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SPECIAL COVERAGE
2015 EMC/SI Symposium

IN COMPLIANCE

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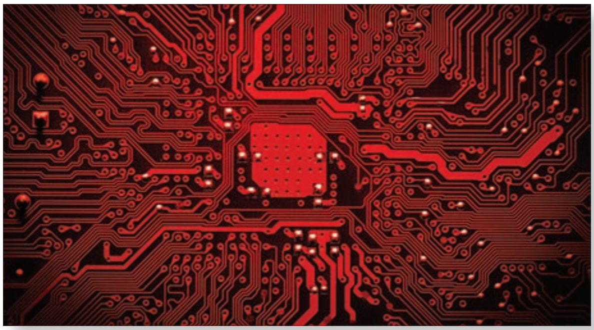
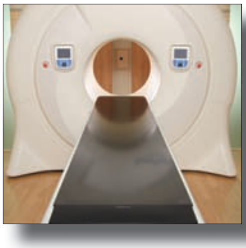
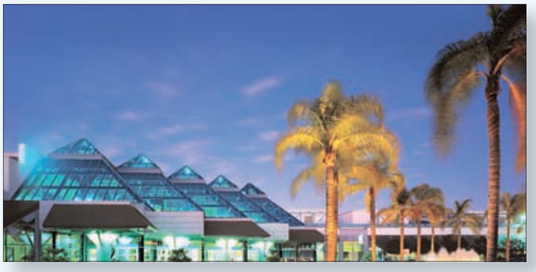






News in Compliance

TV Station Licensee Fined for Broadcasting Private Phone Call

The former licensee of a Salt Lake City television station has agreed to pay a $35,000 civil penalty to settle charges that it broadcast a telephone conversation with a consumer without providing the requisite notification and obtaining their consent.

According to an Order issued by the Commission in November 2014, station KTVX twice broadcast a news report in August 2012 that included a record telephone conversation with a consumer without prior notification to or the consent of that consumer. The FCC's Telephone Broadcast Rule prohibits such actions to protect consumer privacy. In addition, Newport Television LLC, the former licensee of KTVX, reportedly violated FCC requirements to respond promptly and fully to request for information from the agency's Enforcement Bureau.

In addition to the $35,000 monetary forfeiture, Newport Television also admitted wrongdoing in connection with its actions and in its failure to respond in a timely manner to Enforcement Bureau information requests.

The complete text of the Commission's Order in connection with Newport Television is available at incompliancemag.com/news/1502_1.

FCC to Host Emerging Technologies Conference

As part of its ongoing effort to support the emergence of new technologies, the Office of Communications Business Opportunities of the U.S. Federal Communications Commission (FCC) will host a Small Business & Emerging Technologies Conference and Tech Fair on Tuesday, January 27, 2015 at the FCC Headquarters in Washington, DC.

According to the FCC, the Conference and Tech Fair will focus on entrepreneurial innovation in information technology and telecom technologies, and specifically examine the challenges faced by tech start-up companies. The day-long program will include panel discussions on entity formation and incubation and early stage investment strategies, as well as a "Fast Pitch" program in which tech entrepreneurs will be giving an opportunity to present new product ideas and receive feedback from selected technology experts.

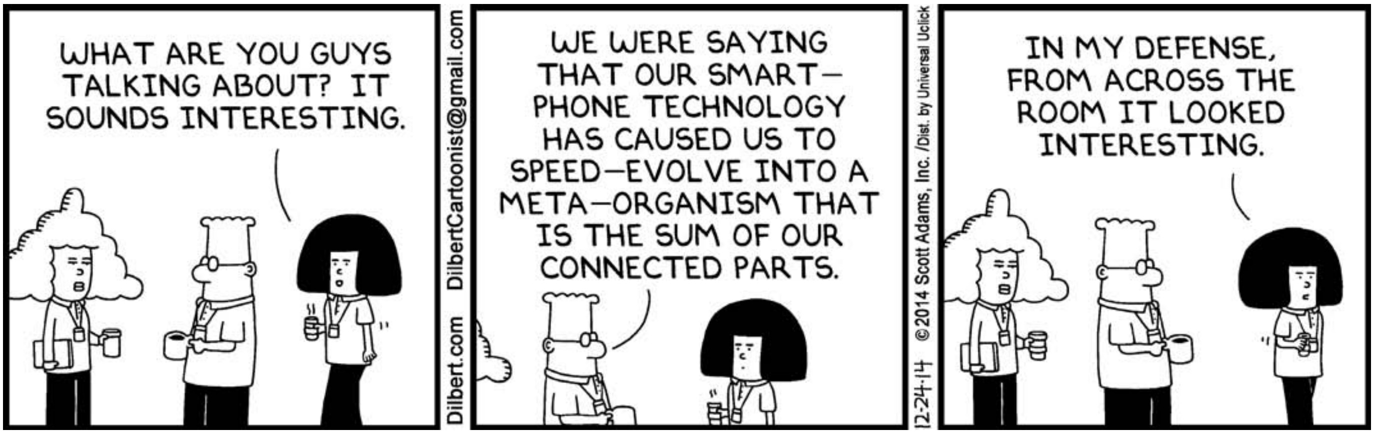
Those interested in attending the event in person can register by calling 202-418-0990, or by sending an email to TechFair@fcc.gov. The event will also be streamed live on the Internet and will be accessible at www.fcc.gov/ocbo.

