. With that increase, however, comes more measurement challenges to address for regulatory approval. This presentation will review the changes and discuss the measurement challenges in achieving regulatory approval.
Presentation will include videos with examples and experimental results.

PRESENTERS

Bill Koerner
Keysight Technologies Inc., USA

TC2-3 TECHNICAL PAPERS

EMC MEASUREMENTS – PROBES

3:30PM - 5:00PM

Room: 127B

Sponsored by TC-2

Chair:
Ghery Pettit, *Pettit EMC Consulting, Olympia, WA, USA*

Co-Chair:
Monrad Monsen, *Oracle, Broomfield, CO, USA*

PLANNED SPEAKERS & TOPICS

3:30PM

On the Feasibility of a Direct Injection Probe with a Capacitively Coupled Return and Integrated Voltage Monitor

Aaron Harmon, Daniel Szanto, Victor Khilkevich, Daryl Beetner

Missouri University of Science and Technology, USA

EMC BEST PAPER FINALIST

ABSTRACT:

Characterizing the susceptibility of an IC while it is integrated within a system can be challenging. Characterization is even harder if one wants to know the waveform at the target IC pin when injecting a signal on the pin. In this work, the feasibility of a direct injection probe with a capacitively coupled return and integrated voltage monitor is proposed. This probe is advantageous because it does not need to be soldered to the test device and its ability to provide a measurement of the waveform on the target IC pin during the injection. Methods for reconstructing the pin waveform based on probe measurements are discussed. Initial results indicate that the presented probe is generally insensitive to landing position variations and can accurately provide the waveform at the target IC during an injection. Future work is focused on further validation of the presented probe.

4:00PM

Design of Waveguide Probe for EMI Characterization of DDR5 SODIMM

Xiangrui Su[1], Junho Joo[1], Minsu Lee[2], Jeongho Ju[2], Hyunsik Kim[2], Taeil Bae[2], Haekang Jung[2], Chulsoon Hwang[1]

[1]Missouri University of Science and Technology, USA; [2]SK hynix Inc., Korea

ABSTRACT:

In the latest portable electronic devices, 5th generation double data rate small outline dual in-line memory modules (DDR5 SODIMMs) are more and more used and have been identified as one of the critical electromagnetic interference (EMI) noise sources that could cause RF desensitization. In this paper, the radiation mechanism of DDR5 SODIMM deployed in a laptop is identified and investigated based on near-field scanning. It was found that a cavity formed by the SODIMM and the main board can generate strong radiation around 2.4 GHz due to their dimensions, which overlap with the Wi-Fi band. To quantify the radiation from the cavity, a waveguide probe was designed to perform quick measurements. The performance of the proposed probe showed better sensitivity compared to conventional loop probes. The designed probe was built and used to characterize 4 different SODIMMs from 3 manufacturers. The waveguide probe-measured noise was proportional to the coupled power on the Wi-Fi antenna with an accuracy of 3 dB.

4:30PM

Full Modal-Admittance Matrix In-Circuit Measurement by Multiple Inductive Probes

Simone Negri, Giordano Spadacini, Flavia Grassi, Sergio A. Pignari

Politecnico di Milano, Italy

EMC BEST PAPER FINALIST

ABSTRACT:

In past years, the use of clamp-on inductive probes was proposed for measuring the impedance or admittance at radio frequencies while the equipment under test (e.g., power electronic converters) is in operation. However, previous one-port methods (involving either one or two probes) allow only an approximate determination of the common-mode (CM) or differential-mode (DM) self-impedance, depending on how the probe/s is/are clamped on wires, and requesting (for DM) the disconnection of the CM return wire. Furthermore, with a single port it is not possible to determine the mutual-modal impedance parameter related to mode conversion. In this paper, a recently proposed multiport measurement method, originally intended for physical admittance measurement, is adapted to modal admittance measurements, resulting in a fast and effective solution for the characterization of full admittance matrices in the modal domain. By experimental tests on passive test networks, it is shown that the proposed method provides accurate results of the true CM/DM self and mutual admittances.

TUESDAY, AUGUST 6

TC9-3 TECHNICAL PAPERS

MULTI-PHYSICS MODELING

3:30PM - 5:00PM

Room: 127C

Sponsored by TC-9

Chair:

Shaowu Huang, *Marvell Semiconductor Inc, Cupertino, CA, USA*

PLANNED SPEAKERS & TOPICS

3:30PM

The Study on How Model Selection Propagates in High Frequency Electromagnetic-Thermal Dosimetry

Mario Cvetković, Dragan Poljak, Hrvoje Dodig
University of Split, Croatia

ABSTRACT:

This paper is on the electromagnetic (EM)-thermal dosimetry workflow in GHz frequency range. The hybrid boundary element method/finite element method (BEM/FEM) is used to calculate the induced electric field due to exposure to plane EM wave at 0.9 GHz, 1.8 GHz, 3.5 GHz, and 6 GHz. Two simplified human head models are considered, homogeneous one and non-homogeneous one. The output of two EM models is used as input to the thermal model based on Pennes' bioheat equation solved by means of FEM. The numerical results for the induced electric field, the specific absorption rate, the temperature increase and the heating factor, respectively, are compared point-wise along the propagation axis. By representing the human head with simplified geometry such as a sphere, the influence of geometry on the calculated metrics can be minimized, while focusing on the results along the diameter of the spherical head, the effect of the plane wave polarization can be neglected. As the frequency increases toward the transition frequency of 6 GHz, similar results are obtained with both homogeneous and non-homogeneous models, respectively. The results suggest that if we are interested in the thermal response, the homogeneous EM model of biological tissue might prove sufficient.

4:00PM

Modeling Non-Linearity in Laplace Domain

Naomi de Mejanes, Olivier Maurice
ArianeGroup, France

ABSTRACT:

In this work a technic is proposed in order to model non-linearity in the Laplace Domain. The main idea is to set the non linearity by its parametric impedance function and to divide the source in temporal subdomains. The method is applied to study the voltage across a Spark Gap knowing its voltage breakdown. The main interest of the technic is its versatility. It can be used to analyze any EMC measurement in the frequency domain.

Photo by Richard Georgarian

TC8 & TC2 TECHNICAL PAPERS

AEROSPACE EMC AND SHIELDING

3:30PM - 5:00PM

Room: 128A

Sponsored by TC-8 and TC-2

Chair:
Jen Dimov, *NASA, Greenbelt, MD, USA*

Co-Chairs:
Jim Lukash, *Lockheed Martin Space Systems, Palo Alto, CA, USA*
John Kraemer, *Kraemer EMC, Marion, IA, USA*

PLANNED SPEAKERS & TOPICS

3:30PM

HIRF Avoidance Approach for Advanced Air Mobility Vehicles
Truong X. Nguyen
NASA Langley Research Center, USA

ABSTRACT:
Advanced Air Mobility (AAM), including Urban Air Mobility (UAM) and Unmanned Aerial Systems (UAS), vehicles may fly in similar airspace to Transport Category Rotorcraft, thereby requiring meeting the same stringent High-Intensity Radiated Fields (HIRF) certification requirements. This effort proposes a map-based approach to avoid high-power transmitters based on the vehicle tolerance level. In addition, a minimum threshold level is suggested for vehicles operating in an urban area. As a result, a vehicle can tolerate common lower-power transmitters by default, and transmitter maps are only needed to avoid high-power transmitters which are far less common. Transmitter data are analyzed for New York City representing an urban area.

4:00PM

Broad Band Measurement of the Shielding Effectiveness of Carbon Fiber Composite Panels for Aerospace Applications
Jinsoo Kim, Pablo Trejo, Jonathan Wang, Ju Hui Yoo, Jason Ehrich, Daniel Dijamco, Kattris Lee, Clifton Courtney, Leonardo Gutierrez Sierra
Lockheed Martin Aeronautics, USA

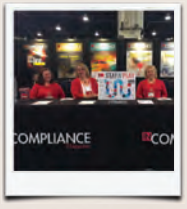
IN COMPLIANCE Magazine

Celebrating 15 years!

In 2009, when Conformity Magazine closed its doors, our team decided to start something new. That's how In Compliance was born, debuting at the IEEE EMC Symposium. Now, 15 incredible years later, we're still here thanks to you. We can't wait to keep bringing you the best in engineering compliance news and insights.

Cheers to the future!

Monthly Issues



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TC10-3 TECHNICAL PAPERS

SIMULATION AND MODELING TECHNIQUES #1

3:30PM - 5:00PM

Room: 128B

Sponsored by TC-10

Chair:
Zhen Zhou, *Intel Corporation, Chandler, AZ, USA*

Co-Chair:
Tao Wang, *Teradyne Inc, Thousand Oaks, CA, USA*

PLANNED SPEAKERS & TOPICS

3:30PM

Truncated Gaussian Monte Carlo Circuit Simulation using an Extracted Resistor Model with Randomized Power Loads

Jeffrey L. Cutcher
Ford Motor Company, USA

ABSTRACT:

EMC requirements span many different types of electronics, including those found in automobiles. These requirements cover areas such as radiated emissions, immunity and susceptibility to external emissions, and voltage fluctuations. DC battery voltage transients presented to the electronics, often lumped into EMC requirements in the Automotive Industry, could cause damage or an undesirable user experience. This paper covers the simulation and modeling steps utilized in estimating the input voltage margin to a battery voltage transient. The end goal is to have some level of confidence that the electronics under consideration can be adequately powered and functional during such a transient.

4:00PM

Far Power Referencing Impact on High-Speed Memory Interface

Yanjie Zhu, Rishik Bazaz
Intel Corporation, USA

ABSTRACT:

To maintain the best signal performance, a solid ground plane on both referencing layers for high-speed memory interfaces is recommended in Printed Circuit Board (PCB) design. Some customers and cost reduction platform designs may choose a far plane power referencing strategy to limit board layer count and meet the PCB design budget. In this paper, using a customer board as an example, memory interface margin impact due to violation of referencing recommendations is analyzed and quantified. A new signal integrity analysis method with a power referencing effect is proposed and correlated with the test platform result. The paper also discusses the future platform power referencing risk projection and mitigation proposals.

4:30PM

AMI DLL Hook: A Novel IBIS-AMI Simulation Debugging Method for Model Users

Chuanyu Li, Alaeddin A. Aydiner, Sleiman Bou-sleiman, Xinjun Zhang
Intel Corporation, USA

ABSTRACT:

With the growing complexity of Serializer / Deserializer (SerDes) Physical Layer (PHY) architecture, the I/O Buffer Information Specification (IBIS) Algorithmic Modeling Interface (AMI) standard has gained widespread acceptance among model developers. However, simulations using IBIS-AMI models can yield varying results across different electronic design automation (EDA) software. As the speed of SerDes continues to escalate, these differences become increasingly unacceptable. The reasons for these discrepancies are varied and challenging to identify, particularly for model users. This paper presents the "AMI DLL hook" method, a debugging tool for IBIS-AMI channel simulations that do not align across EDAs. In its application in a recent SerDes AMI model alternative EDA enabling project, five inappropriate user settings or unexpected EDA behaviors were identified within a single week. This method can reduce the time spent on each parameter or setting adjustment to mere minutes or seconds, as opposed to running a full-channel simulation for hours.

安全与电磁兼容
SAFETY & EMC Magazine

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WEDNESDAY, AUGUST 7

SCHEDULE AT A GLANCE

ROOM	125AB	127A	127B	127C	128A	128B
8:30 AM	TUTORIAL WT13 EMC Testing Basics	WORKSHOP WT14 Streamlined Power Integrity Model (SPIM) Workshop	TUTORIAL WT15 ESD/EMC Needs in Automotive High-Speed Links (including Ethernet): Optimizing Semiconductor Robustness	WORKSHOP WT16 Introduction to Machine Learning for Electromagnetic Compatibility and Signal Integrity	TUTORIAL WT17 Introduction to Modeling Techniques for EMC+SIPI Problems	TUTORIAL WT18 SIPI Challenges and Innovations in High-Speed System and Device Interconnects
10:00 AM	REFRESHMENT BREAK					
10:30 AM						
12:00 PM	LUNCH BREAK					
1:30 PM	TECHNICAL PAPERS TC5_1 Electrostatic Discharge	TECHNICAL PAPERS TC4_1 Control of Electromagnetic Interference: Shielding, Filtering, Modeling, and Prediction	TECHNICAL PAPERS TC9_4 Modeling Techniques for radiated and conducted susceptibility	WORKSHOP WT19 Future EMC/EMI/SI/PI Technologies with Machine Learning and Artificial Intelligence	TECHNICAL PAPERS TC10_4 Simulation and Modeling Techniques #2 & 3	TECHNICAL PAPERS TC10_6 SI/PI/EMI Co-Design
3:00 PM	REFRESHMENT BREAK					
3:30 PM	Special Session SS02 Medical Device EMC		TECHNICAL PAPERS TC9_5 Statistical and Surrogate Models			TECHNICAL PAPERS TC10_7 Power Distribution Networks & Decoupling #2
5:00 PM						

CLAYTON R. PAUL GLOBAL UNIVERSITY: 8:00 AM - 5:15 PM, 124A
(Pre-Registration Required)

GLOBAL SIPI UNIVERSITY: 8:30 AM - 5:30 PM, 129A
(Pre-Registration Required)

EXHIBIT HALL OPEN: 10:00 AM – 5:00 PM
EXPERIMENTS & DEMOS: 10:00 AM - 12:00 PM, 12:00 - 2:00 PM, 2:00 - 4:00 PM
ASK THE EXPERTS PANELS: 10:00 - 11:30 AM
POSTER SESSION - 1:30 - 3:30 PM

ADDITIONAL STANDARDS SESSIONS, WORKING GROUPS AND TECHNICAL COMMITTEES
For Collateral Meetings, please see page 141

IEEE EMC SOCIETY WOMEN IN ENGINEERING (WIE) EVENT:
3:30 - 5:30 PM, 126ABC (Pre-Registration Required)

GALA DINNER: 7:00 - 10:00 PM, 120A - Phoenix Convention Center (Ticketed Event)

SPEAKERS BREAKFAST
Phoenix Convention Center - 126ABC: 7:00 - 8:30 AM (Breakfast Only on the Day of Presentation)

REGISTRATION/INFO DESK: 7:30 AM - 5:00 PM

COMPANION SUITE: Sheraton Phoenix Downtown - North Mountain
Monday - Thursday: 7:00 - 10:00 AM (Pre-Registration Required)

GLOBAL SIPI UNIVERSITY

ANNOUNCING THE INAUGURAL COURSE
GLOBAL SIGNAL INTEGRITY AND POWER INTEGRITY (SIPI) UNIVERSITY

WEDNESDAY, AUGUST 7, 2024 • ROOM: 129A

Chair: Christian Schuster, *Hamburg University of Technology, Germany*
Co-Chair: Francesco de Paulis, *University of L'Aquila, L'Aquila, Italy*

COURSE OVERVIEW: Signal integrity (SI) and power integrity (PI) are gaining an ever-growing attention due to today's higher data rates and larger currents in high-speed digital systems. Industries call for skilled engineers with both basic and advanced background in these two disciplines. Courses dealing with SI and PI related topics at academic level are limited and offered by only a few institutions and research laboratories in the US and worldwide. The inaugural **"Global SIPI University"** aims at bridging this gap with a one-day introductory course at the Electromagnetic and Signal & Power Integrity Symposium to be held in Phoenix, Arizona, from August 5-9, 2024.

The mission of the **"Global SIPI University"** is to provide technicians and engineers the opportunity to acquire SI and PI concepts from experienced and well-known instructors from both industry and academia. The **"Global SIPI University"** offers a rigorous background directly linked with practical problems and solutions. Attendees will acquire application-oriented skills and knowledge about the need for signal and power integrity analysis as well as the tools and methods available for tackling SI and PI related problems. Basic and fundamental concepts involving limited but relevant theory will be offered to fully understand how practical problems can be approached using analytical methods, simulation tools, as well as measurements to validate simulations. Instructors will discuss design examples to provide a clear insight and processes for guiding the attendee towards problem solutions.

COURSE PRE-REQUISITES:

Electrical engineers with a professional background in EMC that want to dive into or broaden their skills in state-of-the-art signal integrity and power integrity.

Full symposium registration required in addition to the SIPI GU course fee.

RATE:

$225

Photo by Patrick Andre

Read the instructor bios and presentation abstracts:
www.emc2024.org/programs/technical-programs/global-sipi-university

SPEAKERS AND TOPICS

TIME	TOPIC	PRESENTER/INSTRUCTOR
08:00 – 8:30	**Registration / Introductions**	**Christian Schuster** and **Francesco de Paulis**
08:30 – 09:15	**Opening:** Progression of SIPI Modeling: A 50-Year Journey to Modern System Design Challenges	**Dr. Albert Ruehli** *(Missouri University of Science and Technology)* **Mr. Stephen Scearce** *(Cisco Systems)*
09:15 – 10:00	**Keynote:** Global industry trends and demands from a system and packaging perspective	**Dr. Kemal Aygün** *(Intel)*
10:00 – 10:30	**Coffee Break / Networking**	
10:30 – 11:15	**Signal Integrity I:** Passive interconnect design, lumped effects, transmission line effects	**Dr. Bhyrav Mutnury** *(AMD)*
11:15 – 12:00	**Signal Integrity II:** Electrical Signaling — Modulation, Equalization, and Channel Design	**Dr. Wendem Beyene** *(Meta)*
12:00 – 13:30	**Lunch Break / Networking**	
13:30 – 14:15	**Signal Integrity III:** Signal integrity measurements and simulation	**Dr. Eric Bogatin** *(University of Colorado, Boulder)*
14:15 – 15:00	**Power Integrity I:** Fundamentals of power integrity with practical analysis techniques for current and emerging designs	**Dr. Ihsan Erdin** *(Celestica)*
15:00 – 15:30	**Coffee Break / Networking**	
15:30 – 16:15	**Power Integrity II:** VRM, package/IC-level PDN design	**Dr. Chulsoon Hwang** *(Missouri University of Science and Technology)*
16:15 – 17:30	**The Future of SI & PI Engineering:** Open discussion with all instructors and attendees	**Christian Schuster** and **Francesco de Paulis**

CHAIR:
Christian Schuster
Hamburg University of Technology, Germany

Christian Schuster (IEEE Senior Member) received a Diploma degree in Physics in 1996 and a Ph.D. degree in electrical engineering in 2000. Since 2006, he is a Full Professor at Hamburg University of Technology (TUHH), Germany. Prior to TUHH he was with the IBM T. J. Watson Research Center, Yorktown Heights, NY. His current interests include signal and power integrity of digital systems, multiport measurement and calibration techniques, and development of electromagnetic simulation methods for communication electronics. He serves as an Associate Editor for the IEEE Transactions on EMC as well as an Adjunct Associate Professor at the School of Electrical and Computer Engineering of the Georgia Institute of Technology.

CO-CHAIR:
Francesco de Paulis
University of L'Aquila, L'Aquila, Italy

Francesco de Paulis (Senior Member IEEE) received the M.S. degree in Electrical Engineering in May 2008 from Missouri University of Science and Technology (formerly University of Missouri-Rolla), USA, and the Ph.D. degree in Electrical and Information Engineering in 2012 from the University of L'Aquila, L'Aquila, Italy. He is currently an Associate Professor at the Electromagnetic Compatibility and Signal Integrity Laboratory at the University of L'Aquila. His main research interests are in signal and power integrity, high speed channel design and optimization, composite materials for shielding and absorption, RF interference in mixed-signal system, TSVs in silicon chips and interposers, antenna design and measurement techniques, remote fault detection in transmission lines, microwave design of electronic devices and systems for space applications.

WEDNESDAY, AUGUST 7

WT13 TUTORIAL

EMC TESTING BASICS

8:30AM - 12:00PM

Room: 125AB

Sponsored by TC-2

Chair:
Jack McFadden, *ETS-Lindgren, Cedar Park, TX, USA*

Co-Chair:
Bob Mitchell, *TUV, Littleton, MA, USA*

Due to the popularity of this tutorial when it was presented in the IEEE EMC+SIPI Symposia held virtually in 2020 and 2021 as well as in person in 2022 and 2023, we have brought it back with many of the original topics and speakers! This tutorial will cover basic topics in EMC testing – from bench top analysis to designing a new laboratory/test capability. Presentations will provide practical information and real-world knowledge that can be implemented immediately. While the topics may be basic to EMC testing, we will also discuss nuances that can challenge even the most experienced EMC test practitioner. Speakers include experts who are actively involved in designing, managing, or supporting EMC test facilities. Attendees will quickly learn the best practices in each topic area.

PLANNED SPEAKERS & TOPICS

Understanding and Using EMC Antennas
Alistair Duffy
De Montfort University, United Kingdom

Calibration of EMC Test Equipment an Introduction to Calibration for EMC Testing
Ross Carlton
Gibbs and Cox Inc, USA

EMC Test Planning
Jack McFadden
ETS-Lindgren, USA

What are Emissions Tests Actually Measuring
Todd Hubing
LearnEMC, USA

EMC Lab Design: An Overview of the Process, Possibilities, and Issues
Bob Mitchell
TUV, USA

ARIZONA FUN FACT

CATTLE IN ARIZONA

In 1540, Francisco Vasquez de Coronado brought the first cattle over to Arizona from Mexico. The rest was history. Not until 1872 did Americans begin ranching in Arizona – the railroad industry a driving force.

WT14 WORKSHOP

STREAMLINED POWER INTEGRITY MODEL (SPIM) WORKSHOP

8:30AM - 12:00PM

Room: 127A

Sponsored by TC-10

Chair:
Kinger Cai, *Intel Corporation, San Jose, CA, USA*

Co-Chair:
Ji Zheng, *Aurora-System, San Jose, CA, USA*

IBIS Open Forum has approved BIRD223.1: Add Support SPIM in IBIS for platform power delivery network design review/sign-off and optimization, which uses the same philosophy as that for the invention of original IBIS for platform SI analysis, through providing minimum IP sensitivity information from chip vendors while sufficient for platform designs.

This workshop starts with an introduction to SPIM background, architecture, Tree structure in .spim file, and its linkage with .ibs. It is followed by the SPIM creation cookbook, which includes major steps of (1) Pre-modeling setups; (2) AC S parameter model generation & correlation, (3) DC R-network model generation & Correlation; and (4) SPIM creation in BIRD223.1 syntax and validation in FastPI.

The workshop will have the demo of two SPIM model creations and applications in supporting platform PDN design review/sign-off and optimization, one for Package-less power rails in industry-standard LPDDR5X devices, and the other for chip (PKG) level power rails in a SOC design.

The workshop will wrap up with SPIM in FastPI Roadmap.

PLANNED SPEAKERS & TOPICS

Platform PI Design Status Quo
Kinger Cai[1], Chi-te Chen[1], Baolong Li[2], Ji Zheng[3]
[1]Intel Corporation, USA; [2]Cadence Design System Inc., USA; [3]Aurora-System, USA

IBIS-Approved BIRD223.1: Add Support for SPIM in IBIS
Kinger Cai[1], Chi-te Chen[1], Baolong Li[2], Ji Zheng[3]
[1]Intel Corporation, USA; [2]Cadence Design System Inc., USA; [3]Aurora-System, USA

SPIM Cookbook
Kinger Cai[1], Chi-te Chen[1], Baolong Li[2], Ji Zheng[3]
[1]Intel Corporation, USA; [2]Cadence Design System Inc., USA; [3]Aurora-System, USA

FastPI Supports SPIM
Kinger Cai[1], Chi-te Chen[1], Baolong Li[2], Ji Zheng[3]
[1]Intel Corporation, USA; [2]Cadence Design System Inc., USA; [3]Aurora-System, USA

Arizona railroads paved the way for ranching, making the land more accessible and available to purchase by early settlers: "the railroads, the Atlantic & Pacific, now the Atchison, Topeka & Santa Fé, and the Southern Pacific were constructed across the territory, thus opening up millions of acres of rich grazing lands for settlement, and putting the great markets of the East within easy reach," explains author Bert Haskett (Haskett, 1935). Another important factor was the American Homestead act of 1862, which granted any adult U.S citizen 160 acres of surveyed government land with the agreement to improve it.

As more families and ranchers began settling in the west, the prairies began to develop into the resource-rich farming communities that we recognize today. The cattle industry continues to be an influential part of the Arizona economy, with over 7,500 farms and 980,000 head of cattle across the state.

WT15
TUTORIAL

ESD/EMC NEEDS IN AUTOMOTIVE HIGH-SPEED LINKS (INCLUDING ETHERNET): OPTIMIZING SEMICONDUCTOR ROBUSTNESS

8:30AM - 12:00PM

Room: 127B

Chair:
Sudhama Shastri, *Nexperia, Phoenix, AZ, USA*

Co-Chair:
Patrick DeRoy, *Analog Devices Inc., Norwood, MA, USA*

High-speed data-links (10 to 1000Mbps & into the10Gbps range) are popular in automotive applications. Ethernet (single pair) is preferred due to bi-directional communication, prevention of vendor lock-in, etc. Traditional CAN networks may be supplanted by 10-50Mbps protocols such as 10BaseT1S Ethernet, and the 100Mbps A2B 2.0 network. Automotive Ethernet enables zonal architecture with high-performance compute, on-board telematics, and sensor networks (LiDAR and RADAR). A2B is a bi-directional digital audio bus for next-gen, low-latency audio/infotainment. ESD requirements are in the range of +/-15kV contact discharge under certain OEM specifications, which reference ISO 10605 as well as IEC 61000-4-2. Another requirement is to maintain communication and signal integrity in the noisy vehicle environment. The OPEN Alliance standardization effort has recommendations for high-speed IVNs, while Tier1s and OEMs have the freedom to deviate. We will present challenges of maintaining data/signal integrity and the concept of external ESD protection as an elegant solution to signal-integrity + ESD needs for UTP cables. SEED models can be used to accurately simulate the ESD strike in a very non-linear system. Optimal placement of protection devices is explored.

PLANNED SPEAKERS & TOPICS

Automotive E/E Architecture and Signal Integrity of In-Vehicle Networks – Part 1
Ajeya Gupta
Ford Motor Corporation, USA

Taming the 3-Headed Dragon: Unpowered ESD Survivability, Powered ESD Resilience and RF/ Transient Immunity Robustness
Patrick DeRoya
Analog Devices Inc., USA

Off-Chip (Standalone) ESD Protection Solutions for Maintaining Robustness and Signal-Integrity
Sudhama Shastri[1], Andreas Hardock[2], Sergej Bub[3], Taimoor Ahmed[1]
[1]Nexperia, USA; [2]Nexperia, Germany; [3]Nexperia BV, Netherlands

Panel Discussion with All Speakers
Sudhama Shastri[1], Patrick DeRoy[2]
[1]Nexperia, USA; [2] Analog Devices Inc., USA

WT16 WORKSHOP

INTRODUCTION TO MACHINE LEARNING FOR ELECTROMAGNETIC COMPATIBILITY AND SIGNAL INTEGRITY

8:30AM - 12:00PM

Room: 127C

Sponsored by SC-3

Chair:
Zhong Chen, *ETS-Lindgren, Cedar Park, TX, USA*

Co-Chair:
Janet O'Neil, *ETS-Lindgren, Cedar Park, TX, USA*

This workshop offers an accessible introduction to machine learning (ML) in the context of Electromagnetic Compatibility (EMC) and Signal Integrity (SI), with a special focus on various ML techniques, including compressed sensing. Tailored for newcomers, the workshop aims to provide an entry point for understanding how ML applies to EMC and SI.

Speakers will present basic concepts such as learning sparse representations and the principles of compressive sensing, as well as reinforcement learning and other ML techniques. Additionally, interactive and graph-based ML approaches will be introduced to demonstrate how they can address challenges in EMC and SI. While real-world examples will be used to illustrate concepts, the main goal is to foster a solid understanding of ML principles.

By the end of the workshop, participants will have been introduced to ML concepts relevant to EMC and SI, including techniques such as compressed sensing and reinforcement learning, and their potential applications. Further exploration may be needed, but attendees will have gained valuable insights to start exploring the application of ML in EMC and SI contexts.

PLANNED SPEAKERS & TOPICS

Compressed Sensing Applications in EMC Chamber Evaluations
Zhong Chen
ETS-Lindgren, USA

Learning Sparse Representations
Douglas Cochran
Arizona State University, USA

Reinforcement Learning for PDN Optimization
Chulsoon Hwang
Missouri University of Science and Technology, USA

Advancements in Artificial Intelligence for Antenna based EMC Measurement Optimization
Dennis Lewis
The Boeing Company, USA

Harnessing Interactive and Graph-Based Machine Learning for EMC
Gautam Dasarathy
Arizona State University, USA

WEDNESDAY, AUGUST 7

WT17
TUTORIAL

INTRODUCTION TO MODELING TECHNIQUES FOR EMC+SIPI PROBLEMS

8:30AM - 12:00PM

Room: 128A

Sponsored by TC-9

Chair:
Lijun Jiang, *Missouri University of Science and Technology, USA*

This tutorial will provide an introduction to commonly used numerical modeling techniques for EMC+SIPI problems 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 its strengths and weaknesses, so engineers can decide which techniques are appropriate for their types of problems.

PLANNED SPEAKERS & TOPICS

Introduction to the Finite Element Method
Chuck Bunting
Oklahoma State University, USA

Modeling with the Method of Moments
Lijun Jiang, James Drewniak, Daryl Beetner
Missouri University of Science and Technology, USA

Introduction to Finite Difference Time Domain Technique
Bruce Archambeault[1,2]
[1]Missouri University of Science and Technology, USA; [2]IBM Corp., USA

Introduction to the Partial Element Equivalent Circuit (PEEC) Approach Applied to EMC+SI/PI Problems
Giulio Antonini[1], Daniele Romano[1], Jonas Ekman[2], Albert E. Ruehli[3]
[1]University of L'Aquila; [2]Luleå University of Technology, Sweden; [3]Missouri University of Science and Technology, USA

Efficient and High-Fidelity Full Wave Methods for Large Platform EMC Analysis
A. Mori[1], M. Bercigli[1], M. Bandinelli[1], D. Romano[2], G. Antonini[2]
[1]IDS, Italy; [2]University of L'Aquila, Italy

ARIZONA FUN FACT

THE SAGUARO CACTUS, A SYMBOL OF THE SOUTHWEST, IS ONLY FOUND IN THE SONORAN DESERT

This iconic giant cactus with its distinctive arms is synonymous with Arizona landscapes. Saguaros can live for hundreds of years and grow to towering heights.

Seeing a saguaro in its natural habitat is a quintessential Arizona experience. They symbolize the resilience of life in a harsh and beautiful environment.

WT18
TUTORIAL

SIPI CHALLENGES AND INNOVATIONS IN HIGH-SPEED SYSTEM AND DEVICE INTERCONNECTS

8:30AM - 12:00PM

Room: 128B

Sponsored by TC-10

Chair:
Thanh Tran, *Rice University, Houston, TX, USA*

Today's fastest serial digital interconnects of systems or devices run at data rates in multi-gigahertz range, and these fast switching signals can generate considerable noise and radiation which degrade and limit system performance. Maintaining good signal integrity of these signals is very challenging as interconnecting traces on a printed circuit board (PCB) or interconnecting cables in AI/cloud computing servers become very lossy which causes major issues related digital timing margin, clock recovery, inter-symbol interference, and electromagnetic radiation, etc. This tutorial session consists of presentations from experts in different industries to discuss challenges and innovations in signal and power integrity to advance next generation compute such as AI servers, aerospace and defense electronics.

The main topics covered in this tutorial session are:

1. Challenges in high-speed system and device interconnects
2. Innovations in high-speed SERDES enabling data higher than 112Gbps

PLANNED SPEAKERS & TOPICS

Enabling High-Speed Interconnects for Future High Performance Computer Applications
Walker Turner
Nvidia Corporation, USA

Methodology for Designing Accurate High-Speed Interconnects of ASICs/FPGAs on a Printed Circuit Board
Wendel Williamson, Thanh T. Tran
Raytheon Technologies, USA

PCB Compensation Techniques for Wideband Analog Filter Designs
Thanh Tran
Rice University, USA

EMI Noise Mitigation in High-Frequency GaN-Based Converters
Qiang Li
Virginia Polytechnic Institute and State University, USA

WEDNESDAY, AUGUST 7

ATE-2
ASK THE EXPERTS
PANEL DISCUSSION

STEP, STIR, OR SHAKE: WHAT'S BEST FOR A REVERBERATION CHAMBER?

10:00AM - 11:30AM

Room: Exhibit Hall

Organizer:

Vignesh Rajamani, *Rohde and Schwarz North America*

Reverberation chambers provide a versatile and efficient means of testing the electromagnetic characteristics of electronic devices in a controlled environment. Closely mimicking the real-world environment in which they operate, reverberation chambers are an essential tool in product development and certification processes. Testing in reverberation chambers is often done to ensure that electronic devices comply with regulatory standards for EMC and EMI. Although mode stirring, mode tuning, and "shaking of the walls" can be used to achieve a statistically uniform distribution in terms of amplitude, phase, and polarization, the natural debate is which is the best technique to use for a specific application.

Our "Ask the Experts" panelists represent a diversity of industry practitioners, academics, metrologists, and members of standard bodies. These experts will share their knowledge on current and future reverberation chamber test considerations. Bring your questions or simply listen and learn.

PLANNED PANELISTS INCLUDE:

Frank Leferink, *Thales and University of Twente, The Netherlands*

Garth D'Abreu, *ETS-Lindgren, Cedar Park, TX, USA*

John Ladbury, *National Institute of Standards and Technology, Boulder, CO, USA*

Craig Fanning, *Elite Electronic Engineering, Downers Grove, IL, USA*

ED09
EXPERIMENT DEMONSTRATION

AUTOMATED SI VERIFICATION METHODS FOR OPTIMAL DESIGN OF DDR SYSTEMS

10:00AM - 12:00PM

Room: Exhibit Hall - E&D Booth 1

This software demo presents the automatic SI verification method for DDR systems and provides background knowledge on the proposed approach. In this demo, the verification method consists of two parts. The first utilizes numerical analysis-related solvers for simulations, including transmission line analysis, characteristic impedance analysis, and crosstalk analysis. It particularly explains how automatic DDR compliance simulation for high-speed DDR systems is structured. The second part is an SI design rule checker based on geometric algorithms. These rules are developed through iterative simulation results and expert knowledge, representing a type of site-dependent Intellectual Property (IP). This enables SI engineers to detect design faults/defects that may violate electrical issues at the early design stage.

While conventional DDR system SI verification methods heavily rely on CAE engineering teams, the proposed approach allows circuit designers to directly detect electrical problems in high-speed DDR designs without the need for prior simulation setup or specialized knowledge of its standard. This helps reduce design iterations caused by SI problems during the development period.

For this demo, Altair PollEx simulation tools are used to analyze high-speed signal waveform data of LPDDR buses and present a methodology to find the optimal net topology. The results showed that compliant waveforms satisfying the signal integrity criteria were found within the simulation run time reduced by up to 60%, demonstrating that the proposed method was valid for automated SI verification. A live demo of the software will be shown during the presentation

PRESENTERS

Junesang Lee
Altair, USA

Photo by Richard Georgarian

WEDNESDAY, AUGUST 7

ED10 EXPERIMENT DEMONSTRATION

TRANSMISSION LINES
10:00AM - 12:00PM
Room: Exhibit Hall - E&D Booth 2

The proper functioning of any electronic system is ultimately determined by the quality of its interconnections between its circuits. Any interconnections whose length is a significant fraction of a wavelength must be treated as a transmission line. This demonstration shows 1) the importance of proper terminations of transmission lines in their characteristic impedance, and 2) impacts of improper terminations.

PRESENTERS
John C. McCloskey, Jen Dimov
NASA/Goddard Space Flight Center, Bowie, MD USA

ED11 EXPERIMENT DEMONSTRATION

COMMON-IMPEDANCE COUPLING
10:00AM - 12:00PM
Room: Exhibit Hall - E&D Booth 3

This hardware experiment demonstrates the impact of the return path impedance and the return current level on common-impedance coupling between circuits. The measurements are performed on a custom PCB, containing audio, video, and high current circuitry where the return paths for each circuit can be selectively shared with other circuits.

PRESENTERS
Nicklas Koeller[1], Bogdan Adamczyk[2]
[1]E3 Compliance, USA, [2]Grand Valley State University, USA

ED12 EXPERIMENT DEMONSTRATION

EMC PRE-COMPLIANCE TEST – DO I NEED IT?
10:00AM - 12:00PM
Room: Exhibit Hall - E&D Booth 4

Slide Presentation containing video of experimental results

To ensure safe operation, and to guarantee quality and accuracy, compliance testing is necessary to sell your device. A compliance test failure can delay produce introduction and add unplanned development expense. Pre-compliance testing allows you to cost-effectively reduce your time to market by maximizing the success your product passing final compliance testing.

PRESENTERS
Steve Narciso
Keysight Technologies Loveland, USA

ED22
EXPERIMENT DEMONSTRATION

COMPUTATIONAL EMC/EMI
12:00PM - 2:00PM
Room: Exhibit Hall - E&D Booth 1

The relentless evolution of electronic systems and the pervasive integration of wireless technologies have presented unprecedented challenges in the domains of Electromagnetic Compatibility (EMC) and Electromagnetic Interference (EMI). As these challenges become increasingly intricate, integrating computational methods has emerged as a pivotal approach to understanding, mitigating, and managing EMC and EMI issues. This workshop seeks to provide a comprehensive exploration of EMC/EMI challenges. Tailored for researchers, engineers, and practitioners involved in EMC, EMI, RF design, and related fields, the workshop aims to bridge the gap between theoretical concepts and practical applications in the context of computational EMC and EMI.

PRESENTERS
Shahid Ahmed
Ansys

ED13
EXPERIMENT DEMONSTRATION

IEC 61000-6-3 SPECTRAL DENSITY – IVL METHOD
12:00PM - 2:00PM
Room: Exhibit Hall - E&D Booth 2

IEC JWG6 has developed a generic standard of emissions limits in the 9-150 kHz frequency range (IEC 61000-6-3/A1/F2/Ed3). The need for these additional conducted emissions limits are based on observed sensitivity of equipment such as powerline communication devices, smart meters, and clocks being disrupted by emitting devices such as switching mode power supplies and PV inverters.

This technical demonstration will include an overview of measurements to implement Integral Voltage Level (IVL) following informative annex guidance, as well as live demonstrations of emissions from various suspected emissions sources (both 6-3 residential and 6-8 commercial/industrial equipment) and how their results compare to the proposed limits.

PRESENTERS
Jacob Dixon
International Business Machines Corp, USA

ED23
EXPERIMENT DEMONSTRATION

SOLUTIONS FOR DESENSE MITIGATION AND RADIATION EMISSION ANALYSIS

12:00PM - 2:00PM

Room: Exhibit Hall - E&D Booth 3

Desense can be defined as, "the degradation in the sensitivity of the receiving antenna due to noise sources, typically which are generated by the same device". With the increase in the data rate and the routing density on the PCB, the issue of desense is becoming more and more important. Considering the example of a cell phone device, nowadays it has multiple connectivity features such as Wi-Fi, Bluetooth, GPS, GSM, NFC, etc. Each of these connectivity features has their own antenna to transmit and receive data. As these features are operating on different frequencies, altogether the antennas on the device cover a wide range of frequencies. As technology advances, mobile devices are designed to achieve a smaller form factor. This forces designers to place electronic components near by each other. Also, the PCB (Printed Circuit Board) of a cell phone device has multiple memory ICs (Integrated Circuits) which are operating at a high frequency. These ICs are connected to the central processing unit via traces/tracks on the PCB. If these routed traces are not shielded properly or if they have an improper return path they start to radiate. All these factors contribute to noise that unwantedly gets coupled with the receiving antenna which reduces its sensitivity. Not only the desense, but also the proper shielding of the connected cables is of utmost importance to an EMC engineer to mitigate the unwanted radiated emissions. This software demonstration presents advanced simulation tools for desense and radiated emissions using a combination of full wave EM solutions, Multi Transmission Line (MTL) method and PCB simulations using SPICE and 2D EM solvers. During this demo, we will present specific case studies as well as live demo using Altair Feko and PollEx.