FCC Reiterates Jammer Prohibition

The U.S. Federal Communications Commission (FCC) is reminding state and local authorities that the ban on the use of radio signal blocking devices applies to them as well.

In an Enforcement Advisory issued in December 2014, the Commission reiterated that its regulations governing the use of so-called signal jammers provide no exemption for their use by school systems, police departments or other state and local authorities. Only federal agencies of the U.S. government are eligible to apply for authorization to use such devices.

Jammers are designed to block, jam or otherwise interfere with authorized radio communications by emitting radio frequencies that prevent wireless communication devices from initiating or maintaining a connection. Such devices can interfere



News in Compliance

with emergency 911 communications as well as communications between first responders, and are illegal under FCC regulations without express authorization. Violations of these regulations can result in monetary penalties of up to $122,500 for any single violation, and criminal sanctions including imprisonment.

The complete text of the FCC's Enforcement Advisory regarding signal jammers is available at incompliancemag.com/news/1502_2.

EU Commission Updates Standards List for ATEX Directive

The Commission of the European Union (EU) has published an updated list of standards that can be used to demonstrate conformity with the essential requirements of its directive concerning equipment and protective systems intended for use in potentially explosive atmospheres.

The directive, 94/9/EC, which is also known as the ATEX Directive, applies to "machines, apparatus, fixed or mobile devices, control components and instrumentation…and detection or prevention systems which…are intended for the generation, transfer, storage, measurement, control and conversion of energy and/or the processing of material," and "which are capable of causing an explosion through their own potential sources of ignition."

The updated list of standards was published in December 2014 in the Official Journal of the European Union, and replaces all previously published standards lists for the ATEX Directive.

The complete list of standards can be viewed at incompliancemag.com/news/1502_3.

EU Commission Updates Standards List for PPE Directive

The Commission of the European Union (EU) has an updated list of standards that can be used to demonstrate conformity with the essential requirements of its Directive 89/686/EEC concerning personal protective equipment.

For the purposes of the Directive, personal protective equipment (or PPE) is defined as "any device or appliance designed to be worn or held by an individual for protection against one or more health and safety hazards." Specifically excluded from the scope of the Directive is equipment designed specifically for private use (such as seasonal outdoor clothing), equipment for use by armed forces or law enforcement personnel, and equipment intended for the protection or rescue of individuals on vessels or aircraft.

The extensive list of CEN and Cenelec standards was published in December 2014 in the Official Journal of the European Union, and replaces all previously published standards lists for the Directive.

The complete updated standards list for the EU's PPE Directive is available at incompliancemag.com/news/1502_4.

You Can't Make This Stuff Up

Bloomberg Calls Off Purchase of Offensive Domain Names

Former New York Mayor Michael Bloomberg has reportedly called off an effort to purge the Internet of website domain names that are critical of him.

According to a recent Reuters report, two law firms working on Bloomberg's behalf had purchased about 400 online domain names, such as boombergfail.nyc and kingmike.nyc, as well as more derogatory ones like michaelbloombergistooshort.nyc. The effort was called off by Bloomberg after news reports of the purging effort surfaced in the local media.

A Bloomberg spokesperson said that lawyers had been "overly aggressive" in their efforts to protect the former mayor and that most of the purchased domains would be released.