PRESENTERS

Gopi Gampala, Jaehoon Kim and C.J. Reddy
Altair

WEDNESDAY, AUGUST 7

ED24
EXPERIMENT DEMONSTRATION

THE CONCEPT OF A MODERN EMI TEST RECEIVER

12:00PM - 2:00PM

Room: Exhibit Hall - E&D Booth 4

This workshop starts with an introduction to the basics of the EMI test receiver. Characteristics, differences to oscilloscopes or spectrum analyzers, as well as important parameters for a successful EMI measurement are highlighted. This serves as a basis for the following topics of the workshop and offers participants with different levels of knowledge the opportunity to attend this workshop. With a short journey back in time to analog instruments, the technological development of EMI measurement technology and the outstanding advantages of modern instruments will be demonstrated. Modern EMI test receivers rely on the Fast Fourier Transform (FFT), which was only made possible by modern signal processing and high computing power. This achieves gigantic speed advantages compared to conventional receivers. Very large bandwidths not only ensure considerably higher measurement speeds, but also offer unprecedented possibilities for analyzing the measurement objects. This will be examined in a practical way on the instrument as well as with external automation software. In addition, the workshop shows current measurement methods in practice that highlights the problem of high input levels and solutions to avoid false masurements or even costly damages to the device. The teaching of theory in this workshop is always supported by practical measurements and demonstrations directly on the instrument.

PRESENTERS

Tobias Gross
Rohde & Schwarz

2025 IEEE INTERNATIONAL SYMPOSIUM ON ELECTROMAGNETIC COMPATIBILITY, SIGNAL & POWER INTEGRITY

EMC+SIPI 2025 RALEIGH, NC • AUGUST 18-22

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RALEIGH, NORTH CAROLINA
AUGUST 18 – 22, 2025

EMC+SIPI 2025 leads the industry in providing state-of-the-art education on EMC and Signal Integrity and Power Integrity techniques. The Symposium features five full days of innovative sessions, interactive workshops & tutorials, "Ask the Experts" panel discussions, experiments and demonstrations, and social networking events.

The Raleigh Convention Center is a bustling hub for the culture, commerce and technologies that make the area one of the most admired and sought-after places in the United States. Surrounded by quality hotels, world-class performance facilities and scores of restaurants, downtown Raleigh offers everything an attendee will enjoy.

Incorporated in 1792, Raleigh, the capital of North Carolina, is known as the "City of Oaks" for its many oak trees, which line the streets in the heart of the city. Often described as a "park with a city in it," an oak canopy practically covers the area, and there are also lakes for water activities, parks and greenways.

Research Triangle Park (RTP) near the "Triangle" cities, Raleigh, Durham, and Chapel Hill, is a hot-spot of extensive, high-tech research in the fields of science and technology. In addition, Raleigh has a vibrant arts and culinary culture. From dynamic local troupes to nationally acclaimed touring companies, theatre and symphony concerts, there's always something to see on stage. The North Carolina Museum of Art, CAM Raleigh and numerous galleries offer visual arts for the viewer.

BENEFITS & FEATURES

- Learn EMC, Signal Integrity and Power Integrity (SIPI) techniques
- Three days of expert technical papers
- Two full days of practical EMC & SIPI workshops and tutorials
- Experiments and demonstrations of fundamental and advanced topics
- Add-on educational courses to expand your knowledge of EMC and SIPI.
- Find out the latest development in IEEE EMC and SIPI standards
- Exhibits! New Technologies, Instrumentation and Solutions
- Social gathering, connecting, and the Southern hospitality of in Raleigh, NC

IEEE | EMC SOCIETY

WT19 WORKSHOP

FUTURE EMC/EMI/SI/PI TECHNOLOGIES WITH MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE

1:30PM - 5:00PM

Room: 127C

Sponsored by SC-3

Chair:
Lijun Jiang, *Missouri University of Science & Technology, Rolla, MO, USA*

Co-Chair:
Alistair Duffy, *De Montfort University, Loughborough, United Kingdom*

Machine learning (ML) and artificial intelligence (AI) are heavily investigated with the good will to advance technologies into a new age. No matter if we like it or doubt it, ML and AI will be part of the future and EMC Society has to consider how to work with ML and AI technologies.

This workshop intends to picture the potential future that we could vision or would like to have for EMC/EMI/SI/PI technologies with the augmentation of ML and AI. Experts from industries and academia are invited to present their ideas and exchange opinions. Instead of focusing on technical details, this workshop focuses on visions. It does not applaud or criticize ML and AI. It presents possible merits and potential concerns to the EMC society.

This workshop is part of EMC SC3 “ML and AI in EMC and SIPI” initiatives. After all presentations, a discussion forum will be open to all audiences for opinion exchanges.

PLANNED SPEAKERS & TOPICS

EMC SC3 ML and AI in EMC and SIPI
Alistair Duffy
De Montfort University, United Kingdom

Large Language (LLM) and Machine Learning based Design for Signal Integrity and Power Integrity
Joungho Kim, Keunwoo Kim
Korea Advanced Institute of Science and Technology (KAIST), Korea

Creating an SI/PI Database for ML Applications!?
Christian Schuster, Morten Schierholz, Til Hillebrecht
Hamburg University of Technology, Germany

AI for Integrated Chiplets Electromagnetic Integrity Design and Simulation
ErPing Li
Zhejiang University, China

Outlook of AI and ML Assisted Signal Integrity and Power Integrity Engineering
Matteo Cocchini
IBM Corp., USA

Perspective and Challenges in the Integration and Co-Design of Brain-Inspired Systems for Artificial General Intelligence
Jose Schutt-Aine
University of Illinois at Urbana-Champaign, USA

AI/ML Augmentation of Hardware Compliance Processes
Samuel Connor
IBM Corp., USA

Neural Network for the Prediction of Electric Field Intensity Applied to a Simple Scenario
Sebastian Salas Laurens, Anne Roc'h
Eindhoven University of Technology, Netherlands

LLM, ChatGPT, and GPT as the SI and PI Assistant
Lijun Jiang
Missouri University of Science and Technology, USA

Using AI/ML for Lightning Direct Effects
Philipp Boettcher, Jason S. Damazo, Benjamin A. Westin, Brian A. Carpenter, Louisa Michael, Sofia Gaham, Stefani Mokalled, Derek R. Tuck, Brain P. Justusson, Hunter B. Johnston
The Boeing Company, USA

WEDNESDAY, AUGUST 7

TC4-1 TECHNICAL PAPERS

CONTROL OF ELECTROMAGNETIC INTERFERENCE: SHIELDING, FILTERING, MODELING AND PREDICTION

1:30PM - 5:00PM

Room: 127A

Sponsored by TC-4

Chair:
Daryl Beetner, *Missouri University of Science and Technology, Rolla, MO, USA*

Co-Chairs:
Charles Jullien, *Safran Electrical & Power, Blagnac, France*
Victor Khilkevich, *Missouri University of Science and Technology, Rolla, MO, USA*

PLANNED SPEAKERS & TOPICS

1:30PM

Operation of the Bifilar Common-Mode Voltage Suppressor
James McLean
TDK Corp., USA
EMC BEST PAPER FINALIST
ABSTRACT: :
The common-mode (CM) voltage suppressor (CMVS) is essentially a tightly-coupled, center-grounded inductor. While the CM choke ideally presents an open circuit impedance to CM current, the CM voltage suppressor presents a short circuit to CM voltage. The efficacy of the CM voltage suppression depends on the magnetic coupling coefficient between the two symmetrical halves of the inductor. Bifilar winding is typically necessary in order to effect sufficiently tight magnetic coupling. However, bifilar winding causes the device to behave in a distributed sense. This, in turn, hard limits the bandwidth of the device–when the winding is one-half of the odd-mode wavelength (in the bifilar transmission line) long, it acts as a CM open circuit and a differential mode (DM) short circuit. It is further shown that the effective upper operating frequency limit is about one octave below the half wavelength frequency. These assertions are supported by an analytical model, finite element numerical simulations, and experimental data. The author believes the model and the predictions of bandwidth limitations in the bifilar CM voltage suppressor have not previously been published.

2:00PM

Analysis of Common-Mode Filter Effect for Induced Voltage by Bulk Current Injection using Chain Parameter Matrix
Nobuo Kuwabara, Tohlu Matsushima, Yuki Fukumoto
Kyushu Instiute of Technology, Japan
ABSTRACT:
Telecommunications equipment should be designed to maintain performance in electromagnetic environments. The common-mode filter (CMF) is one of the significant devices to improve immunity against electromagnetic disturbances. In this paper, the induced voltage by the bulk current injection was calculated using a chain parameter matrix, and we evaluated the CMF effect from the induced voltage. The equipment was replaced by a balun, and the matrix elements of the balun, the CMF, the injection probe, and an unshielded twisted pair cable were determined from the measurement. The relation between the source voltage of the injecting signal and the induced voltage was calculated using these matrixes in the frequency range from 1 MHz to 400 MHz, and they were compared to the measured value. The results showed that the calculated value agreed well with the measured value for the induced common-mode voltage, and the countermeasure effect of CMF could be analyzed using the proposed method. Results also showed that the induced differential-mode voltage was affected by the Scd21 of CMF.

2:30PM

Evaluating Electromagnetic Interference Effects on GNSS Receivers
Giorgi Tsintsadze[1], Haran Manoharan[1], Arushi Sahai[1], Daryl Beetner[1], Brian Booth[2]
[1]Missouri University of Science and Technology, USA; [2]Deere and Company, USA
ABSTRACT:
Electromagnetic interference can be highly disruptive to global navigation satellite system (GNSS) receivers. Interference can be intentional, but can also occur from electronics modules placed within the same system, where these modules may create sufficient unintended radiated emissions to disrupt GNSS operation. In this paper, GNSS receiver performance is evaluated in the presence of multi-tone interference. An expression for the GNSS correlator output in the presence of continuous wave interference (CWI) is derived and is extended to predict the carrier to noise density ratio, C/N0, of the receiver in the presence of multi-tone interference. C/N0 is widely used for characterizing interference with GNSS receivers. Analytical estimates of C/N0 are compared to results from measurements performed on a commercially available GNSS unit. The value of C/N0 was predicted within a standard deviation of 0.97\ dB when the noise type and level was varied,

demonstrating the accuracy of the derived equations. These equations will be used in the future to develop more intelligent guidelines for evaluating the impact of interference from electronic modules placed in the same system as a GNSS receiver.

3:30PM

Use of Embedded Ferrites for Routing under Inductors in Compact Printed Circuit Boards

Sami Heinisuo, Kari Mansukoski, Anil Kumar
Intel Corporation, USA

ABSTRACT:
Routing signals on a Printed Circuit Board (PCB) under inductors and other electromagnetic interference (EMI)-emitting components, such as switching field-effect transistors (FET), can be challenging since they induce noise to other signals. For example, using current methods, many high-speed signals cannot be routed under an inductor on any layer of the PCB stack up. By implementing embedded ferrite material in the PCB as described here, the routing constraints can be relaxed, which can enable signal routing under these devices. In this solution, ferrite is laminated as part of the PCB stack-up structure to either replace copper or dielectric insulation or both. Ferrite placement within the PCB is defined during the PCB layout design phase, so it can be placed exactly where the application requires it. This ferrite layer, or layers, may be local or may consist of the whole PCB area within the applicable layer(s) depending on application needs. Simulations of embedded ferrite placed under the typical power delivery inductor, with ferrite on dielectric layers between layers 1, 2, and 3 and traces on layer 4 of the PCB, showed up to 25-55% reduction in common mode noise when compared to a design without the embedded ferrite. By laminating ferromagnetic material as part of PCB structure to act as magnetic shield within the PCB, we can enable high speed signal routing under inductors, or free up this space to decrease the board size, increase customer product's battery size and capacity, and reduce the overall costs. All these create compelling new products and product categories for customer systems with longer battery life. Keywords—Embedded Ferrite, Routing Under Inductors, Printed Circuit Board stack-up, Noise Coupling.

4:00PM

Feasibility of Coherent Perfect Absorption based on Spoof Surface Plasmon Polaritons

Jiaqi Xing, Da Li, Ling Zhang, Er-Ping Li
Zhejiang University, China

ABSTRACT:
The coherent perfect absorption (CPA) technology has gained extensive attention in recent years. This study explores strips array configurations based on Spoof Surface Plasmon Polaritons (SSPP) to demonstrate their feasibility in achieving electromagnetic CPA by simulations. Leveraging the dispersion characteristics of metal strips of specific dimensions, electromagnetic absorption can be achieved at the corresponding frequency points. The SSPP absorptive structure is strategically positioned within the standing wave field formed by two counter-propagating coherent waves. Manipulating the phase of the control wave facilitates dynamic adjustment of the absorber's location within the standing wave field, thereby selectively enhancing or attenuating the coherent absorption effect. Particularly, the control wave's phases of 0° and 180° correspond to the two extremes for the coherent absorption. Furthermore, the frequency of the absorption peak can be manipulated by varying the size of the metal strips. Based on the above findings, this paper further presents a dual-polarized SSPP-based coherent absorber and a multi-frequency SSPP-based coherent absorber.

WEDNESDAY, AUGUST 7

TC10-4 TECHNICAL PAPERS

SIMULATION AND MODELING TECHNIQUES #2 & 3

1:30PM - 3:00PM

Room: 128A

Sponsored by TC-10

Session #2
Chair:
Yuandong Guo, *AMD, San Clara, CA*
Co-Chair:
Zhichao Zhang, *Intel, Chandler, AZ, USA*

Session #3
Chair:
Shaohui Yong, *Marvell, Santa Clara, CA*
Co-Chair:
Yuandong Guo, *Missouri University of Science and Technology, Foster City, CA, USA*

PLANNED SPEAKERS & TOPICS

1:30PM

The Worst-Case Eye Prediction Algorithm for MIPI C-PHY Signaling on Mobile Artificial Intelligence (AI) Chips

Yu-Ying Cheng[1], Suani-Kai Yang[2], Shih-Hsien Wu[2], Tzong-Lin Wu[3]
[1]*National Taiwan University, Taiwan;* [2]*Industrial Technology Research Institute, Taiwan;* [3]*National Taiwan University, Taiwan*

ABSTRACT:
This paper presents a novel method for efficiently estimating the worst-case eye diagram in MIPI C-PHY signaling. Conventional approaches for generating an eye diagram on this three-channel (four-conductor) transmission interface with particular three-phase encoding are time-intensive. To address this challenge, a novel greedy algorithm is proposed that predicts the worst-case eye based on the single state response (SSR). In addition, the combination of the C-PHY interface and the AI-chip provides a better high-resolution display. Therefore, the method is applied successfully to predict C-PHY signaling on AI chips, with the results aligning well with the transient eye.

2:00PM

Modelling Weave Effect in PCBs using 2D Cross-Sectional Analysis

Victor Khilkevich[1], Scott Hinaga[2]
[1]*Missouri University of Science and Technology, USA;* [2]*Cisco Systems, USA*

ABSTRACT:
Printed circuit board dielectric substrates are composite materials produced by embedding fiber glass fabrics into epoxy resin. Because of this the medium in the PCB transmission lines is inhomogeneous which often leads to degradation of the signal integrity performance of the lines, particularly due to the differential skew. The detrimental effect of the fiber weave can be modeled relatively accurately using full-wave analysis, but at a high computational cost. Alternative modelling techniques are less demanding, but often lack accuracy. This article investigates a possibility of using the 2D cross-sectional analysis for the fiber weave effect modeling, which considerably decreases the computational cost of modeling while retaining the accuracy inherent to the field solvers.

2:30PM

A Sub-Channel based Chord™ Signaling Channel Analysis Method

Sherman S. Chen[1], Nithin VM[1], Bob Xu[2], Francesco de Paulis[3]
[1]*Kandou Bus, United Kingdom;* [2]*Analogix semiconductor Inc., USA;* [3]*University of L'Aquila, Italy*

ABSTRACT:
A novel sub-channel-based frequency domain analysis method is proposed for analyzing the performance of the ChordTM signaling. The algorithm of converting a channel s-parameter into a ChordTM signaling sub-channel matrix is presented and validated. In the context of Ensemble Non-Return-to-Zero (ENRZ), which is the 4-wire member of ChordTM signaling, the sub-channel matrices based reflection/transmission/crosstalk parameters including the 1st/2nd/.../nth-order adjacent crosstalk, power-sum crosstalk (PSXT), and integrated crosstalk noise (ICN) are calculated and analyzed. The proposed method is then applied to three transmission line based ENRZ channels with similar return loss and insertion loss, but different crosstalk and uniformity levels. ENRZ channel simulations running at 64 Gbps are performed and the obtained eye diagrams well align with the predictions made using the recommended sub-channel based metrics, evidencing the effectiveness of the proposed method. The study also reveals that uniformity across the subchannels is crucial for the optimal performance of a ChordTM signaling system. To facilitate the assessment of the uniformity of sub-channel eye diagrams, three evenness metrics RHM, RWM, and REM are defined and can be applied for the performance evaluation of a ChordTM signaling system.

3:30PM

Linear Equalizer Effect-Included Worst Eye Diagram Estimation Method for PCIe 6.0

Seonghi Lee, Hyunwoong Kim, Seunghun Ryu, Jiseong Kim, Seongho Woo, Seungyoung Ahn
Korea Advanced Institute of Science and Technology, Korea

SIPI BEST STUDENT PAPER SEMI-FINALIST

ABSTRACT:
In this paper, linear equalizer effect-included eye estimation method was proposed for Peripheral component in- terconnect express (PCIe) Gen 6. To reflect the equalizer effect, the overall transfer function was calculated by combining the transfer function of the channel and the equalizer. The worst eye contour was predicted using the pulse amplitude modulation- 4 (PAM-4) peak distortion analysis (PDA) method. For the verification, the feed forward equalizer (FFE) and continuous time linear equalizer (CTLE) were used. For channels, 9 channel cases with different loss values were assumed. The proposed method was compared with circuit simulation by eye diagram results and simulation time. The proposed method predicted the worst contours well, including the linear equalizer effect, and significantly reduced the simulation time, down to 93% faster, which is approximately 0.86 seconds.

4:00PM

SI Impact and Modeling Accuracy of Non-Ideal Signal Routing over GND Void

Sungjoo Kim, Esha Kondapuram, Benjamin P. Silva
Intel Corporation, USA

4:30PM

COM Qualification of 100Gbps and 200Gbps High Speed Channels

Tao Wang, Brian Brecht, Benjamin Harding
Technoprobe S.p.A, Taiwan

ABSTRACT:
High speed links are favored by industries as necessary hardware that supports machine learning and data center. In this work, we present using COM (Channel Operation Margin) to evaluate physical channel's performance in IC testers. First, 100 Gbps link was studied by simulation and measurement correlations to verify our COM assessment. Then by extending the design to 200 Gbps, we apply simulated data in COM to assess the crosstalk impact from via holes in the layout. It effectively avoids over design and helps us to quickly debug the channel.

Photo by Karthik Vepuri

WEDNESDAY, AUGUST 7

POSTER SESSIONS

POSTER SESSIONS
1:30PM - 3:30PM
Room: Exhibit Floor

Dispensible Multi-Functional EMI Gap Filler for ADAS Applications
Bongjoon Lee, Michael Trebisovski, John Timmerman
Henkel Corporation, USA
ABSTRACT:
Due to miniaturization, modern electronics are prone to electromagnetic interference by cavity resonance and crosstalk. Also, as more computation power is needed to improve performance, more heat is generated, requiring enhanced heat dissipation. In this paper, we report the first silicone-free thermally conductive and EM absorbing gap filler for high frequency (77GHz) ADAS application. Multi-functional fillers enable high dispensability and processability despite the moderate thermal conductivity (4.0W/mK) and EM attenuation (90dB/cm) at 77GHz. The silicone-free matrix provides advantages for sensitive applications including camera and ADAS modules. This study shows, through simulation and direct material testing, that a multi-functional EM absorbing thermal gap filler dramatically reduces the power coupling between an antenna and an IC chip in a model ADAS application.

Voice Quality Analysis Method in NR Cellular Network
Tong Liang[1], Weijia Wu[1], Yu Liu[2], Xu Wang[2], Zhiyong Liu[1]
[1]*China Mobile Group Design Institute Co., Ltd, China;* [2]*China Mobile Communications Group Co., Ltd, China*
ABSTRACT:
With the progressing and developing of 5G voice services, to provide users with better voice calling services in complex electromagnetic environments, an effective method to evaluate the Voice over New Radio (VoNR) service quality is necessary. In this paper, a method to evaluate the voice service quality based on an AI algorithm is proposed, in which the mean opinion score (MOS) of VONR calls can be calculated with the network-side indicators as input based on a model trained with the drive test score, which is verified in the session-level voice quality scoring and can be used in cell-level voice quality scoring. This method is helpful to discover cells with poor voice service quality and verify the network optimization effects so as to increase the network quality.

Electromagnetic Shielding Analysis of Bent Slot Loaded with Absorbing Materials
Jong Hwa Kwon[1], Hyun Ho Park[2]
[1]Electronics and Telecommunications Research Institute, Korea; [2]The University of Suwon, Korea
ABSTRACT:
This paper analyzes the electromagnetic shielding property of a bent slot filled with absorbing materials by an analytic modal solution for transverse magnetic (TM) wave incidence. The penetrated fields are calculated in terms of the size of bent slot and the types of absorbing materials.

Advanced Electrically Conductive Silicones for EMI/EMC Applications
Shuangbing Han[1], Dan Zhao[1], Joe Sootsman[1], Brandon Crosby[1], Dan Marple[1], Julia Sunderland[1], Kyle McDonald[1], Scott Fleming[1], Alex Axtell[1], Yanhu Wei[1], Tom Bekemeier[1], Bin Fan[2]
[1]*Dow Performance Silicones, USA;* [2]*Dow Performance Silicones, China*
ABSTRACT:
Electrically Conductive Silicone Composites (ECSCs) have become essential solutions for EMI shielding, electrical connectivity, and grounding in consumer electronics, automotive, aerospace, and telecommunications. Distinguished by their exceptional thermal stability, broad application temperature range, flexibility, and low flammability, ECSCs offer unique advantages in EMI shielding, with the added flexibility to incorporate thermal conductivity (TC) as needed. In this presentation, we introduce several novel ECSCs characterized by high electrical conductivity (EC) and shielding effectiveness (SE). These conductive silicone composites exhibit robust adhesion to various substrates and good dispensability, making them suitable for use as adhesives, gaskets, and sealants in electromagnetic compatibility (EMC) applications.

Innovative Immunity Testing Method of Train Detection Systems to Magnetic Fields Coming from Passing Railway Rolling Stock
Krzysztof Sieczkarek, Bartłomiej Nagórny, Tomasz Warzyński, Adam Maćkowiak, Michał Rokossowski, Radosław Szczepański
Łukasiewicz Research Network - Poznan Institute of Technology, Poland
ABSTRACT:
The article shows how to acquire real-life magnetic field disturbances patterns coming from railway rolling stock emission sources and re-create them in laboratory environment. The signal coming from a moving train consisting of a locomotive and wagons was recorded in the time domain and reproduced in controlled manner with the use of EMC equipment.

A Novel System to Measure Composite Electromagnetic Fields in Underground Mines
Ronald D. Jacksha[1], Carl B. Sunderman[1], Chenming Zhou[2]
[1]*CDC NIOSH Spokane, USA;* [2]*CDC NIOSH Pitssburgh, USA*
ABSTRACT:
Electronic devices and systems used to enhance miner safety and health as well as improve production processes are becoming commonplace in underground mines. The ability of these devices and systems to function properly in each other's presence, and in the presence of legacy electrical systems, in the unique environments of underground mines is not entirely understood. To better understand possible electromagnetic compatibility issues of critical mine electronic devices and systems, researchers from the National Institute for Occupational Safety and Health (NIOSH) are conducting surveys of electromagnetic emissions in underground mines. This paper presents the design of a novel system to measure the superposition of electromagnetic electric fields generated by different sources in underground mines from 10 kHz to 6 GHz —a system which has applications in other industrial settings.

The Design and Simulation of a Broadband Low RCS Radome
Xianben Liu, Shuangshuang Meng, Wenyuan Hao, Mingbin Hu, Shaozhong Fu, Cheng Zhu
Xidian University, China
ABSTRACT:
Metasurfaces are effective tools to modulate the radiation and scattering properties of electromagnetic waves. This paper introduces the design of a broadband low radar cross section (RCS) radome based on an equivalent circuit model(ECM). The radome element consists of a lossy layer, an air layer, and a frequency selective surface(FSS) from top to bottom, which could achieve absorption in low and high frequency ranges and transmission at middle frequency band. Based on the comparison of ECM and full-wave simulation results, the radome has the advantages of TE/TM dual polarization consistency, high angle stability, miniaturization, and low profile characteristics. Besides, the integrated modeling and simulation of the radome and antenna array were carried out, which prove that the radome achieves broadband low RCS property while doesn't affect the radiation performance of the antenna array. The proposed design could be potentially applied in the field of stealth radome technology.

PCB Parameter Extraction for Frequencies up to 120 GHz
Kaisheng Hu
Ciena, Canada
ABSTRACT:
This study emphasizes the critical role of PCB material parameters, including dielectric constant (Dk), dissipation factor (Df), and surface roughness, in signal integrity analysis for high-frequency designs. The conventional reliance on vendor datasheets often results in substantial disparities between simulation outcomes and actual lab measurements due to production variations. Furthermore, lacking vendor-provided parameters in the millimeter-wave frequencies complicates accurate analysis. To address these challenges, a unique approach is proposed, involving the design, fabrication, and measurement of a dedicated test coupon board. Parameters extracted from lab measurements, rather than datasheets, are utilized in simulations, ensuring a design's success by predicting transmission line performance on real PCB products with reliable accuracy up to 120 GHz. This methodology offers a pragmatic solution for enhancing precision in signal integrity analysis, especially in the demanding millimeter-wave frequency domain.

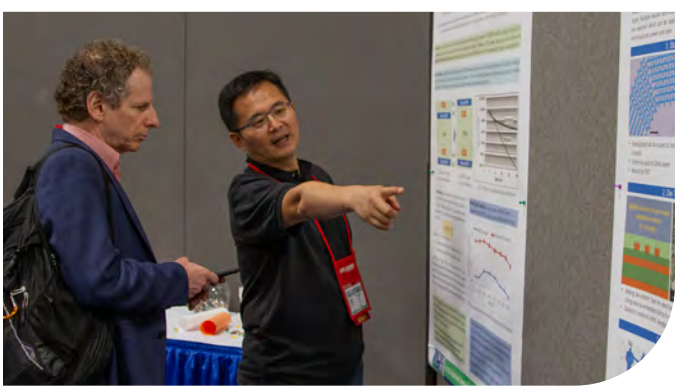

Photo by RPatrick Andre

The Generation of Hybrid-Mode Orbital Angular Momentum Beams based on Holographic Metasurfaces
Shaozhong Fu, Shuangshuang Meng, Liangliang Hu, Xianben Liu, Mingbin Hu, Wenyuan Hao, Cheng Zhu
Xidian University, China
ABSTRACT:
In this paper, a new method of designing a vortex wave beam carrying hybrid-mode orbital angular momentum (OAM) generated by holographic impedance metasurfaces is proposed. Based on the proposed impedance superposition method, OAM beams with hybrid mode composed of mixed positive and negative integer orders and fractional orders can be realized. Two typical OAM beams with 31 modes and 31.5 modes are generated through the holographic impedance metasurfaces at 20GHz, which have the benefits of multi-mode, high mode purity, and uniform mode distribution. Simulation results verify the correctness and rationality of the proposed method. The hybrid-mode OAM vortex beams have great potential applications in wireless communication, radar detection, and other fields.

Research on Shielding Performance of the Secondary Cable Armor Layer in Smart Substation
Zhonglu Liu, Weidong Zhang, Guangxiao Luo
North China Electric Power University, China
ABSTRACT:
The shielding effectiveness of secondary cables is a key feature in improving the level of EMC in substations. Howev-er, the shielding effectiveness of the secondary cable armor layer is still an unclear issue, and the armor layer's grounding method is not explained in the relevant IEEE and IEC standards. In this paper, the shunt capacity and grounding methods of shield and armor layers were tested in the laboratory and substation to clari-fy the respective shielding performance. The results show that the armor layer also has the same shunt capacity as the shield; and the method of double-end grounding of the armor layer, single-end grounding of the shield on the control room side can effectively reduce the core wire induced voltage. Finally, through test analysis and comparison, some engineering suggestions were put forward.

PCI Express Package Level Interconnection for Chiplet Design
Yang Wu[1], Xiaofeng Li[1], Yi Zeng[1], Huichao Weng[2], Amer Samarah[1], Wenjuan Zhang[2]
[1]*Intel Corporation, USA;* [2]*Montage Technology Inc., China*
ABSTRACT:
Chiplets present an effective solution to challenges encountered in advanced silicon nodes. Concurrently, chiplets raise the need for package-level data exchange among dies. This paper proposes the use of the mature PCI Express protocol for package level interconnection with benefits from the cost and technical risk control. The feasibility of this approach is discussed from both specification and transceiver design perspectives. The paper also explores potential verification methods for the transceiver and analyzes verification data, culminating in valuable insights for package-level channel design.

POSTER SESSIONS CONTINUED

Switching Transient Immunity Analysis of Wireless Communication Unit in Smart Substation
Weidong Zhang
North China Electric Power University, China
EMC BEST PAPER FINALIST
ABSTRACT:
In smart substation, the electromagnetic disturbance caused by switching operations can affect the reliable operation of wireless communication units. In this paper, taking the temperature sensor in a smart substation in China as an example, the wireless communication unit's immunity to spatial electromagnetic disturbance generated by switching operations is studied by simulation and experiment. Combined with the results of simulation and experiment, the voltage induced by the port of the 5V battery is at least 4.1 V, which will affect the chip that needs battery power. The common mode voltage and differential mode voltage between TXD, RXD and GND pins of the E22-230T22S wireless module all exceed the noise tolerance of the chip, which will cause the chip to fail to communicate with the outside world normally. The research results of this paper will provide reference for the application of wireless communication units in smart substations.

New Lightning Channel-Base Current Functions
Nathan S. Roberts
NASA Johnson Space Center, USA
ABSTRACT:
We introduce channel-base currents to represent standard lightning waveforms such as component A and actual lightning waveforms measured at launch pad 39B, Kennedy Space Center (KSC), Florida. We work with transcendental equations to peak-correct or "normalize" new and existing functions, then solve for parameters graphically. We conclude with percent error values showing that our derived waveforms can be used to meet specifications more closely than contemporary standards.

Dual-Band Dual-Circularly Polarized Transmitarray Antenna
Boxiang Yang, Yuanjun Shen, Lei Chen, Tianling Zhang
Xidian University, China
ABSTRACT:
A dual-band dual-circularly polarized transmitarray antenna (DDCPTA) operating in 28GHz/39GHz millimeter-wave band is proposed in this letter. The DDCPTA unit uses the form of receive/transmit. The receiving unit is a wideband linearly polarized patch antenna, and the transmitting unit is a dual-band dual-circularly polarized patch antenna. When the receiving patch is rotated 180°, a phase shift of 1-bit is generated. The DDCPTA is fed by a wideband linear polarization corrugated horn antenna, which has good radiation characteristics. A 20×20 TA prototype is built up by using the proposed units with a size of about 74mm × 74mm and simulated by using HFSS. The simulated results show that the maximum gain of DDCPTA is 21.58 dBic within the low-band (27GHz-29GHz) and 22.51 dBic within the high-band (37.5GHz-39GHz), respectively.

A Dual-Port Antenna Integrated Co-Axial Filter for Port-Isolation Enhancement
Rui He, Yiqi Zhang, Yang Zhou, Jian Ren
Xidian University, China

Design of Wideband Phased Array Feed based on Low-Profile Vivaldi Antenna
Tinglei Shi, Honghuan Zhu, Yuanjun Shen, Lei Chen, Tianling Zhang
Xidian University, China
ABSTRACT:
In this paper, a dual-polarized phased array feed (PAF) based on the bend Vivaldi antenna is proposed with low profile, broadband and good impedance matching characteristics. The PAF is fed by coaxial lines and made with an all-metal structure to reduce losses and strengthen the structural integrity robustness. The proposed PAF operates in 1.7-4.3 GHz and achieves a stable phase variation. Additionally, the secondary radiation pattern is synthesized using weight coefficients calculated by conjugate field matching (CFM) method, demonstrating the efficiency of the reflector antenna equipped with the proposed PAF exceeding 77.3%. The proposed PAF can be a good candidate for radio astronomy applications.

1-bit Amplifying Reconfigurable Intelligent Transmission Element Design
Yongji Chen, Xuenan Ren, Tao Yin, Shen Yin, Jian Ren, Yinzeng Yin
Xidian University, China

Analytical Solution of the Lightning Transmission Line (TL) Model, at the Speed of Light
Nathan S. Roberts
NASA Johnson Space Center, USA
EMC BEST PAPER FINALIST AND BEST STUDENT PAPER SEMI-FINALIST
ABSTRACT:
In 1969, Uman and McLain introduced the lightning transmission line (TL) model, along with numerical solutions. In this paper, we present perhaps some of the first analytical solutions of the TL model, under the assumption that the return stroke rises at the speed of light. We introduce some new general channel-base currents, use image theory to account for reflections, and solve for the electromagnetic fields using Euler substitution and integration by parts.

Analysis of Radiated Emission Due to the Wirewound Type Power Inductor in High Voltage DC to DC Converter
Jungrae Ha, Minho Kim, Sangwoo Kim, Hyewon Lee, Chuleui Park, Sangwon Yun
HL Mando Corp, Korea
ABSTRACT:
Nowadays, the parts of eco-friendly vehicles such as hybrid and electric car are being developed very quickly. In particular, braking and steering system for the eco-friendly vehicles are being more important. This is because existing internal combustion engines require engine power for braking and steering, but eco-friendly cars do not have engines or are not in constant operation. Therefore, actuators and electronic controllers that enable braking and steering without an engine are used. However, electronic controllers for controlling actuators cause many EMC problems. In this paper, the radiated noise generated from the DC-DC converter that converts the vehicle 12V battery within the ECU, an electronic control system, was analyzed through 3D EM analysis. In the process of switching the vehicle battery voltage, the DC-DC converter generates a large amount of EMI noise, which causes problems such as reduced sensitivity of the vehicle's radio reception. In this paper, a 3D analysis model was established for the switching noise radiation of a DC-DC converter according to the mounting conditions of a high-voltage wire-wound type power inductor, and a design method for reducing radiation noise was presented through this.

RFI Improvement of MIPI C-PHY CDR Signal for Stub Filter using Transmission Line Structure
Hyoseob Lee[1,2], SoYoung Kim[1]
[1]Samsung Electronics, Korea; [2]Sungkyunkwan University, Korea
ABSTRACT:
As the available area for mounting components in mobile phones becomes smaller, the radio frequency interference (RFI) between the camera MIPI and the Wi-Fi Tx antenna increases. In this paper, we propose a stub filter designed and implemented on the camera MIPI transmission line in the PCB of a mobile phone to cancel noise in the Wi-Fi 5GHz band. Through full 3D EM simulation, we compared H-field of 3D EM simulation, S-parameter, TDR, and eye-diagram data with and without Wi-Fi 5GHz Tx RFI. The S-parameters, TDR characteristics, eye-diagram data with and without Wi-Fi 5GHz TX RFI and the signal margin measurement at Wi-Fi 5GHz Tx RFI through CDR sweep test were performed by a real SET. Simulation results and real measurement results show that our proposed stub filter structure achieves at least 2dB signal integrity improvement when RFI is present.

WEDNESDAY, AUGUST 7

TC5-1 TECHNICAL PAPERS

ELECTROSTATIC DISCHARGE

1:30PM - 3:00PM

Room: 125AB

Sponsored by TC-5

Chair:
Michael McInerney, *Consultant, Champaign, IL, USA*

Co-Chair:
William Radasky, *Metatech Corporation, Goleta, CA, USA*

PLANNED SPEAKERS & TOPICS

1:30PM

A Model for Corona Streamer Propagation on Glass during an Air Discharge

Zhekun Peng[1], Jianchi Zhou[2], Darryl Kostka[2], David Pommerenke[3], Daryl Beetner[1]

[1]Missouri University of Science and Technology, USA; [2]Apple Inc., USA; 3Technische Universitat Graz, Austria

EMC BEST PAPER FINALIST AND BEST STUDENT PAPER SEMI-FINALIST

ABSTRACT:

Corona discharge to a glass surface is challenging to model due to a poorly understood air and surface ionization process. A modeling methodology based on the transmission line modeling (TLM) approach is proposed to simulate the streamer propagation process. The time-changing corona streamer resistance is estimated using the Rompe and Weizel spark model. The streamer is represented using small segments consisting of the arc resistance, per unit length (PUL) capacitance of the streamer, PUL inductance, a switch representing streamer formation, and a surface discharge gap voltage representing the voltage drop caused by ions within the streamer length. The propagation of the corona streamer depends on the tangential electric field strength at the streamer tip being higher or lower than the breakdown threshold for streamer formation. This preliminary 1D model shows plausible results for the current waveform shape, Lichtenburg dust figure diameter and streamer propagation velocity for a positive surface discharge to the glass. Although the model requires further improvement to predict propagation of multiple corona streamers, it provides a basis for simulation of a corona discharge on a glass surface which is related to the behavior of the underlying physics.

2:00PM

Metamaterial-Enabled Localization of Electrostatic Discharges using Time Reversal

Elias Le Boudec[1], David Martinez[2], Nicolas Mora[3], Marcos Rubinstein[4], Felix Vega[2], Islem Yahi[2]

[1]Ecole Polytechnique Federale de Lausanne, Switzerland; [2]Technology Innovation Institute, United Arab Emirates; [3]Universidad Nacional de Colombia, Colombia; [4]University of Applied Sciences and Arts Western Switzerland, Switzerland

ABSTRACT:

Protection against electrostatic discharges requires knowledge of the discharge-current path. Thanks to the time-reversal technique combined with a GHz-range resonant metalens, we present an experimental gateway to imaging subwavelength interference sources.

2:30PM

Time-Dependent Resistance-Based Dynamic Behavior Model of Spark Gap Device under ESD Pulse

Mingming Yang, Guangxiao Luo, Jianfang Dang, Zhaolong Xue, Weidong Zhang

North China Electric Power University, China

EMC BEST STUDENT PAPER SEMI-FINALIST

ABSTRACT:

This paper investigates the dynamic response characteristics of spark gap structures on printed circuit boards (PCB) under electrostatic discharge (ESD). A gas discharge tube (GDT) is selected as the research subject. Initially, voltage and current signals at the device ports are measured under transmission line pulse (TLP) excitation, and the variation in the time lag of the spark gap structures with different voltage levels is analyzed. Subsequently, a dynamic behavior model, based on a time-dependent typical arc resistance model, is developed to predict the response of the GDT to TLP pulses. This system-level model is further validated through experiments using an electrostatic generator excitation.

TC9-4 TECHNICAL PAPERS

MODELING TECHNIQUES FOR RADIATED AND CONDUCTED SUSCEPTIBILITY

1:30PM - 3:00PM

Room: 127B

Sponsored by TC-9

Chair:
Ying Cao, *Apple Inc, Santa Clara, CA, USA*

PLANNED SPEAKERS & TOPICS

1:30PM

Radiated Susceptibility Simulations from 40-100 GHz (A New Frontier)
David Norte, Rachel Lumnitzer
BAE Systems, Inc., USA

ABSTRACT:
EMC standards, such as the RS103 standard, subject hardware to electric fields of varying strengths over the frequency range from 2 MHz and 40 GHz [1]. However, some programs have extended this frequency range up to 100 GHz, where many EMC test facilities don't have the equipment or the capital to complete this testing. In these cases, it is necessary to simulate the performance of the hardware in the presence of the RS103 environment through computational resources. This paper highlights the results of such an effort when two chassis are interconnected by a double shielded 1.0 m long cable. The inner shield contains a single 100 ff differential circuit that is terminated at both ends with 100 ff resistances, and where the common-mode and differential-mode currents are extracted from 40 GHz to 100 GHz. The impacts of the induced DM interference on a 5 Gbps digital interconnect are extracted with respect to the received differential eye patterns, as well as the associated degradations on the bit-error-rates (BERs).

2:00PM

RS103 Nonuniform Exposure of Shielded Cables
David Norte, Rachel Lumnitzer
BAE Systems, Inc., USA

ABSTRACT:
The RS103 standard requires exposing electrical systems to E fields from 2 MHz to 40 GHz, where the system must perform as intended during this exposure. This paper addresses the induced currents on cable shields that are not uniformly exposed to the E fields due to the 3 dB beamwidths from practical antennas, as well as the location of the antenna along the shield. The impact of these currents on a received differential signal for a digital link at 1.6 Gbps is addressed.