The Reuters report notes that "the purchase of negative website domains is a common strategy among politicians and other public figures in an effort to protect their reputations."

Who knew???

emtest
the benchmark for emc
FUTURE PROOF
BY UPGRADING
RINGWAVE
6,000 V
em.safe
EUT-PROTECTION
em.flow
INTUITIVE OPERATION
MAGNETIC FIELD
IEC/EN
POWER FAIL
300 V
SURGE
7,000 V
EFT/BURST
5,500 V
emtest UCS 500N
UCS 500N7
emtest CNI 503
THE POWER PACKAGE!
UCS 500N7 & CNI 503Nx
READY FOR HYBRID AND E-VEHICLES
Up to 3-phase 690 V AC and 1000 V DC/200 A
Compliant with:
› ANSI/IEEE C62.41
› IEC 61000-4-4, -5, -8, -9, -11
› IEC 61000-4-12
› IEC 61000-4-29
› IEC 61851-21, Ed 2, Part 21
› ECE-Regulation No. 10

News in Compliance

Battery Packs Recalled

Goal Zero LLC of Bluffdale, UT has recalled about 10,000 of its Goal Zero Sherpa-brand 50 and 120 rechargeable battery packs manufactured in China.

According to a press release issued by the U.S. Consumer Product Safety Commission (CPSC), the battery packs can overcharge, overheat, bulge and melt the battery pack's enclosure, posing a fire hazard and a risk of property damage. Goal Zero says that it has received one report of a fire and two reports of property damage due to the overheating of a battery pack. In addition, one consumer reported becoming ill after inhaling fumes from an overheated pack.

The recalled battery packs were sold at REI and other sporting goods stores nationwide, and online at Amazon.com and Goalzero.com from March 2010 through November 2013 for between $200 and $400.

Additional information regarding this recall is available at incompliancemag.com/news/1502_5.

Lenovo Recalls Computer Power Cords

Lenovo, Inc. of Morrisville, NC is recalling about 500,000 AC power cords manufactured in China and provided with certain models of the company's laptop computers.

According to Lenovo, the AC power cord can overheat, posing fire and burn hazards to users. The company says that it has received reports from outside the U.S. of 15 separate incidents involving the overheating, sparking, melting or burning of the power cords that are part of this recall. However, there have been no reports of any incidents in either the U.S. or Canada. Further, there have been no reports of injuries.

The recalled power cords were included in the sale of certain models of Lenovo laptop computers sold at computer and electronic stores, authorized Lenovo dealers, and online at www.lenovo.com. The laptop computers retailed for between $350 and $1500.

Further details about this recall are available at incompliancemag.com/news/1502_6.

Radio Controlled Aircraft Power Supplies Pose Fire Hazard

Horizon Hobby LLC of Champaign, IL has recalled the chargers and power supplies for about 6800 of its HobbyZone Super Cub-brand radio-controlled aircraft manufactured in China.

The company says that the power supply units and chargers sold with the model aircraft can overcharge the battery, posing a risk of fire and property damage. Horizon Hobby has received 18 separate reports of incidents involving the power supply units and chargers, including reports of small fires, exploding batteries and property damage to surrounding areas. However, there have been no reports of injuries.

The recall affects the chargers and power supplies supplied with selected models of HobbyZone radio-controlled aircraft that were sold in hobby stores nationwide and online at HorizonHobby.com from April through August 2014 for between $170 and $200, depending on the model.

Additional details about this recall are available at incompliancemag.com/news/1502_7.

Animated Monkey Toy Recalled Due to Burn Hazard

Giggles International, Ltd. of Hong Kong has announced the recall of about 13,000 animated sing-along toys manufactured in China.

The company says that the battery compartment in the toy can reach temperatures of up to 230 degrees Fahrenheit, posing a burn hazard to children and consumers. Giggles International says that it has received two reports of toys overheating and melting their battery compartments. There is no information on whether any injuries are attributable to the overheated battery compartments.

News in Compliance

The recalled sing-along toys were sold exclusively at Cracker Barrel Old Country Stores nationwide during September and October 2014 for about $25.

More information about this recall is available at incompliancemag.com/news/1502_8.

UL Standards Updates

UL 21: Standard for LP-Gas Hose
New Edition dated December 15, 2014

UL 555C: Standard for Ceiling Dampers
New Edition dated December 16, 2014

UL 860: Standard for Pipe Unions for Flammable and Combustible Fluids and Fire-Protection Service
New Edition dated December 15, 2014

UL 1008: Transfer Switch Equipment
New Edition dated December 22, 2014

UL 1696: Mechanical Protection Tubing (MPT) and Fittings
New Edition dated January 9, 2015

UL 1786: Direct Plug-In Nightlights
New Edition dated December 17, 2014

UL 2883: Standard for Sustainability for Disposable Wipers
New Edition dated January 5, 2015

UL 7001: Sustainability Standard for Household Refrigeration Appliances
New Edition dated December 19, 2014

UL 60079-2: Standard for Explosive Atmospheres - Part 2: Equipment Protection by Pressurized Enclosures
New Edition dated August 27, 2010

UL 62133: Standard For Safety For Secondary Cells And Batteries Containing Alkaline Or Other Non-Acid Electrolytes - Safety Requirements For Portable Sealed Secondary Cells, And For Batteries Made From Them, For Use In Portable Applications
New Edition dated January 9, 2015

UL 25: Standard for Meters for Flammable and Combustible Liquids and LP-Gas
Revision dated December 19, 2014

UL 79: Standard for Power-Operated Pumps for Petroleum Dispensing Products
Revision dated December 19, 2014

UL 234: Standard for Low Voltage Lighting Fixtures for Use in Recreational Vehicles
Revision dated January 15, 2015

UL 248-6: Low-Voltage Fuses - Part 6: Class H Non-Renewable Fuses
Revision dated January 5, 2015

UL 248-5: Low-Voltage Fuses - Part 5: Class G Fuses
Revision dated January 5, 2015

UL 300: Standard for Fire Testing of Fire Extinguishing Systems for Protection of Commercial Cooking Equipment
Revision dated December 16, 2014

UL 360: Standard for Liquid-Tight Flexible Metal Conduit
Revision dated January 8, 2015

UL 539: Standard for Single and Multiple Station Heat Alarms
Revision dated December 23, 2014

UL 541: Standard for Refrigerated Vending Machines
Revision dated December 23, 2014

UL 1561: Standard for Dry-Type General Purpose and Power Transformers
Revision dated December 22, 2014

UL 1653: Electrical Nonmetallic Tubing
Revision dated December 23, 2014

UL 1727: Standard for Commercial Electric Personal Grooming Appliances
Revision dated January 7, 2015

UL 1740: Standard for Robots and Robotic Equipment
Revision dated January 7, 2015

UL 1741: Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources
Revision dated January 7, 2015

UL 1746: Standard for External Corrosion Protection Systems For Steel Underground Storage Tanks
Revision dated December 19, 2014

UL 1795: Standard for Hydromassage Bathtubs
Revision dated January 7, 2015

UL 1838: Standard for Low Voltage Landscape Lighting Systems
Revision dated January 13, 2015

UL 2024: Standard for Cable Routing Assemblies and Communications Raceways
Revision dated January 9, 2015

UL 2079: Standard for Tests for Fire Resistance of Building Joint Systems
Revision dated December 17, 2014

UL 8754: Holders, Bases, and Connectors for Solid-State (LED) Light Engines and Arrays
Revision dated December 18, 2014

UL 60745-2-13: Hand-Held Motor-Operated Electric Tools - Safety - Part 2-13: Particular Requirements for Chain Saws
Revision dated December 19, 2014

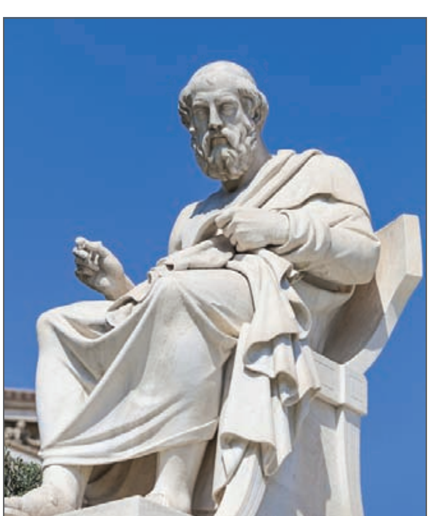
REALITY Engineering

The Reality of Engineering a Symposium

BY MIKE VIOLETTE

As far as I can tell, the first Symposium was described on papyrus by Plato, ca. 400 BC. The first order of the day was to decide how the event would go.