2:30PM

The Impact of the CS115 Excitation on the Performance of Digital Interconnects – A Time and Frequency Domain Approachh
David Norte, Rachel Lumnitzer
BAE Systems, Inc., USA

ABSTRACT:
Conductive susceptibility requirements for many programs require that the hardware demonstrate full functionality in the presence of the expected conductive noise environment that is subjected to the hardware. The CS115 standard attempts to simulate such environments by subjecting cables to conductive interference signals. These signals simulate repetitive short duration impulse events that may arise in the case of switched inductive loads that are nearby the hardware. It is of interest to understand how this conductive interference signal manifests itself as common-mode and differential-mode currents and voltages that can degrade the performance of high-speed digital interconnects. This paper addresses the performance of a 5.0 Gbps differential digital interconnect in the presence of the CS115 standard and attempts to disclose how this interference degrades the received differential signal.

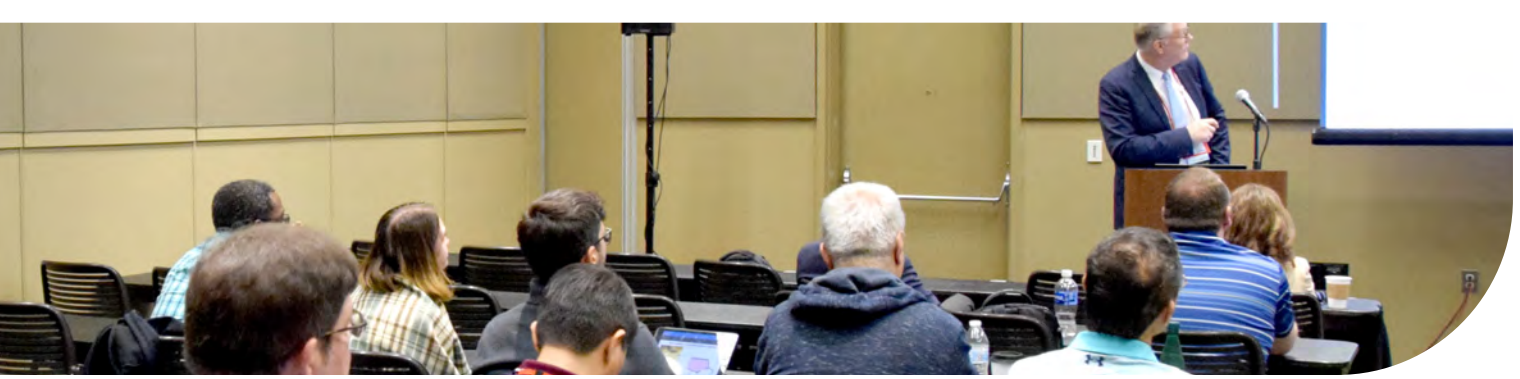

Photo by Richard Georgarian

WEDNESDAY, AUGUST 7

TC10-6 TECHNICAL PAPERS

SI/PI/EMI CO-DESIGN
1:30PM - 3:00PM
Room: 128B
Sponsored by TC-10

Chair:
Ling Zhang, *Zhejiang University, Hangzhou, China*
Co-Chair:
Baolong Li, *Cadence Design Systems Inc, San Jose, CA, USA*

PLANNED SPEAKERS & TOPICS

1:30PM
Reducing EMI in Wire-Bond BGA IC-Chips through Magnetic Dipole Moment Control
Satoshi Tago, Keita Sasaki, Yasuhiro Ochiai
Sony Semiconductor Solutions Corporation, Japan
SIPI BEST PAPER FINALIST
ABSTRACT:
The proportion of IC-Chips in the components of electronic devices is increasing year by year. IC-Chips can be a noise source of Electro-Magnetic Interference (EMI), which should be minimized. IC-Chip suppliers require the development of low-cost and low-noise IC-Chips to enhance product value. This paper introduces a method for reducing EMI radiation (herein after referred to as EMI) from IC-Chips each packaged in a wire-bond Ball Grid Array (BGA). EMI was measured using near-field scanning and analyzed using magnetic dipole moments. Based on the results, current sources and current paths of the noise were predicted and validated through simulations. We prove that the magnetic dipole moments accurately represent EMI from the bonding wires (hereinafter referred to as wires) and balls in the IC-Chip package and propose a method for reducing EMI. The method greatly reduces EMI by mutually inverting vectors of EMI from wires and vectors of EMI from balls. This method is referred to as EMI cancellation in this paper. Finally, we demonstrate the effectiveness of the method through simulations and measurements, confirming that changing ball arrangements in existing IC-Chips reduces EMI by 4 dB. Moreover, the ball arrangement change is minimal, reducing EMI at very low cost is feasible.

2:00PM
Porous Absorber for Electromagnetic Radiation Suppression in Chip-Packages
Chaolong Lin, Jiaqi Xing, Da Li, Ling Zhang, Hanzhi Ma, Er-Ping Li
Zhejiang University, China
SIPI BEST STUDENT PAPER SEMI-FINALIST
ABSTRACT:
In this paper, a low profile absorber for suppressing the electromagnetic radiation in the chip packages is proposed. The incorporation of porosity reduces the dielectric constant of the absorbing material which makes it easier to meet the impedance matching condition. Additionally, the porosity causes incident electromagnetic waves to undergo multiple reflections within the pores, effectively lengthening their propagation path within the absorber and enhancing the absorption capability. The simulated results in the chip-package model demonstrate an effective absorption of -14 dB within 20.3-29.8 GHz by adding the proposed absorber into the package. The detailed working mechanism of this structure is explained through the effective medium theory. Finally, the porous absorber is fabricated and experimental measured within a real chip-package inside a reverberation chamber, where the measured results bring out a -12 dB absorption effect covering 20-30 GHz.

2:30PM
Novel DIE-PKG-PCB Co-Design Methodology for High-Speed Interfaces for Complex Automotive SoCs
Rishi Bhooshan[1], Swapnil Tiwari[1], Sanamdeep Singh[1], Bihua He[2], Ajay Kumar Sharma[1], Sachin Kumar[1], Osvaldo Romero[3], Jesus Armando Sanchez Carranza[4]
[1]NXP Semiconductor, India; [2]NXP Semiconductors, China; [3]NXP Semiconductors, Germany; [4]NXP Semiconductors, Mexico
ABSTRACT:
With shrinking technology, increasing functionality and performance including high speed interfaces imposes major challenges for DIE, Package and PCB Co-design to meet overall system level electrical specifications (e.g. Power, Performance, Area, Timing, PISI, IR Drop, Thermal, EMI/EMC) and BOM Cost (e.g. DIE, PKG, PCB Cost). In this paper, we present DIE-PKG-PCB Co-Design Methodology for high speed interfaces to optimize DIE, PKG and PCB overall to meet system level electrical specifications as well as to optimize the overall system cost for complex Automotive SoCs.

ED14
EXPERIMENT DEMONSTRATION

EMC SOCIETY EMC PCB EXPERIMENTS KIT

2:00PM - 4:00PM

Room: Exhibit Hall - E&D Booth 1

The EMC Society has created a set of nine PCBs that are each constructed to illustrate a particular principle of EMC engineering. At this demonstration we will put them through their paces, demonstrating the boards (and the Nano VNA that comes with them). In addition we will be showing how simulations of each board can help with demonstrations and education.

PRESENTERS

Hardware Demonstration
Karen Burnham
Electro Magnetic Applications, Inc., USA

Simulation Demonstration
Jason Bommer
Ansys, USA

ED15
EXPERIMENT DEMONSTRATION

EMC WORKSHOP FOR POWER SUPPLY DESIGNERS

2:00PM - 4:00PM

Room: Exhibit Hall - E&D Booth 2

I plan to show a portable conducted emissions test setup that utilizes low voltage (<60VDC) to demonstrate fundamental EMC troubleshooting in a practical way by using a lecture style that includes first the explanation of theory, then the simulation, then a live test to prove empirically how the theory holds true on a real design. Our test board separates out common mode and differential mode noise so that the exact source of the EMI can be understood more fully and therefore a better solution can be implemented. It is common to see engineers using a guess and check method by just grabbing whatever components are available nearby, testing and then deciding what the next step is based on the test results. Although this iterative method sometimes works, as engineers, we should strive to better understand the underlying phenomena to be able to implement a more precise solution and resolve EMC issues with less time and effort. I hope to accomplish this in my session by focusing on practical tips and tricks. Topics include CMC selection, Xcap, and Ycap selection.

PRESENTERS

Jared Quenzer
Würth Elektronik, USA

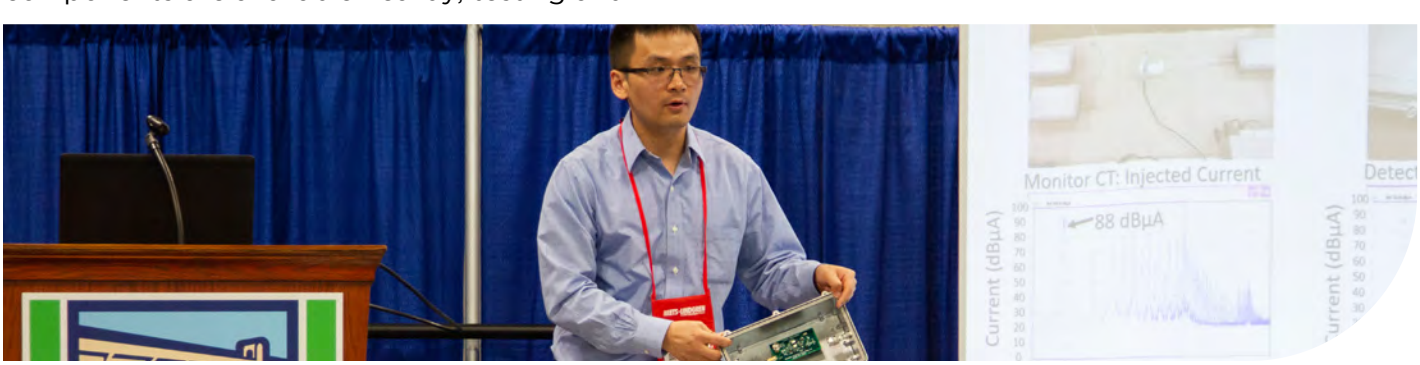

Photo by Patrick Andre

ED16
EXPERIMENT DEMONSTRATION

EXPERIMENTAL DEMONSTRATION OF THE NOISE ATTENUATION PERFORMANCE OF AN ACTIVE EMI FILTER WITH EMIC

2:00PM - 4:00PM

Room: Exhibit Hall - E&D Booth 3

Electromagnetic interference (EMI) from power converters during switching operations has become a significant problem due to increased demand for high-power products. EMI filters are commonly implemented on AC powerlines in power systems to suppress conducted emissions (CE) noise. A conventional passive EMI filter typically consists of a low-pass L-C topology with Y-capacitors, common-mode (CM) chokes, and X-capacitors. However, in high-power appliances or industrial systems, the size and cost of CM chokes can be prohibitive considering several practical issues.

Active EMI filters (AEFs) are a practical solution for high-power applications to effectively reduce the size and number of CM chokes in passive filters. In previous studies, the topologies and implementations of analog AEFs are demonstrated, and design guidelines for stability, reliability, and noise attenuation performance have been proposed. Also, recently, AEFs have been implemented as EMI management-integrated circuits (EMIC) to reduce CE noise.

In this proposal for Experiments & Demonstrations, we would like to demonstrate the performance of the AEF with EMIC using a simplified experimental setup. The EMIC is the active EMI filter IC for high-voltage and high-current application. An evaluation board has been designed to help designers to evaluate the operation and performance of the EMIC with three-phase four-line ac utility. The evaluation board can be used for small signal testing as well as real application testing. The proposed AEF is designed as a fully-isolated structure using magnetic core components of the sensing and injection transformers. It can operate with 12V supply.

PRESENTER

Jingook Kim
Ulsan National Institute of Science and Technology (UNIST), Korea

ED17
EXPERIMENT DEMONSTRATION

MEASURING POWER DISTRIBUTION NETWORK NOISE AND IMPEDANCE EFFECTS ON SIGNAL INTEGRITY

2:00PM - 4:00PM

Room: Exhibit Hall - E&D Booth 4

Power integrity including power distribution network (PDN) impedance and noise is one of the primary sources of signal integrity issues in digital transmission systems. Sources of noise can include power supply switching harmonics, high speed clocks, EMI and even nearby RF signals. The impedance of the PDN often varies widely with frequency resulting in ranges within which the impedance is higher allowing increased noise ingress. This demonstration will show how jitter analysis using an oscilloscope can reveal specific source of periodic jitter leading to higher oiverall peak to peak jitter.

Further analysis of the PDN impedance, again using an oscilloscope, will be shown to reveal the specific frequency ranges corresponding to the periodic jitter sources where the impedance is higher. The resulting analysis is then used to provide a solution for mitigating the PDN noise and, along with it, the peak to peak jitter.

PRESENTERS

Michael Schnecker
Rohde & Schwarz, USA

WEDNESDAY, AUGUST 7

SS02 SPECIAL SESSION

MEDICAL DEVICE EMC

3:30PM - 5:00PM

Room: 125AB

Chair:
Ji Chen, *University of Houston, Houston, TX, USA*

Co-Chair:
Ananda Kumar, *US Food and Drug Administration, Baltimore, MD, USA*

Moderator:
Jianfeng Zheng, *University of Houston, Houston, TX, USA*

With the continuous advancement of electrical and electronic medical instruments, there is an increasing prevalence of medical devices that can be implanted inside the human body or operated in close proximity to humans. However, the operation of these devices introduces the emission of electromagnetic signals, raising safety concerns for individuals. Moreover, the potential interaction of these devices with nearby medical equipment poses risks of device interference and malfunctions, especially in scenarios involving multiple electronic devices implanted within human bodies. Addressing these challenges requires the establishment of comprehensive scientific standards for both human safety and product safety assessment methodologies. Further advancements in computation and measurement techniques are crucial to achieve this objective. This special issue aims to delve into various critical aspects of Electromagnetic Compatibility (EMC) concerning electromagnetic safety and its application in biomedicine.

The areas to be covered in this **Special Session include:**

- Computational Methods for Interaction with Biological Bodies
- Human Exposure Safety and Compliance Assessment
- EMC in Biomedicine

This special issue aims to contribute to the ongoing discourse in the field by exploring these diverse and crucial topics in EMC, fostering the development of advanced scientific standards and methodologies for enhanced safety in the rapidly evolving landscape of medical electronics.

PLANNED SPEAKERS & TOPICS

3:30PM

A Measurement Method for Magnetic Field Characteristics of Inductive Wireless Power Transfer Chargers for Consumer Electronics

Yasaman Ardeshirpour, Joshua Guag, Jeffrey L. Silberberg, Seth Seidman
US Food and Drug Administration, USA

ABSTRACT:

The use of wireless power transfer (WPT) for charging consumer electronics has grown in recent years owing to its convenience. However, due to inadequate information regarding the emissions characteristics of commercially available WPT systems, the electromagnetic (EM) immunity test protocols of many current consensus standards applicable to medical devices have not been assessed for their appropriateness in evaluating interference caused by such WPT systems. In this paper, we present a methodology for measuring the EM disturbances of these WPT devices and provide some preliminary results, aiming to address this critical knowledge gap.

4:00PM

Safety Assessment of Pulsed Electromagnetic Field Pelvic Floor Therapies with Implanted Sacral Neuromodulation Devices

Xuechen Huang[1], Shanie Scoles[1], Paul Nguyen[1], Jeff Chen[1], Jeremie Wisniewski[2], Yuqing Wan[1], Guangqiang Jiang[1]
[1]*Axonics, Inc., USA;* [2]*CentraleSupelec, France*

ABSTRACT:

Patients with Sacral Neuromodulation (SNM) implantable systems may seek Pulsed Electromagnetic Field (PEMF) therapy in pelvic floor muscle training due to symptoms of stress urinary incontinence. However, the use of PEMF therapy may raise safety concerns for these patients. Patients implanted with Axonics SNM implants are currently prohibited from receiving this PEMF treatment. In this study, the induced risks to patients implanted with Axonics SNM systems from the BTL EMSELLA pelvic floor muscle training system were investigated. The potential risks include heating, device malfunction, and unintended nerve stimulation. The results demonstrate that the PEMF therapy under investigation is a safe therapeutic option for patients with Axonics SNM implants under specific use conditions, potentially broadening patients' therapeutic choices. The results of this study have been submitted to the U.S. Food and Drug Administration (FDA), and the safety claim of PEMF therapy for patients with implanted Axonics SNM systems is currently under review.

4:30PM

The Effect of Lead Winding Near IPG on AIMD Models under MR RF Exposure

Ziyu Zuo[1], Qingyan Wang[1], Jianfeng Zheng[1], Hongbae Jeong[2], Ananda Kumar[2], Ji Chen[1]
[1]*University of Houston, USA;* [2]*US Food and Drug Administration, USA*

ABSTRACT:

This paper explores the effects of lead winding near an Implantable Pulse Generator (IPG) on a Transfer Function (TF) model under Magnetic Resonance Imaging (MRI) Radio Frequency (RF) exposure. Three commercial AIMD systems are used in the study. Multiple sets of measurement are carefully conducted. Revealing that the TF model remains unchanged for one AIMD, while it undergoes significant changes for the other two systems. Upon closer examination of the leads' structure, it is observed that leads with thicker insulation layer tend to preserve the TF model. This observation is in agreement with the transmission line theory, wherein the AIMD with a thick insulation layer can preserve a low lossy transmission line mode in contrast to the other two devices.

TC9-5 TECHNICAL PAPERS

STATISTICAL AND SURROGATE MODELS

3:30PM - 5:00PM

Room: 127B

Sponsored by TC-9

Chair:
Yansheng Wang, Rivos Inc., *Santa Clara, CA, USA*

PLANNED SPEAKERS & TOPICS

3:30PM

Estimating Effects of Residual Physics with Machine Learning for Earbud Performance Prediction

Srinivasa Mohan[1], Jingchen Liang[1], Mingfeng Xue[2], Krishna Mellachervu[1], Pavani Gottipati[1], Jianmin Zhang[3]
[1]*Ansys, Inc., USA;* [2]*Google Inc, USA;* [3]*Google Inc., USA*

EMC BEST PAPER FINALIST

ABSTRACT:
Consumer electronics devices like earbuds include small components like the voice coil speaker. The damping coefficient of the voice coil speaker system and the acoustic resistance of the mesh at the aperture used in Finite Element Analysis (FEA) based simulation needs to be tuned to match predictions with measurements. In this paper, a machine learning method is proposed to combine experimental data with simulation data, that accounts for uncertainties in model and parameters to obtain a hybrid analytics model that can predict the performance of the speaker for unmeasured parameter values.

4:00PM

Fusion of Parameterized and Physics-Oriented Statistical Surrogate Models for EM Coupling on Wires in Complex Electronic Enclosures

Shen Lin[1], Sangrui Luo[1], Yang Shao[1], Zhen Peng[1], Bisrat D. Addissie[2], Zachary B. Drikas[2]
[1]*University of Illinois Urbana-Champaign, USA;* [2]*U.S. Naval Research Laboratory, USA*

EMC BEST PAPER FINALIST

ABSTRACT:
In this paper, we explore a novel approach in the domain of statistical electromagnetics for high-frequency coupling on wires installed in complex electronic enclosures. The study involves the integration of two distinct types of statistical surrogate models: parameterized models, which are based on predefined parameter spaces for internal wire/cable components, and physics-oriented statistical models, which leverage statistical representations of cavity eigenfunctions and eigenvalues. The fusion of parameterized and physics-oriented statistical surrogate models allows for a comprehensive and versatile statistical analysis, accommodating the complex details and variability present in real-world electronic systems. The proposed work has been validated numerically, including the commercial software and traditional Monte Carlo simulation.

Photo by Richard Georgarian

TC10-7 TECHNICAL PAPERS

POWER DISTRIBUTION NETWORKS AND DECOUPLING #2

3:30PM - 5:00PM

Room: 128B

Sponsored by TC-10

Chair:
Junyong Park, *Missouri University of Science and Technology, Rolla, MO, USA*

Co-Chair:
Shaowu Huang, *Marvell Semiconductor Inc, Santa Clara, CA*

PLANNED SPEAKERS & TOPICS

3:30PM

Efficient Optimization of Decoupling Capacitors using Iterative Inversion Technique
Sriram Hariharan, Dinesh Junjariya, Jai Narayan Tripathi
Indian Institute of Technology Jodhpur, India
ABSTRACT:
To maintain Power Integrity (PI) in a high-speed electronic system, the Power Delivery Network (PDN) needs to be optimized with respect to its impedance. To minimize power supply noise, decoupling capacitors are used in a PDN. By selecting appropriate decoupling capacitors (decaps) and placing them on optimal locations on board/package, the overall impedance of a power delivery network can be effectively reduced to a desired level to minimize the variationa in supply voltage due to varying load current. In this paper, a time-efficient matrix inversion approach is used for impedance calculation within Particle Swarm Algorithm (PSO) algorithm which helps to enhance the efficiency of the optimization proces. The proposed approach is demonstrated through a practical case study. The applied technique significantly reduces the overall runtime of the algorithm, enhancing computational efficiency. A comparative evaluation of the performance of the proposed approach with the conventional algorithm is presented.

4:00PM

IBIS-Approved Streamlined Power Integrity Model (SPIM) for Platform Power Integrity Analysis
Xingjian Kinger Cai, Chi-te Chen, Ei Jun Cheng
Intel Corporation, USA
ABSTRACT:
The Streamlined Power Integrity Model (SPIM) has received approval from the IBIS Open Forum. After a comprehensive overview of the structure, SPIM is elaborated with its generation, correlation, validation, and practical application in the context of the actual design, review, sign-off, and optimization of platform Power Delivery Networks (PDN).

4:30PM

Enhanced S-Parameter Rational Function (SRF) Model Revolutionizing Power Delivery Analysis
Mohammad Islam, Kinger Cai, Sophia Alvarez, You Zhang Tan, Yihong Yang, Vijay Govindarajan, Thim Khuen Wong, Julio Soto
Intel Corporation, USA
ABSTRACT:
The S-parameter model with abundant ports, extracted from the routing of power delivery network (PDN), is enhanced by reducing model complexity and enforcing passivity and causality, when transformed into a broadband S-parameter rational function (SRF) model. The enhanced SRF model is integrated into power integrity (PI) and power delivery (PD) simulations flow with HSPICE, resulting in accurate AC impedance analysis rectifying the anomalies in the sub-MHz frequency range, and more efficient transient simulation with further High Precision Parallel (HPP) boosting efficiency, making simulation runtime 50 times faster than that using IFFT of a conventional macro-model of the original S-parameter.

THURSDAY, AUGUST 8

SCHEDULE AT A GLANCE

ROOM	125AB	127A	127C	128A	128B	129A
8:30 AM	TECHNICAL PAPERS TC2_4 EMC Measurements – VHF-LISN Termination, Current Coupling & Capacitive Coupling	TECHNICAL PAPERS TC7 Low Frequency EMC	SPECIAL SESSION SS03 EMC & EMF Safety of Wireless Power Transfer Systems	TECHNICAL PAPERS SC3 Machine Learning and Artificial Intelligence Technologies	TECHNICAL PAPERS TC10_8 Simulation and Modeling Techniques #4	
10:00 AM	REFRESHMENT BREAK					
10:30 AM	TECHNICAL PAPERS TC2_5 EMC measurements: Pulsed RFI in Motors, Multi-Tone Susceptibility Impact, & Bench to On-Vehicle Emissions Comparison	TECHNICAL PAPERS SC5_1 Passive Components and Semiconductor Devices	SPECIAL SESSION SS04_1 Stochastic Electromagnetics	TECHNICAL PAPERS TC12_1 RF Interference and De-sense	TECHNICAL PAPERS TC10_9 Power Distribution Networks & Decoupling #3	TECHNICAL SESSION ES01 Exemplary Paper Session
12:00 PM	LUNCH BREAK					
1:30 PM	TECHNICAL PAPERS TC3 Data Analysis in Electromagnetic Environments	TECHNICAL PAPERS SC5_2 Modeling of Wireless Power Transfer Systems		TECHNICAL PAPERS TC12_2 Wireless Coexistence	TECHNICAL PAPERS TC10_11 High-Speed Interconnects	
2:30 PM	TECHNICAL PAPERS TC11 Nanotechnology and Advanced Materials					
3:00 PM	REFRESHMENT BREAK					
3:30 PM	TECHNICAL PAPERS TC10&SC3 Applications of AI & Optimization Algorithms	TECHNICAL PAPERS SC5_3 EMI Mitigation in Wearable Devices and EV Drives		TECHNICAL PAPERS TC12_3 Wireless System Measurement / Testing	TECHNICAL PAPERS TC10_10 Crosstalk, Jitter, Noise Coupling, BER Analysis #2	
4:30 PM / 5:00 PM		TECHNICAL PAPERS TC5_2 Immunity and EM Info Leakage				
5:30 PM						

CLAYTON R. PAUL GLOBAL UNIVERSITY: 8:00 AM - 12:00 PM, 124A

EXHIBIT HALL OPEN: 10:00 AM - 1:00 PM
EXPERIMENTS & DEMOS: 10:00 AM - 12:00 PM

TECHNICAL TOUR: ARIZONA STATE UNIVERSITY, 4:00 – 7:30 PM

ADDITIONAL STANDARDS SESSIONS, WORKING GROUPS AND TECHNICAL COMMITTEES
For Collateral Meetings, see page 141

AWARDS LUNCHEON:
12:00 - 1:30 PM, 120A (Ticketed Event)

SPEAKERS BREAKFAST
Phoenix Convention Center - 126ABC: 7:00 - 8:30 AM (Breakfast Only on the Day of Presentation)

REGISTRATION/INFO DESK: 8:00 AM - 5:00 PM

COMPANION SUITE: Sheraton Phoenix Downtown - North Mountain
Monday - Thursday: 7:00 - 10:00 AM (Pre-Registration Required)

TC2-4
TECHNICAL PAPERS

EMC MEASUREMENTS – VHF-LISN TERMINATION, CURRENT COUPLING AND CAPACITIVE COUPLING

8:30AM - 10:00AM

Room: 125AB

Sponsored by TC-2

Chair:
Monrad Monsen, *Oracle, Broomfield, CO, USA*

Co-Chair:
Ahalya Srikanth, *Ford Motor Company, Lasalle, ON, Canada*

PLANNED SPEAKERS & TOPICS

8:30AM

Justification and Background for Terminating AC Mains Cable with Balanced VHF-LISN to Radiated Emission Measurement

Kunihiro Osabe[1], Nobuo Kuwabara[2], Hidenori Muramatsu[1]
[1]*VCCI Council, Japan;* [2]*Kyushu Institute of Technology, Japan*

ABSTRACT:
This document provides a background for proposing a balanced Very High Frequency–Line Impedance Stabilization Network (VHF-LISN). The device is designed to terminate the Alternating Current (AC) mains cable of the Equipment Under Test (EUT) with 50 ohms balanced for radiated emission measurements. In 2017, Joint Ad-hoc Group 6 (JAHG6) of CISPR began discussing this proposal. The deliberation is ongoing towards international standardization. Throughout the discussions and studies, several findings were originally presented in this paper and requested to be summarized including the past studies as archives for future reference.

9:00AM

Visualization of Common Mode Current Coupling to Attached Cables of Power Converters

Daniel L. Commerou[1], Kasper M. Paasch[1], Morten Sørensen[2]
[1]University of Southern Denmark, Denmark; [2]FORCE Technology, Denmark

ABSTRACT:
Common mode currents on attached cables are often the dominant source of unwanted emissions at frequencies below 400 MHz as the cables act as unwanted antennas. High coupling to these cables combined with strong nearfields are seen as two conditions for radiated emission. This paper introduces a novel method and workflow to use nearfield scanning results to visualize areas with high coupling to attached cables from a device. The method is successfully demonstrated on a simple device and thereafter in a case study.

9:30AM

Industrial EFT Capacitive Coupling Analysis

Mohit Gopalraj, Sachinkumar Goudnoor, Michael Donaruma, Thane Sanford
Analog Devices Inc., USA

ABSTRACT:
This paper talks about the transient coupling analysis during industrial EFT (Electrical Fast Transients) tests using the Capacitive Coupling Clamp based on IEC 61000-4-4. The energy coupled onto to tested and untested ports on a DUT PCB are analyzed. This provides better insight on how much the untested ports are affected during the actual EFT tests.

THURSDAY, AUGUST 8

TC7 TECHNICAL PAPERS

LOW FREQUENCY EMC

8:30AM - 10:00AM

Room: 127A

Sponsored by TC-7

Chair:
Flavia Grassi, *Politecnico di Milano, Milano, Italy*

PLANNED SPEAKERS & TOPICS

8:30AM

Identification of Internal Impedance of Brush Motor in Operation using AMN

Akito Mashino, Shohei Kan, Kengo Iokibe, Yoshitaka Toyota

Okayama University, Japan

EMC BEST STUDENT PAPER SEMI-FINALIST

ABSTRACT:
In brush motor drive systems, electromagnetic interference (EMI) due to brush noise can cause problems, thus it is essential to design an appropriate EMI filter built into the brush motor. Since the cable length also affects EMI, we are studying a multi-purpose design method for EMI filters that includes the cable length. In this study, it is important to identify the internal impedance of the brush motor with high accuracy. In EMI problems, not only differential mode (DM) but also common mode (CM) should be noted, and the identification of equivalent circuit models of noise sources in brush motors should cover the internal impedances of both DM and CM. More importantly, since brush noise arises during motor operation, it is necessary to identify the internal impedance during operation. A method using a vector network analyzer (VNA) and two current probes has been proposed to identify the internal impedance, but it is effective only up to 30 MHz. Therefore, this paper identifies the internal impedance in operation up to 100 MHz while using an artificial mains network (AMN) to supply power to a brush motor. Here, the impedance of the AMN is removed by de-embedding. Comparing the internal impedance at rest and in operation, the impedance related to DM was only slightly different, but the impedance related to CM changed significantly. On the other hand, the internal impedance characteristics changed little with the DC voltage applied to the brush motor or the load torque.

9:00AM

Using the Wavelet Packet Transform to Evaluate Parameters of Harmonics Clustered in Quadruples using Linear Systems

Ileana Diana Nicolae, Petre-Marian Nicolae, Marian-Ştefan Nicolae

University of Craiova, Romania

ABSTRACT:
The paper presents an original technique used to evaluate the parameters of quadruples of harmonics clustered in an almost exclusive manner to quadruples of nodes from the bottom level of a Wavelet Packet Tree . The harmonic signal (RHS) generated by harmonics from a quadruple can be deduced with approximation from the analyzed signal by using original computational techniques. Linear systems were conceived based on the harmonics superposition and randomly chosen components of RHC (the approximated version of RHS). Their solving yields sets of possible solutions, that are afterward refined to exclude values with non-zero imaginary parts or deviant values. Averages over refined values are used. The indetermination relative to phase-shifts is solved considering the criterion of “best approximation” of RHC by the signal obtained through the superposition of the computed clustered harmonics. The harmonics from the studied quadruples are: (11, 13, 19, 21), (23,25,39,41) and (27,29,35,37). This paper provides the complementary technique for the odd harmonic identification within the range 3...41 (the odd harmonics not belonging to quadruples are coupled in pairs and were approached in a previous publication).

9:30AM

Black-Box Model of a Single-Phase Industrial Variable Frequency Drive

Dusan Kostic[1], Lu Wan[2], Abduselam Hamid Beshir[2], Iurie Nuca[1], Petre-Marian Nicolae[1], Flavia Grassi[1]
[1]University of Craiova, Romania; [2]Aalborg University, Denmark; [3]Politecnico di Milano, Italy

ABSTRACT:
When an electrical device is power quality compliant, it means that its efficiency and coexistence within an energy system satisfies the standards that cover the harmonic range up to order of 40 (2/3 kHz), or in the electromagnetic compatibility (EMC) frequency (frequency higher than 150 kHz). Low-frequency (LF) EMC range, which covers the frequency range from 2kHz to 150kHz, is a grey area in standards for energy systems and the measurement of emissions in this range. Line impedance stabilization networks (LISNs) are the devices used to measure the EMC of devices. LISN standards cover only part of the LF EMC range (usually above 9kHz), thus making this range especially interesting for research. In this paper, measurements were made on a variable frequency drive (VFD) systems in the low-frequency electromagnetic compatibility range, where the switching frequency of the converter varied in steps from 5kHz to 15kHz, a common range for VFD and photo-voltaic inverters switching frequency, which corresponds to the LF EMC range. This research focuses firstly on common mode (CM) current measurements for a single-phase system where a VFD driving a motor without load is connected to two one-phase LISNs, where the active and passive part of the converter were computed to derive its black-box model. Because the results are different for each frequency, the authors found it convenient to derive a black-box model for 10kHz frequency, as it is also in the range of LISN standards.

SS03 SPECIAL SESSION

EMC AND EMF SAFETY OF WIRELESS POWER TRANSFER SYSTEMS

8:30AM - 10:00AM

Room: 127C

Co-Chairs:

Francescaromana Maradeii, *University of Rome La Sapeinza, Rome, Italy*
Mauro Feliziani, *Univerisity of Aquila, L'Aquila, Italy*

Wireless Power Transfer (WPT) technology is poised to revolutionize electric mobility in the near future. This technology facilitates the transmission of electrical energy from a power source to an electric vehicle (EV) without the need for physical connections, making it a crucial component for the advancement of electric transportation. Unlike traditional plug connections, WPT offers several advantages: it enhances safety by eliminating the need for cables that users must connect to the vehicle, and it improves convenience by automating the charging process. Both stationary and dynamic WPT systems, based on inductive coupling, are an intentional source of strong magnetic fields in the environment. These fields pose potential health risks to individuals exposed to them and may interfere with the operation of electronic systems in vehicle and on roads, including cardiac implanted electronic devices (CIEDs) worn by passengers and pedestrians. Addressing electromagnetic compatibility (EMC), electromagnetic fields (EMF) safety, and electromagnetic interference (EMI) in CIEDs is a critical challenge for the widespread deployment of WPT systems. This special session focuses on models, methods, technologies and applications for the characterization and mitigation of the electromagnetic field emission produced by stationary and dynamic WPT systems for e-mobility. The assessment of compliance with EMC, EMF safety, and CIED standards is also a central theme of the special session.

PLANNED SPEAKERS & TOPICS

8:30AM

Design of a Shielding Coil for Fiber Composite Electric Vehicles with a SAE J2954 WPT System

Tommaso Campi[1], Silvano Cruciani[2], Francescaromana Maradei[1], Mauro Feliziani[3]

[1]Sapienza University of Rome, Italy; [2]Tor Vergata University of Rome, Italy; [3]University of L'Aquila, Italy

ABSTRACT:

This work deals with the mitigation of magnetic field levels produced by an automotive wireless power transfer (WPT) system. For this purpose, a 1-turn passive shielding coil is adopted, positioned on the underneath of the vehicle, around the receiving coil and terminated on a tuning capacitor. The design of an efficient shielding coil is detailed in terms of dimensions, shape, and position, along with a methodology for selecting an optimal terminal capacitance. The shielding effectiveness (SE) during stationary wireless charging of an electric city car with a carbon fiber reinforced polymer (CFRP) chassis is calculated numerically. The proposed mitigation technique allows compliance with the limits set for electromagnetic field (EMF) safety and demonstrates how a correct design of a shielding coil does not degrade WPT system performance.

9:00AM

Determination of Optimal Current Phase Difference between Transmitter and Receiver Coils for Minimizing Leakage Magnetic Field in Wireless Power Transfer Systems

Seongho Woo[1], Yujun Shin[2], Sungryul Huh[1], Hyunsoo Lee[1], Seungyoung Ahn[1]
[1]*Korea Advanced Institute of Science and Technology, Korea;* [2]*Keimyung University, Korea*

ABSTRACT:
This paper proposes a method for determining the optimal phase difference between transmitter and receiver coils for suppressing leakage magnetic field in wireless power transfer (WPT) systems. As the power level of WPT systems increases, the leakage in the magnetic field also increases. As a result, the possibility of electromagnetic field (EMF) or electromagnetic interference (EMI) issues also increases. There are various shielding methods for reducing leakage magnetic field, but all the methods need additional materials or power sources. In contrast, the proposed method can suppress leakage magnetic field by determining the phase difference between TX and RX coils current without additional materials. So, the proposed method also can reduce the weight and cost of the WPT systems.

9:30AM

Thermal-Aware Wireless Charging System Design and Optimization for Wearable Devices with Magnetic Shielding

Jingchen Liang, Kamyar Keikhosravy, Mehdi Abarham, Pavani Gottipati
Ansys, Inc., USA

ABSTRACT:
Design of wireless chargers has become an increasingly complex subject in recent years due to the demand for reduced footprint of the wireless charger, increasing operating frequency and addition of permanent magnets for improved alignment. This paper presents a complete simulation workflow to address end-to-end design challenges for the wireless charging system of a smart watch including an integrated electromagnetic and thermal analyses and experimental validation of wireless charging coils, magnetic shielding to reduce electromagnetic interference, and system analysis with power electronics for efficiency calculation. Spatial power and temperature distributions are shared between the electromagnetics and thermal solutions and temperature dependent materials are considered for calculations to make this workflow unique and accurate. This provides engineers with a comprehensive wireless charging design and optimization workflow for consumer electronics applications.

Photo by Karthik Vepuri

THURSDAY, AUGUST 8

SC3 TECHNICAL PAPERS

MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE TECHNOLOGIES

8:30AM - 10:00AM

Room: 128A

Sponsored by SC-3

Chair:
Ling Zhang, *Zhejiang University, Hangzhou, China*

PLANNED SPEAKERS & TOPICS

8:30AM

Unsupervised Anomaly Detection of a Home Appliance by Monitoring EMI Data

Hyeonwoo Yu[1], Sangyeong Jeong[2,3], Jingook Kim[2,3]
[1]Sungkunkwan University, Korea; [2]Ulsan National Institute of Science and Technology, Korea; [3]EMcoretech, Co., Korea

ABSTRACT:
We propose an anomaly detection method by approximating the system state using electromagnetic interference (EMI) data. Since the harmonics of switching frequency cause characteristic patterns in conducted emission (CE) currents, understanding CE patterns can be exploited to detect an anomaly state caused by physical or functional defects in the system. To capture the CE patterns that follow an intractable distribution, we introduce a method based on a variational generative model. The anomaly data in a real-world scenario is challenging to obtain, and as such, we determined an approximated distribution for the normal states of a system to detect an outlier. Further, we designed a manifold space with a multi-modal prior distribution, thus our method can be extended to consider the entire system. To evaluate our approach, we manually collected normal and anomaly EMI data from the outdoor unit of an air conditioner. Using the EMI data from a normal state, we approximated the manifold distribution that follows an tractable distribution and demonstrate the possibilities for outlier detection. While common-mode (CM) CE EMI noise are mainly used for configuring the state of a system, we also apply our approach to the differential-mode (DM) as well as for direct power line noise.

9:00AM

Machine Learning based Radiation Source Reconstruction in Terms of Spherical Wave Expansion Coefficients

Carlo Olivieri, Lino Di Leonardo, Francesco de Paulis
University of L'Aquila, Italy

ABSTRACT:
Modern high-end electronic systems require accurate control of unwanted electromagnetic radiation. This paper proposes a novel source reconstruction method based on the combined use of Spherical Wave Expansion theory and Machine Learning techniques. The proposed method aims to estimate the equivalent spherical wave expansion coefficients describing the radiation from a generic source starting from the knowledge of its field magnitude information only (measured or simulated). The main details of the proposed method and preliminary results are summarized in the paper.

TC10-8 TECHNICAL PAPERS

SIMULATION AND MODELING TECHNIQUES #4

8:30AM - 10:00AM

Room: 128B

Sponsored by TC-10

Chair:
Jianquan Lou, *Cisco Systems (China) R&D Co., Ltd., Shanghai, China*

Co-Chair:
Di Hu, *General Motors Company, Sunnyvale, CA, USA*

PLANNED SPEAKERS & TOPICS

8:30AM

Novel Formulation for Generalization of Mixed-Mode S-Parameters for Coupled Differential High-Speed Digital Channels

Manish K. Mathew[1], Kevin Cai[2], Chaofeng Li[1], Mehdi Mousavi[1], Shameem Ahmed[2], DongHyun Kim[1]

[1]Missouri University of Science and Technology, USA; [2]Cisco Systems, Inc., USA

ABSTRACT:

As the demand for higher data rates intensifies, achieving accurate S-parameter calculation becomes increasingly critical. The conventional single-ended to mixed-mode S-parameter conversion formulation assumes uncoupled structures, which may not be true for high-speed digital channels. This work introduces a novel, generalized formulation for mixed-mode S-parameters and their corresponding transformation matrices [M_1] and [M_2], enabling comprehensive analysis of multi-pair coupled differential traces. An intra-pair crosstalk analysis of a tightly coupled stripline and microstrip line verifies and highlights the difference between the proposed and old formulations. A loosely coupled case is analyzed as an additional validation of the proposed formulation. Finally, the generalized conversion formulation is used to perform an inter-pair crosstalk analysis which compares the old and the new conversion formulation.

9:00AM

Fast Macromodeling of Large-Scale Multiports with Guaranteed Stability

Tommaso Bradde[1], Ion Victor Gosea[2], Stefano Grivet-Talocia[1]

[1]Politecnico di Torino, Italy; [2]Max Planck Institute for Dynamics of Complex Technical Systems, Germany

ABSTRACT:

This contribution introduces a novel approach for generating guaranteed stable macromodels of large multiport structures in a completely automated and efficient manner. The presented method is based on the Adaptive Antoulas-Anderson (AAA) algorithm for rational fitting of scalar transfer functions. We propose a computationally cheap multi-input multi-output extension of the AAA, and we combine the resulting algorithm with a novel post-processing stability enforcement step that is formulated in terms of a small-size convex program. Applying the resulting framework to a large Power Delivery Network (PDN), we show a significant computational cost reduction with respect to commonly employed state-of-the-art methods. The proposed scheme fits naturally as a bridge between electromagnetic and circuit simulation, enabling the representation of high-frequency phenomena and parasitics as low-order equivalent circuits synthesized from the computed macromodels.

9:30AM

Reassessing the FER3 of the IEEE 370 Standard

Chiu-Chih Chou

National Central University, Taiwan

ABSTRACT:

This paper reassesses the third fixture electrical requirements (FER3) in the IEEE 370 Standard. The link with the problem of spectrum truncation is explained, and through a simulated test case, it is shown that by properly handling the truncation, accurate de-embedding could be achieved even at frequencies significantly violating FER3. The results therefore suggest that the FER3 may be relaxed to avoid overdesign.

THURSDAY, AUGUST 8

ED18 EXPERIMENT DEMONSTRATION

ON THE APPLICATION OF FFTS FOR ACCELERATED TIME DOMAIN SCAN TO REDUCE EMI MEASUREMENT TIME

10:00AM - 12:00PM

Room: Exhibit Hall - E&D Booth 1

EMC testing is required for just about any product that has digital and radio components. With the growth of those products, time to complete EMC testing typically takes longer, due to competition for lab time, and for the surprises in tracking down short-burst or impulse-type emissions. The automotive industry, for example, requires exacting methodologies to measure all emissions accurately. Long test times impact test facility availability and potentially reduces the number of devices that are certified. It's also easy to miss intermittent disturbance signals with conventional scans since an extended dwell time must occur at each frequency.

With the implementation of a Short Time FFT (STFFT) engine, Keysight's N9048B PXE EMI receiver includes Time Domain Scan (TDS) and Accelerated TDS capabilities that enable independent compliance test laboratories and in- house certification labs to shorten their overall test time.

This presentation will provide an overview of TDS and Accelerated TDS capabilities to meet EMI measurement requirements and comply with EMC standards such as CISPR 16-1-1 and MIL-STD-461 and highlight how you can easily reduce receiver scan and test time from multiple hours to seconds.

PRESENTER

Bill Koerner
Keysight Technologies Inc., USA

ED19 EXPERIMENT DEMONSTRATION

PATUXENT RIVER LIGHTNING AND ELECTROTSTATICS TEAM "PRECEPITATION STATIC DEMONSTRATION"

10:00AM - 12:00PM

Room: Exhibit Hall - E&D Booth 2

Demonstration Idea – P-Static has characteristics can be demonstrated in a few different forms. We can set-up 3 different configurations.

UHF/VHF or any sort of aircraft antenna partially screwed on to a grounded aluminum plate. This will demonstrate the sound of the arcing on our Sony radios that can hook up to a speaker.

A grounded windshield/windscreen or piece of plastic that demonstrates how the charge can remain on the surface with a static voltmeter. We then use a static control brush to show the how voltage decreases then increases when the brush moves away.

A simple, aluminum sheet set up, that has one set-up demonstrating the arcing and one set-up that has it grounded and bonded. Painted Bolts could be a backup. This will show us the ideal and non-ideal conditions for proper bonding.

Modify the appearance of the wand to be more presentable.

Create a safety enclosure for the different configurations and HV Power Supply.

PRESENTERS

Christophor Hillyard[1], John Y. Howson[2], Tiffany Morisak[1]
[1]NAWCAD, USA; [2]NAWCAD, USA

ED20
EXPERIMENT DEMONSTRATION

SPEED UP YOUR RC: ACCELERATED E-FIELD MEASUREMENTS IN REVERBERATION CHAMBERS

10:00AM - 12:00PM

Room: Exhibit Hall - E&D Booth 3

The demo session will start with a brief introduction on the basics of reverberation chambers (RCs). Validation and radiated immunity testing are discussed.

We will bring a small, but fully working, stirred RC to the stage. Eight fast, synchronized electric-field probes will showcase real-time E-field strength measurements and closed loop E-field control based on statistics. LUMILOOP's LSProbe E-field Probes enable accelerated measurements according to ISO 11451-5.

Learn on how to improve you EMC measurement. Save time and money while testing!

PRESENTER

Samuel Hildebrandt
LUMILOOP GmbH, Germany

ED21
EXPERIMENT DEMONSTRATION

TROUBLESHOOTING EMI FAILURES ON POWER DELIVERY NETWORKS USING AN OSCILLOSCOPE AND NEAR FIELD PROBES

10:00AM - 12:00PM

Room: Exhibit Hall - E&D Booth 4

Power delivery networks (PDNs) including PCB planes, capacitors, inductors and power conversion devices are common sources of both cunducted and radiated EMI. Methods for using near field probes and an oscilloscope to troubleshoot these problems are presented in this demonstration. While oscilloscopes are generally considered for observing and measuring signals in the time domain, most modern digital oscilloscopes are capable of accurate spectrum measurements as well. The benfit of using an oscilloscope with FFT-based spectrum analysis is its ability to measure in both time and frequency domains simultaneousy.

Near field EMI measurements on a switched mode power supply under different load conditions and their relationship to the inductor saturation are used to illustrate this benefit.

PRESENTERS

Michael Schnecker
Rohde&schwarz, USA

THURSDAY, AUGUST 8

TC2-5 TECHNICAL PAPERS

EMC MEASUREMENTS: PULSED RFI IN MOTORS, MULTI-TONE SUSCEPTIBILITY IMPACT AND BENCH TO ON-VEHICLE EMISSIONS COMPARISONS

10:30AM - 12:00PM

Room: 125AB

Sponsored by TC-2

Chair:
Ahalya Srikanth, *Ford Motor Company, Lasalle, ON, Canada*

Co-Chair:
John Kraemer, *Kraemer EMC, Marion, IA, USA*

PLANNED SPEAKERS & TOPICS

10:30AM

Influence of Multi-Tone on the Susceptibility of Electronic Devices at the System Level

Alexis Gandon, David Martinez, Islem Yahi, Felix Vega, Chaouki Kasmi

Technology Innovation Institute, United Arab Emirates

ABSTRACT:

This work experimentally compares the impact of single-tone (ST) and Multi-tone (MT) immunity tests on an electronic device. The objective is to assess and compare the system's behavior for both conditions. Moreover, the work aims to highlight that MT testing can lead to worsened failure conditions of the equipment with a reduced power ratio.

11:00AM

Bench vs On-Vehicle Emissions Correlation?

Ch. U. Sajjad[1], John F. Dawson[1], Andy Marvin[1], Ayhan Gunsaya[2]

[1]University of York, United Kingdom; [2]Ford Motor Company, United Kingdom

ABSTRACT:

This paper explores the radiated emissions from transmission line driven from an equipment enclosure using 1/10th scaled models of a CISPR 25 bench and a commercial van. The differences are presented from the perspective of the radiation pattern of the system in the hemisphere above the ground plane.

ARIZONA FUN FACT

ARIZONA CLIMATE

Welcome to the Sunniest City on Earth and Sunniest State in the USA. The World Record Academy states that Yuma, Arizona receives 91 percent of daylight hours per year (an average of 4,055 hours per year out of 4,456 possible daylight hours). During summer there are up to 13 hours of sunlight and a total of 11 hours during the winter– earning Yuma a world record! As a state, Arizona collects average annual sunlight of 5,755 kJ/m^2 (Kilo-joule per square meter), making us the sunniest state in the U.S.

Arizona is known for its low humidity, low altitude (in some areas), low average rainfall, and extremely diverse geographical makeup. In addition, Arizona is a favorable place to live for arthritis due to consistent humidity and barometric pressure levels.

4 TIPS FOR ENJOYING AN ARIZONA SUMMER

Arizona is warm and sunny all year round, but those temperatures can get hot in the summer.

STAY HYDRATED
Be sure to bring a bottle of water with you and make an effort to sip on it throughout the day to stay healthy and hydrated.

WEAR SUNBLOCK
If you plan on spending the day outdoors, wear sunblock, so you don't get a sunburn.

CHECK THE WEATHER
Before you plan an afternoon outdoors, check how hot it will be. Knowing the day's weather will help you to prepare ahead of time.

STICK TO THE SHADE
By sticking to the shade, you will lower your body temperature and decrease your risk of sunburn or dehydration.

SS04 SPECIAL SESSION

STOCHASTIC ELECTROMAGNETICS

10:30AM - 4:30PM

Room: 127C

Sponsored by TC-4

Chair:
Paul Bremner, *Robust Physics, Del Mar, CA, USA*

Co-Chair:
Evelyn Dohme, *Sandia National Laboratories, Albuquerque, NM, USA*

Many design challenges in EMC and Signal Integrity involve complexity and uncertainty that can only be quantified statistically. Reverberation chamber testing in EMC; bit error rate (BER) metric for signal integrity (SI) and RMS delay spread in 5G/6G wireless are examples. Stochastic Electromagnetics encompasses both probabilistic simulation methods and supporting statistical testing methods that are rapidly evolving to reliably address these challenges. This special session will highlight new developments in emerging Stochastic Electromagnetics, such as stochastic power balance, random coupling modeling, and stochastic Green's function analysis. The scope of this session encompasses all aspects of stochastic EMC methods, including novel theoretical developments, practical implementation and complexity analysis, and experimental validation.

PLANNED SPEAKERS & TOPICS

10:30AM

Statistics of Electromagnetic Fields within Wire-Coupled, Nested Reverberant Enclosures
Marshall D. Sowell, Kyle Shea, Carl E. Hager IV
Naval Surface Warfare Center, USA
EMC BEST PAPER FINALIST
ABSTRACT:
A study has been performed to characterize the statistics within an inner reverberant enclosure when it is electromagnetically illuminated within a larger reverberant enclosure (i.e., nested enclosure). The coupling mechanism used to exchange energy between the two cavities were a series of N = 1, 2, … , 30 wire penetrations. The wires act as the dominate leakage mechanism between the two coupled enclosures and represent each test case. Two well studied distributions were used to fit the measured power – the power form of the double-Rayleigh (termed the double-exponential) distribution and the exponential distribution. The Anderson-Darling and Pearson's chi-squared goodness-of-fit tests were used at the 95% confidence level to evaluate the distributions. The chi-squared goodness-of-fit rejected the null hypothesis at a 5.52% rejection rate when testing against the double-exponential distribution for the N = 1 test case, indicating a good fit. The exponential distribution showed evidence of a good fit only for N ≥ 20 test cases, indicating the two enclosures were statistically acting as a single enclosure. A new hypothesized distribution termed the modified double-exponential distribution was shown to provide a good fit for all N test cases. This distribution indicates that it is a good fit under the conditions of this experiment, and further study into coupled enclosure statistical behavior is ongoing.

11:00AM

On the Formulation of Stochastic Green's Function Method for Aperture Coupled Enclosures
Sangrui Luo, Shen Lin, Yang Shao, Zhen Peng
University of Illinois Urbana-Champaign, USA
EMC BEST STUDENT PAPER SEMI-FINALIST
ABSTRACT:
The stochastic Green's function method was recently introduced as a physics-oriented, statistical surrogate model for the vector wave equation in large, complex enclosures. It provides a computationally efficient means of approximating confined EM environments by leveraging a statistical representation of the cavity eigenfunctions and eigenvalues. This paper advances the formulation of the stochastic Green's function method to address the challenges posed by complex targets with hierarchical interactions. The scope of applications spans electromagnetic coupling into multiple interconnected cavities and the prediction of shielding effectiveness for nested enclosures.

11:30AM

Experimental Validation of Model for Cavity Field Statistics when Q Factor or Excitation Level are Uncertain
P. Bremner[1], R. Afra1, J. West[2], C. Bunting[2], M. Mustafa[2], S. Mostafa[2]
[1]RobustPhysics, USA; [2]Oklahoma State University, USA
ABSTRACT:
Statistical power balance (SPB) modeling has previously been shown to efficiently predict electric field levels inside enclosures – both shielding effectiveness from exterior sources and radiation from cables inside the enclosure. At high frequencies, the enclosure field is complex, multi-modal (reverberant) and can only be described statistically. However, the maximum expected field level can also be impacted by model uncertainty in the enclosure Q factor and/or uncertainty (variability) in source excitation field

strength. This paper documents the theoretical development and the experimental validation of an extension to SPB modeling (Bremner, Proc. EMC Symp. 2023) which incorporates uncertainty in Q factor and/or uncertainty in excitation field strength.

1:30PM

Statistical Analysis of Electromagnetic Coupling to Printed Circuit Boards

Shengxuan Xia, Victor Khilkevich, Daryl Beetner
Missouri University of Science and Technology, USA

ABSTRACT:
Determining electromagnetic (EM) coupling to printed circuit boards (PCBs) is essential to finding potential EM susceptibilities early in the design process. For realistic PCB structures, analysis usually relies heavily on time-consuming full-wave simulations because of the complexity of the geometries and the lack of analytical solutions. In this paper, we adopt a segmentation approach based on far-field reciprocity which allows for rapid estimation of the voltage induced at trace terminations over frequency, and which is then used to estimate statistical characteristic of coupling across trace geometries. Frequency-domain results can then be used to estimate time-domain responses with appropriate transformations. Super-position is then used to separate the coupling contributed by different PCB structures, which provides better insight into the mechanisms responsible for susceptibility.

2:00PM

Three Coupling Models Compared in a Distributed Port

E.A.D. Dhombridge[1], T.W. Hussey[2], Z.V. Peng[3], P. Bremner[4], E. Schamiloglu[2]
[1]Sandia National Laboratories, USA; [2]The University of New Mexico, USA; [3]University of Illinois at Urbana-Champaign, USA; [4]RobustPhysics, USA

ABSTRACT:
It is well known that electromagnetic fields in overmoded high Q cavities are difficult to characterize deterministically because of extreme sensitivity to small variations in boundary conditions. The acoustics community first explored a variant of this problem where, in the highly overmoded limit, the distribution of pressure within a room could be characterized statistically.

2:30PM

Extended Resistance Matrix Formulation for Radiation Coupling of a Multi-Conductor Transmission Line

Weitao Dai, Paul G. Bremner
RobustPhysics, USA

ABSTRACT:
This paper proposes a method to extend the resistance matrices of multi-conductor transmission lines (MTL) to model shields. The imperfect shielding effectiveness is modeled with transfer impedance. The radiated emission and susceptibility of quite general MTLs are found to require a full non-diagonal matrix. The full equations with radiation resistance terms, ohmic resistance terms, and shield transfer impedance are derived. The resulting model is validated against published test data.

3:30PM

Chassis-Integrated Mode Stirring for Statistical Shielding Effectiveness Characterization

Jon W. Wallace
Sandia National Laboratories, USA

ABSTRACT:
Characterizing shielding effectiveness (SE) of enclosures is important in aerospace, military, and consumer applications. Direct SE measurement of an enclosure or chassis may be considered an exact characterization, but there are several sources of possible variability in such measurements, e.g., mechanical tolerances, the absence of components during test that exist in a final assembly, movement of components and cables, and perturbations due to probes and associated cabling. We explore internal stirrers as a way to quantify variability and sensitivity of an SE measurement, not only indicating the uncertainty of the SE measurement, but also delineating frequency ranges where either deterministic or statistical simulations should be applied.

4:00PM

Statistical Comparison of Time- and Frequency-Domain Measurements for Cylindrical Cavities

Saif Mostafa[1], Charles F. Bunting[1], Mazin M. Mustafa[1], Mostafa Ibrahim[3], Paul Bremner[2], Reza Afra[2], James C. West[1]
[1]Oklahoma State University, USA; [2]RobustPhysics, USA; [3]Texas A&M University, USA

ABSTRACT:
The efficacy of direct time-domain measurements is compared to frequency-domain measurements in the characterization of a cylindrical, reverberant cavity within frequencies ranging from 1 GHz to 3.69 GHz. Considered is the agreement and challenges posed by both methods rather than exclusively focusing on the advantages relative to their alternatives. Moreover, the inquiry undertaken is expected to result in a robust alignment between the investigated experimental methods, demonstrating that the frequency domain is not necessarily more accurate than the time domain, but is nonetheless reliable and satisfactory.

THURSDAY, AUGUST 8

ES01 TECHNICAL PAPERS

EXEMPLARY PAPER SESSION
10:30AM - 4:30PM
Room: 129A

Chair:
Frank Gronwald, *Universitat Siegen Fakultat IV Naturwissenschaftlich-Technische Fakultat, Siegen, Germany*

Back for the second year at the EMC+SIPI Symposium, authors of already published exemplary papers have been invited to present their work to the IEEE EMC & SPI community. All of the selected exemplary papers are either award-winning, heavily cited, frequently downloaded, or of great practical value. Attendees of this session have the possibility to directly interact with high quality authors and to experience an interesting mix of different EMC & SPI topics. Presenting authors and the audience are encouraged to interact with each other and to initiate discussions and new ideas for future work.

PLANNED SPEAKERS & TOPICS

10:30AM
Echo TEMPEST: EM Information Leakage Induced by IEMI for Electronic Devices
Presenting Author: Yuichi Hayashi
Kaji, S., Fujimoto, D., Kinugawa, M., & Hayashi, Y. (2023)
Citation: S. Kaji, D. Fujimoto, M. Kinugawa and Y. Hayashi, "Echo TEMPEST: EM Information Leakage Induced by IEMI for Electronic Devices," in IEEE Transactions on Electromagnetic Compatibility, vol. 65, no. 3, pp. 655 – 666, June 2023, doi: 10.1109/TEMC.2023.3252636.

11:00AM
Predicting Statistical Wave Physics in Complex Enclosures: A Stochastic Dyadic Green's Function Approach
Presenting Author: Zhen Peng
Lin, S., Luo, S., Ma, S., Feng, J., Shao, Y., Drikas, Z.B., Addissie, B.D., Anlage, S.M., Antonsen, T., & Peng, Z. (2023)
Citation: S. Lin, S. Luo, S. Ma, J. Feng, Y. Shao, Z.B. Drikas, B.D. Addissie, S.M. Anlage, T. Antonsen and Zhen Peng, "Predicting Statistical Wave Physics in Complex Enclosures: A Stochastic Dyadic Green's Function Approach," in IEEE Transactions on Electromagnetic Compatibility, vol. 65, no. 2, pp. 436 – 453, April 2023, doi: 10.1109/TEMC.2023.3234912.

11:30AM
Mode-Decomposition-Based Equivalent Model of High-Speed vias up to 100 GHz
Presenting Author: DongHyun Kim
Li, C., Cai, K., Ouyang, M., Gao, Q., Sen B., & Kim, DH. (2023)
Citation: C. Li, K. Cai, M. Ouyang, Q. Gao, B. Sen and DH. Kim, "Mode-Decomposition-Based Equivalent Model of High-Speed Vias up to 100 GHz," in IEEE Transactions on Signal and Power Integrity, vol. 2, pp. 74 – 83, doi: 10.1109/TSIPI.2023.3268255.

1:30PM
An Approach to Identify Noise-Source Parameters of DC-DC Converter and Predict Conducted Emissions with Different Loads
Presenting Author: Yoshitaka Toyota
Zhang, S., Iokibe, K., & Toyota Y. (2023)
Citation: S. Zhang, K. Iokibe, and Y. Toyota, "An Approach to Identify Noise-Source Parameters of DC–DC Converter and Predict Conducted Emissions With Different Loads," in Letters on Electromagnetic Compatibility Practice and Applications , vol. 5, pp. 5 – 9, March 2023, doi: 10.1109/LEMCPA.2022.3228199.

2:00PM
Electric Field Probe De-Embedding Calibration based on Through and Line Standards
Presenting on behalf of the Authors: Yuandong Guo
Xue, S., Yang, S., Shao, W., Tian, X., & Wu, D. (2023)
Citation: S. Xue, S. Yang, W. Shao, X. Tian and D. Wu, "Electric Field Probe De-Embedding Calibration Based on Through and Line Standards," in IEEE Sensors Journal, vol. 23, no. 7, pp. 6999 – 7007, April 2023, doi: 10.1109/JSEN.2023.3248863.

3:30PM
Impact of Parasitic PCB and EMI Filter Inductances on System-Level ESD Protection
Presenting Author: Andreas Hardock
Mergens, M., Bub, S., Seider, S., Holland, S., Hardock, A., & Schütt, J. (2022)
Citation: M. Mergens, S. Bub, S. Seider, S. Holland, A. Hardock and J. Schütt, „Impact of Parasitic PCB and EMI Filter Inductances on System-level ESD Protection," in Proceedings of the 17th ESD Forum 2022, Dresden, Germany.

4:00PM
Practical SI EM Simulator using Neural Language Models
Presenting Author: Chulsoon Hwang
Park, H., Ding, Y., Zhang, L., Bondarenko, N., Ye, H., Achkir, B., & Hwang, C. (2024)
Citation: H. Park, Y. Ding, L. Zhang, N. Bondarenko, H. Ye, B. Achkir and C. Hwang, "Practical SI EM Simulator using Neural Language Models," in Proceedings of DesignCon 2024, Santa Clara, CA, USA.

SC5-1 TECHNICAL PAPERS

PASSIVE COMPONENTS AND SEMICONDUCTOR DEVICES

10:30AM - 12:00PM

Room: 127A

Sponsored by SC-5

Chair:
Shuo Wang, *University of Florida, Gainesville, FL, USA*

Co-Chair:
Sebastian Koj, *Jade Hochschule, Wilhelmshaven, Germany*

PLANNED SPEAKERS & TOPICS

10:30AM

A New Method for Extracting Parasitic Capacitance of MOSFET in a Half-Bridge Configuration

Jaewon Rhee, Sanguk Lee, Hongseok Kim, Jiseong Kim, Seungyoung Ahn

Korea Advanced Institute of Science and Technology, Korea

ABSTRACT:
Parasitic capacitance of silicon carbide (SiC) metal–oxide–semiconductor field effect transistor (MOSFET) significantly affects the operation of power circuits and their electromagnetic interference (EMI) performance. The parasitic capacitance of the MOSFET can resonate with PCB traces or cables, generating noise during switching, making it crucial to extract the parasitic capacitance accurately and conveniently. With the increasing use of various electronic devices, such as electric vehicles and household appliances, there is growing interest in inverters for driving motors, where MOSFETs are mainly used in a half-bridge structure. Recently, chip-type MOSFET with a half-bridge type has been developed for miniaturization and weight reduction of the devices. This study proposes a method to simplify the extraction of parasitic capacitance from half-bridge MOSFET, which traditionally requires complex and many procedures. This method allows for the stable and straightforward extraction of parasitic capacitance in a 3-terminal structured MOSFET using a 2-port network without floating errors. The proposed method, compared to the conventional methods, can reduce the required steps, and it has been verified through 3D EM simulation.

11:00AM

Comprehensive Surge Analysis: Shielding Cable Response and Power Port Protection Circuit Design

Jianquan Lou[1], David Tang[1], Haiwen Lu[1], Alpesh Bhobe[2], Xuxian Jiang[3]

[1]Cisco Systems (China) R&D Co., Ltd., China; [2]Cisco Systems, Inc., USA; [3]Shanghai University, China

ABSTRACT:
This paper introduces two surge generation circuits designed to comply with the IEC61000-4-5 standard. Leveraging these circuits, we conduct a comprehensive investigation into the impact of surges on shielding coaxial cables through simulation. The analysis involves calculating the noise coupled into the inner signal wire across various cable lengths. Additionally, surge noise is applied to the power port, prompting an initial exploration of Coupling/Decoupling Network (CDN) modeling. The study extends to the comparison of three surge protection circuit configurations in the power port through both simulation and measurement. A model incorporating a variable capacitance was established to enhance agreement. The alignment of simulation and measurement results serves as valuable guidance for the early-stage design of surge protection circuits in projects.

11:30AM

Accurate Method for Extracting the Multi-Layered Ceramic Capacitor Impedance by Eliminating the Influence of Mounting Pads and Via-Hole

Sanguk Lee, Jaewon Rhee, Seunghun Ryu, Hongseok Kim, Seungyoung Ahn

Korea Advanced Institute of Science and Technology, Korea

ABSTRACT:
In this paper, we propose a method for de-embedding the influence of the mounting pads and via-hole in the test fixture for accurate impedance extraction of the multilayered ceramic capacitors (MLCCs). The proposed method can extract the parasitics of the mounting pads and via-hole using the short fixture and de-embed the influence of the mounting pads and via-hole from the measurement results. To accurately extract the parasitics of mounting pads and via-hole, the technique in which the reference plane underneath the mounting pads and short bar is cleared is introduced. The proposed method can reduce the error in self-resonant frequency and equivalent series inductance (ESL) by up to 3.00% and 1.54%.

THURSDAY, AUGUST 8

TC12-1 TECHNICAL PAPERS

RF INTERFERENCE AND DE-SENSE

10:30AM - 12:00PM

Room: 128A

Sponsored by TC-12

Chair:
Francesco de Paulis, *University of L'Aquila, L'Aquila, Italy*

Co-Chair:
DongHyun (Bill) Kim, *Missouri University of Science and Technology College of Engineering and Computing, Rolla, MO, USA*

PLANNED SPEAKERS & TOPICS

10:30AM

Impact of Aging on PIM and DC Resistance of Fabric-over-Foam Metallic Contacts

Kalkidan W. Anjajo[1], Seunghun Ryu[1], Shengxuan Xia[1], Gracie Boyer[3], Yuchu He[2], Haicheng Zhou[2], Hanfeng Wang[2], Jonghyun Park[3], Chulsoon Hwang[1]
[1]Missouri University of Science and Technology, USA; [2]Google Inc., USA

ABSTRACT:
In this paper the impact of aging on the level of passive intermodulation (PIM) and DC resistance of fabric-over-foam metallic contacts is presented. These contacts are widely used to maintain metallic connections between modules and chassis in electronic devices. The PIM caused by the loose metallic contact of these materials mainly affects a receiver's RF sensitivity in mobile devices. This aging test under elevated temperature and relative humidity conditions offers an experiment-based approach with respect to various metallic contact cases. Energy dispersive spectroscopy and scanning electron microscopy are used to characterize the change in material composition and the contact surface throughout the aging. The experimental environmental effects showed the aging on the generated PIM level to have little to no impact from weakened adhesive contact and an increase in lowest PIM floor. Also, an increase in DC resistance level of these metallic contact materials was observed due to an oxide growth on the fabric-over-foam surface.

11:00AM

Design of Experiment Analysis on Multiple PIM Sources in an RF Antenna System

Shengxuan Xia[1], Yuchu He[2], Haicheng Zhou[2], Hanfeng Wang[2], Chulsoon Hwang[1]
[1]Missouri University of Science and Technology, USA; [2]Google Inc., USA

EMC BEST PAPER FINALIST AND BEST STUDENT PAPER SEMI-FINALIST

ABSTRACT:
Passive intermodulation (PIM) has been identified as one of the common root causes for receiving sensitivity degradation (desense) on radio-frequency (RF) antennas working in frequency-division duplex mode. The component-level PIM characterization and simulation have been well-established over the years. However, the study has been using an ideal 50 ff transmission line system while antenna modules are more complicated than a simple transmission line structure. Moreover, the metallic contacts can exist in multiple locations with different connection topologies in real applications. This paper provides a method to simulate the PIM performance caused by the metallic contacts in a practical environment. In addition, the design of experiment (DoE) analysis is conducted to understand the statistical relationship between the component nonlinearity and the total PIM levels. Prioritizing the critical contact locations design insights including what-if scenario studies are found with the DoE.

TC10-9 TECHNICAL PAPERS

POWER DISTRIBUTION NETWORKS AND DECOUPLING #3

10:30AM - 12:00PM

Room: 128B

Sponsored by TC-10

Chair:
Ying Cao, *Apple Inc, Cupertino, CA*

Co-Chair:
Kaisheng Hu, *Ciena, Ottawa, ON, Canada*

PLANNED SPEAKERS & TOPICS

10:30AM

Dual-Structure Genetic Algorithm-Based Optimization Method for PDN Design

Suhyoun Song, Ook Chung, Hogeun Yoo, Jaehoon Lee
Korea University, Korea

ABSTRACT:

Optimizing the placement of decoupling capacitors (decaps) is crucial in power delivery network (PDN) design, yet it poses challenges due to the large search space. In this paper, we present a dual-structure genetic algorithm (GA)-based optimization method that optimizes both via placement and decap configurations to achieve the target impedance while minimizing the number of capacitors used. The resulting design exhibits a lower cost function compared to previous methods that optimizes decaps at fixed locations, displaying enhanced optimization performance.

11:00AM

PDN Noise-Jitter Co-Optimization using Physics-Assisted Genetic Algorithm

Li Jiang, Ling Zhang, Er-Ping Li
Zhejiang University, China

SIPI BEST STUDENT PAPER SEMI-FINALIST

ABSTRACT:

Determining the selection of decoupling capacitors (decaps) in power distribution networks (PDNs) is essential to co-designing signal integrity (SI) and power integrity (PI) for high-speed integrated circuits, but it usually requires a long optimization time. This article proposes an efficient decap optimization method for PDN noise-jitter co-optimization with a physics-assisted genetic algorithm (GA). The proposed method can efficiently minimize the number of decaps to simultaneously reduce the power supply induced jitter (PSIJ) and PDN transient noise. Firstly, an initial solution is quickly determined by adding decaps sequentially and evaluating the PSIJ and transient noise through an analytical calculation approach. Secondly, a physics-assisted GA is adopted to continuously improve the solution quality. Instead of using the analytical calculation method, Hspice simulation is adopted to evaluate the PSIJ and transient noise more accurately during the second-stage optimization. The validation result shows that the proposed method can efficiently minimize the decap number and reliably achieve the target PSIJ and transient noise. The proposed method demonstrates a remarkably better performance than the existing GA regarding solution quality and time efficiency.

11:30AM

Behavior Model of a Multiphase Voltage Regulator Module with Rapid Voltage Drop Protection

Junho Joo[1], Hanyu Zhang[1], Hanfeng Wang[2], Wei Shen[2], Zhigang Liang[2], Lihui Cao[2], Seungtaek Jeong[2], Chulsoon Hwang[1]
[1]Missouri University of Science and Technology, USA; [2]Google Inc., USA

SIPI BEST STUDENT PAPER SEMI-FINALIST AND BEST PAPER FINALIST

ABSTRACT:

In this paper, a modeling method of voltage regulator module (VRM) with rapid voltage drop protection is introduced. The proposed VRM model captures a pulse-width modulation scheme developed to counteract substantial load currents with high di/dt, resulting in a large voltage drop across the power delivery network (PDN). The equations to describe the non-linear behavior associated with the multiphase VRM behavior are proposed and successfully validated for both light and heavy loads, the latter being particularly crucial to trigger the voltage drop protection measures.

THURSDAY, AUGUST 8

SC5-2 TECHNICAL PAPERS

MODELING OF WIRELESS POWER TRANSFER SYSTEMS

1:30PM - 3:00PM

Room: 127A

Sponsored by SC-5

Chair:
Shuo Wang, *University of Florida, Gainesville, FL, USA*

Co-Chair:
Chulsoon Hwang, *Missouri University of Science and Technology, Rolla, MO, USA*

PLANNED SPEAKERS & TOPICS

1:30PM

Enhancing Efficiency and Robustness in Bi-Directional Wireless Power Transfer via CLLLC Resonant Networks

Babatunde Soyoye, Indranil Bhattacharya, Mary Vinolisha Antony Dhason

Tennessee Technological University, USA

ABSTRACT:

Wireless power transfer (WPT) is a rapidly developing field, and strong and efficient systems are essential, especially for bi-directional applications. In this study, the performance of a CLLLC resonant network in a bi-directional WPT system is analyzed and its implementation is explored. We find that the CLLLC network achieves soft-switching capabilities and improves voltage regulation, load adaptability, and provides a considerable improvement in phase shift control and resonant frequency regulation. To build a resonant inverter with a 60kW output, we carefully tune the system parameters using Fundamental Mode Analysis. A noteworthy 90.4% efficiency in power transfers from the grid to the car and from the vehicle to the grid is confirmed by the simulation. The results highlight the advantages of using CLLLC networks and possible drawbacks, demonstrating their superiority in efficiency and system adaptability when compared to traditional LLC converters.

2:00PM

An Equivalent Coil Model of a Wireless Power Transfer System Including Eddy Loss

Hanyu Zhang, Daryl Beetner

Missouri University of Science and Technology, USA

ABSTRACT:

A wireless power transfer (WPT) system suffers from eddy loss if a conductive object is placed near the coupling coil. In this paper, a 3-coil equivalent circuit model for the coupling coil in a WPT system is proposed for analyzing the eddy loss due to nearby conductors. This model uses a third coil with inductive coupling to the original transmitting and receiving coils to model the eddy loss. The proposed model was validated by comparing the Z-parameters with a full-wave simulation and showing good correlation over the frequency of interest, where the traditional 2-coil model fails. The 3-coil model is compared with the Steinmetz equivalent circuit model and shows better accuracy in terms of efficiency simulation. This proposed model can be used in efficiency analysis and design optimization of a WPT system.

2:30PM

Radiated Emission Modeling of a Wireless Power Transfer System

Hanyu Zhang[1], Guanghua Li[2], Viswa Pilla[2], Chulsoon Hwang[1]

[1]Missouri University of Science and Technology, USA; [2]Apple Inc., USA

EMC BEST PAPER FINALIST

ABSTRACT:

A radiated emission (RE) model of a wireless power transfer (WPT) system is proposed in this paper to help designers predict, analyze, and mitigate the RE issues during the design process. The proposed model employs both full-wave simulation and circuit simulation to derive a transfer function. Subsequently, it predicts the emission level by combining the transfer function with the measured transmitter waveform through a straightforward calculation. The predicted emissions match the measured RE peaks well up to 300 MHz, with the error within 3 dB. The impact of functional parameters, such as load and coil gap distance, is analyzed based on the proposed model.

TC12-2 TECHNICAL PAPERS

WIRELESS COEXISTENCE

1:30PM - 3:00PM

Room: 128A

Sponsored by TC-12

Chair:

DongHyun (Bill) Kim, *Missouri University of Science and Technology College of Engineering and Computing, Rolla, MO, USA*

PLANNED SPEAKERS & TOPICS

1:30PM

On Comparing Interference Impacts

Aric Sanders[1], Michelle Pirrone[1,2], M. Keith Forsyth[1], Adam Wunderlich[1]

[1]National Institute of Standards and Technology, USA; [2]University of Colorado Boulder, USA

ABSTRACT:

Interference between communication systems is a critical issue that can impact performance and operability of devices. A wide range of methods and testbeds have been developed to study susceptibility to interference, and each of these testbeds and their experimental test schedules can have different factors and responses. Although there is a variety in testbed design and measurement, it is common to choose a response that is assumed to vary with signal-to-noise ratio. A fundamental issue in any interference study of this type is the assignment of the power of the interference signal in a way that represents the desired environmental situation. This can be a challenging task for signals with disparate time, frequency and power dynamics. In particular, whether to assign a maximum (peak power) or a time averaged power becomes ambiguous for inter-interference signal comparisons. To address this problem we propose a quantitative scale based on the impact on the receiver of interest. We demonstrate how to form an interference signal agnostic scale and apply that scale for different interference situations. This scale, impact equivalent power ratio, can be transformed into an impact equivalent power with knowledge of the effective noise figure of the system under test.

2:00PM

Coexistence Testing: Comparing Conducted and Radiated Test Results

Susanna Mosleh[1], Nadia P. Yoza-Mitsuishi[1], Jason B. Coder[1], Carl B. Sunderman[2]

[1]National Institute of Standards and Technology, USA; [2]National Institute for Occupational Safety and Health, USA

ABSTRACT:

In an era of ubiquitous wireless devices, ensuring their coexistence in shared electromagnetic environments has become increasingly critical. This paper explores the dynamics of coexistence testing and compares two coexistence test environments outlined in the ANSI/USEMCSC C63.27 standard: conducted and radiated-anechoic. The objective is to demonstrate how the results from two different test environments can be compared. We conducted a series of tests involving a commercial wireless Emergency Stop (E-Stop) system and IEEE 802.11 WLAN technology - two wireless technologies deployed in machine safety applications in industrial settings, including the mining sector. These tests provide insights into how the different testing environments can influence the outcomes of coexistence tests and how one can compare the results between two different test environments. The paper also presents an overview of general coexistence testing procedures.

THURSDAY, AUGUST 8

TC10-11 TECHNICAL PAPERS

HIGH-SPEED INTERCONNECTS
1:30PM - 3:00PM
Room: 128B
Sponsored by TC-10

Chair:
Tao Wang, *Missouri University of Science and Technology, Rolla, MO, USA*
Co-Chair:
Thanh Tran, *Rice University, Houston, TX, USA*

PLANNED SPEAKERS & TOPICS

1:30PM
Signal Integrity Comparison of Commercially Available Sockets for the 50Gbps Ethernet Channel
Nupur Basak, Oluwafemi Akinwale, Michael E. Ryan
Intel Corporation, USA
ABSTRACT:
As the demand for data center networking bandwidth proliferates, improving the test sockets available in the market is imperative. This paper looks at two commercially available sockets, the elastomer and pogo pin sockets, to investigate the feasibility of Ethernet speeds of 50 Gbps and beyond. 3D FEM (Finite Element Modeling) Ansys HFSS software, along with COM (Channel Operating Margin), is used to evaluate the performance delta between socket-less, elastomer, and pogo-pin sockets. The results show that the elastomer socket performs similarly to the socket-less case and is transparent during channel analysis despite additional components in the channel path. The pogo pin socket has only a slight performance degradation due to the resonance interaction between the pin and channel.

2:00PM
Mitigation of Fiber Weave Induced Intra-Pair Skew for Differential Signaling at 64Gbps and Above
Chenghai Yan, Xinjun Zhang, Weizhe Li, Xiaoning Ye, Vijay Kunda, Yi Amy H. Luoh, Luis E. Rosales Galvan, Octavio Miramontes
Intel Corporation, USA
ABSTRACT:
Despite the use of multiple mitigation technologies, new challenges arise in the latest server systems to control the intra-pair skew induced by the fiber weave effect when I/O speeds are upgraded to 64Gbps. CuMax and jogged routing are two new mitigation methods proposed in this paper. CuMax can reduce the total intra-pair skew to less than 1ps, while the jogged routing can reduce the largest intra-pair skew by two-thirds. The design guidelines for the impact of the intra-pair skew with mitigation on PCIe 6.0 running at 64Gbps are also discussed.

2:30PM
Identification of Bandwidth Requirements for Channel Optimization at 200 Gbps
Rick Rabinovich[1], Richard Mellitz[2], Mike Resso[1], Francesco de Paulis[3]
[1]Keysight Technologies, USA; [2]Samtec Corporation, USA; [3]University of L'Aquila, Italy
ABSTRACT:
With the advent of higher bit rates such as 200 Gb/s PAM4, it is necessary to determine the minimum frequency range required to fully characterize electrical channels and still keep accurate results consistent with the simulation models. This paper dives into the relationship between this range of interest and the receiver equalization input filter. The authors will present the different options available at the standard bodies to agree on a convenient middle ground between “pure science” and “practical world”. The Channel Operating Margin (COM) will be utilized to document the findings.