Socrates and Aristophanes were drinking together at Agathon's house. Agathon had just won a prize for penning his first tragedy and the boys were celebrating their friend's success. In the manner of such lubricated gatherings, the discussion rambled a bit, beginning with an argument about just how heavy the drinking was going to be. A dozen or so of Athen's fairest youths had been imbibing since the previous day and were urging restraint (no youth I am familiar with). Others were in a more celebratory mood (that's more like it). Being a consensus-driven group, they ultimately resolved that "drinking was not to be the order of the day, but that they were all to drink only so much as they pleased."[1]



Plato: The First Symposia Correspondent

This important point of order out of the way, *The Symposium* goes on, Plato describing Socrates' method of discerning the nature of Love, ultimately determining that the highest purpose is to become a "lover of wisdom"--a philosopher.

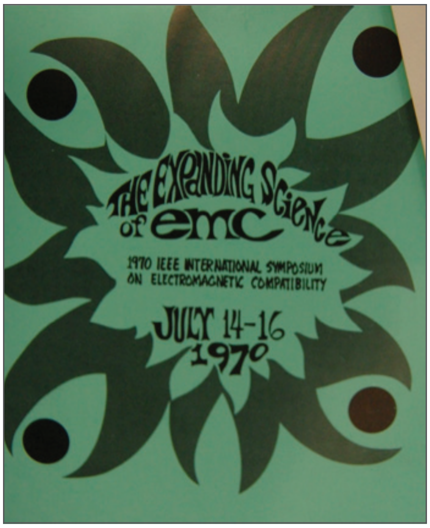
MODERN SYMPOSIA

Fast-forward a few millennia and we arrive in Santa Clara. This *In Compliance Magazine* issue is all about the show, thus we thought it relevant to describe how modern Symposia are put together.

From the inside, assembling the Symposium is a little bit like sausage-making, with a casing holding the stuff together. One part of the casing is the all-important bag, the design, color, features, and selection debated year-on-year. "Remember the 199x bag? Now THAT was a cool bag with tons of space for my engineering swag." I'm not sure when this whole bag thing started, but know several members that can boast a collection of 20 or more. My current favorite and "daily driver" is from Fort Lauderdale (2010).

Early on, it is critical to outline a theme and there is always a lively conversation as it's important to link the theme with

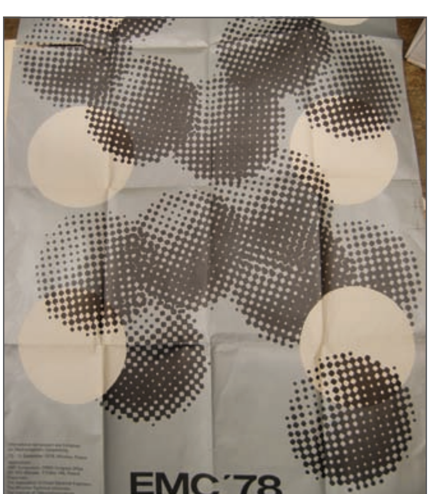
My Favorite Bag



The Expanding Science of EMC

the city and mingle icons and branding. Turns of phrase are encouraged and, during the naming process, double entendres are not rare.

As such, the Symposium reflects the times, too. Not sure what was served in 1970 when the "Expanding Science of EMC" was held, but the promo looks really *far out*, *man*. [2] This was the same year Apollo 13 returned to Earth safely, the first Earth Day was announced, Kent State happened, the Ford Pinto was introduced and the Beatles released their last Album *Let it Be*. Pretty groovy times.



EMC '78

The 1978 Symposium was truly international and held in Wroclaw, Poland.

Once the theme is derived, a logo is built and the all-important committee shirt comes up as the next major debate: Short or long-sleeve? Polo or button down? Color? Pocket or no? Fabric? What size are you? Can I get a comp shirt for my kid? All these questions are ultimately resolved and the show planning begins in-earnest.

Central to all this is "The Committee," a volunteer group that molds and shapes the event, according to the EMC Symposium Guide. As with any group, a culture emerges, driven largely by the Big Boss, the Chair.