TC3 TECHNICAL PAPERS

DATA ANALYSIS IN ELECTROMAGNETIC ENVIRONMENTS

1:30PM - 2:30PM

Room: 125AB

Chair:
Randy Jost, *Utah State University, Hyde Park, UT, USA*

PLANNED SPEAKERS & TOPICS

1:30PM

Estimating Radiated Emissions from Device Cabling using Common-Mode Current Measured at a Single Point

Hamidreza Karami1, Marcos Rubinstein1, Melina Bouldi2, Christophe Perrenoud2, Pascal Kraehenbuehl2
1University of Applied Sciences Western Switzerland, Switzerland; 2Federal Office of Communications Electromagnetic Compatibility Section, Switzerland

2:00PM

Visual Space-Time Complexity Analysis of Big Signal Data

Jan Nemec, Stanislav Kovar, Jan Valouch, Milan Adamek
Tomas Bata University in Zlin, Czechia

ABSTRACT:

This paper will focus on introducing visual analysis for big signal data suitable for preliminary conclusions and information presented to others. The analysis is to determine uniqueness, focusing on spatial-temporal complexity by the nature of the test data. Alongside introducing the analysis and optimization for programming purposes, the real data will be presented and used to display possible usage of this analysis and to determine the uniqueness of electromagnetic background for the possible use in true random number generators. The data consists of measurements in frequency band increments in many locations using widely available consumer-grade equipment. Visual analyses are especially valuable in situations like search for entropy sources because there is no immediate need for a concrete number or boolean statement of the uniqueness; moreover, presenting work is the daily job of a researcher, and the ability to visualize findings in a simple figure is easier to digest by the wider population.

Photo by Richard Georgarian

THURSDAY, AUGUST 8

TC11 TECHNICAL PAPERS

NANOTECHNOLOGY AND ADVANCED MATERIALS

2:30PM - 3:00PM

Room: 125AB

Sponsored by TC-11

Chair:
Marina Koledintseva, *The Boeing Company, St. Charles, MO, USA*

PLANNED SPEAKERS & TOPICS

2:30PM

Design and Manufacture of Periodic Metastructure Materials with Broadband EM Absorption

Dandan Zhang[1], Steven Mamolo[2], Kanat Anurakparaorn[1,2], Eric Michielssen[1], Alan Taub[1]
[1]University of Michigan, USA; [2]King Mongkut's Institute of Technology Ladkrabang, Thailand

ABSTRACT:
Computational modeling and optimization were utilized to design the metastructure of a polymer nanocomposite system. The goal is to minimize the reflection loss (RL) and broaden the absorption bandwidth. Truncated cones with a perfect electric conductor on the top surface were chosen. With this innovative metastructure, the absorption bandwidth of RL at -20dB has been increased from 0, as observed in non-porous materials, to 1.83 GHz. The samples with optimized metastructures were manufactured using hot pressing and computer numerical control (CNC) machining techniques. This approach provided an efficient way to design and precisely manufacture materials with targeted EM absorption.

SC5-3
TECHNICAL PAPERS

EMI MITIGATION IN WEARABLE DEVICES AND EV DRIVES

3:30PM - 4:30PM

Room: 127A

Sponsored by SC-5

Chair:
Chulsoon Hwang, *Missouri University of Science and Technology, Rolla, MO, USA*

Co-Chair:
Sebastian Koj, *Jade Hochschule, Wilhelmshaven, Germany*

PLANNED SPEAKERS & TOPICS

3:30PM

A Study on Audio-Frequency Near-Field Electromagnetic Interference System in Wearable Audio Devices

Min Zhang, Xiaolong Yue
Xiaomi Inc., China

ABSTRACT:

In the rapidly growing market of wearable wireless audio devices, consumer expectations for comfort, functionality, and sound quality are rising. These demands introduce complex challenges in electromagnetic compatibility (EMC) design, primarily due to increased multifunctionality leading to more sensitive components and interference sources, diversified industrial designs complicating internal layouts, and the necessity for miniaturization which intensifies component interference. This paper presents a focused study on True Wireless Stereo (TWS) earbuds, offering a novel methodology for EMC design to mitigate current noise issues caused by electromagnetic interference, particularly from power inductors. By proposing a new symmetric magnetic field lines guidance method validated through comprehensive analysis and simulations, this study contributes an effective solution for enhancing EMC in wearable audio devices.

Photo by Richard Georgerian

THURSDAY, AUGUST 8

TC10 & SC3 TECHNICAL PAPERS

APPLICATIONS OF AI AND OPTIMIZATION ALGORITHMS

3:30PM - 5:00PM

Room: 125AB

Sponsored by TC-10

Chair:
Hanfeng Wang, *Google Inc, Mountain View, CA, USA*

PLANNED SPEAKERS & TOPICS

3:30PM

5G Base Station Electromagnetic Field Strength Estimation Method in Complex Hotspot Area using Deep Learning

Dongryul Park[1], Seunghun Ryu[1], Seonghi Lee[1], Namwoo Kang[1], Seongsin Kim[2], Kihwea Kim[3], Donggeun Choi[3], Seungyoung Ahn[1]

[1]Korea Advanced Institute of Science and Technology, Korea; [2]Seongsill University, Korea; [3]National Radio Research Agency, Korea

ABSTRACT:

Recently, with the commercialization of 5G, a new electromagnetic field (EMF) evaluation methods is need. However, conventional EMF evaluation methods are only based on measurements that practically impossible to apply to 5G base station (BS). Therefore, in this paper, we propose a 5G BS EMF evaluation method using deep learning (DL) as an alternative to traditional measurement-based evaluation. We selects a U-net that can analyze the entire area based on the technical characteristics of 5G. Furthermore, we design a 2D and numeric converter to inform the physical information of the wireless channel to the U-net. Through network design based on technical features and physical information, the proposed DL model can effectively predicts the EMF radiated from BS. Then, we generate data through simulations that reflect real-world scenarios and use it for training. The results of the training show that the proposed method achieves very high accuracy in various cases, regardless of location and antenna specifications. Furthermore, when quantitatively evaluated, the proposed method only have an 8\% low mean absolute error (MAE), thus demonstrating the superiority of the proposed method. These verification results confirm that the potential of the proposed method can replace EMF evaluations based on measurements with DL-based evaluations in the future.

4:00PM

Reinforcement Learning-Based Power/Ground Ball Map Design Optimization for Multi-Power Domain in 3D-ICs Package

Seunghun Ryu, Dongryul Park, Hyunwoong Kim, Seonghi Lee, Sanguk Lee, Seungyoung Ahn

Korea Advanced Institute of Science and Technology, Korea

SIPI BEST PAPER FINALIST AND BEST STUDENT PAPER SEMI-FINALIST

ABSTRACT:

In this paper, the reinforcement learning-based power/ground ball map design optimization methodology is proposed for 3D-ICs package in multi-power domain environments. Multi-power domain forms diverse levels of simultaneous switching noise (SSN) in the complicated form; accordingly, power integrity design becomes more complex than a single power domain. The ball grid array (BGA) is one of the most challenging areas in terms of power integrity design optimization due to a large number of solder balls, multiple domains, and the condition of confined space. Here, the reinforcement learning algorithm is adopted with a deep learning network to optimize the power/ground ball map so that overall SSNs can be minimized. To deal with the sequential action decision problem, Markov decision process (MDP) is designed and the analytical modeling of the power/ground ball map is implemented to establish learning environment. The proposed method successfully optimizes the power/ground ball map, and shows superior optimization performance to conventional optimization algorithms.

TC12-3 TECHNICAL PAPERS

WIRELESS SYSTEM MEASUREMENT/TESTING

3:30PM - 5:00PM

Room: 128A

Sponsored by TC-12

Chair:
Lie Liu, *Xidian University, Shenzhen, China*

Co-Chair:
Gang Feng, *Christie Digital Systems Canada Inc, Waterloo, ON, Canada*

PLANNED SPEAKERS & TOPICS

3:30PM

A Method for Eliminating the Phantom Shell Effect using Negative Permittivity Material in Absorbed Power Density Measurement

Changmin Lee[1], Jaewon Rhee1, Seonghi Lee[1], Hyukchoon Kwon[2], Yongho Park[2], Yujun Shin[3], Seungyoung Ahn[1]
[1]Korea Advanced Institute of Science and Technology, Korea; [2]Samsung Electronics, Korea; [3]Keimyung University, Korea

ABSTRACT:
In this paper, we propose a method for eliminating the phantom shell effect using negative permittivity material. The absorbed power density (APD) distribution in the phantom provided by IEC TC 106 is analyzed for the effects of changes in the dielectric characteristics of the phantom shell. The effect of the phantom shell is calculated and analyzed through absorbed power density using the finite-difference time-domain (FDTD) method in the 6-10 GHz. Similar to the existing SAR (Specific Absorption Rate) measurement method, the measurement of the APD requires the presence of the equivalent human tissue model. To measure APD, it is necessary to have not only a phantom but also a phantom shell to contain the phantom liquid. Furthermore, with the increasing communication frequency bands of 5G and 6G, an analysis that reflects the dielectric properties of both the phantom and the phantom shell is required during the actual APD measurement process. A problem arises due to the relative permittivity of the phantom shell, which can lead to the overestimation of APD reaching the phantom. This paper utilizes an impedance model to calculate and analyze the impact of the phantom shell and we propose a method to reduce its effect using negative permittivity material. The APD results are compared with and without the shell and with the proposed method. The proposed method is validated through 3D electromagnetic (EM) simulations.

4:00PM

OTA Measurement of UWB Handhold Devices

X. Wang[1], L. Liu[1,2], D. Shang[1], F. Yu[1]
[1]General Test Systems, China; [2]Xidian University, China

ABSTRACT:
The ultra-wide broadband (UWB) handhold devices were measured with compact over-the-air (OTA) test systems. The key technical index like time of flight (TOF) and arrival angle (AOA) were obtained with compact OTA chamber and communication tester with function kits. The measurement uncertainty may be attributed to the reflection of anechoic chamber or the multiple path effect of the environment.

4:30PM

Low Noise Wireless Sensing in Termite Detection

Wei Zhang[1], Xiangshu Qi[1], Yunlong Luo[2], Alex Qi[3], Yihong Qi[2,3,4], Gang Feng[5]
[1]Changsha University, China; [2]Southwest Jiaotong University, China; [3]Pontosense Inc., Canada; [4]Missouri University of Science and Technology, USA; [5]Christie Digital Systems Canada Inc., Canada

ABSTRACT:
Termites cause enormous financial damages all around the world every year. The majority of research on wireless sensing is always concerned with the various human-centric applications, however, the vast potential of wireless sensing for termite detection is often disregarded. In this article, a Wireless Intelligent Sensing (WISe) millimeter-wave (mmWave) radar system for termite detection is proposed. Here, we design a three-layer architecture with some intelligent resources to monitor the movement signs of the termites. In addition, we present a low noise sensing architecture that minimizes the noise in hardware and digital signal processing, which can reduce the impact of environment factors on termite detection. Experimental results demonstrate that, the proposed system is capable of detecting termites and differentiating them from other insects.

THURSDAY, AUGUST 8

TC10-10 TECHNICAL PAPERS

CROSSTALK, JITTER, NOISE COUPLING, BER ANALYSIS #2

3:30PM - 5:00PM

Room: 128B

Sponsored by TC-10

Chair:
Songping Wu, *Rivos Inc., Mountain View, CA, USA*

Co-Chair:
DongHyun (Bill) Kim, *Missouri University of Science and Technology, College of Engineering and Computing, Rolla, MO, USA*

PLANNED SPEAKERS & TOPICS

3:30PM

DB-KBNN based Approach for PSIJ Analysis with a Comparative Study of Energy Models

Ahsan Javaid[1], Ramachandra Achar[1], Jai Narayan Tripathi[2]

[1]Carleton University, Canada; [2]Indian Institute of Technology Jodhpur, India

SIPI BEST PAPER FINALIST

ABSTRACT:

An efficient hybrid neural network method for handling multiple noise sources, including the power supply noise, input data noise, and the ground bounce noise in a power integrity analysis is presented. The proposed hybrid model, combination of deep belief and knowledge-based neural networks, provides reasonable accuracy for PSIJ response using training data from semi-analytical models as well as a circuit simulator. Also, a comparative study of different energy models in generating an optimal training data set is presented.

4:00PM

Nonparametric Crosstalk Evaluation Method using the Kolmogorov-Smirnov Test

Beatrice Jiang[1], Ping Li[2]

[1]Westlake High School, USA; [2]Shanghai Jiao Tong University, China

ABSTRACT:

Evaluating the crosstalk level in a system is essential for signal integrity in high-speed systems. A rarely discussed question is whether it is possible to determine if a contaminated signal's crosstalk level is acceptable or not without knowing the system's network parameters. This paper introduces a novel approach using the goodness-of-fit method, specifically the two-sample Kolmogorov-Smirnov Test (K-S Test). The K-S Test is a nonparametric method used to test the null hypothesis between two samples. For crosstalk analysis, the K-S Test is applied to a reference signal and another signal that may contain crosstalk. The resulting K-S statistic indicates the maximum discrepancies in the empirical cumulative distribution functions (CDF) of two tested signals. This statistic is then compared to a threshold based on the statistical significance level a to determine whether to reject the null hypothesis. Accepting the null hypothesis implies that the crosstalk noise in the contaminated signal is within acceptable limits, and so the original signal and the contaminated signal are not significantly different. The comparison threshold can be further calibrated to meet the specific crosstalk requirements of practical applications. The results demonstrate that the proposed method is effective and reliable in determining the crosstalk level for both ideal sinusoidal and practical PRBS signals.

4:30PM

Novel Coupled Via (CV) Feature for Far-End Crosstalk Reduction

Zhichao Zhang, Yidnekachew Mekonnen, Saikat Mondal, Kemal Aygun

Intel Corporation, USA

ABSTRACT:

The far-end crosstalk (FEXT) from socket pins and motherboard Plated-through-hole (PTH) vias is a major signal integrity performance limiter, especially for crosstalk sensitive single-ended memory signals. A novel passive crosstalk reduction feature called coupled via is proposed to effectively mitigate the risk. This paper demonstrates an on-package implementation of the coupled via concept within existing substrate design rule and cost boundary conditions. The benefits of coupled via was verified through modeling and validation data and it has been adopted for multiple generations of Intel's CPU products.

TC5-2 TECHNICAL PAPERS

IMMUNITY AND EM INFO LEAKAGE

4:30PM - 5:30PM

Room: 127A

Sponsored by TC-5

Chair:
Yuichi Hayashi, *Nara Sentan Kagaku Gijutsu Daigakuin Daigaku Joho Kagaku Kenkyuka, Ikoma, Japan*

Co-Chair:
William Radasky, *Metatech Corporation, Goleta, CA, USA*

Phoenix exists thanks to the sophisticated irrigation system created and maintained by the Hohokam tribe. The indigenous prehistoric Hohokam people had a thriving metropolis in the region from around 800 A.D. to 1450 A.D. The advanced canal system they built supplied water throughout the Sonoran Desert.

When the early pioneers settled in Phoenix, they realized they needed to find just the right name for the city. Darrel Duppa, one of the pioneers in the group, was familiar with the Greek myth of the Phoenix — an immortal Phoenix bird burns and then rises from the ashes ad infinitum. Aware that there was once a flourishing community of Hohokam in the area, Duppa suggested naming the city "Phoenix" because they were building a new community on top of an ancient community that had built and then abandoned a complex canal system that set the foundation for the city of Phoenix.

The pioneers believed Phoenix was going to "boom" and they needed a name that represented a sign of renewal and rebirth. Phoenix officially was recognized on May 4, 1868.

PLANNED SPEAKERS & TOPICS

4:30PM

Experimental Study of Radiated Immunity Impact Analysis due to Conventional and Broadband Signal Sources

GyeongRyun Choi[1], Younggi Hong[1], Taewook Kwon[1], Hongsik Keum[2], Se-eun Park[3], Wansoo Nah[1]
[1]Sungkyunkwan University, Korea; [2]E&R, Korea; [3]National Radio Research Agency, Korea

ABSTRACT:
The radiated immunity standard IEC 61000-4-41, which utilizes orthogonal frequency division multiplexing (OFDM) signal sources to address the drawbacks of existing immunity test signal sources such as IEC 61000-4-3, 61000-4-39 and ISO 11452-1, is currently being developed. This study was conducted to compare and analyze the impact of existing test signal sources and OFDM signal sources on the EUT. Various signals, including continuous wave(CW), amplitude modulation(AM), pulse modulation(PM), and an OFDM signal within the 20 MHz bandwidth, were used for RI tests at a 1 meter distance from the antenna to the EUT. Comparing the impact of each signal based on the immunity level as a reference parameter, it is revealed that the OFDM signal had the lowest immunity level across most of the frequency ranges. During the immunity test, CE in the low-frequency range (9 kHz to 30 MHz, CISPR standard) were also measured using a LISN. When malfunctions occurred in the EUT, it was observed that the CE spectrum remained almost unchanged up to 20 MHz, but the CE spectrum changed quite a lot with malfunctions, especially in the frequency range from 20 MHz to 30 MHz.

5:00PM

Information Leakage of a Quantum Receiver based on Polarization of EM Radiated Emissions

John J. Pantoja, Dimitris Anagnostou, Ross Donaldson
Heriot-Watt University, United Kingdom

ABSTRACT:
In this contribution, a side-channel attack based on the polarization of radiated emissions is presented. Results show that the particular orientation of electronic components lead to radiated emissions with different polarizations that can be used for side-channel attacks.

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FRIDAY, AUGUST 9

SCHEDULE AT A GLANCE

ROOM	125AB	127A	127B	127C	128A	128B
8:30 AM	TUTORIAL WT20 EMC in Power Electronics: Electrical Systems and Electrical Transport	TUTORIAL WT21 Product Safety Compliance and Global Market Access		TUTORIAL WT22 Application of Reverb Chambers	TUTORIAL WT23 Heterogenous Integrated Chiplet System	TUTORIAL WT24 Lessons Learned Creating Reliable Computational Models for SI, PI and EMC Applications
10:00 AM	REFRESHMENT BREAK					
12:00 PM	LUNCH BREAK					
1:00 PM 1:30 PM	WORKSHOP WT26 Nanotechnology and Advanced Materials for EMI Control & EMC	WORKSHOP WT27 Effectively Navigating Measurement Uncertainties in the Real World	WORKSHOP WT25 When Open Source Meets SIPI	TUTORIAL WT30 Electromagnetic Compatibility of Switched-Mode Power Supplies	TUTORIAL WT28 Progress in IEC SC 77C Standards Regarding HEMP and IEMI Environments, Test Methods and Protection Methods	TUTORIAL WT29 Amateur Radio - Avocation & Vocation
3:00 PM	REFRESHMENT BREAK					
5:00 PM 5:30 PM						

TECHNICAL TOUR: THE BOEING FACILITY, 9:00 AM – 1:00 PM

ADDITIONAL STANDARDS SESSIONS, WORKING GROUPS AND TECHNICAL COMMITTEES
For Collateral Meetings, please see page 141

SPEAKERS BREAKFAST
Phoenix Convention Center - 126ABC: 7:00 - 8:30 AM (Breakfast Only on the Day of Presentation)

REGISTRATION/INFO DESK: 8:00 AM - 10:00 AM

WT20
TUTORIAL

EMC IN POWER ELECTRONICS: ELECTRICAL SYSTEMS AND ELECTRICAL TRANSPORT

8:30AM - 12:00PM

Room: 125AB

Sponsored by TC-7

Co-Chairs:

Niek Moonen, *Universiteit Twente, Enschede, Netherlands*
Sebastian Koj, *Jade Hochschule, Wilhelmshaven, Germany*

Before electrical energy can be made available at the point of use, it must be distributed, converted, and regulated. This is the task of power electronics. Their importance will continue to increase because the share of electrical energy in primary energy consumption will increase massively due to the energy transition and growing digitalization. Regardless of the area of application - automotive, aerospace, electrical energy supply - power electronics always brings challenges with regard to electromagnetic compatibility. In this tutorial, the different areas of application of power electronics and the resulting requirements for electromagnetic compatibility as well as methods for controlling them are presented, explained and discussed.

PLANNED SPEAKERS & TOPICS

Introduction to EMC in Power Electronics and Systems
Niek Moonen
Universiteit Twente, Netherlands

DC-DC Converter as Educational and Research Platform
Sebastian Koj, Alexandra Burger, Jens Werner, Karsten Schubert
Jade University of Applied Sciences, Germany

Power Electronics in the Automotive Industry, a Design for EMC
Michelle Liu, Rodrigo Rodriguez
Tesla Inc., USA

Modelling of Power Converters for EMC Analyses
Flavia Grassi
Politecnico di Milano, Italy

Aviation HV Electrical System EMC Challenges and Solutions
Cong Li
GE Aerospace Research, USA

WT21
TUTORIAL

PRODUCT SAFETY COMPLIANCE AND GLOBAL MARKET ACCESS

8:30AM - 12:00PM

Room: 127A

STANDARDS WEEK
WORKSHOP FROM IEEE PSES
SISTER SOCIETY OF IEEE EMCS

Chair:
Grant Schmidbauer, *British Columbia Institute of Technology, Carlsbad, CA, USA*

Co-Chairs:
Kevin Hight, *Thermo Fisher Scientific, Waltham, MA, USA*
John Allen, *Product Safety Consulting, Inc., Bensenville, IL, USA*

The goal of most companies is not to only design products to be safe, perform according to customer demands, and to meet regulatory requirements, it is to sell those products globally. While your product must comply with the EMC and SIPI requirements, there are a myriad of other technical requirements that must also be considered to facilitate the sale of the product.

The plan for this tutorial is to delve into some of the "other technical requirements" that products must comply with, including product safety requirements (ie, concepts such as fire, shock, mechanical, temperature, and radiation); and then once your products are compliant, we will discuss the commercialization of the product through obtaining the many country approvals that are needed in order to legally sell the product around the world.

This tutorial should be attended by product realization managers, design engineers, test technicians, product regulatory personnel, project managers, marketing personnel, and others interested in learning more about product safety and global market access requirements.

PLANNED SPEAKERS & TOPICS

PSES Tutorial – Part 1: Compliance 101
Kevin Hight
IEEE PSES, USA

PSES Tutorial – Part 2: Compliance 201
John Allen
Southern Illinois University, USA

PSES Tutorial – Part 3: Global Market Access
Grant Schmidbauer
Nemko North America, Inc., USA

PSES Tutorial – Part 4: Panel Discussion
Grant Schmidbauer
Nemko North America, Inc., USA

WT22
TUTORIAL

APPLICATION OF REVERB CHAMBERS

8:30AM - 12:00PM
Room: 127C

Chair:
Vignesh Rajamani, *Rohde & Schwarz USA, Inc., Phoenix, AZ, USA*

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 & TOPICS

Introduction and Overview of Reverberation Chamber Theory
Vignesh Rajamani
Rohde & Schwarz, USA

Absorbing Materials – Reverberation Chamber Assessments
Chuck Bunting
Oklahoma State University, USA

Electromagnetic Probability-of-Effect Assessment Tool (EMPAT) for High-Power HERO/EMV Test and Evaluation
Carl Hager IV
Naval Surface Warfare Center Dahlgren Division, USA

Reverb Chamber Challenges
Garth D'Abreu
ETS-Lindgren, USA

Flexible Testing: Shaken, Not Stirred
Frank Leferink
University of Twente, Netherlands

Stirring Up Trouble – Hidden Challenges in Stirred (and Shaken) Measurements
John Ladbury
National Institute of Standards and Technology, USA

WT23
TUTORIAL

HETEROGENOUS INTEGRATED CHIPLET SYSTEM

8:30AM - 12:00PM

Room: 128A

Sponsored by TC-10

Co-Chairs:
Zhen Zhou, *Intel Corporation, Chandler, AZ, USA*

To continue the journey driven by Moore's law for higher integration, other avenues than further shrinking down the dimension of the transition must be explored. One of these new paradigms would be chiplets built on the advanced package technology. While chiplet architecture offers many benefits, it introduces manifold challenges including thermal, physical, signal integrity, and power integrity. To succeed in chiplet integrated system era, the system codesign on electrical, packaging, thermal will be essential.

In the tutorial, the system codesign will be advocated and demonstrated through illustration and demonstration. Two topics can be covered by the tutorial including:

1. Advanced Packaging for Heterogenous Integration
2. Interconnects for Chiplet System and its design challenges for SI/PI

PLANNED SPEAKERS & TOPICS

Advanced Packaging for Heterogeneous Integration
Lesley A. Polka
Intel Corporation, USA

Power Supply Layout Design Best Practice for EMC
Di Hu, Ajit Pal
Cruise LLC, USA

WT24 TUTORIAL

LESSONS LEARNED CREATING RELIABLE COMPUTATIONAL MODELS FOR SI, PI AND EMC APPLICATIONS

8:30AM - 12:00PM

Room: 128B

Sponsored by TC 9

Chair:
Patrick DeRoy, *Analog Devices Inc, Norwood, MA, USA*

Co-Chairs:
Bruce Archambeault, *Missouri University of Science & Technology, Rolla, MO, USA*
Davy Pissoort, *Katholieke Universiteit Leuven, Bruges, Belgium*

This tutorial will expose the attendees to the lessons learned by a number of industry experts over the years. The goal being that the attendees will benefit from the, sometimes painful, learning experiences of the presenters. Computational tools are very powerful and simulation is invaluable to the modern design engineer but there is still an art to using these tools effectively. In all disciplines, hindsight is perfect and the opportunity to learn from others is a valuable resource. This tutorial will not only show lessons learned but also expose the attendees to fundamental ways of thinking through their models to better ensure success. Examples relevant for Signal Integrity, Power Integrity and Electromagnetic Compatibility design will be shared.

PLANNED SPEAKERS & TOPICS

Model Validation
Bruce Archambeault[1,2]
[1]Missouri University of Science and Technology, USA; [2]IBM Corp., USA

What I Wish I Knew About EMC Simulation When I First Started
Scott Piper
Dassault Systèmes, USA

What Did I Learn and Why Did I Learn It?
Colin Brench
IEEE, USA

Establishing Confidence in Field Solvers
Eric Bogatin
University of Colorado Boulder, USA

Leveraging Simulation Tools for Deeper Insights into Real-Life Shielding Challenges
Davy Pissoort
Katholieke Universiteit Leuven, Belgium

WT25 WORKSHOP

WHEN OPEN SOURCE MEETS SIPI

1:00PM - 5:30PM

Room: 127B

Sponsored by TC-9

Chair:
Yansheng Wang, *Rivos Inc., Santa Clara, CA, USA*

Co-Chair:
Giorgi Maghlakelidze, Cisco Systems Inc., San Jose, CA, USA

Open source is attracting more and more attention these days. You must have heard of some open source big names like Linux, RISC-V etc. But how can the SIPI community contribute to and benefit from the "open source rush"? Join us in this workshop to learn about more details. This workshop will introduce several open source projects and tools that are being developed for the SIPI community. The invited speakers will also share insights as a maintainer, a contributor, or a user of an open source project. We hope all the audience after attending this workshop can be inspired and motivated by the presented ideas and eventually get involved in open source projects.

PLANNED SPEAKERS & TOPICS

The Open Circuit: Advancing Signal and Power Integrity with Open Source
Giorgi Maghlakelidze
Cisco Systems Inc, USA

Five (or more) Favorite Free SIPI Tools
Eric Bogatin
University of Colorado Boulder, USA

Open-Source PDN Modeling and Optimization with AI Techniques
Ling Zhang
Zhejiang University, China

IEEE P370 Briefcase: Integrating IEEE 370 Open Source MATLAB Scripts
Se-Jung Moon[1], Xiaoning Ye[2]
[1]Amazon Inc., USA; [2]Intel Corporation, USA

OpenSIPI: An Open Source Platform to Renovate the S-Para Extraction
Yansheng Wang
Rivos Inc., USA

OpenROAD and CircuitOps: An ML EDA Infrastructure for Research and Education
Vidya A. Chhabria[1], Wenjing Jiang[2], Andrew B. Kahng[3], Rongjian Liang[4], Haoxing Ren[4], Sachin S. Sapatnekar[2], Bing-Yue Wu[1]
[1]Arizona State University, USA; [2]University of Minnesota, USA; [3]University of California - San Diego,;USA; [4]NVIDIA, USA

From Toy to Tool – A Python Journey
David Banas
Keysight Technologies, Inc., USA

Panel Discussions
Yansheng Wang, *Rivos Inc.*
Eric Bogatin, *University of Colorado Boulder, USA*
Giorgi Maghlakelidze, *Cisco Systems Inc, USA*
Ling Zhang, *Zhejiang University, China*
Se-Jung Moon, *Amazon Inc., USA*
Vidya Chhabria, *Arizona State University, USA*
David Banas, *Keysight Technologies, Inc., USA*

FRIDAY, AUGUST 9

WT30 TUTORIAL

ELECTROMAGNETIC COMPATIBILITY OF SWITCHED-MODE POWER SUPPLIES

1:30 – 3:00 PM

Room: 127C

Sponsored by SC-5

Chair:
Günter Keller, *Technische Hochschule Deggendorf, Deggendorf, Germany*

The tutorial begins with an overview of legal regulations such as CE mark and Declaration of Conformity, followed by a selection of emission and immunity standards. Test setups for measuring conducted emissions and test parameters based on European and International standards are described. Coupling mechanisms (impedance, capacitive, magnetic, and radiated) and basic countermeasures applicable to switched-mode power supplies are discussed. The signals and characteristics section explains common-mode and differential-mode interferences, Fourier Transform, and typical waveforms for switched-mode power supplies, with a focus on switching transients and wide band gap devices like GaN transistors.

The second part focuses on EMC design of switched-mode power supplies, including efficiency and control issues. It includes power factor correction, EMC filters (pre and post filters), and filter effectiveness. An outlook on active EMI filters, design aspects of magnetic components, and comparisons of soft-switching and hard-switching circuits are presented. Shielding basics, PCB layout structures, grounding, component placement, and selection are also covered. Most aspects are illustrated with practical examples and basic physics principles for a comprehensive understanding. Many principles are transferable to other electronic circuits.

PLANNED SPEAKERS & TOPICS

Electromagnetic Compatibility of Switched-Mode Power Supplies
Günter Keller
Deggendorf Institute of Technology, Germany

ARIZONA FUN FACT

ARIZONA ILLUMINATES THE PATH TO A GREENER FUTURE WITH SOLAR RESEARCH

Arizona, known for its sunny skies and desert landscapes, isn't just a hotspot for tourism; it's also a leader in solar technology development! With over 300 days of sunshine per year, Arizona boasts ideal conditions for harnessing the power of solar energy. In fact, the state is home to some of the largest solar installations in the country, including the Solana Generating Station near Gila Bend, which can power over 70,000 homes.

WT26 WORKSHOP

NANOTECHNOLOGY AND ADVANCED MATERIALS FOR EMI CONTROL AND EMC

1:30PM - 5:00PM

Room: 125AB

Sponsored by TC-11 and TC-4

Chair:
Marina Koledintseva, *The Boeing Company, St. Charles, MO, USA*

Co-Chair:
Daryl Beetner, *Missouri University of Science and Technology, Rolla, MO, USA*

The scope of this Workshop is research, design, development, characterization, and applications of various nanomaterials and advanced materials for EMI control and solving various practical EMC problems, e.g., absorbers and filters with outstanding performance and capabilities, nanostructures shields, innovative gaskets, advanced interconnects, nanowires for high-speed interconnects and high-density integrated systems, etc.

PLANNED SPEAKERS & TOPICS

Thin Films and Nanomaterials for EMI and EMC
Fabrizio Marra
Sapienza University of Rome, Italy

EMC Applications of 3D Printable Materials
Victor Khilkevich
Missouri University of Science and Technology, USA

EMI Shielding Solution Covering Physical Pre-Shaped and Dispensable Materials
Julia Sunderland
The Dow Chemical Company, USA

Magneto-Dielectric Absorbers for EMI and EMC
Marina Y. Koledintseva
Boeing Defense Space and Security, USA

Application of Ferrites to MRI Safety
Md Zahidul Islam, Ji Chen
University of Houston, USA

Crosstalk Measurement using Absorber Loading
Seyed Mostafa Mousavi
Missouri University of Science and Technology, USA

Arizona isn't just content with traditional solar panels. The state is at the forefront of pioneering solar technology development, with research institutions and companies collaborating to push the boundaries of energy production. One exciting example of Arizona's solar innovation is reasearch in transparent solar panels. Imagine windows that not only let in natural light but also generate electricity! Researchers at Arizona State University and the University of Arizona are working on transparent solar materials that could revolutionize building design and energy production, turning every window into a power source.

So, the next time you soak up the Arizona sun, remember that it's not just warming your skin—it's also powering the future of technology and sustainablity. From cutting-edge solar cell designs to breakthroughs in energy storage and grid integration, Arizona is a melting pot of creativity and ingenuity in the realm of solar energy.

FRIDAY, AUGUST 9

WT27 WORKSHOP

EFFECTIVELY NAVIGATING MEASUREMENT UNCERTAINTIES IN THE REAL WORLD

1:30 – 5:00 PM

Room: 127A

Sponsored by TC-2

Co-Chairs:

Janet O'Neil, *ETS-Lindgren, Cedar Park, TX, USA*

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

This workshop provides insights into methods for assessing measurement uncertainty in electromagnetic compatibility (EMC) and antenna characterization. Presentations will cover practical techniques like polynomial chaos for sensitivity analysis, offering applicable insights. Additionally, speakers will discuss the evolution of uncertainty analysis in reverberation chambers and share practical insights into managing EMC measurement uncertainty in laboratory settings. Evaluations of complex uncertainties in robotic antenna test systems will also be presented, providing valuable perspectives on addressing real-world challenges. Attendees will gain practical tools and insights to enhance the accuracy of electromagnetic field measurements in their respective fields. This workshop aims to facilitate discussion and collaboration, empowering participants to navigate measurement uncertainties effectively in their work.

PLANNED SPEAKERS & TOPICS

Assessment of Uncertainties and Sensitivity Analysis using Polynomial Chaos
Karol Niewiadomski
University of Twente, Netherlands

Uncertainty Analysis from the Early Days to Modern Usage of Reverberation Chambers
John Ladbury
Shared Spectrum Metrology Group, USA

Understanding Uncertainties for EMC Antenna Measurements in Accordance with the Guide to Uncertainty in Measurements
Zhong Chen
ETS-Lindgren, USA

Evaluation of Complex Measurement Uncertainties in a Multipurpose Robotic Antenna Test System
Dennis Lewis
The Boeing Company, USA

Measurement Uncertainty of HEMP and HPEM Testing Methods
Sven Fisahn
Bundeswehr Research Institute for Protective Technologies and NBC Protection, Germany

The Known Unknown – Characterizing Measurement Uncertainty (M) in EMC
Nicholas Abbondante
Intertek USA Inc., USA

WT28
TUTORIAL

PROGRESS IN IEC SC 77C STANDARDS REGARDING HEMP AND IEMI ENVIRONMENTS, TEST METHODS AND PROTECTION METHODS

1:30PM - 5:00PM
Room: 128A

STANDARDS WEEK

Chair:
William Radasky, *Metatech Corporation, Goleta, CA, USA*

The session will start with an introductory presentation summarizing all of the 22 publications of IEC SC 77C (EMC: High Power Transient Phenomena) and their status. The introduction will then indicate the recent work underway and will introduce the papers to be discussed in detail following the introduction. The publications to be discussed in detail include: IEC 61000-2-9 (Radiated HEMP Environment); IEC 61000-2-10 (Conducted HEMP Environment); IEC 61000-4-23 (Radiated Test Methods); IEC 61000-4-24 (Conducted Test Methods); 61000-5-6 (Protection Against External EM Influences)

PLANNED SPEAKERS & TOPICS

Introduction to IEC SC 77C Publications
Edl Schamiloglu
University of New Mexico, USA

Updates of IEC 61000-2-9 (Radiated HEMP Environment) and IEC 61000-2-10 (Conducted HEMP Environment)
William A. Radasky
Metatech Corporation, USA

Update of IEC 61000-4-24 (Conducted Test Methods)
Sergio Longoria
ETS-Lindgren, USA

Update of IEC 61000-4-23 (Radiated Test Methods)
William A. Radasky
Metatech Corporation, USA

Update of IEC 61000-5-6: Mitigation of High Power EM Transients
Richard Hoad[1], Bill Radasky[2]
[1]QinetiQ Ltd.,United Kingdom; [2]Metatech Corporation, USA

Photo by Karthik Vepuri

FRIDAY, AUGUST 9

WT29
TUTORIAL

AMATEUR RADIO – AVOCATION AND VOCATION

1:30PM - 5:00PM

Room: 128B

Chair:
Kimball Williams, *IEEE, Dearborn, MI, USA*

We will be exploring some of the many aspects of Amateur Radio, often described as 'The hobby of a thousand hobbies'. We will touch on those features where Hams (Amateur Radio Operators) interact with the public in accordance with the five primary provisions of an Amateur Radio license governed by the <u>FCC Part 97:</u> Emergency Communications, Advancing the radio art, Advancing skills in both the communication and technical phases of the art, Providing trained operators and RF experts and "the Amateur's unique ability to enhance international good will."

PLANNED SPEAKERS & TOPICS

Amateur Radio – Community and Traditions
Kimball Williams
N8FNC, USA

Slaying Power Line Interference
Gary Bishop[1], Daniel Fisher[2]
[1]NQ0V, USA; [2]AI4GK, USA

POTA – Experiences from the Field
Chuck Bunting
Oklahoma State University, USA

From a Hobby to a Career Can a Ham be Cured
Connie Kelly
AC9CK, USA

Photo by Karthik Vepuri

BEST SYMPOSIUM PAPER FINALISTS

BEST EMC PAPER FINALISTS

SS01-1
MACHINE LEARNING AIDED SI, PI, EMC AND EMI SESSION
Room: 125AB
10:30AM: Imitation Learning-Based Fast Optimization of SSD Interface for PCIe 6.0 considering Signal Integrity
Seonguk Choi[1], Jihun Kim[1], Taein Shin[1], Jungmin Ahn[1], Keunwoo Kim[1], Keeyoung Son[1], Joonsang Park[1], Jinwook Song[2], Kyungsuk Kim[2], Sunghoon Chun[2], Joungho Kim[1]
[1]Korea Advanced Institute of Science and Technology, Korea; [2]Samsung Electronics, Korea
4:00PM: A Fast Metalearning Algorithm for Neural Network Enabled Uncertainty Quantification of Graphene based Interconnects with Passive Shielding
Asha Kumari Jakhar, Dyuti Basu, Km Dimple, Surila Guglani, Avirup Dasgupta, Sourajeet Roy
Indian Institute of Technology Roorkee, India

TC2-3
EMC MEASUREMENTS – PROBES
Room: 127B
3:30PM: On the Feasibility of a Direct Injection Probe with a Capacitively Coupled Return and Integrated Voltage Monitor
Aaron Harmon, Daniel Szanto, Victor Khilkevich, Daryl Beetner
Missouri University of Science and Technology, USA
4:30PM: Full Modal-Admittance Matrix In-Circuit Measurement by Multiple Inductive Probes
Simone Negri, Giordano Spadacini, Flavia Grassi, Sergio A. Pignari
Politecnico di Milano, Italy

TC4-1
CONTROL OF ELECTROMAGNETIC INTERFERENCE: SHIELDING, FILTERING, MODELING AND PREDICTION #1
Room: 127A
10:30am: Statistics of Electromagnetic Fields within Wire-Coupled, Nested Reverberant Enclosures
Marshall D. Sowell, Kyle A. Shea, Carl E. Hager IV
Naval Surface Warfare Center, USA
11:00am: Design of Experiment Analysis on Multiple PIM Sources in an RF Antenna System
Shengxuan Xia[1], Yuchu He[2], Haicheng Zhou[2], Hanfeng Wang[2], Chulsoon Hwang[1]
[1]Missouri University of Science and Technology, USA; [2]Google Inc., USA
1:30pm: Operation of the Bifilar Common-Mode Voltage Suppressor
James McLean
TDK Corp., USA

TC5-1
ELECTROSTATIC DISCHARGE
Room: 125AB
1:30PM: A Model for Corona Streamer Propagation on Glass during an Air Discharge
Zhekun Peng[1], Jianchi Zhou[2], Darryl Kostka[2], David Pommerenke[3], Daryl Beetner[1]
[1]Missouri University of Science and Technology, USA; [2]Apple Inc., USA; [3]Technische Universitat Graz, Austria

POSTER SESSIONS
Room: Exhibit Floor
1:30PM: Analytical Solution of the Lightning Transmission Line (TL) Model, at the Speed of Light
Nathan S. Roberts
NASA Johnson Space Center, USA

1:30PM: Switching Transient Immunity Analysis of Wireless Communication Unit in Smart Substation
Weidong Zhang
North China Electric Power University, China

TC9-5
STATISTICAL AND SURROGATE MODELS
Room: 127B
3:30PM: Estimating Effects of Residual Physics with Machine Learning for Earbud Performance Prediction
Srinivasa Mohan[1], Jingchen Liang[1], Mingfeng Xue[2], Krishna Mellachervu[1], Pavani Gottipati[1], Jianmin Zhang[2]
[1]Ansys, Inc., USA; [2]Google Inc., USA
4:00PM: Fusion of Parameterized and Physics-Oriented Statistical Surrogate Models for EM Coupling on Wires in Complex Electronic Enclosures
Shen Lin[1], Sangrui Luo[1], Yang Shao[1], Zhen Peng[1], Bisrat D. Addissie[2], Zachary B. Drikas[2]
[1]University of Illinois at Urbana-Champaign, USA; [2]U.S. Naval Research Laboratory, USA

SC5-2
MODELING OF WIRELESS POWER TRANSFER SYSTEMS
Room: 127A
2:30PM: Radiated Emission Modeling of a Wireless Power Transfer System
Hanyu Zhang[1], Guanghua Li[2], Viswa Pilla[2], Chulsoon Hwang[1]
[1]Missouri University of Science and Technology, USA; [2]Apple Inc., USA

BEST SYMPOSIUM PAPER FINALISTS

BEST SIPI PAPER FINALISTS

TC10-13
POWER DISTRIBUTION NETWORKS AND DECOUPLING #1
Room: 128A
2:30PM: Novel Interdigital Capacitor-Type Power Distribution Network Design for Power Noise Suppression in Redistribution Layer Interposer
Haojie Wu[1], Xinglin Sun[2], Keeyoung Son[2], Jonghyun Hong[2], Yin Sun[3], Joungho Kim[2]
[1]Zhejiang University, China; [2]Korea Advanced Institute of Science and Technology, Korea; [3]Ningbo Detool Technology Co. Ltd, China

TC10-6
SI/PI/EMI CO-DESIGN
Room: 128B
1:30PM: Reducing EMI in Wire-Bond BGA IC-Chips through Magnetic Dipole Moment Control
Satoshi Tago, Keita Sasaki, Yasuhiro Ochiai
Sony Semiconductor Solutions Corporation, Japan

TC10-9
POWER DISTRIBUTION NETWORKS AND DECOUPLING #3
Room: 128B
11:30am: Behavior Model of a Multiphase Voltage Regulator Module with Rapid Voltage Drop Protection
Junho Joo[1], Hanyu Zhang[1], Hanfeng Wang[2], Wei Shen[2], Zhigang Liang[2], Lihui Cao[2], Seungtaek Jeong[2], Chulsoon Hwang[1]
[1]Missouri University of Science and Technology, USA; [2]Google Inc., USA

TC10-S1
CROSSTALK, JITTER, NOISE COUPLING, BER ANALYSIS
Room: 128B
3:30pm: DB-KBNN based Approach for PSIJ Analysis with a Comparative Study of Energy Models
Ahsan Javaid[1], Ramachandra Achar[1], Jai Narayan Tripathi[2]
[1]Carleton University, Canada; [2]Indian Institute of Technology Jodhpur, India

TC10&SC3
APPLICATIONS OF AI AND OPTIMIZATION ALGORITHMS
Room: 125AB
4:00PM: Reinforcement Learning-Based Power/Ground Ball Map Design Optimization for Multi-Power Domain in 3D-ICs Package
Seunghun Ryu, Dongryul Park, Hyunwoong Kim, Seonghi Lee, Sanguk Lee, Seungyoung Ahn
Korea Advanced Institute of Science and Technology, Korea

EMC+SIPI 2024 STUDENT HARDWARE DESIGN COMPETITION

New this year, the **Student Hardware Design Competition** will feature three teams participating in an exciting radio "fox hunt" in our Symposium exhibit hall! These teams will be testing their skills in finding a hidden transmitter in a harsh electromagnetic environment. The participating teams will be required to track down hidden transmitters located throughout the exhibit hall.

THERE WILL BE THREE TEAMS PARTICIPATING:

MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY in Rolla, MO, USA lead by **Aaron Harmon**

MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY in Rolla, MO, USA lead by **Neil Lawhead**

UNIVERSITY OF MOUNT UNION IN ALLIANCE, Ohio, USA lead by **Glauco Fontgalland**)

WEDNESDAY, AUGUST 7

Following the completion of the Student Hardware Design Competition, the fox hunt will be OPEN TO ALL with bragging rights that go along with victory, so bring your favorite tools to participate. This open event does NOT require an amateur radio license to participate, so reach out to Kimball Williams (find him in the app!), if you want more information.

BEST SYMPOSIUM PAPER FINALISTS

BEST EMC STUDENT PAPER FINALISTS

TC2-1
EMC MEASUREMENTS FOR PCBS AND MEMORY COMPONENTS
Room: 127B (Tuesday)
11:00AM: Reactive Magnetic Near-Field to Far-Field Transformation based on Plane Wave Spectrum at PCB Level
Dong-Hao Han, Ming-Jie Pang, Xing-Chang Wei
Zhejiang University, China

TC2-2
EMC MEASUREMENTS FOR WIRELESS COMMUNICATIONS, PULSED INTERFERENCE AND TRANSISTORS
Room: 127B (Tuesday)
1:30PM: Assessing Time-Scale-Dependent Interference Vulnerabilities in Wireless Communications
Michelle Pirrone[1,2], Jordan Bernhardt[1], Adam Wunderlich[1]
[1]National Institute of Standards and Technology, USA;
[2]University of Colorado Boulder, USA

TC7
LOW FREQUENCY EMC
Room: 127A (Thursday)
8:30am : Identification of Internal Impedance of Brush Motor in Operation using AMN
Akito Mashino, Shohei Kan, Kengo Iokibe, Yoshitaka Toyota
Okayama University, Japan

BEST SIPI STUDENT PAPER FINALISTS

TC10-13
POWER DISTRIBUTION NETWORKS AND DECOUPLING #1
Room: 128A (Tuesday)
2:00PM: Experimental Study of PCB Vibration Induced by MLCC Assembly Orientation and Process Variations
Yifan Ding[1], Ming-Feng Xue[2], Jianmin Zhang[2], Xin Hua[2], Benjamin Leung[2], Eric A. MacIntosh[2], Chulsoon Hwang[1]
[1]Missouri University of Science and Technology, USA;
[2]Google Inc., USA

TC10-4
SIMULATION AND MODELING TECHNIQUES #2 & 3
Room: 128A (Wednesday)
3:30PM: Linear Equalizer Effect-Included Worst Eye Diagram Estimation Method for PCIe 6.0
Seonghi Lee, Hyunwoong Kim, Seunghun Ryu, Jiseong Kim, Seongho Woo, Seungyoung Ahn
Korea Advanced Institute of Science and Technology, Korea

TC10-9
POWER DISTRIBUTION NETWORKS AND DECOUPLING #3
Room: 128B (Thursday)
11:00AM: PDN Noise-Jitter Co-Optimization using Physics-Assisted Genetic Algorithm
Li Jiang, Ling Zhang, Er-Ping Li
Zhejiang University, China

SEE PAGE 41 FOR DETAILS ABOUT THE BEST STUDENT PAPER POSTER SESSION: TUESDAY AT 2:45 - 3:45 PM EXHIBIT HALL

STANDARDS WEEK 2024

This is the week when we come together and focus on EMC Standards, something that impacts EMC practitioners worldwide. We're having meetings that will be open to people in person in Phoenix and remotely. You're welcome to attend and we encourage you to do so. How much do we want you to be a part of Standards Week? We'll be holding a special Happy Hour on Thursday afternoon (see below for details)—everyone who sits through to the end of one of the standards meetings listed below will receive a ticket. If one of these meetings seems to overlap with your professional interests, please join us! Standards are part of the life blood of the EMC Society, and they don't happen by accident. They happen because people like you care enough to create high quality standards that lay out the very best practices of the discipline. We hope you'll join us!

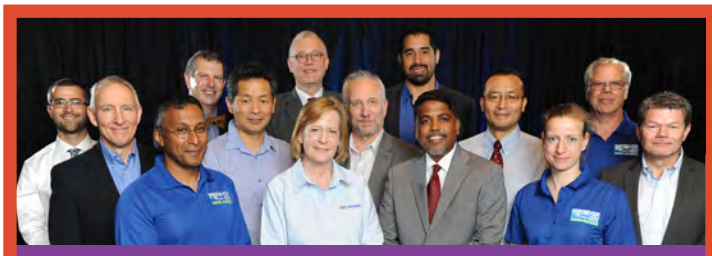


Photo by Jamie Ramie

STANDARDS RECOGNITION

WEDNESDAY AUGUST 7
12:00 – 12:30PM
Location: Ask the Experts area in the Exhibit Hall

Please join us as we recognize the working group members who were instrumental in publishing new IEEE EMC Society Standards in the past year. Writing a new standard, or even revising an old one, is no trivial task. So, we'd like to recognize those who put in so many volunteer hours and contributed their extensive technical expertise to making it happen.

We will be celebrating the official publication of:
IEEE 1897 "Recommended Practice for Location of Power-Line Gap Interference Sources"

IEEE 2718 "IEEE Guide for Near Field Characterization of Unintentional Stochastic Radiators"

Photo by Karthik Vepuri

STANDARDS HAPPY HOUR

THURSDAY AUGUST 8
4:00 – 6:00 PM
Location: 124B

Open to all who join us for one of the Standards Meetings this week, while supplies last.

Come join us for a chance to mingle and network with professionals who care about standards and technical excellence just as much as you do. As thanks to everyone who sits around a U-shaped conference table for an hour or two, we'd like to provide you with a more relaxed and informal setting to chat. Drinks and heavy appetizers will be available with ticket.

Meeting Name	Date	Start Time	End Time	Room
Standards Advisory and Coordination Committee Meeting	Monday, August 5	12:00 PM	2:00 PM	132A
Shielding Standards Continuity Group Meeting + IEEE 299/299.1 WG	Tuesday, August 6	8:00 AM	10:00 AM	132A
P2710, Flexible Shielding Characterization, Working Group	Tuesday, August 6	12:00 PM	2:00 PM	131C
IEEE P1848.1 Working Group Information Session	Tuesday, August 6	1:00 PM	2:00 PM	132C
IEEE 1560 Power Line Filters Working Group	Wednesday, August 7	8:00 AM	9:00 AM	131C
Managing Functional Safety Risks Caused by EMI - IEEE 1848-2020 Continuity Working Group	Wednesday, August 7	8:30 AM	10:30 AM	132C
Standards Recognition	Wednesday, August 7	12:00 PM	12:30 PM	Exhibit Hall
IEEE Standard P2855 Group Monthly Meeting	Wednesday, August 7	2:00 PM	4:00 PM	132C
Computational Electromagnetics Continuity Group - Annual Meeting	Wednesday, August 7	2:00 PM	5:00 PM	131AB
PAR 2838 WG Aircraft Components Lightning Direct Effects Qualification	Thursday, August 8	9:30 AM	11:00 AM	131C
Standards Development and Education Meeting	Thursday, August 8	2:00 PM	4:00 PM	131C
Standards Happy Hour	Thursday, August 8	4:00 PM	6:00 PM	124B
IBIS Summit	Friday, August 9	8:00 AM	12:00 PM	132A

EMISSION MEASUREMENTS OF ANSI C63.4 AND TIME DOMAIN APPLICATIONS (ANSI C63.25 SERIES)

(Visit www.c63.org for more information)

This workshop will share the activity currently underway in the ANSC C63® committee for C63.4 and C63.25 series. Among the many updates, EMC Site Validation requirements are migrating from C63.4 to the C63.25 standards series: ANSC C63 - C63.25.1, C63.25.2, and C63.25.3. Topics covered include: (1) Review of the latest draft edition of ANSI C63.4:20xx and (2) Application of Time Domain (TD) SVSWR in C63.25.1 (1 GHz – 18 GHz) (3) Newly streamlined procedures for site validation measurements in C63.25.2 (30 MHz – 1 GHz) (4) Latest development for site validations using Cylindrical Mode Filtered SVSWR (CMF SVSWR) measurements for test site validation and antenna calibration (18 GHz – 40 GHz) to be included in C63.25.3.

This workshop is designed to increase your understanding of the C63.4 standard and the expected changes in the next revision, and what to anticipate in the new C63.25 series on EMC site validation methods.

For the C63.4 discussions, there will be an analyses and changes in the requirements for the above 1 GHz test method, use of the 2 dB rule, compliance files, test setup changes and many other aspects.

For the C63.25 discussion, application of time domain and mode filter methods for validating EMC test sites will also be presented along with a live demonstration on its usage.

NEW this year – an update will be provided on the recently published C63.2 "Specifications of Electromagnetic Interference and Field Strength Measuring Instrumentation in the Frequency Range 9 kHz to 40 GHz."

In the C63.4 workshop, you will learn:

- RF emission measurement procedures
- National and international regulatory implications
- Test facility and instrumentation requirements
- Equipment test arrangements and configurations

In the Time Domain (C63.25) workshop, you will learn:

- Application for site validation
- Application for antenna calibration

With the C63.2 update, you will learn:

- The new requirements for instruments used for EMI measurements
- Importance of quasi-peak, peak, and average detection in the frequency range 9 kHz to 40 GHz

WHO SHOULD ATTEND

Those responsible for determining compliance with FCC Rules and Regulations (and CISPR 22), including:

- Product managers and developers
- EMC engineers and test technicians
- Regulatory compliance managers
- Test instrumentation developers
- Those using and calibrating antennas in making radiated emission compliance measurements
- Calibration technicians
- Calibration and measurement accreditation bodies
- Lab quality assessors
- Test instrumentation and chamber manufacturers

EXPERT INSTRUCTORS

The workshop features industry experts and active technical contributors to ANSC C63, including Andy Griffin (Cisco), C63.4 Working Group Chair and Chair of Subcommittee 1 (SC1), Techniques and Development. Standards C63.4 and C63.25 are developed and maintained by SC1; as well as Zhong Chen (ETS-Lindgren), Vice Chair ANSC C63 and C63.25.1 Working Group Chair; plus Jens Medler (Rohde & Schwarz), C63.2 Working Group Chair.

DATES AND LOCATION • AUGUST 2 AND 3, 2024

Compliance Testing in Mesa, AZ. See www.emc2024.org for symposium hotel info and to reserve your hotel room.

FEE INCLUDES

Complete lecture slides, continental breakfast, lunch, breaks, and completion certificate. Fee does NOT include copies of the draft or published standards. Fee does NOT include hotel accommodations.

AGENDA

FRIDAY, AUGUST 2

8:30 am: Registration and Continental Breakfast

9:00 am to 5:00 pm: Workshop Lectures

SATURDAY, AUGUST 3

8:30 am: Continental Breakfast

9:00 am to 12:00 pm: Workshop Lectures and Live Demonstrations

REGISTRATION FORM

Contact: Janet O'Neil • Telephone: 425-443-8106 • j.n.oneil@ieee.org

Ms./Mr._____

Company_____

Address_____

City_____State_____Zip_____

Daytime Phone_____Fax_____

Email_____

Signature: _____

Check or Credit Card Number must accompany registration.

To pay by credit card, please so indicate when you submit your registration form and an invoice will be emailed to you.

Workshop Fee – All Day August 2 and Morning Only August 3

By July 5*:	$1,100 USD _____
C63® & S/C Members (by July 5)	$975 USD _____
Add $200 if after July 5 or at the door**	$200 USD _____
	Total USD $_____

Make check payable to:

U.S. EMC Standards Corporation in U.S. dollars drawn on a U.S. bank.

Mail to:* Janet O'Neil
ETS-Lindgren
8422 NE Meadowmeer Drive
Bainbridge Island, WA 98110

NOTE: You are not registered until you receive confirmation.

***Please do not mail after July 15. **With prior telephone or email registration only.**

The organizing committee reserves the right to substitute speakers, modify the program (or lecture notes), restrict attendance or to cancel the workshop(s). In the event the workshop is canceled, registration fees will be refunded. No refunds will be made to individuals who cancel after July 1. Substitutions are allowed. Workshops without a minimum of 10 attendees registered by 10 July 2024 will be cancelled and registration fees returned. It is suggested that you book refundable travel arrangements as appropriate if workshop is cancelled.

TECHNICAL TOURS

ARIZONA STATE UNIVERSITY

Two decades ago, Arizona State University (ASU) set forth a new and ambitious trajectory to become a comprehensive knowledge enterprise dedicated to the simultaneous pursuit of excellence, broad access to quality education, and meaningful societal impact. From that point forward, all of its energy, creativity and resources have been brought to bear on the design of a uniquely adaptive and transdisciplinary university committed to producing master learners. Today, ASU exemplifies a new prototype for the American public research university. ASU's culture of innovation and inclusion draws pioneering researchers to its faculty and attracts highly qualified students from all 50 states and more than 130 nations. ASU is expanding academic and entrepreneurial opportunities for every type of learner at all stages of life.

Join us for this unique technical tour where attendees will see three distinct laboratories addressing Antenna and Microwave, Terahertz, and NanoFab research. The Antenna Lab includes one of the largest university-based anechoic chambers in the US. This lab is well-known as the hub of activity for ASU Regents' Professor Emeritus, Constantine A. Balanis. The Terahertz Lab houses a variety of small and large signal tools tailored for characterization of high frequency circuits and systems. NanoFab is a flexible nanoscale processing and fabrication facility offering state-of-the-art device processing and characterization tools for university research and external company prototype development. Attendees will see a 3,800 square-foot class 100 cleanroom and eight auxiliary labs.

Date: Thursday, August 8
Time: 4:00 pm – 7:30 pm
Cost: $65

THE BOEING COMPANY

The Boeing facility in Mesa, Arizona, stands as a cornerstone of the company's defense and aerospace endeavors. Specializing in the production and maintenance of military aircraft, particularly the renowned AH-64 Apache attack helicopter, it serves as a vital component of U.S. military operations. The facility not only boasts advanced manufacturing capabilities but also houses a suite of material measurements laboratories. These labs play a crucial role in ensuring the quality and reliability of materials used in Boeing's products, employing cutting-edge techniques for material analysis and testing. Through the dedication of its skilled workforce, the Mesa facility upholds Boeing's reputation for excellence in defense aviation. It stands as a testament to Boeing's commitment to innovation and precision in aerospace engineering.

Date: Friday, August 9
Time: 9:00 am – 1:00 pm
Cost: $90 (Registration is Closed)

THIS TOUR HAS BEEN CANCELED
We apologize for the inconvenience

COLLATERAL MEETINGS

WORKING GROUPS, COLLATERAL MEETINGS & SOCIAL EVENTS

Technical Committees, Standards, and EdCom Meetings -
All meetings will be held via WebEx for those unable to attend in person.
Meeting URL: https://ieee.webex.com/ieee
Password: EMC2024

SUNDAY, AUGUST 4

Meeting Name	Start Time	End Time	Room	Type	Attendees	Webex Meeting ID
EMC Board Meeting	9:00 AM	5:00 PM	Sheraton - PV	Other	Pre-Registration	

MONDAY, AUGUST 5

Meeting Name	Start Time	End Time	Room	Type	Attendees	Webex Meeting ID
Speaker Breakfast	7:00 AM	8:30 AM	126ABC	Other	Speakers Only	
Technical Advisory Committee (TAC) Meeting #1	7:00 AM	8:30 AM	131AB	Technical Services		2632 069 6081
EMC Society Chapter Chair Training	12:00 PM	1:30 PM	131AB	Member Services		2634 488 5171
Standards Advisory and Coordination Committee Meeting	12:00 PM	2:00 PM	132A	Standards Services		2634 192 4680
SC-1 Smart Grid and EMC Issues Committee Meeting	5:30 PM	6:30 PM	132A	Technical Services		2630 041 4523
EMC+SIPI Jeopardy! YP Event	6:00 PM	10:00 PM	The Arrogant Butcher	Social Event	Pre-Registration	

TUESDAY, AUGUST 6

Meeting Name	Start Time	End Time	Room	Type	Attendees	Webex Meeting ID
Speaker Breakfast	7:00 AM	8:30 AM	126ABC	Other	Speakers Only	
TC-2 EMC Measurements Committee Meeting	7:00 AM	9:00 AM	132B	Technical Services		2632 243 1463
Shielding Standards Continuity Group Meeting + IEEE 299/299.1 WG	8:00 AM	10:00 AM	132A	Standards Services		2633 077 0551
TC-8 Aeronautics and Space EMC Committee Meeting	12:00 PM	1:00 PM	131AB	Technical Services		2631 862 2020
TC-10 Signal and Power Integrity Committee Meeting	12:00 PM	1:00 PM	132A	Technical Services		2630 356 0019
TC-7 Electrical Systems and Power Electronics EMC Committee Meeting	12:00 PM	1:30 PM	132B	Technical Services		2632 634 4686
P2710, Flexible Shielding Characterization, Working Group	12:00 PM	2:00 PM	131C	Standards Services		2630 033 6101
IEEE P1848.1 Working Group Information Session	1:00 PM	2:00 PM	132C	Standards Services		2633 165 6128
Member Elevation Event - Taking Your Membership to the Next Level	2:30 PM	4:00 PM	129B	Member Services		2631 096 6404
Welcome Reception	5:00 PM	7:00 PM	Exhibit Hall 5&6	Social Event		
"After the Welcome Reception" YP Event	7:00 PM	10:00 PM	Huss Brewing	Social Event	Pre-Registration	

WEDNESDAY, AUGUST 7

Meeting Name	Start Time	End Time	Room	Type	Attendees	Webex Meeting ID
Speaker Breakfast	7:00 AM	8:30 AM	126ABC	Other	Speakers Only	
Education Committee (EdCom) Meeting	7:00 AM	8:30 AM	132C	Technical Services		2630 978 2440
TC-1 EMC Management Committee Meeting	7:30 AM	9:00 AM	132A	Technical Services		2632 560 0210
IEEE 1560 Power Line Filters Working Group	8:00 AM	9:00 AM	131C	Standards Services		2630 345 1036
TC-12 EMC for Emerging Wireless Technologies Committee Meeting	8:00 AM	9:00 AM	132B	Technical Services		2634 942 4932
Managing Functional Safety Risks Caused by EMI - IEEE 1848-2020 Continuity Working Group	8:30 AM	10:30 AM	132C	Standards Services		2633 582 5581
Standards Recognition	12:00 PM	12:30 PM	Exhibit Hall 5&6	Standards Services		
TC-9 Computational Electromagnetics Committee Meeting	12:00 PM	1:00 PM	131AB	Technical Services		2631 849 4054
TC-5 High Power Electromagnetics (HPEM) Committee Meeting	12:00 PM	1:30 PM	131C	Technical Services		2633 768 6739
TC-11 Nanotechnology and Advanced Materials Committee Meeting	12:00 PM	1:30 PM	132B	Technical Services		2632 249 6543
Past President Lunch	12:00 PM	1:30 PM	126A	Social Event	Invitation Only	
TC-4 Electromagnetic Interference Control Committee Meeting	12:00 PM	2:00 PM	132A	Technical Services		2630 464 4078
IEEE Standard P2855 Group Monthly Meeting	2:00 PM	4:00 PM	132C	Standards Services		2634 587 2372
Computational Electromagnetics Continuity Group - Annual Meeting	2:00 PM	5:00 PM	131AB	Standards Services		2632 164 8226
Women in Engineering Meeting	3:30 PM	5:30 PM	126AB	Member Services	Pre-Registration	2633 798 7582
Gala Dinner	7:00 PM	10:00 PM	120A	Social Event	Pre-Registration	

THURSDAY, AUGUST 8

Meeting Name	Start Time	End Time	Room	Type	Attendees	Webex Meeting ID
Team EMC Spin Class	6:30 AM	8:00 AM	Sheraton Lobby	Other	Pre-Registration	
Speaker Breakfast	7:00 AM	8:30 AM	126ABC	Other	Speakers Only	
TC-6 Spectrum Engineering Committee Meeting	7:00 AM	9:00 AM	131AB	Technical Services		2633 679 4322
TC-3 Electromagnetic Environment Committee Meeting	8:00 AM	9:30 AM	131C	Technical Services		2631 683 2035
T-EMC, T-SIPI, L-EMCPA Associate Editor Meeting	8:00 AM	10:00 AM	132A	Communication Services		2633 331 7277
PAR 2838 WG Aircraft Components Lightning Direct Effects Qualification	9:30 AM	11:00 AM	131C	Standards Services		2631 369 5434
SC-3 Special Committee on Machine Learning and AI in EMC and SIPI	10:30 AM	12:00 PM	131AB	Technical Services		2634 525 2965
Awards Lunch	12:00 PM	1:30 PM	120A	Social Event	Pre-Registration	
Standards Development and Education Meeting	2:00 PM	4:00 PM	131C	Standards Services		2633 329 4826
EMC-S PerCom Meeting	2:30 PM	3:30 PM	132A	Communication Services		2631 193 6295
Standards Happy Hour	4:00 PM	6:00 PM	129B	Standards Services	Invitation Only	
EMC+SIPI 2024 Wrap-up Meeting	4:00 PM	6:00 PM	131AB		Invitation Only	
EMC Board Meeting	6:00 PM	8:00 PM	131AB	Other	Pre-Registration	

FRIDAY, AUGUST 9

Meeting Name	Start Time	End Time	Room	Type	Attendees	Webex Meeting ID
Speaker Breakfast	7:00 AM	8:30 AM	126ABC	Other	Speakers Only	
Technical Advisory Committee (TAC) Meeting #2	7:00 AM	9:00 AM	131AB	Technical Services		2630 212 4850
IBIS Summit	8:00 AM	12:00 PM	132A	Standards Services		2633 483 8353
EMC+SIPI 2025 Symposium Planning Meeting	12:00 PM	1:30 PM	131AB	Other	Invitation Only	

TECHNICAL COMMITTEES

EMC SOCIETY TECHNICAL COMMITTEES – BUILD YOUR EXPERTISE AND YOUR CAREER

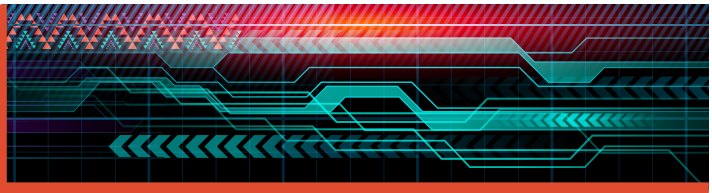
No matter where you are in the industry, at some point you will deal with an EMC issue. Maybe a device is causing interference or maybe it's vulnerable to radio-frequency fields. Maybe a device crashes or resets after an electrostatic discharge. Maybe you've been looking for help explaining an EMC problem to your customer or your boss. All of these things happen. **Become part of the solution.**

The **IEEE EMC Society's Technical Committees (TCs)** convene to set EMC standards & practices and develop tools for success. Covering topics ranging from professional development to nanotechnology, the TCs are volunteer consensus groups that build our industry's foundations. Join remotely or in-person and help form important technical practices.

Find your place among these forward-looking committees. Join a TC today and set standards, explore emerging technology and help develop programs and create the tools that you and your industry need.

WORKING GROUPS AND TECHNICAL COMMITTEE MEETINGS

The EMC Society has many working groups and committees that are tackling the wide range of functions of the society's mission. The working groups primarily come out of the EMC Society Standards activities developing new EMC Standards and revising existing standards. Standing and special committees are formed to address a broad range of needs, ranging from interfacing with other industry organizations to dealing with the administration of the society. All of these meetings are open to everyone (unless listed otherwise). Join them for breakfast, breaks, lunch or dinner. Learn what other EMC members are working on and influence how the society operates.



COLLATERAL MEETINGS

With so many people attending this pinnacle event from across the globe, it's a perfect opportunity for groups other than the EMC Society to hold meetings in parallel to the Symposium. Be sure to check out the schedule to find out about the numerous collateral meetings and who can participate. The EMC Society is neither responsible for nor endorses any of these collateral meetings and discourages any meetings from conflicting with the technical and networking programs of the Symposium.

Photo by Richard Georgerian

TECHNICAL COMMITTEES

TC 1 EMC Management	This committee is concerned with the development and dissemination of Best Practices and Methodologies for the successful leadership, supervision and guidance of EMC related activities. These Best Practices and Methodologies shall be structured so as to provide assistance to all managers, and engineers. Appropriate and convenient tools shall serve as a foundation to these Best Practices and Methodologies.
TC 2 EMC Measurements	The committee reviews the adequacy of measurement procedures and measurement instrumentation specifications for radiated and conducted emission and immunity tests. Also discussed is the rationale for product emission limits and immunity test levels including performance requirements. The committee also supports EMC standards and procedures that deal with measurements and their uncertainty and how they are interpreted and applied.
TC 3 Electromagnetic Environment	The charter of TC3, the Technical Committee on Electromagnetic Environment is to encourage research on the: • electromagnetic environment (EME) • development of standards for EME measurement and characterization • natural and man-made sources of electromagnetic environment that comprise this environment • effects of noise (unwanted portions of EME) on systems performance • effects of international civil and military standards intended to control man-made intentional and unintentional emissions of electromagnetic energy.
TC 4 Electromagnetic Interference Control	This committee is concerned with design, analysis, and modeling techniques useful in suppressing interference or eliminating it at its source. Bonding, grounding, shielding, and filtering are within the jurisdiction of this committee. These activities span efforts at the system, subsystem, and unit levels
TC 5 High Power Electromagnetics	This committee is concerned with the effects and protection methods for electronic equipment and systems for all types of high power and other electromagnetic threat environments. These environments include electromagnetic pulse (EMP), intentional EMI environments (i.e., narrowband and wideband), lightning electromagnetic currents and fields, electrostatic discharge and geomagnetic storms. In addition this committee deals with the commercial data security issue through electromagnetic information leakage activities. Interactions with subsystems, systems and platforms are included.
TC 6 Spectrum Engineering	This committee is concerned with the analysis, design, and measurement techniques for intentional RF transmitting and receiving equipment to prevent interference and promote efficient spectrum use through technology and operational based approaches,such as software design, dynamic spectral allocation, waveform control, as well as frequency coordination and management procedures.
TC 7 Electrical Systems and Power Electronics EMC	This technical committee is concerned with low-frequency EMC including Power Quality in electric power systems. The committee is focusing on application of fundamental EMC concepts also to low frequency conducted disturbances. EMC in power systems is expected to be increasingly important. This is due to increased use of electronics in renewables, electric vehicles, energy efficient technologies and Smart Grid applications.

TECHNICAL COMMITTEES

TC 8 Aeronautics and Space EMC

This committee is concerned with EMI/EMC issues in aircraft, spacecraft & space launch vehicles, robotic and crewed. The space environment provides unique challenges in the design, development, test and operation of space systems to avoid EMI and achieve EMC. Aeronautics & space EMC covers a wide range of topics on the part, board, box, system, multi-system, planetary and interplanetary levels. The harshness of the atmospheric, launch and space environments necessitates a broader view of EMC issues than traditional terrestrial projects, often leading to creative methods and solutions that can benefit our society's efforts elsewhere on Earth.

TC 9 Computational Electromagnetics

This committee is concerned with broad aspects of Applied Computational Electromagnetic techniques which can be used to model electromagnetic interaction phenomena in circuits, devices, and systems. The primary focus is with the identification of the modeling methods that can be applied to interference (EMC) phenomena, their validation and delineating the practical limits of their applicability. Included are low and high frequency spectral-domain techniques and time-domain methods.

TC 10 Signal and Power Integrity

This committee is concerned with the design, analysis, simulation, modeling and measurement techniques useful in maintaining the quality of electrical signals and power distribution network in printed circuit boards, ICs and within systems. These activities encompass all aspects of signal and power integrity from the integrated circuit level to the system level.

TC 11 Nanotechnology and Advanced Materials

Concerned with modelling, simulation and experimental characterization of nanomaterials and nanodevices for EMC applications. Nanotechnology is the understanding and controlling of matter at atomic and molecular scale.
Nanotechnology has already found its way into various EMC applications. New materials such as single- and multi-phase composites filled with nanoparticles, nanotube and/or nanofibres have been designed and tested for gaskets and absorbing screens with outstanding performance and capabilities. Innovative nanostructured shields have shown multifunctional properties and higher efficiency than commonly used materials. Nanowires for high speed interconnects and high density integrated systems, could replace copper in the near future, but require adequate modelling and simulation approaches for signal integrity and also to avoid electromagnetic interference problems.

TC 12 EMC for Emerging Wireless Technologies

This committee is concerned with the EMC design, analysis, modeling, measurement, and testing aspects of emerging wireless products, such as Internet of Things and 5th Generation of Wireless Communication. The committee encourages research including but not limited to the following areas:

- Innovative Wireless Component Design for System Integration: wireless component design with integrated EMC functions and/or meeting certain EMC specifications
- Radio-Frequency Interference and De-sense: characterization and mitigation of interference from digital circuits to wireless antennas
- EMC and OTA Measurement & Testing of Wireless Systems: development of methods and standards for wireless performance and compliance testing
- Wireless Coexistence: interference control/mitigation among various wireless radios, as well as related testing methods and standard development
- Wireless Product or Subsystem EMC: wireless-specific EMC design for Autonomous cars, Phased Array, and others.

SC 1 Smart Grid Support and EMC Issues

This special committee is concerned with coordinating the EMC Society activity on providing EMC principles for those organizations and associated documentation and specifications that address the efficient use of the AC power grid including the control of power entering a house or building. Such control may be from a meter at the point of power entry into these facilities to control incorporated into appliances and other electronic devices in these facilities. Such controllers may be sources of undesirable RF emissions and at the same time vulnerable to the RF environment which speaks to the need for EMC. It is expected that the coordination aspect of this special committee will involve several EMCS Technical Committees.

TECHNICAL COMMITTEES

SC 3 Artificial Intelligence and Machine Learning in EMC + SIPI

This special committee is concerned with all aspects of machine learning, artificial intelligence and deep learning as it applies to the Society's Field of Interest (FoI). It is not limited to any specific aspect of the Society but recognizes that machine learning and related approaches have relevance across the entire spectrum of Society activities.

SC 5 Power Electronics EMC

This special committee is concerned with power electronics converters EMI/EMC issues. These are mainly, converters that use switching frequency schemes to control the output parameters, such as voltage and current. These converters, including inverters, can be found as interface between the raw power and the electrical grid to provide the end-user with the desired operating power. Applications can range from grid-connected PV systems, wind farms, automotive, aerospace, and communication systems.

Standards Advisory and Coordination Committee (SACCom)

The IEEE EMC Society Standards Advisory and Coordination Committee is responsible for providing technical liaison between the IEEE EMC Society Standards Development Committee and various non-IEEE entities involved with EMC standards activities.

In particular, the SACCom will include the following:

- Propose to the EMCS board of directors (BOD), the appointment of representatives to various non-IEEE standards developing entities.
- To monitor the activities of various non-IEEE standards developing organizations with a view toward making recommendations to the EMCS board of directors on any required coordination of those activities within the society.
- To communicate and coordinate with non-IEEE standards developing activities and the EMCS Standards Development Committee on matters relating to the development of EMC related standards.

Standards Development and Education Committee (SDECom)

The IEEE EMC Society Standards Development and Education Committee is responsible for guiding the development of IEEE EMC Standards, the training of those involved in the standards making process and the education of the EMC Society community on all aspects of EMC Standards. The IEEE EMC Society is the primary international developer of fundamental test, measurement and verification standards for EMC.

Education Committee (EdCom)

This committee's mission is to promote EMC education related activities of the IEEE EMC Society. Our vision is to provide opportunities for individuals and organizations involved with electrotechnology and products to become aware of EMC at levels consistent with their needs, and our goals are to establish an awareness of EMC fundamentals throughout industry and academia as well as to enhance EMC education through the development of improved education techniques, materials, opportunities, and communications.

MEET AND NETWORK WITH LIKE-MINDED INDIVIDUALS AT OUR SOCIAL EVENTS

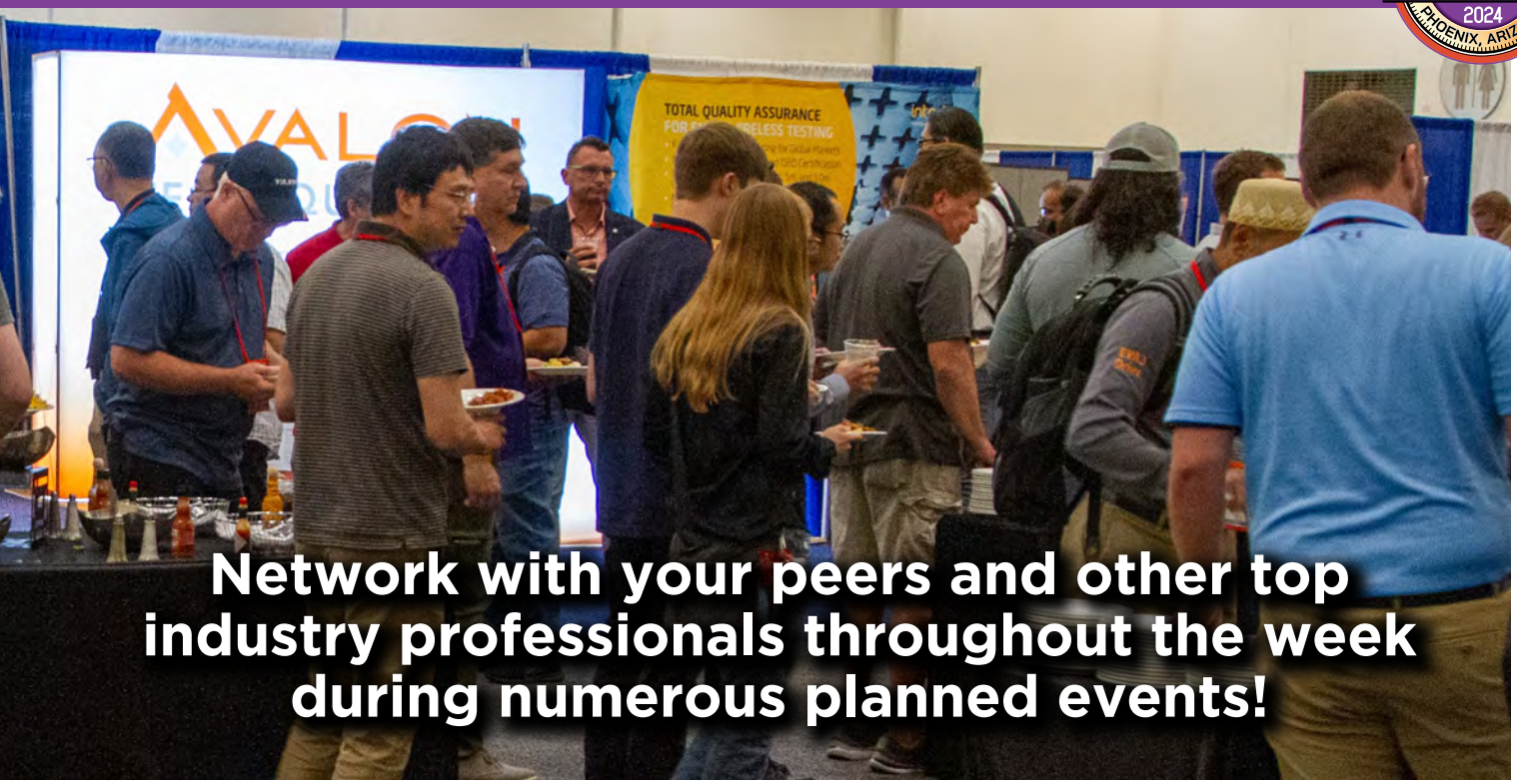
WELCOME RECEPTION

The EMC+SIPI 2024 Welcome Reception will be held in the Exhibit Hall at the Phoenix Convention Center on Tuesday. **New for this year**, the attendance is open to everyone with a Symposium name badge, regardless of registration type. Food will be provided, but drinks will be available for purchase.

Join us for this chance to celebrate the beginning of the Symposium and to meet our Exhibitors.

Photo by Patrick Andre

Location: Exhibit Hall 5 & 6
Phoenix Convention Center
Date: Tuesday, August 6, 2024
Time: 5:00 – 7:00 PM



Network with your peers and other top industry professionals throughout the week during numerous planned events!

Photo by Patrick Andre

EVENING GALA EVENT

The Gala is our Symposium celebration that is traditionally a sit-down dinner event with entertainment. Thanks to our sponsor, Rohde & Schwarz, the EMC+SIPI 2024 Gala will have a fun Oktoberfest themed dinner, décor, and entertainment!

One ticket to this event is included in all 5-Day technical registrations EXCEPT student registrations. Extra tickets to the Gala may be purchased as an add-on to your registration.

SPONSORED BY:

ROHDE&SCHWARZ
Make ideas real

Location: 120A–Phoenix Convention Center
Date: Wednesday, August 7, 2024
Time: 7:00 – 10:00 PM
Cost: $120

Photo by Richard Georgerian

AWARDS LUNCHEON

The Awards Luncheon is a wonderful opportunity to recognize achievements and network with families and EMC professionals from academia, industry, government, military, and retired sectors. The event will start off with a catered sit-down meal. Afterwards, the EMC Society will take time to recognize members and non-members for their contribution to the Society and for professional excellence.