THE COMMITTEE

There are several positions on the committee that are hard-wired, but some of the roles evolve over time. The most important positions are, well, all of them. A short description of the assignments and roles is described below.

General Chair: Chaos management and is largely the 'personality' of the event (taking some liberal license). The General Chair is called upon to impart some local flavor to the event and, more importantly, wisdom. The Chair generally ramps things up three or so years in advance and I've heard that it's sort of like volunteering for indentured servitude, but not as much fun.

The Chair is, naturally, beholden to the EMC Society Board of Directors who expects certain tenets be followed. Success, ultimately, is measured in many ways by the Board both quantitatively (of course) but also qualitatively. The Chair proposes a city, normally chosen for its likelihood to attract not only attendees, but their families, too, since this event is traditionally held in late summer.

The US-based symposium in 2015 is an oddball, in a sense, being held in March in order to avoid conflict with the Dresden, Germany show. In general, the idea is to promote a truly international show and still have something for the domestic audience.

The **Vice-Chair** is the backstop for the Chair and is generally around to provide guidance, wisdom and mop up spills.

The **Secretary** is, naturally, a pivotal position and needs to pays loads of attention to detail and must have skills to finesse conference calls/webinar sessions, to-do lists and minutes. It's helpful to be acquainted with the personalities of the troupe, particularly with regards to voice recognition during the calls. Tracking action items means assigned them to the *vox sine corpore* on the con calls. This, this is obviously a position that requires lots of coordination. A very direct style helps a lot—proven well in the last couple of committees, IMO.

Other critical support is provided by:

The **Treasurer/Finance Chair**. This position, in my opinion, is one of the hardest jobs but that's because I'm not so good with numbers (I tend to lean towards engineering as an estimation of the optimal, perhaps it is because I've been corrupted by the inherent inaccuracies in EMC and its practice). Anyway, this part takes the indentured part out a few months *after* the show to close out all the various accounting/vendor/collection and other fiscal hangovers. Continuity of position really really helps here.

The **Technical Program Chair(s)** is really a multi-faceted position because of the breadth of the Symposium, from papers to teaching. These positions are where the soul of the program lies and the love of our practice

REALITY Engineering

flourishes. Yeah, sure, the Exhibit hall gets the beer and ice cream breaks, but the technical program is where the community shares the spark of engineering innovation. The Technical Program, most deservedly has the most Chairs including the General **Technical Program Chair**, **Technical Papers Chair** and a number of Vice-Chairs including SIPI, Emerging Technology and Industry Papers.

Particular topics of interest may land into the **Special Session** and, rounding out the technical part of the program is the education component which features **Workshops, Tutorials, Experiments, Demos** and the several day long **Global University**. All-in, twenty individuals are usually pressed into service to arrange this part of the Symposium. Add up all the reviewers and other that sort through the 150+ papers that are normally received and we could deploy a couple of basketball teams, if we had enough guys with good knees, that is.

Revenue from Exhibitors is largely how we float this boat, financially, so the **Exhibit Chair** is a critical role for the happiness of our exhibitors and the comfort of the bean-counters. Some continuity in this role is nice here, too, and a good pick for this role is someone who either a) has done this job before b) been/is a past exhibitor, c) is a conference junkie or d) all of the above. This job requires loads of attention to detail, an appreciation for filling large spaces, some sales charisma and a coordinating capability with nearly all the other chairs because the exhibits is a pivot point, not just financially, but for communing; not everyone makes it to the technical sessions. Nearly everyone cruises the exhibit hall. The exhibits chair needs to think large, but act minutely.

Hospitality encompasses a few functions on the committee

Bedecked Future Past Chair

including: **Arrangements, Social and Companion Program Chairs**. My wonderful mother-in-law would like all of these tasks because she's a planner and an entertainer. This is the right-brain stuff of our show and it involves picking some fine regionally-accented events, get head counts, review catering menus and herd the cats when the busses arrive. My wise wife once said that, when meeting someone for the first time, it's more important *how* you make them feel than *what* you said. These are the "feely" parts of the EMCS. Some of my favorite memories occurred at the Air and Space Museum in DC, log-rolling in Boston and an amazing evening at a vineyard the last time the show was in Santa Clara.

The **Publications Chair** plays a critical role because after the lights are turned off it the record of the technical efforts that will endure. The Publications chair has to make sure the conference proceedings are collected together and published to various places, both physically and electronically. The ultimate output of the event are the collection of papers, workshop content and, increasingly, video documentation of the sights and sounds of the activity.

The **Marketing Chair** has the best job, IMO and I'll tell you why shortly. The main duties of the MC are to be involved in the early planning, logo-building and themes. Various "institutional practices" have evolved over the years and certain protocols have developed, as for other positions. Most of these protocols involve mapping out cooperative arrangements with various publications, both on-line and in-print to get the message out. Social media, email campaigns and the like are part of the purview of the MC, usually working closely with the web magicians. It's nice to have help in this area because the ways to get the attention of potential attendees continues to change. The great thing about this role is that by the Symposium rolls around, all the marketing work is done and MC can spend the time enjoying the show and scrounging for spare drink tickets.

The *hardest* job during the show—at least the busiest—is the **Registration Chair**. This is where the rubber hits the road, so to speak and months of preparation hits with a wave of engineers and families gathering their badges, bags and EMC ephemera. This is really where it helps to have an experienced person(s) that have done the work year-on-year to assist. This is yeoman's work and it helps to be unflappable.

The other "full-time" position is the **Volunteer Coordinator** who is charged with collecting local (mostly youthful) talent to act as room monitors, schleppers and other odd-and-ends duties that go on during the five-day event.

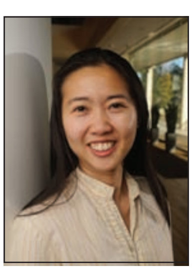
Now, finally, there is a ringmaster that coordinates many of the moving parts. As the event has grown and the details more complex, it has been the practice of hiring an event management group. This has greatly improved the quality of the Symposia and the Committee Members' lives. Pivotal roles are filled by the **Conference Manager** who can speak all that good hotel/hospitality-speak and juggle room-nights and exhibit booth space allocation and the innumerable placards and signage with ease, saving the committee numerous dosages of aspirin.

Finally, like what happened to Michael Corleone in *The Godfather* there is the role of the **Past Symposium Chair** whose job is to shepherd the new committee. If you make it that far, you may receive many badges when you arrive at the show.

THE 2015 COMMITTEE

GENERAL CHAIR

Caroline Chan - Lockheed Martin



Caroline spent much of her youth (18 years) in Africa, growing up in the former French Colonies of Cameroon and Côte d'Ivoire (Ivory Coast). Her father worked in accounting and her parents were originally from China. She attended international schools in both countries, making friends from other parts of the globe. She arrived in the US in 1999 to get a BS and MS from UC Santa Barbara, with a concentration in Electrical Engineering. She became interested in lightning phenomena at a tender age, noticing that the speed of light was faster than sound. (There was plenty of lightning to observe in the African tropics.) Caroline started to investigate the mathematics of the natural world at ten years of age. She starting soldering circuits when she was eleven years old because, as she says: it was "mainly due to necessity as fans broke down easily and would not last too long in some seasons." She loves dogs and was surprised to find out that dogs in the US are treated as pets, not for self-protection as in Africa. She is an amalgam of diversity, speaking Mandarin, Cantonese, French and English, enjoys gardening, has traveled extensively in Europe and Asia and loves to meet new people, learn new cultures and recently received her open water SCUBA certification in Bali. She is delighted to chair the 2015 EMCSI Conference.

VICE CHAIR

Bob Davis-Lockheed Martin

Bob is a Senior Staff E3 Engineer at Lockheed martin Corporation. He has over 30 years of E3 design, test and analysis experience on DoD and Space Shuttle Programs. Bob is an IEEE Senior Member (35 years) and Director at Large for IEEE EMC Society 2008 – 2013 and VP for Member Services IEEE EMC Society 2009 – 2014. He enjoys playing golf, working on home projects and international travel.

SECRETARY

Dana Craig – McAfee

Dana is a native Californian and first joined the IEEE EMC Society in 1984. He is a Senior member of the IEEE. His main education came during his service the US Air Force from 1975 to 1981. In 1981 he joined ISS Sperry Univac in the EMC department as a test technician, performing VDE and FCC evaluations. In 1984 he was promoted to EMC Engineer while working at Qume. He enjoys his seven grandchildren and is an avid racecar fan for over thirty years, building racecars and participating in local dirt-track racing hijinks.