Location: 120A – Phoenix Convention Center
Date: Thursday, August 8, 2024
Time: 12:00 – 1:30 PM
Cost: $70 after July 1

CHAPTER CHAIR TRAINING SESSION AND LUNCHEON

The Chapter Chair Training Session provides a forum for focused training to the Chapter Chairs, the opportunity to discuss chapter issues and get group feedback. Additionally, the session gives the Chapter Chairs the opportunity to meet other Chapter Chairs from around the world and for the Chapter Coordinator to disseminate important information from IEEE headquarters and the EMC Society Board of Governors. A Social Session will precede the Luncheon to give the Chapter Chairs the opportunity to socialize with the other Chapter Chairs and their Angels.

The Luncheon will be served at the end of the Social Session. Besides a great meal, each Chapter Chair or their representatives will have the opportunity to share what their chapter has been doing for the past year. After the Luncheon, an interactive brainstorming session will conclude the meeting. This session is intended to allow participants to exchange information and new ideas for effective chapter management, as well as to discuss best practices and suggestions for future development and growth of the EMC chapters.

Location: 131AB – Phoenix Convention Center
Date & Time: Monday, August 5 • 12:00 – 1:30 PM
Cost: Free for Chapter Chairs
This is a free event open to Chapter Chairs or their representatives. Please check with your Chapter Chair, as you can be that representative for your chapter if your Chapter Chair cannot attend this event

Photo by Karthik Vepuri

PAST PRESIDENTS LUNCHEON

The Luncheon is open to Past-Presidents of the EMC Society, and current members of the Board of Directors. The luncheon is a chance for the old and the new to mix, exchanging experiences of the past and challenges of the future relative to the EMC profession. A sit down lunch is provided. Past-Presidents should inform the Chair of the History Committee (danhoolihanemc@aol.com) of their interest in attending so there will be seating and food available for all.

Location: 126A- Phoenix Convention Center
Date: Wednesday, August 7, 2024
Time: 12:00 – 1:30 PM

TEAM EMC

Please join us and your fellow EMC colleagues for an in-door, air conditioned private spin class. The ride is for all levels of participation. A TEAM EMC jersey will be included for 1st-time participants on a first come first serve basis, while quantities last. If you received a jersey on one of our past rides, please don't forget to bring it with you. This year's artwork "Mountain Bike Cowboy Skeleton" for the jersey has been designed by PHX local artist Bill Gulino.

Seats are limited to first come, first serve. Reservations are binding due to the limited seats available. **Contact for reservation by July 15th: Susanne Vogel,** susanne.vogel@ieee.org

The spin class will take place at a nearby gym. Sports clothes will be recommended in the gym. No helmet required. If you have a car available, please provide a ride for other riders too. We will also organize a shared ride via Uber/Lyft to the gym for all registered participants.

Meeting Location: Sheraton Registration Desk, 340 N 3rd St
Class Location: The Underground
Date & Time: Thursday, August 8 • 6:30 - 8:00 AM

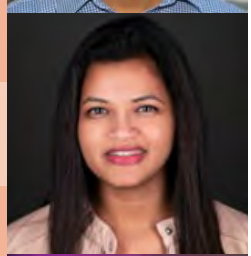
IEEE EMC SOCIETY WOMEN IN ENGINEERING (WIE) EVENT

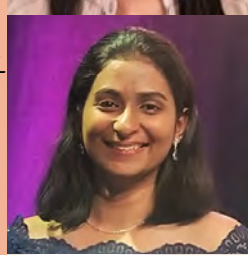
IEEE Women in Engineering (WIE) is a global network of IEEE members and volunteers dedicated to promoting women engineers and scientists, and inspiring girls around the world to follow their academic interests in a career in engineering and science. Our goal is to facilitate the recruitment and retention of women in technical disciplines globally. We envision a vibrant community of IEEE women and men collectively using their diverse talents to innovate for the benefit of humanity.

Location: 126BC – Phoenix Convention Center
Date: Wednesday, August 7, 2024
Time: 3:30 – 5:30 pm
Cost: $10, refreshments included

Let's meet for a networking and enrichment event during the IEEE EMC+SIPI 2024 Symposium and share experiences. We, the IEEE WIE and the IEEE EMC Society, invite you to attend this wonderful event. Please join us for a special celebration at the end of the presentations.

Everyone is welcome - men and women - to attend the special presentations!

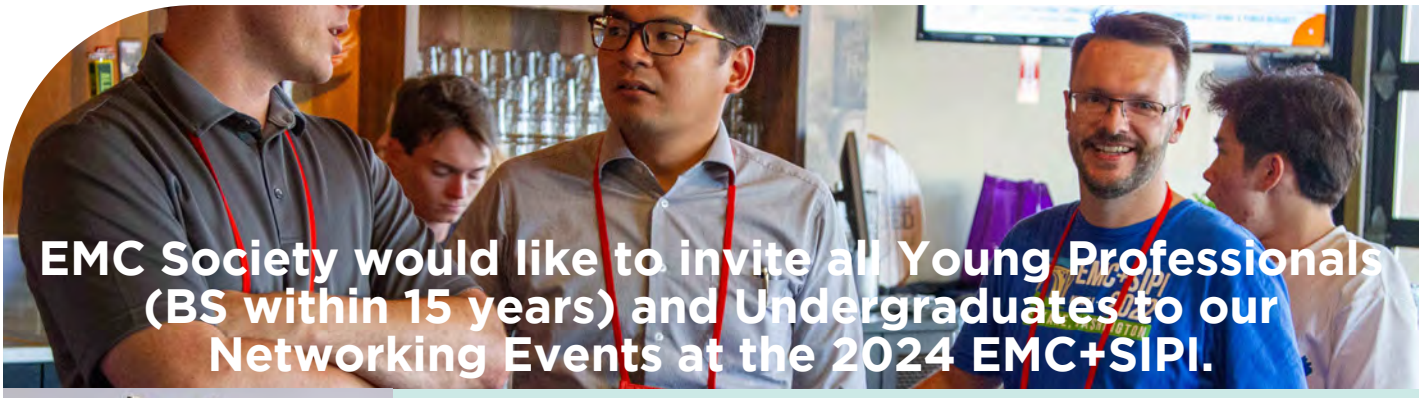




AGENDA

3:30 pm	**Welcome** **Ms. Tara Kellogg**, *ETS-Lindgren, EMC Society WIE Chair, Americas, IEEE EMC Chapter Chair, Central Texas*
3:40 pm	**Speaker Introduction** **Mr. Anil Kumar**, *Principal Engineer, Client Computing Group, INTEL*
3:50 pm	**WIE Panel Discussion: Artificial Intelligence: What Motivates the Women in Engineering at INTEL?** **Ms. Nikita Tiwari**, *Senior AI Enabling Engineer, Client Computing Group, INTEL* **Ms. Neethu Elizabeth Simon**, *Senior Software Engineer, Network & Edge Group, INTEL* **Ms. Joyce Weiner**, *Principal Engineer, AI Software Architecture, INTEL* This panel of semiconductor industry engineering experts has over 50 years of combined experience. From data science to software to artificial intelligence (AI), hear how they have navigated their demanding careers while juggling their personal lives and giving back through their community leadership. Ask your questions during the interactive section. You'll learn there is nothing artificial about these women engineers!
4:50 pm	**Break & Networking Exercise**
5:20 pm	**Welcome Back Toast and Refreshments to Celebrate WIE!**
5:30 pm	**Adjourn**

YOUNG PROFESSIONALS



EMC Society would like to invite all Young Professionals (BS within 15 years) and Undergraduates to our Networking Events at the 2024 EMC+SIPI.

EMC+SIPI JEOPARDY! YP EVENT

During the 2024 Symposium, back by popular demand, we will hold "EMC+SIPI Jeopardy!" – Trivia, with a Twist! This event is great at building your expertise in EMC+SIPI as well as providing a welcoming, informal environment to network with YP colleagues and experienced professionals alike. You'll have the opportunity to play alongside EMC+SIPI Experts (including Todd Hubing, Lee Hill, Eric Bogatin, Patrick Andre, CJ Reddy, Davy Pissoort, Karen Burnham, Anne Roc'h) and prizes will be awarded to the winners! Come mingle with your fellow YPs and these EMC+SIPI gurus, who will share their experiences and insights from volunteering within IEEE EMC Society. We'll also be highlighting the Best Student Paper Candidates and we'll be announcing the newly selected 2024-2025 EMC Society YP Ambassadors.

Location: The Arrogant Butcher - 2 E. Jefferson #150
Date: Monday, August 5, 2024
Time: 6:00 – 10:00 PM
Registration Fee: $40
Includes: Dinner and 1 Drink ticket, Limited space available

"AFTER THE WELCOME RECEPTION" EVENT

Get to know your fellow Young Professionals in a casual, informal setting after the Welcome Reception. We'll have networking games planned, intended to help YPs get to know one another, and to gain a better understanding of the EMC Society. Besides the games, drinks and appetizers, this is a great time to continue the conversations started during the Welcome Reception or to introduce your friends to one another. Relationships formed in the EMC Society can lead to future collaborations on projects and will provide valuable contacts when you need a friend to bounce ideas off!

Location: Huss Brewing Downtown PHX Brewpub - 225 E Monroe St
Date: Tuesday, August 6, 2024
Time: 7:00 – 10:00 PM
Registration Fee: $20 registration
Includes: 2 drink tickets and shared appetizers included
Limited space available

YOUTH TECHNICAL PROGRAM

The following information is preliminary and subject to change.

HARNESS THE POWER OF THE SUN!

Have you ever stood outside on a hot, sunny day, and wondered whether all that sunshine could be used for something? Join us on August 7 for the 2024 Youth Technical Program of the IEEE EMC+SIPI Symposium in Phoenix, AZ, where we will discuss the principles of renewable energy, the photoelectric effect, and their application to photovoltaic technology. Each participant will apply these principles to construct a solar powered car, useful for cruising the streets of Phoenix, and beyond! Open to children 6-16. Younger participants are welcome if accompanied by an older sibling or parent. Sign up via the registration portal.

Location: 129B – Phoenix Convention Center
Date: Wednesday, August 7, 2024
Time: 1:00 PM - 3:30 PM
Registration Fee: FREE

COMPANION CLUB

The Companion Club is your chance to meet new people and catch up with old friends. You may register for the Companion Club as a part of the technical attendee's registration or separately.

Paid Companion Club members are welcome to visit the beautiful Companion Suite where a delicious breakfast will be served Monday to Thursday, from 7:00 to 10:00 am. There will also be daily raffles!

This year, the EMC+SIPI Symposium offers two attractive group Companion Tours. However, you don't have to be registered for the Companion Club to participate in a tour.

If you register for the Companion Club, you may sign up for the tours with your own registration. Otherwise, you may purchase tours through the technical attendee's registration; there will be a drop down space to add your name.

Join your technical attendee at any of our Social Events for more fun and to meet more people. We have special prices for companions under the age of 18. Tickets to the Welcome Reception, a great networking time for all, are included in all Companion Club registrations. The Evening Gala is also a fun event, and companions are invited to register for this event separately in their Companion Club or technical attendee's registration.

For the younger crowd, our ever popular Youth Technical Program is back once again to amaze all companions and guests aged 8 to 17. This program will again be free of charge, but please register early to be assured a project kit. Registration for each young person can be made either through your own Companion Club registration or the technical attendee's registration. Your children don't have to be registered in the Companion Club to sign up for the Youth Technical Program, but an adult must accompany them to the session since this is a hands-on project.

JOIN THE BREAKFAST CLUB

Would you like to invite your technical attendee to join you for breakfast in the Companion Suite? **"Breakfast Club"** tickets may be purchased by the technical attendee as an option for each day breakfast is desired. Tickets must be purchased at a minimum 24 hours in advance to ensure adequate seating and catering.

Join fellow companions at the symposium by registering for the Companion Club. This is an excellent opportunity to meet new people and reconnect with old friends! Adult or youth (ages 8 to 17) companions who are pre-registered may go directly to the registration desk located in the Convention Center to obtain a special Companion Registration Packet.

This will include:

- Name badge that will allow you access to the Companion Suite and Exhibit Hall (during regular hours)
- Gift bag with goodies
- One ticket to the Tuesday evening Welcome Reception
- Any tour or social event tickets you may have purchased

Youths (ages 8-17) who are registered for the Junior Companion Club are welcome in the Companion Suite with an adult Companion Club member. Children under age 8 do not receive a gift bag, but will be admitted free if accompanied by a registered adult Companion Club member.

Your ticket to the Welcome Reception is an opportunity to enjoy another great event with your technical attendee where everyone can have more fun and meet new people. It is a great networking time for all. The Wednesday night Gala Banquet is also a fun event; however, companions must purchase tickets separately for that event. Discounted prices are available for youth under age 18, and children under age 8 will be admitted for free if accompanied by a registered adult.

COMPANION CLUB RATES:

Adult, age 18+:
Rate: $270
Junior, age 8-17:
Rate: $85
Children under 8: No charge

A LA CARTE TOURS ARE AVAILABLE

www.emc2024.org/programs/companions-tours

COMPANION TOURS

The following information is preliminary and subject to change.

TALIESIN WEST TOUR

Your personalized tour of Taliesin West takes you along the courtyards and terraces, garden paths and reflecting pool area, past a bearing citrus grove and beside the former working drafting studio of the Taliesin Architectural Group. This World heritage Site and national landmark occupies over 600 acres of Sonoran Desert in the foothills of the spectacular McDowell Mountains. Designed by architectural genius Frank Lloyd Wright, Taliesin West was designed to be a bold new architectural experiment.

Date: Monday, August 5, 2024
Time: 9:00 AM – 12:30 PM
Cost: $155
Includes: Transportation and entrance fees

CALL FOR SUBMISSIONS

The IEEE EMC Society is seeking original, unpublished papers covering all technologies that are affected by EMC, Signal & Power Integrity

Join us in Raleigh, NC. Share your insight, ask questions, learn from the experts/innovators and see new products at the 2025 IEEE International Symposium on Electromagnetic Compatibility, Signal & Power Integrity. Your published paper will be seen by thousands in the EMC community and across the wide array of disciplines that look to the IEEE EMC Society for technical guidance. In addition, it will be uploaded to IEEE Xplore® with the exposure and recognition that brings.

The committee proposes Special Topic Areas:

Biomedical Devices, DC Electrification / Microgrids, EMI/EMC issues for transportation electrification, Wireless Charging; Intentional EMI and Cybersecurity; AI/ML for EMC and SIPI Problems.

KEY DATES

December 11, 2024: Submission Deadline for Special Session Proposals
January 13, 2025: Submission Deadline for Traditional and Special Session Papers
February 3, 2025: Submission Deadline for Workshops & Tutorials and Experiments & Demonstrations Proposals
February 24, 2025: Notification of Acceptance/Rejection for Traditional and Special Session Papers
March 10, 2025: Submission Deadline for Abstract-Reviewed Papers
March 10, 2025: Notification of Acceptance/Rejection for Workshops & Tutorials and Experiments & Demonstrations
March 24, 2025: Submission Deadline for Revised Traditional and Special Session Papers
April 25, 2025: Notification of Acceptance/Rejection for Traditional, Abstract-Reviewed, and Special Session Papers
May 19, 2025: Submission Deadline for Final Papers and Workshop & Tutorial Presentations (Registration Required)

#IEEE_ESP25

Learn more at www.emc2025.org!

IEEE | EMC SOCIETY

EXHIBIT HALL

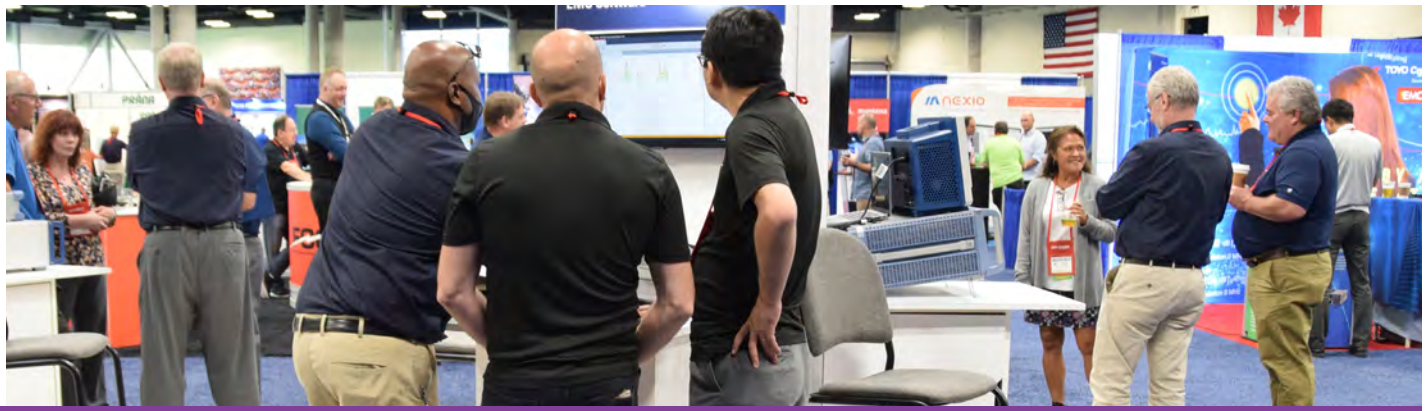


Photo by Richard Georgerian

EXPLORE THE EXHIBIT HALL AND LEARN ABOUT NEW TECHNOLOGIES, INSTRUMENTATION AND SOLUTIONS THAT SERVICE THE INDUSTRY

WHAT'S HAPPENING IN THE EXHIBIT HALL?

- Explore and learn from over a hundred top suppliers
- Attend "Ask the Experts" panels and get your questions answered
- Enjoy Experiments, Demonstrations and Poster Sessions
- Visit exhibitor booths to play the Scavenger Hunt and participate in raffles and games.
- Student Hardware Competition

EXHIBIT HALL SCHEDULE

EXHIBIT HOURS:

TUESDAY, AUGUST 6
Exhibits Open: 9:30 AM – 7:00 PM
Welcome Reception: 5:00 PM – 7:00 PM

WEDNESDAY, AUGUST 7
Exhibits Open: 10:00 AM – 5:00 PM

THURSDAY, AUGUST 8
Exhibits Open: 10:00 AM – 1:00 PM

EXHIBIT HALL IS LOCATED IN PHOENIX CONVENTION CENTER EXHIBIT HALL 5&6

MEET THE EMC+SIPI 2024 EXHIBITORS

EXHIBITOR LIST

DISCOVER OUR EXHIBITORS!

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A2LA	522
Absolute EMC Llc.	708
Advanced Test Equipment Rentals	309
AE Techron	709
ALTAIR	818
Amber Precision Instruments	623
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Amphenol Canada Corp.	808
Anechoic Solutions, Inc.	300
Antenna Measurement Techniques Association (AMTA)	823
ANSI-ASQ National Accreditation Board (ANAB)	302
AP Americas Inc.	713
*Applied Technical Services	304
Boeing Little Mountain Test Facility	201
Bureau Veritas Consumer Products Services, Inc.	313
CKC Laboratories, Inc	210
*Compliance Testing	714
Com-Power Corporation	400
Comtest Engineering, bv	620
*Copper Mountain Technologies	812
CPI Electron Device Business	724
D.L.S. Electronic Systems, Inc	301
Dassault Systèmes SIMULIA	323
DesignCon	823
Detectus	518
*DEWETRON	523
*Diamond Microwave Chambers Ltd	208
Electro Magnetic Applications, Inc.	525
Element Materials Technology	321
Elite Electonic Engineering, Inc.	519
EMC Electronic LTD	805
*EMcoretech co., Ltd.	613
EMCoS LLC	418
EMCPIONEER	419
ESDEMC Technology	212
ETS-Lindgren Inc.	401
Exodus Advanced Communications	514
Fair Rite Products Corp.	619
Faraday Defense Corporation	413
•Fil-Coil International	211
Fischer Custom Communications Inc.	509
GAUSS Instruments International GmbH	409
Global Sealing Systems, INC.	425
*Global Validity Corporation	521
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Keysight Technologies	615
KGS America	618
Lightning EMC, LLC	712
LUMILOOP GmbH	325
M Precision Laboratories, Inc.	718
Maury Microwave	310
MESAGO Messe Frankfurt GmbH	421
MVG, Inc.	609
Narda Safety Test Solutions S.r.l. - Italy	520
NEMKO USA, Inc.	717
NEXIO Technologies	308
Nexperia Semiconductor	422
Ohtama Co., Ltd.	810
OnRule	813
OPHIR RF Inc.	404
Picotest	209
PPG Cuming Microwave & Cuming Lehman Chambers	816
R&K Company Limited	205
RATLR, Inc.	701
Raymond EMC	701
RF Exposure Lab	303
Robust Physics	625
Rohde & Schwarz USA, Inc.	600
Safety & EMC China	621
Schlegel Electronics Materials, Inc.	319
Siemens	423
Spira Manufacturing Corp	415
TDK Lambda Americas	315
TDK RF Solutions, Inc.	701
The Boeing Company	203
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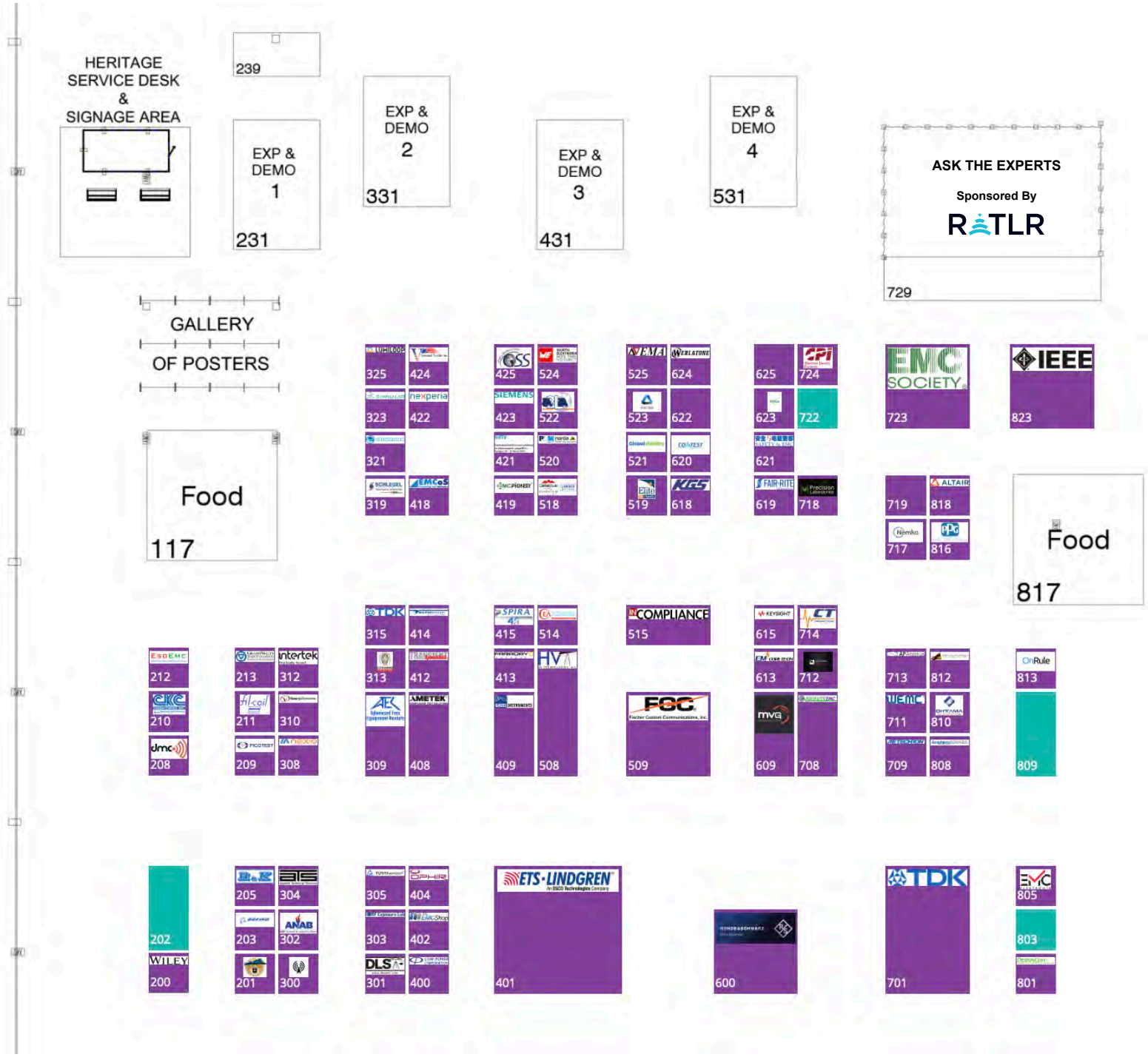
*** Please welcome our new first-time exhibitors**

EXHIBIT HALL FLOORPLAN



EXHIBITOR PROFILES

412 TW BENEFIELD ANECHOIC FACILITY

Booth 622

www.edwards.af.mil/Units/772nd-Test-Squadron

The BAF provides a robust RF T&E infrastructure to ensure system survivability and mission effectiveness for the DoD, industry and allies. The largest anechoic test facility provides a secure "virtual open-air RF range within four walls" — a valuable tool providing test engineering applied to the development and the T&E of RF systems. We conduct Antenna Pattern, EW/IO, Survivability, Electromagnetic Interoperability and Electromagnetic Environmental Effects (E3) tests. The uniquely large and well-equipped BAF offers a highly flexible and scalable indoor antenna range and test capability for installed and uninstalled antenna systems across a wide spectrum.

A2LA

Booth 522

www.a2la.org

Our accredited organizations span a variety of industries, operating where consumer and public safety is paramount. Accreditation provides confidence that the systems in place will support quality services.

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Booth 708

www.absolute-emc.com

Absolute EMC Llc. Offers decades of experience with EMC testing, standards, and test equipment. We are partnered with only the best manufacturers in the industry. Offering high-quality products from BOLAB Systems, EMC Instruments, EMZER, Lumiloop, HILO/TEST, GTEMCELL Group, Schloder EMV-Systems, Seibersdorf Laboratories, Schwarzbeck, Tekbox, and MK Messtechnik. We offer our technical knowledge and expertise to help you make the correct choice the first time. Our customers come first and are treated like family. Offering Impulse generators, ESD, Surge, EFT, Lightning, RF Test systems, GTEMs, Turnkey projects, Test Tables, EUT supports, Coax, Antennas, Preamps, LISNs, Hardened fiber-optic interfaces/cameras.

ADVANCED TEST EQUIPMENT RENTALS

Booth 309

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Advanced Test Equipment Corp. (ATEC) is a leading provider of test & measurement equipment rentals, sales, calibration, and service. Since 1981, test engineers, government agencies, and Fortune 500 companies have relied on ATEC to guide them to the right equipment, ship it quickly, and offer them the industry's best technical expertise and customer care. ATEC's broad inventory includes EMC, Power Supplies & Loads, RF Safety, Electrical, NDT, Environmental, Communications, and General Purpose test equipment. Explore the ATEC inventory at www.atecorp.com.

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Booth 709

2507 Warren Street

AE Techron is a recognized world leader in the design and manufacture of precision, audio bandwidth industrial power amplifiers and EMC product safety compliance test systems. We provide comprehensive and innovative solutions for power quality, conducted immunity, and induced susceptibility testing for EMC, Automotive, Aviation, Imaging, Energy Sector, and Research markets. With a focus on modular testing systems and configurable amplifier solutions for difficult requirements, we consistently meet the challenges of the EMC industry with innovative design and exacting performance.

ALTAIR

Booth 818

www.altair.com

Altair is a global leader in computational intelligence that provides software and cloud solutions in simulation, high-performance computing (HPC), data analytics, and AI. Altair's EMC solutions are trusted across industries for solving diverse electromagnetic challenges, from static to high frequencies. Ensure your electronic system's performance and reliability by evaluating magnetic fields radiated by power cables and busbars, assessing external field impacts on sensors and actuators, and simulating conducted emissions, radiation, and irradiation of cables and antennas. Discover how Altair can enhance your electromagnetic compatibility at our booth #818. To learn more, please visit https://altair.com/electronic-system-design and https://altair.com/electromagnetics-applications.

AMBER PRECISION INSTRUMENTS

Booth 623

http://www.amberpi.com

Amber Precision Instruments is a research-oriented EMC solution provider and EMC scanner manufacturer providing measurement technologies to resolve urgent and long-sought-after industry problems.

EXHIBIT PROFILES

AMERICAN NATIONAL STANDARDS COMMITTEE (ANSC) C63-EMC

Booth 719

www.c63.org

C63® is a major United States EMC standards developer focused on many aspects of emission and immunity measurements, instrumentation and resources for test lab competency and quality control. Its standards are highly diversified.

The uniqueness of the committee is the close link of its EMC standards with the needs of manufacturers and testing organizations, but most importantly the acceptance of its standards by US regulatory organizations such as the Federal Communications Commission, which references several C63® standards in its Rules. The broad diversity of active members provides extensive representation of the stakeholders served by the efforts of the C63® committee and the standards it creates.

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COMPLIANCE TEST SOLUTIONS

AMETEK CTS US, INC.

Booth 408

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AMETEK CTS unites the key EMC and RF amplifier industry leaders EM TEST, TESEQ and Amplifier Research in a single powerhouse. We are a leading manufacturer of test and measurement instrumentation for electromagnetic compatibility (EMC) testing, producing a broad range of conducted and radiated EMC compliance testing systems and RF amplifiers. We serve a wide range of industries, including automotive, consumer and industrial electronics, medical equipment, telecommunications, defense, and avionics.

Amphenol CANADA
MILITARY & AEROSPACE

AMPHENOL CANADA CORP.

Booth 808

www.amphenolcanada.com

Headquartered in Markham, just outside of Toronto, Canada, and with subsidiaries in Belleville Canada, and Nogales Mexico, Amphenol Canada Corp. has been an international leader in the interconnect industry. From design and manufacturing through quality inspection and shipping, Amphenol Canada has over 50 years of experience in the Military/Aerospace and Commercial markets.

ACC has pioneered many unique technologies to address the interconnect needs of increasingly demanding applications, including Filtered Connectors and Interconnect devices for EMI and EMP protection, Ruggedized connectors for Harsh Environments, industry-leading High-Speed signal connectors for use in the rapidly growing In-flight Entertainment industry of Commercial Aviation.

ANECHOIC SOLUTIONS, INC.

Booth 300

www.AnechoicSolutions.com

Anechoic Solutions was formed to allow for more flexibility to design and build new technically advanced measurement systems utilizing state of the art chamber technology. Our resources are not limited to only what we manufacture, instead we search the world for the right material to suit our customer's needs.

ANAB
ANSI National Accreditation Board

ANSI NATIONAL ACCREDITATION BOARD (ANAB)

Booth 302

www.anab.ansi.org/accreds/calibration-laboratory-accreditation

More than 2,500 organizations in almost 80 countries have received accreditation from the ANSI National Accreditation Board (ANAB), the largest multidisciplinary accreditation body in the western hemisphere. ANAB is formally recognized by NACLA for satisfying technical requirements. The exceptionally skilled personnel of ANAB are engaged in Standards Development Organizations (SDOs) and other pertinent endeavors. ISO/IEC 17025 calibration and testing laboratories, ISO/IEC 17020 inspection bodies, ISO/IEC 17065 product certification bodies, and ISO/IEC 17043 proficiency test providers are all included in ANAB's accreditation portfolio. Please stop by the ANAB booth and meet our team.

2024 CINCINNATI • OHIO AMTA

ANTENNA MEASUREMENT TECHNIQUES ASSOCIATION (AMTA)

Booth 823

www.2024.amta.org

The Antenna Measurement Techniques Association (AMTA) is a non-profit, international organization dedicated to the development and dissemination of theory, best practices and applications of antenna, radar signature and other electromagnetic measurement technologies. Visit www.amta.org for more information.
Resonant Sciences is proud to host the 46th Annual Meeting and Symposium of the AMTA at the Northern Kentucky Convention Center in the greater Cincinnati, OH, USA area from October 27 – November 1, 2024. Resonant Sciences cordially invites you to attend and participate in this annual event. AMTA 2024 is the premier conference dedicated to the field of antenna & related measurements.

EXHIBITOR PROFILES

AP AMERICAS INC.

Booth 713

www.apamericas.com

AP Americas is a leading global manufacturer of RF/anechoic chambers and RF shield rooms for EMC, antenna testing and high-frequency technology. Our expertise lies in the development, design, and construction of test environments to verify the electromagnetic compatibility of your products according to international standards. Our global strength is managing your project with all interfaces. We work by your side to meet the needs of your chamber project within your timeline. This is supported by the highest level of experience, expertise, innovation and understanding of your requirements. Start with Trust - Start with AP Americas

APPLIED TECHNICAL SERVICES

Booth 304

www.atslab.com

Applied Technical Services assists commercial and industrial clients by providing inspection, testing, and calibration services. Our experienced experts provide assistance to numerous industries, including aerospace, automotive, construction, communications, consumer products, insurance and legal, petrochemical, power generation, and more. Our family of companies allows us to offer a broad range of capabilities across the globe.

BOEING LITTLE MOUNTAIN TEST FACILITY

Booth 201

www.boeing.com

Little Mountain Test Facility is a state-of-the-art laboratory dedicated for testing operations in direct support of nuclear hardness and survivability for the US Air Force Intercontinental Ballistic Missile (ICBM) Program. LMTF performs testing in support of this mission and various other DOD / DOE programs, military systems, and aerospace products. LMTF has extensive nuclear hardness and survivability experience that specializes in Radiation, Electro Magnetic Pulse (EMP), Electro Magnetic Compatibility (EMC), Shock & Vibration, and other various environments.

BUREAU VERITAS CONSUMER PRODUCTS SERVICES, INC.

Booth 313

www.cps.bureauveritas.com

Bureau Veritas is one of the world's leading consumer and technology product testing, inspection/audit and certification bodies. We work closely with our clients to achieve safe, quality and sustainable products.

Bureau Veritas' Detroit automotive laboratory houses the latest technology for the compliance of automotive products within connected and autonomous vehicles. Services include EMC Validation, Wi-Fi RF, Bluetooth RF, Emark, GNSS and V2X Testing to help clients tackle the ever changing and complex national and international regulations.

CKC LABORATORIES, INC.

Booth 210

www.ckc.com

Founded in 1973, CKC Laboratories offers customer centered EMC testing, EMI testing and EMC Design Consultation services. Our customer service oriented laboratory staff is composed of technically expert EMC engineers and technicians. EMI testing services include FCC, CE, Automotive, Medical, Aerospace, Military and other global market requirements.

COMPLIANCE TESTING

Booth 714

www.compliancetesting.com

Expert and Accredited EMC Testing Lab
Gain FCC, CE, ISED and other regulatory compliance with our ANSI-accredited EMC testing lab that makes the process of electronic device compliance easy. Operating since 1963, our engineers have an unprecedented depth of knowledge in EMC testing, with a combined 130 years of hands-on lab testing experience. Our testing and certifications open the door for your products to global markets, helping you get your products to market quickly and grow your revenue.

EXHIBIT PROFILES

COM-POWER CORPORATION

Booth 400

www.com-power.com

Com-Power is a leading supplier of EMC test instrumentation. We offer a wide selection of products and unique solutions. Our products are suitable for compliance or pre-compliance EMC testing. All our products are calibrated and conform to the latest test standards and are usually available from stock. Products can be ordered directly from Com-Power or from distributors listed on our website.

COMTEST ENGINEERING, BV

Booth 620

www.comtest.com

We deliver cost-effective and compliant EMC and Antenna test facilities and RF- shielded rooms that will enable you to achieve your goals resulting in a better and safer world. In our family business, we were taught that our products must be right down to the smallest details. Details that others often don't even notice but that make the difference between good and perfect. We do this with a Dutch entrepreneurial spirit from the village where Rembrandt's father's mill once stood. This is how we help companies protect and connect people all over the world. As in one big family.

For more background information on Comtest you can visit: About – Comtest

COPPER MOUNTAIN TECHNOLOGIES

Booth 812

www.coppermountaintech.com

Copper Mountain Technologies (CMT) pioneered metrology-grade USB VNAs in 2011 and continues to drive industry change through customer-focused solutions including a broad range of vector network analyzers, calibration kits, and accessories. We offer the best customer value through an unparalleled combination of price, performance, and portability which has expanded VNA use to new industries and applications. Our expert engineers work as an extension of your team, helping users complete unique and complex projects. The Indianapolis-based company has an R&D center and service center in Cyprus, and sales offices in Singapore, London, and Miami.

CPI ELECTRON DEVICE BUSINESS

Booth 724

www.cpii.com/tmd

CPI TMD Technologies Division (CPI TMD) is one of the world's leading manufacturers of microwave power sources, high-voltage power supplies and transmitters for radar, electronic warfare, communications, industrial testing and scientific applications. CPI TMD's specialty is innovative, custom solutions for some of the industry's most challenging applications. CPI TMD offers a unique range of microwave power modules, traveling wave tubes, high-voltage power supplies, as well as rugged amplifiers and instrumentation amplifiers for radar, electronic warfare, communications and electromagnetic compatibility (EMC) testing, scientific and medical applications. CPI TMD's products are optimized for use on airborne, ground based and shipboard platforms.

DASSAULT SYSTÈMES SIMULIA

Booth 323

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Dassault Systèmes SIMULIA reveals the world we live in through realistic simulation of product, nature & life. We provide high-value end-to-end industry processes for digital engineering that employ state-of-the-art connected multidisciplinary-multiscale simulation applications. With SIMULIA, customers can reduce testing, increase confidence & quality, and get to market faster using always-available virtual worlds for discovery and testing. www.3ds.com/simulia

DESIGNCON

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www.designcon.com

DesignCon is the premier high-speed communications and system design conference and exposition, offering industry-critical engineering education in the heart of electronics innovation — Silicon Valley.

Attend the expertly curated 14-track conference created by engineers for engineers featuring technical paper sessions, tutorials, and industry panels covering all aspects of chip, board, and systems design.

Browse exhibits with hundreds of new products and technologies in the expo hall, attend educational sessions in the Chiphead Theater, see interactive demos, and network with high-caliber industry professionals at multiple social functions. Join us in Santa Clara, CA, January 28-30, 2025!

EXHIBITOR PROFILES

DETECTUS
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Now you can SEE high frequency electromagnetic fields. There are high demands for electromagnetic compatibility (EMC) of electronic products. The Detectus solutions are measurement systems with which the designers can measure the intensity and the location of a radiation source at a component level. The results of such a measurement can be shown as two or three dimensional colored maps.
Langer EMV offer Near Field Probes (E & H field), Development System Disturbance Emissions, Pre-compliance EMC test and measuring devices, Measure Disturbance Immunity Systems and more.

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DEWETRON is your reliable partner for data acquisition challenges. With a high "Made in Austria" quality, we offer our customers a wide range of data acquisition systems that guarantee highest precision and comprehensive measurement data. The design of each chassis is flexible and customizable, allowing you to build your own ideal measuring system yourself. Choose your preferred measurement board, implement it into your system and you are ready to start taking measurements. More than 30 years of experience, innovation, and collaboration have awarded DEWETRON the trust and respect of the global market.

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DMC offers custom-built RF, EMC and Acoustics Anechoic Chambers, RF Shield rooms, High-Performance RF and Microwave Broadband absorbers, High power handling Hybrid absorbers, RF shielded enclosure, Millimeter-wave components, and Antenna Measurement System. With our combined experience of more than 30 years, we have supplied state-of-the-art turnkey system in RF, Microwave and Millimeter-wave application, the range that we offer is subjected to strict quality assurance tests in various stages.

D.L.S. ELECTRONIC SYSTEMS, INC
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www.dlsemc.com
DLS Electronic Systems offers one of the largest Compliance Testing operations in North America, with 16 EMC testing chambers, plus two open field sites, Product Safety testing laboratory, and environmental testing services. ANAB accredited to ISO 1702, we operate in three locations, two in Wheeling, IL and one in Genoa City, WI. We have one of the largest staff of certified iNARTE testing engineers of any testing organization. D.L.S. regularly supports MIL STD 461, MIL STD 810, MIL STD 202, MIL STD 704, MIL STD 1399, RTCA DO 160, UL, EN, IEC, ISTA, ILAC, ASTM, and ANSI requirements. www.dlsemc.com

ELECTRO MAGNETIC APPLICATIONS, INC.
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EMA provides excellence in electromagnetic research and development by combining theoretical understanding, innovative thinking, and practical experience. Our staff includes both theoreticians and experimentalists, all of whom have advanced degrees in engineering or physics. EMA has a world wide reputation for its excellence in application of the understanding of electromagnetics to practical problems of real interest.

ELEMENT MATERIALS TECHNOLOGY
Booth 321
www.element.com
Element specializes in providing a comprehensive range of materials and product qualification testing, consulting, and certification services. Our network includes over 6,700 Engaged Experts operating out of 188 facilities in more than 30 countries across multiple industry sectors. Service offering includes EMC, Wireless, Product Safety Testing and Certification. With an extensive roster of accreditations and international recognition coupled with unparalleled service and facilities, Element is your testing partner for both materials and product qualification testing.

EXHIBIT PROFILES

ELITE ELECTONIC ENGINEERING, INC.

Booth 519

www.elitetest.com

Founded in 1954, Elite Electronic Engineering, Inc. is a full-service electromagnetic compatibility/interference (EMC/EMI), environmental stress, and photometric testing laboratory. We are the premier test provider for the aerospace, military, automotive, heavy equipment, electronics, and telecommunications industries.

Elite is recognized worldwide as a leader in product qualification, compliance testing, and consulting services. Few laboratories offer our combination of expert engineers, state-of-the-art equipment, and cutting-edge test facilities all in one location. Contact Elite to find out how we can help get your product to market.

EMC ELEKTRONIK LTD.

Booth 805

www.emcelectronic.com

EMC Elektronik LTD is a global leading manufacturer of High Performance RF Absorbers, Power Line Filters, Anechoic Chambers, EMC Testing Devices, Antennas for EMC , RF, Antenna test facilities. We are also serving as a ISO 17025 accredited EMC laboratory for Automotive and Military products.

EMCORETECH CO., LTD.

Booth 613

www.emcoretech.com

EMcoretech has developed the world's first EMI filter IC, and we called as EMIC.

An EMIC is an integrated circuit that prevents electronic malfunctions by compensating electromagnetic interference generated from other electronic devices. In the growing trend of high-powered and compact devices, EMcoretech has succeeded in developing the world's first IC chip for EMI filter. We are currently carrying out PoC(Proof of Concept) testing that goes into products of global electronics companies and automobile manufacturers.

1. Active EMI filtering module can substitute existing choke used on passive EMI filter.
2. You can reduce the customizing period compared to passive EMI filters.

EMCOS LLC

Booth 418

www.emcos.com

EMCoS focuses on problems related to electromagnetic fields, data visualization and generation of special simulation software. Application areas include: EMC/EMI in large systems, complex harness processing, solutions for hybrid vehicles, shielding study, antenna simulations, and PCB simulations.

EMCPIONEER

Booth 419

www.emc-emi.com

EMCPIONEER is specilized in providing EMC products for Shielded Rooms, Antenna& EMC Test Chambers. Our products include Power Line Filter with UL certification, EMP Filter, Signal Filter, Honeycomb Ventilation, Knitted Wire Mesh Gaskets, RF Absorber etc.
Each product is strictly manufactured and has good shielding performance. Our engineers with 30 years of experience working with you from design to production. High-quality products and excellent services have helped us win many stable and trustworthy customers all over the world. Meanwhile, We provide customized services to meet the individual needs of our clients.

ESDEMC TECHNOLOGY

Booth 212

www.esdemc.com

ESDEMC develops ESD and EMC solutions. We are devoted to delivering creative, advanced, high-quality, and cost-effective solutions as well as general consulting, test services, and customized projects.

ETS-LINDGREN INC.

Booth 401

www.ets-lindgren.com

ETS-Lindgren designs, manufactures and installs EMC/EMI, RF/Microwave, MIMO/OTA, and Acoustic test and measurement systems and components. Our patented technology has resulted in many milestones: the world's first CTIA Authorized Test Lab and the first oversize RF shielded sliding door for full vehicle test chambers. Our full line of EMP/IEMI products is the first to be independently tested and certified. Services include calibration at our A2LA accredited calibration lab. For more information, visit us at www.ets-lindgren.com.

EXHIBITOR PROFILES

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www.exoduscomm.com
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FAIR RITE PRODUCTS CORP.
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www.fair-rite.com
Fair-Rite Products Corporation is a full-line ferrite component manufacturer. The company has industry-leading engineering support &is ISO9001/IATF 16949 certified &ITAR registered. Fair-Rite has a comprehensive lineup of high-performance ferrite materials available in a wide variety of core types. Focusing on material offerings for suppression, inductive, and power magnetics, both contemporary and high frequency, to meet the demands of current and new semiconductor technologies, such as GAN and SiC. Fair-Rite components include cable cores, flat cable cores, split round/flat cable snap-its, connector plates, IEC mated cores, toroidal cores, surface mount beads, and PC board suppressor cores, rod/bobbin cores, and chip beads.

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Fil-Coil International is a New York based manufacturer of electromagnetic filters for Power Lines, Data Communications, HEMP (High Altitude Electromagnetic Pulse), RFI/EMI (Radio Frequency Interference/Electro-Magnetic Interference), MRI (Magnetic Resonance Imaging) Rooms ranging from 1 to 2000 Amperes

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GAUSS INSTRUMENTS manufactures highest performance EMC test equipment and provides advanced EMI test solutions and instrumentation pushing your product development and testing capabilities ahead, and speeding up your time to market cycles. GAUSS offers a wide range of solutions from DC to 44 GHz for all kind of test requirements – full-compliance as well as pre-certification or even customized solutions perfectly fitting to your specific requirements pushing your testing capabilities ahead.
Driven by our ultimate mission: Smarter testing for smarter products.

GLOBAL SEALING SYSTEMS, INC.
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GSS manufactures knitted wire mesh, which can be used as economical gaskets for EMI/RFI shielding. It reduces electronic malfunction by blocking unintended external electromagnetic waves or preventing internal electromagnetic waves. GSS provides guaranteed EMI/RFI shielding solutions for various types of industrial application.

EXHIBIT PROFILES

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We are your trusted certification partner – recognized by Fortune 500 companies as an industry leader in providing transparent and efficient Global Market Access (GMA) services for over 200 countries & territories around the world. Our tech-enabled GMA experts use Access Manager, a proprietary platform, to manage your country certification projects with the highest level of efficiency, ensuring predictable certification outcomes.

GRAND VALLEY STATE UNIVERSITY
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www.gvsu.edu
The 6,000 sq ft EMC Center at Grand Valley State University is a one-of-a-kind facility that supports EMC education, research, and EMC pre-compliance testing for industry.

HV TECHNOLOGIES, INC.
Booth 508
www.hvtechnologies.com
HV Technologies is a premier supplier of High Voltage (HV) and Electromagnetic Compatibility (EMC) test equipment with many years of experience and dedication serving the needs of the electronic equipment industries. HVT's dedicated and skilled staff strives to provide the highest quality EMI/EMC test and measurement equipment and support available to our customers. Our strategic partnership with industry-leading manufacturers allows our customers to increase their products' quality, reliability, and safety.

IEEE 2025 INTERNATIONAL SYMPOSIUM ON EMC AND SIPI
Booth 723
www.emc2025.org
EMC+SIPI 2025 leads the industry in providing state-of-the-art education on EMC and Signal Integrity and Power Integrity techniques. The IEEE EMC Society is seeking original, unpublished papers covering all technologies that are affected by EMC, Signal & Power Integrity. Join us in Raleigh, NC. Share your insight, ask questions, learn from the experts/innovators and see new products at the 2025 IEEE International Symposium on Electromagnetic Compatibility, Signal & Power Integrity. Your published paper will be seen by thousands in the EMC community and across the wide array of disciplines that look to the IEEE EMC Society for technical guidance. In addition, it will be uploaded to IEEE Xplore® with the exposure and recognition that brings.

IEEE ANTENNAS AND PROPAGATION SOCIETY
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www.aps.ieee.org
The field of interest of the AP-S includes: antennas, including analysis, design, development, measurement, standards and testing; radiation, propagation, and the interaction of electromagnetic waves with discrete and continuous media; and applications and systems pertinent to antennas, propagation, and sensing, such as applied optics, millimeter- and submillimeter-wave techniques, antenna signal processing and control, radio astronomy, bioelectromagnetics, and propagation and radiation aspects of terrestrial and space-based communication, including wireless, mobile, satellite, and others.

IEEE EMC SOCIETY
Booth 723
www.emcs.org
The IEEE Electromagnetic Compatibility Society is the world's largest organization dedicated to the development and distribution of information, tools and techniques for taming electromagnetic interference beasts. The society's field of interest includes standards, measurement techniques and test procedures, instrumentation, equipment and systems characteristics, interference control techniques and components, education, computational analysis, and spectrum management, along with scientific, technical, industrial, professional or other activities that contribute to this field.

Explore the many benefits of EMC Society membership, from being part of the Young Professionals, the many Standards resources, Distinguished Lecturer and engagement at the local Chapter level. Join today and give your career a much-need zap!

IEEE EMC SOCIETY HISTORY COMMITTEE
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The EMC Society is responsible for recording and maintaining the historical records of the EMC Society. That includes photos and papers as well as equipment artifacts. The Committee has digitized old EMC Symposium records and has distributed them via USB memory sticks and CDs.

IEEE EMC SOCIETY STANDARDS
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www.emcs.org/standards
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EXHIBITOR PROFILES

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Booth 723

www.emcs.org/membership/ieee-emc-young-professionals

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- Community Programs

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Booth 823

www.mtt.org

The IEEE Microwave Theory and Technology Society (MTT-S) is a transnational society with more than 13,000 members and 200 chapters worldwide. MTT-S promotes the advancement of microwave theory and its applications, including RF, microwave, millimeter-wave, and terahertz technologies. It is an all-volunteer society, driven to excellence by its leadership and with the active participation of all its world-wide members. The activities sponsored by the MTT-S include a broad spectrum of conferences, workshops, technical committees, chapter meetings, publications and professional education programs. Our principal publications and conferences are peer-reviewed and recognized as top of the class.

IEEE PRODUCT SAFETY ENGINEERING SOCIETY (PSES)

Booth 823

www.ewh.ieee.org/soc/pses

The IEEE Product Safety Engineering Society focuses on the theory, design, development and practical implementation of product safety engineering methodologies and techniques for equipment and devices. This includes the study and application of analysis, techniques, construction topologies, testing methodologies, conformity assessments and hazard evaluations. The Society provides a focus for cooperative activities, including the promotion of product safety engineering for the benefit of humanity.

IEEE WOMEN IN ENGINEERING

Booth 723

www.ieee.org/women

IEEE Women in Engineering (WIE) is the largest international professional organization dedicated to promoting women engineers and scientists and inspiring girls around the world to follow their academic interests to a career in engineering. The mission of IEEE WIE is to inspire, engage, encourage, and empower IEEE women worldwide.

IN COMPLIANCE MAGAZINE

Booth 515

www.incompliancemag.com

In Compliance is a leading source of news, information, and resources for electrical engineering professionals. We deliver coverage on the latest standards updates, global compliance news, and technical explanations & guidance. Visit incompliancemag.com to discover the latest design practices and testing tips, stay current with important updates, learn fundamental concepts, and explore our many resources. Activate your free subscription and join our community of over 17,000 engineers world-wide.

INTERTEK

Booth 312

www.intertek.com/emc

With one of the largest global network of EMC Testing labs, Intertek provides the capacity, proximity and engineering resources to streamline your EMC Compliance Testing process for any market you want to reach.

Intertek is a leading Total Quality Assurance provider to industries worldwide. Our network of more than 1,000 laboratories and offices in more than 100 countries, delivers innovative and bespoke Assurance, Testing, Inspection, and Certification solutions for our customers.

We deliver Total Quality Assurance expertise with precision, pace, and passion,

EXHIBIT PROFILES

JIANGSU WEMC ELECTRONIC TECHNOLOGY CO., LTD.

Booth 711
www.wemctech.com/en
Jiangsu WEMC Electronic Technology Co., Ltd. is a leading filter specialist in China. Our commitment to RFI/EMC/TEMPEST/EMP/HEMP industry has resulted in a sound comprehensive range of filter products available from us. All our manufacturing is done on site and most of products are in compliance with IEC-60939, UL-1283, CISPR17, IEEE-299....
We have:

- EMC/EMI Filters
- Power Line Filters
- Signal Line Filters
- TEMPEST Filters
- Filters for Shielded Room
- Filters for Anechoic Chamber
- Customzied Filters
- EMP Filters
- High Voltage Filters
- Filters for Medical (devices)
- Filters for EV

KEYSIGHT TECHNOLOGIES

Booth 615
www.keysight.com
Keysight Technologies (formerly Agilent's Electronic Measurement Group) delivers test platforms such as signal analyzers, signal sources, network analyzers, high-performance oscilloscopes and modular and hybrid systems. It also offers the most comprehensive EDA portfolio and the widest range of measurement application software.

KGS AMERICA

Booth 618
www.kgs-ind.com
KGS (KITAGAWA INDUSTRIES): designer/manufacturer of solution materials to solve engineering needs for EMC mitigation, heat dissipation, vibration/shock damping, cable management, and PCB spacing. KGS solutions include space conscious components such as tiny on-board grounding contacts and flexible ferrite cores through large automotive ferrites and industrial cores.

KGS products are engineered for current and future requirements in wide varieties of markets and trends. KGS core competencies include fusing different materials together to come up with completely unique and practical products such as plastic grounding clamps (fused metal to plastic) and vibration damping fan holders (fused vibration damping gel and plastic).

LIGHTNING EMC, LLC

Booth 712
www.LightningEMC.com
Lightning EMC is the exclusive distributor for Haefely AG's EMC product line. Our team works closely with the manufacturing plant in Basel, Switzerland in the development of future products. Lightning EMC cooperates with many representatives in the US. Please contact us for your transient needs.

LUMILOOP GMBH

Booth 325
www.lumiloop.de
LUMILOOP's key competence is the optical supply of sensor systems using Lasers in combination with a proprietary packaging technology and power regulation method. LUMILOOP combines this Power-over-Fiber (PoF) technology with state-of-the-art low power electronics to design and manufacture high performance electronic measurement devices which can be applied in the field of Electromagnetic Compatibility (EMC) as well as other RF applications.

By combining LUMILOOP's E-field probes and RF power meters users can speed-up EMC chamber validation by a factor of more than 100 and reduce down-time significantly. LUMILOOP's products can be used to characterize and validate reverberation chambers at high speed.

M PRECISION LABORATORIES, INC.

Booth 718
www.mprecisionlabs.com
M Precision Laboratories, INC is a global supplier of Electromagnetic Compatibility (EMC) and Electrostatic discharge (ESD) systems and solutions (high voltage test devices). Along with manufacturing our own line of products, we are also A2LA accredited calibration laboratory for multiple types of test equipment.

EXHIBITOR PROFILES

MAURY MICROWAVE
Booth 310
www.maurymw.com
Maury Microwave is a trusted calibration, measurement, and modeling solutions partner that leverages measurement expertise to identify, create, and supply every single component from the smallest adapter to the largest test system. Customers can develop and validate the world's most advanced wireless communications systems through seamless lab integration and best-in-class solutions. Maury Microwave solutions for the EMC market include both components and turn-key solutions. Typical components are amplifiers, synthesizers, power sensers, couplers, adapters, cable assemblies and calibration kits. Turn-key characterization solutions include system integration and measurement software.

MESAGO MESSE FRANKFURT GMBH
Booth 421
www.emv.mesago.com/stuttgart/en.html
Mesago Messe Frankfurt GmbH is organizing EMV - Europe's leading exhibition and conference on electromagnetic compatibility which will take place 25 - 27 March 2025 in Stuttgart, Germany. More than 100 exhibitors present their EMC-specific products and services. Parallel a conference and workshops are held. It is the ideal platform for the dialogue between science, research, product development and application. EMV is the perfect opportunity to get the latest information on trends in the EMC industry!

MVG, INC.
Booth 609
www.mvg-world.com/en/products/emc
MVG provides anechoic chambers and absorbing materials for EMC testing and antenna measurement as well as RF and EMP shielding. Our SmartShieldTM modular shielding and precision cut and coated absorbers are designed with the flexibility to meet specific customer requirements. Our knowledge gained from over 30 years of experience ensures the high quality and durability of our products and the expertise from our team.

For EMC Test and Measurement Solutions we design, manufacture, supply and install shielded enclosures, anechoic chambers, shielded doors, absorbers and more. We can provide exceptional turnkey solutions for the most demanding EMC requirements.

NARDA SAFETY TEST SOLUTIONS S.R.L. - ITALY
Booth 520
www.narda-sts.it
Since 1980 we design and manufacture EMC instruments and test systems under the well recognized brand "PMM, as well as measuring instruments and systems for assessing the exposure to electromagnetic fields. Worldwide support is assured by highly qualified Sales Partners. Quality system certified ISO 9001: 2008. Accredited Calibration Center LAT n. 008, traceable on national and international standards.

We are part of the Narda Safety Test Solutions Group, a global leader that owns over 95% of the published patents for electromagnetic field testing equipment. Highly innovative solutions matching the highest standards of quality and reliability are the Company's trademarks.

NEMKO USA, INC.
Booth 717
www.nemko.com
Nemko serves as a comprehensive hub for compliance testing, certification, and global market access. With Nemko Direct, clients access major market certifications through a single point of contact. Services include EMC, Wireless, Electrical Safety, and Environmental testing. Pre-compliance reliability testing to aid in design-to-deployment success. Nemko offers US and Canadian NRTL Safety certification, CB certification, and is a TCB for several regions including the US, Canada, Taiwan, and more. It also provides international telecom and type approval certifications for over 150 countries. Operating in 24 locations globally, Nemko assures timely testing, inspection, and certification with Scandinavian reliability.

NEXIO TECHNOLOGIES
Booth 308
www.nexiogroup.com
NEXIO, founded in 2003, offers the market's widest range of electromagnetic automation test software through a global network of support staff and sales representatives. NEXIO develops the software range called BAT, which stands for "Benchtop Automated Testing". BAT is a package of high-performance automation test software for a variety of lectromagnetic compliance and RF testing requirements for all industries. Our star product, BAT-EMC, is a world leader in automated test software. The world's top accredited labs and top industries leaders are equipped with BAT-EMC. BAT-EMC is used in more than 20 countries worldwide (Germany, USA, China, Japan, Canada, Mexico...). Other star products are BAT-SCANNER (near field measurements), and BAT-ELEC (for burst, surge, transients, etc.). Our key points are:

- Hardware independant & free drivers
- 25 years experience
- Support and maintenance
- Flexibility and evolution
- Monitoring functions
- Automatic report

EXHIBIT PROFILES

NEXPERIA SEMICONDUCTOR
Booth 422
www.nexperia.com
Nexperia is a leading expert in high-volume essential semiconductors, that are required in every electronic design. The company's extensive portfolio includes diodes, bipolar transistors, ESD protection, MOSFETs, GaN FETs and analog & logic ICs. Headquartered in the Netherlands, Nexperia ships +100 billion products annually, meeting automotive standards. Our industry-leading packages are recognized as benchmarks in efficiency – in size, power and performance. Nexperia has +12,000 global employees.

OHTAMA CO., LTD.
Booth 810
www.e-motorchamber.jp
Ohtama is the specialist of Magnetics technology and EMC Test. Now Ohtama is promoting EMC Test System "e-MotorChamber". e-MotorChamber has very special and unique LONG SINGLE SHAFT SYSTEM which is developed to meet CISPR25 Annex I. This shaft can handle 20,000RPM without any gear on. For more detail, please visit tabletop T6.

ONRULE
Booth 813
www.onrule.com
OnRule is a world-leading cloud-based software platform to manage product regulatory compliance. OnRule enables enterprises to rapidly launch new products in the global marketplace by accelerating the product certification process, streamlining collaboration, and delivering up-to-date global regulatory intelligence. OnRule organizes the compliance records by products, markets, record types, and record disciplines. It creates SmartCerts™ enabling a quick search and secured sharing; the view-only privileges allow the internal and external stakeholders to have visibility on the compliance status and records. The notifications of upcoming expirations alert the compliance team, prevent stop ship and ship hold; and enable proactive budgeting and allocation of resources. The Standards Update Notifications inform the enterprises of upcoming changes in the standards and identify the impacted products and records portfolio.

OPHIR RF INC.
Booth 404
www.ophirrf.com
Designer and manufacturer of High power RF amplifiers, microwave amplifiers, linear amplifiers, solid state power amplifiers, wideband amplifiers and band specific amplifiers.

PICOTEST
Booth 209
www.picotest.com
Driven by the practical needs of engineers, Picotest specializes in high-fidelity testing and measurement tools, primarily for power-related applications.

Our products help you analyze, characterize, and test all aspects of your circuitry. Picotest products are designed to simplify your measurements while providing optimal accuracy and resolution.

We offer technical support for various test and measurement equipment including Vector Network Analyzers (VNAs) and Oscilloscopes. In addition to Picotest-developed products, we offer solutions from Tektronix, Keysight, OMICRON Lab, and Rohde & Schwarz.

PPG CUMING MICROWAVE & CUMING LEHMAN CHAMBERS
Booth 816
www.cumingmicrowave.com
PPG Cuming Microwave Corporation is an ISO 9001:2015 US manufacturer of C-RAM® RF/Microwave absorbers, C-STOCK® low-loss dielectric materials, and PPG C-SHIELD™ conductive materials, serving defense and commercial markets for over 40 years. Cuming-Lehman Chambers, a wholly owned subsidiary, provides design, project management and installation of new anechoic chambers, specialty test boxes, and other RF test environments. When your project calls for a retrofit, refurbishment or relocation of an existing chamber our expert staff will guide you through all of the considerations. Call 508-521-6700 or email cmcsales@ppg.com Point browsers to www.cuminglehman.com www.cumingmicrowave.com

R&K COMPANY LIMITED
Booth 205
www.rk-microwave.com
R&K is a Japanese manufacturer of "RF Solid State Power Amplifier" and "Other Functional RF Components" which is established in 1977. Our product line-up includes broadband power amplifiers, connectorized components of both active and passive, analog phase shifters of both narrow and broadband, surface-mountable products, and 8-pin packaged products.

EXHIBITOR PROFILES

RATLR, INC
Booth 701
www.ratlr.net
RATLR is Phillip and Cathy Miller, Innovation Architects performing independent research. Phil grew up on a pig farm in Iowa, Cathy in a family restaurant outside LA. Diverse in perspective, with an uncommon work ethic.

RATLR is the innovative force behind Deployable EMC Labs, SCIFs, Quiet Labs, Quiet Shelters, and low risk/low-cost Chamber Validations. RATLR has the Insight to identify opportunities and the Integrity to protect your intellectual property and honor our agreements. Talk to us about how we can aggregate incremental improvements in your business and generate the same record revenue as prior clients.

RAYMOND EMC
Booth 701
www.raymondemc.com
Raymond EMC specializes in the engineering, design, fabrication, installation, and testing of custom radio frequency (RF) shielded enclosures, reverb, and anechoic chambers for military, government, automotive, high-tech, medical, medical, and industrial applications. Raymond EMC prides itself on being an industry leader in product quality, performance, and innovation while providing unmatched client care and product support.

Products: Shielded Enclosures - Electromagnetic Compatibility (EMC) Chambers - Reverberation Chambers - Deployable Solutions - Shielded Doors - Shielded Cabinets - Anechoic Chambers

Services: Chamber Relocation - Chamber and Shielded Enclosure Upgrades - Maintenance Programs – Consulting – Engineering – Installation - RF Testing

RF EXPOSURE LAB
Booth 303
www.rfexposurelab.com
RF Exposure Lab, LLC is an independent, privately owned SAR Testing Lab. We are A2LA Accredited and have significant expertise in SAR Testing from both an industry and a laboratory environment. We provide SAR testing for companies and other test laboratories. We are located in Southern California.

ROBUST PHYSICS
Booth 625
www.robustphysics.com
San Diego-based RobustPhysics has developed STOCHASTICA-a new class of simulation software for system-level EMC design. Based on statistical wave mechanics, STOCHASTICA eliminates the need for detailed geometry and numerical meshing, providing FAST, INTERACTIVE solutions... enabling full system level EMC design to 10GHz and beyond. The software has been extensively validated experimentally under years of research funding by NASA, DARPA and NAVY. This is something NEW and DIFFERENT. Whether you're an EMC simulation specialist looking for faster/higher frequency tools; or an EMC Test engineer wanting to add simple, effective simulation to your toolset... you should come and evaluate this new technology.

ROHDE & SCHWARZ USA, INC.
Booth 600
www.rohde-schwarz.com
Rohde & Schwarz is the leader in EMC testing and has been supplying EMC test equipment for over 50 years. Our test experts have been advising EMC standard authorities on T&M issues for decades. Rohde & Schwarz has a wide-ranging test equipment portfolio that is based on in-depth EMC compliance, precompliance, and debugging expertise and supports all relevant commercial, wireless, automotive, military and aerospace EMC standards. Rohde & Schwarz is a proven supplier of state-of-the-art EMC test solutions and a reliable service partner for our current products and our extensive back-catalog.

SAFETY & EMC CHINA
Booth 621
www.safetyandemc.com
《SAFETY & EMC》 is the unique official publication (CN 11-3452/TM, ISSN 1005-9776) synthetically introducing the safety and EMC technology of electronic and electric industry at present in China, which is supervised by Ministry of Industry and Information Technology of PRC and sponsored by China Electronic Standardization Institute (CESI). It started the first publication in 1989.

《SAFETY & EMC》 contents involve standard interpretation, design, testing, prediction and simulation, material development and application, electromagnetic environment construction, electrostatic discharge, signal and power integrity, research progress of advanced technology and challenges in application, and suggestions for future development direction.

EXHIBIT PROFILES

SCHLEGEL ELECTRONICS MATERIALS, INC.

Booth 319

www.schlegelemi.com

At Schlegel Electronic Materials, we are committed to upholding core values that define our company's identity and guide our actions. These values are not just words on paper; they are the foundation of our culture and the driving force behind our success as a leading manufacturer of products for the Electronics, Automotive, and Buildings industries. Our unwavering dedication to these values shapes our decisions, interactions, and business with our partners, customers, and colleagues.

SIEMENS

SIEMENS

Booth 423

www.eda.sw.siemens.com/en-US/pcb

Siemens is driving transformation to enable a digital enterprise where electronic systems engineering and manufacturing meet tomorrow. Xcelerator, the comprehensive and integrated portfolio of software and services from Siemens (Xpedition, PADS, HyperLynx, and Valor), helps companies of all sizes create and leverage a comprehensive digital twin that provides organizations with new insights, opportunities, and levels of automation to drive innovation.

SPIRA MANUFACTURING CORP

Booth 415

www.spira-emi.com

Spira Manufacturing Corporation is at the forefront of EMI gasket innovation, design, and customer service. With over 40 years as experts in the field and using our uniquely patented spiral EMI gasket, we offer customers a range of EMI gaskets, shielded honeycomb filters, and other products. Our products are of the highest quality and reliability, built to meet your requirements for the life of a system. Spira's commitment to quality is demonstrated through our ISO-9001 and AS9100 certifications. Our products also meet requirements including REACH, ITAR, RoHS, DFAR, FCC, EC, HIRF, TEMPEST, DFAR, and others.

TDK LAMBDA AMERICAS

Booth 315

www.us.lambda.tdk.com

TDK-Lambda Americas, Inc. is a leading manufacturer of high reliability Low/High Voltage Programmable DC and High Voltage Programmable Capacitor Charging power supplies and DC Electronic Loads. Programmable DC products include the Genesys™Series, the GENESYS+™ Series, the ALE Series and the SFL Series. For more information, please visit https://www.us.lambda.tdk.com.

TDK RF SOLUTIONS, INC.

Booth 701

www.tdkrfsolutions.com

TDK RF Solutions is a world leader in the design, development & manufacture of technical solutions for the EMC testing and Antenna measurement industries. We offer a complete range of solutions including automated test systems, anechoic chambers, RF absorber, antennas, software, RF filters, and a wide range of test products & accessories. We call it Total System Technology®, and it means TDK RF Solutions is your best choice of partner for proven solutions & services. TDK.... attracting tomorrow!

THE BOEING COMPANY

Booth 203

www.jobs.boeing.com

As a leading global aerospace company, Boeing develops, manufactures and services commercial airplanes, defense products and space systems for customers in more than 150 countries. As a top U.S. exporter, the company leverages the talents of a global supplier base to advance economic opportunity, sustainability and community impact. Boeing's diverse team is committed to innovating for the future, leading with sustainability, and cultivating a culture based on the company's core values of safety, quality and integrity.

THE EMC SHOP

Booth 402

www.theemcshop.com

The EMC Shop is an ISO 17025 accredited company, registered government contractor (Cage Code #7JDN6) and an established vendor in Exostar, Ariba and other purchasing networks for large companies. The EMC Shop brings the ease and convenience of online shopping to the electromagnetic compliance and test equipment market.

TRANSIENT SPECIALISTS, INC.

Booth 412

www.transientspecialists.com

Transient Specialists is a lead provider of EMC test equipment rentals designed for a variety of applications including commercial, automotive, and military. We carry test systems from all the major manufacturers including Teseq, EM Test, Amplifier Research, Rhode & Schwarz, and many others. With over 30 years experience in the industry, we know what it takes to complete your testing on time and on budget.

EXHIBITOR PROFILES

TUV RHEINLAND
Booth 305
www.tuv.com/usa/en
TUV Rheinland offers a comprehensive service portfolio for testing and certification, including regulatory, interoperability, performance, safety and security. As an EMC Notified Body and international service provider, we offer a flexible service to help you meet the requirements of the EMC directive 2004/108/EC as well as FCC. Our EMC/wireless labs are equipped with 3, 5, and 10 meter chambers as well as OTA chambers and SAR test systems to handle a wide range of products. We are a TCB for the US and an FCB for Canada and an authorized test lab for Wi-Fi, ZigBee, Thread, Bluetooth and LoRa Alliance.

V TECHNICAL TEXTILES, INC.
Booth 424
www.vtechtextiles.com
V Technical Textiles, Inc. (VTT) is a specialized, conductive textile company and integrator of custom designed RF shielding solutions. Our comprehensive range of products includes portable RF shielding enclosures, curtains, pouches, and garments. We serve a diverse customer base, spanning industries such as aerospace, automotive, military, medical and defense sectors. We collaborate closely with our customers to develop tailor-made solutions from initial concept to final manufactured product. Our expertise lies in utilizing world renowned Shieldex conductive textiles, leveraging cutting-edge conductive textile plating technology for the development of these products.

VECTAWAVE
Booth 414
www.vectawave.co.uk
Vectawave Technology Ltd is a manufacturer of class A broadband power amplifiers for use in industrial, military and medical applications. Our amplifier range covers 10kHz-6GHz with powers up to 4kW. Vectawave have been designing and manufacturing power amplifiers for 19 years. These amplifiers, based on proven technology, are in daily use in EMC labs and test houses around the world. Most of our amplifiers have been designed to meet the specific needs of EMC applications.

WERLATONE, INC.
Booth 624
www.werlatone.com
Founded in 1965, Werlatone®, Inc. is a leading supplier of high power, broadband passive RF components to include, RF Directional Couplers and RF Combiners & RF Dividers to customers worldwide. Our commitment to the highest quality, best performance, and on-time delivery places us among the most respected suppliers in the industry.

WE EXCEL when your application requires a custom, high power, broadband solution. As year-to-year product sales consist of 65% custom passive RF components and 35% catalog items, our entire staff is dedicated to your individual specifications. Like most companies, we first address a customer's application with a similar design and then modify as necessary.

WILEY
Booth 200
www.wiley.com/en-us
A trusted leader in research and learning, our pioneering solutions and services are paving the way for knowledge seekers as they work to solve the world's most important challenges. We are advocates of advancement, empowering knowledge-seekers to transform today's biggest obstacles into tomorrow's brightest opportunities.

With over 200 years of experience in publishing, we continue to evolve knowledge seekers' steps into strides, illuminating their path forward to personal, educational, and professional success at every stage. Around the globe, we break down barriers for innovators, empowering them to advance discoveries in their fields, adapt their workforces, and shape minds.

WURTH ELEKTRONIK
Booth 524
www.we-online.com
Würth Elektronik offers sophisticated electronic components for a multitude of applications in all industrial sectors. For us, it's not the individual component that's most important – it's finding the solutions to problems. We're the reliable partner for our customers. With Würth Elektronik, customers realize electronic visions – we're on board from start to finish.

The passive division include inductors, ferrites, chokes, LEDs, capacitors, crystals, resistors, sensors, transformers and wireless charging coils. Board-to-Board, Wire-to-Board, Terminal Blocks, and Input/Output connectors are included in the electromechanical division. REDEXPERT was developed for use by engineering customers to design in magnetics for switchmode power supplies.

ATTENDEES

Photo by Richard Georgerian

EMC+SIPI 2024 ONCE AGAIN COMBINES ELECTROMAGNETIC COMPATIBILITY AND SIGNAL & POWER INTEGRITY INTO ONE INSPIRING SYMPOSIUM

A full, 5-day attendee registration includes:

- Access to all of EMC+SIPI 2024
- Multiple days of EMC+SIPI original papers
- Five days of practical EMC+SIPI Workshops and Tutorials
- Experiments and Demonstrations of fundamental and advanced topics
- Exhibit Hall, showcasing the latest EMC+SIPI products and services
- Welcome Reception
- Gala Event
- Awards Luncheon
- Symposium Proceedings with all Workshop & Tutorial slide presentations and Technical papers

REGISTRATION TYPES

TECHNICAL ATTENDEE:

We offer 5-Day or 1-Day Registrations:
You have access to all EMC and SIPI paper sessions, Workshops & Tutorials, Experiments & Demonstrations, and the Exhibit Hall. There are also special events available, as well as Technical Committee Meetings, Standards Meetings, and networking opportunities.

- The 5-Day registration includes 5 days of technical sessions, 3 day pass to the exhibit hall, Symposium Record, and social events.
- The 1-Day registration includes 1 day of technical sessions, same day pass to the exhibit hall (if open), and the Symposium Record.

EXHIBIT HALL ONLY:

This is an EMC+SIPI exhibition with many technical activities. For adult (age 18+) customers and clients of our exhibitors. **$25/day**.

- Exhibitors and their reps must pre-register through EXHIBITORS registration using their assigned exhibitor's code.
- Companions/guests may be obtain a pass (Basic Badge) through their technical attendee's registration. Anyone under age 18 may be registered as a companion, and must be accompanied by a registered adult. A minor release form will need to be completed and submitted before obtaining a badge for anyone under the age of 18.

COMPANIONS/GUESTS:

For family and friends of all ages who accompany a registered, technical attendee or exhibitor.
We offer two types of badges:

- Companion Club: This package will again include a gift, access to the Companion Suite (4 mornings with breakfast), Exhibit Hall pass, and Welcome Reception ticket. Individual registrations are required. (Add cost section) Cost: $240 Advanced/ $280 Regular
- Basic Badge: For Exhibit Hall entrance and/or Youth Technical Program registration. Sign up your companion within your own 5-Day or 1-Day technical registration. No bar code, no tracking, no charge. Basic Badges are limited to 1 adult companion and their children. **Cost: Free**

EXHIBITOR:

All adult (age 18+) exhibitor staff, reps, and booth workers must register using the link and discount code sent to the Exhibitor/ Sponsor contact to receive an EXHIBITOR ribbon and early access to the Exhibit Hall. Anyone under age 18 must be accompanied by a registered adult and a minor release form submitted prior to obtaining a badge. **There are two badge types:**

- Technical Exhibitor: receives a full, 5-Day Technical Registration plus EXHIBITOR ribbon.
- Booth Staff: receive 3-Day pass to the Exhibit Hall, with early access plus an EXHIBITOR ribbon and access to the welcome reception is included.

www.emc2024.org/registration

IMPORTANT REGISTRATION INFORMATION

AUTHORS: Symposium registration (IEEE Member or Non-Member) is required by at least one author, or the speaker, before the final paper submission deadline, 15 May 2024. Failing to meet this requirement will result in the paper not being published or presented – no exceptions. Your registration confirmation number will be needed for the final paper submittal.

More details can be found on the AUTHOR/SPEAKER page

EMC SOCIETY MEMBERS: Special rate for full, 5-Day Technical Registrations only. Your membership must be in good standing and paid in full for 2024. If you are not a member and would like to become a EMC-S member, please CLICK HERE or call 1-800-678-IEEE. Please note that you must be a member at the time of registration to receive the member rate.

IEEE MEMBERS: Your membership must be in good standing and paid in full for 2024. Have your member number and current member grade ready when registering. If you are not a member and would like to become an IEEE member, please CLICK HERE or call 1-800-678-IEEE. Please note that you must be a member at the time of registration to receive the member rate.

SISTER SOCIETY MEMBERS: Members of IEEE EMC-S Sister Societies are eligible for the discounted EMC-S Member rate at the annual symposium. Contact the Registration Service to obtain this discount.
View a list of the 2024 active Sister Society relationships.

IEEE LIFE MEMBER: There is a further rate reduction for IEEE Life members. IEEE Life Membership is automatically bestowed upon an active IEEE member based on age and years of membership.

EMC-S HONORED MEMBER: You must be an EMC Society Honored Award recipient who was presented with this award in a prior year. No discount code is necessary to register; this is a special rate category.

EMC-S RETIRED OR UNEMPLOYED: EMC-S Retired or Unemployed. Special ADVANCE rate discount for retired / unemployed EMC Society members only. Have your last place of employment and the date of retirement or unemployment ready when registering.

COMPANY GROUP RATE: Sign up to request a company-wide discount code now! We will give each employee a special discounted rate which is roughly 35% off the non-member rate, and over 10% off the EMC-S Member rate! Send an email to: EMC@iplanitmeetings.com to receive your Company Discount Code.
Cost: Advance rate is $715/person

FULL-TIME STUDENTS: Special rates for both IEEE members and non-members. You must be enrolled in a full time course of study at a college or university to register in the student categories. Have your college ID number and advisor's name & email ready when registering.
Note: Student 5-Day registration packages will include the attendee bag, Symposium Record, and tickets to the Welcome Reception & Awards Luncheon. The Gala ticket however is NOT included, but may be purchased separately or awarded through volunteering at the symposium.

More details at the EMC+SIPI 2024 Website AUTHOR/PRESENTER page

OTHER INFORMATION:

CERTIFICATE OF PARTICIPATION

A Certificate of Participation may be used to officially document attendance at the Symposium. A personalized certificate will be available at no charge to all registered Symposium attendees and participants. Please visit the Registration Desk to verify your name and affiliation and to pick up your certificate. If you have any questions, please email: emc@iplanitmeetings.com.

PAYMENT

Payment is due upon submittal of your registration. Payment can be made by:

- Check (in USD) made out to IEEE EMC+SIPI 2024, and mailed within 2 weeks.
- Credit Card: Visa, MasterCard, American Express, Discover Card.
- Wire Transfer: (Note: Banks usually charge a fee for wire transfers. These are the responsibility of the registrant.)
- Invoice (Government Purchase Order)

Payments by credit card will be charged immediately upon submission of registration. Checks and Wire Transfers must be received within two weeks of the registration date.
You may pay for Companion Club Registration along with your own registration, or via a separate credit card. If you need to pay for tours and social events separately, select "Check" as your payment method and then contact Registration Services at the number on your email confirmation.

CANCELLATION POLICY

For Registration and total order:

- Notice of cancellation must be received in writing via email, sent to emc@iplanitmeetings.com. A $50.00 (USD) processing fee will be charged for registrations cancelled by June 24, 2024. For cancellations between June 25 and July 15, 2024, a 50% refund will be given. There will be no refunds after midnight PDT on July 15, 2024.
- If you applied for a Visa and it is denied, a full refund will be issued less a $20 service charge.
- In the event of a full cancellation of the conference, IEEE and EMC Society are not responsible for, and will not reimburse, flight costs and other expenses incurred by the attendee

FOR SOCIAL EVENTS, TOURS AND EXTRAS ONLY

- Notice of cancellation of an individual "extra" item must be received in writing via email, sent to emc@iplanitmeetings.com, by June 27, 2024. There will be no refunds after midnight PDT on June 28, 2024.
- The EMC 2024 Symposium Committee reserves the right to cancel any tour that does not meet the minimum requirement. If a tour is cancelled, you will receive a full refund and will be contacted prior to the symposium.

2024 TECHNICAL REVIEWERS

THE EMC+SIPI 2024 TECHNICAL PROGRAM COMMITTEE
would like to extend our gratidue to this year's reviewers for their support of the Symposium and dedication to a high-quality technical program.

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Majid Ahadi Dolatsara, *Keysight Technologies*
Rajalakshmi Alavanthan, *Rajalakshmi Engineering College*
Nika Amralah, *Raymond EMC Enclosures*
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