ADVISOR AND PAST SYMPOSIUM CHAIR

Bruce Archambeault - IBM

Dr. Archambeault is an IEEE Fellow, an IBM Distinguished Engineer Emeritus and an Adjunct Professor at Missouri University of Science and Technology. He chaired the 2014 IEEE EMC&SI Symposium in Raleigh. He is the author of the book "PCB Design for Real-World EMI Control" and the lead author of the book titled "EMI/EMC Computational Modeling Handbook." He likes to sail and do woodworking.

TREASURER/FINANCE CHAIR

John LaSalle - Northrop Grumman Corporation

John works working in the E^3 department at Northrop Grumman. He is a member of the Distinguished Technical Leadership Program and has been working in the EMC field for Over 28 years. He is the Treasurer for the IEEE EMC Society, as well as the Financial Chair for the past six EMC Symposia. He holds an MBA from Dowling College and a BSEE from Old Dominion University. John is an avid bike rider and co-founded the TEAM EMC bicycling ride that meets at the annual symposiums.

REALITY Engineering

PUBLICATIONS CHAIR/ CONTENT

John Rohrbaugh - Northrop Grumman

Northrop Grumman Minuteman III, Nuclear Hardness and Survivability Lead Northrop Grumman Technical Services, Ogden, UT John works on EM Effects for NGC on the Minuteman III program (2007 to present); pulsed power systems development for NGC/ TRW, Albuquerque, NM (2000 to 2007); AFRL – Kirtland AFB, NM (1998-2000). He enjoys doing home remodeling projects and favors talking dog videos over cat Youtube videos.

MARKETING CO-CHAIRS

Mike Violette - Washington Labs

Mike is President of Washington Labs and Director of American Certification Body. He has been involved in EMC and compliance for over 200 dog-years and does a bit of international business development stuff. He has served as Marketing Chair for a couple of past Symposia, likes to travel, write about travel and play music, on occasion.

Ashleigh O'Connor - In Compliance Magazine

Ashleigh is Marketing Manager of In Compliance Magazine. She has over 10 years of experience in marketing and communications. She enjoys finding unique and meaningful ways to connect and engage with targeted audiences. In her spare time, Ashleigh is also an independent fitness coach.

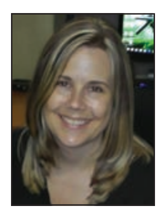
CONFERENCE MANAGER

John Vanella - ConferenceDirect

John Vanella brings 28 years of experience in conference and event management. He has worked for Four Seasons, Marriott International and Hilton Hotels Corporation. John is a Vice President/ Team Director with ConferenceDirect managing comprehensive services for The National Hockey League, American National Standards Institute, IEEE EMC Society and others. John is a member of Meeting Planners International, USA Hockey, Coyotes Adult Hockey League and Arizona Puckhead Hockey Club.

WEBSITE/DESIGN

Kelly Scott-Olson - ATG Productions



Kelly is Founder, President and Creative Director of ATG Productions, a design agency formed in 1997. Over the years, she has expanded her client base, creative team, capabilities and scope of services. A strategic alliance with ConferenceDirect has allowed her to complement their meeting management services with designs for clients such as Microsoft, Siemens, Marriott and the IEEE. Kelly lives in Surprise, AZ with her husband, Steve, daughter Lorraine, and son Devon. She enjoys reading, music, baking, crafting, walking her dogs or riding bikes in the beautiful Sonoran Desert.

WEBSITE MAINTENANCE

Joseph Nghiem, TrimbleSue

Joseph is Senior Compliance Engineer with Trimble Navigation. He has over twenty years of experience in EMC design and test of high speed products. He is webmaster for the SC EMC Chapter. Previously, he worked for Cisco Systems as lead EMC Designer for major data product lines. He lives in the San Francisco Bay area.

EXHIBITS CHAIR

James K. Baer - Comply Tek, Inc.

Jim has over 25 years Regulatory Compliance Experience from being an EMC Test Engineer, EMC Engineer, Senior EMC Engineer, EMC Division/Lab Manager, and Global Compliance Engineering Manager. He also has over 10 years of experience as sales engineer/account manager for EMC and RF products for southern California and Nevada. Jim likes the ocean and loves to play Hollywood Gin and Poker.

ARRANGEMENTS CO-CHAIRS

Rhonda Rodriguez

Rhonda has been Arrangements Chair or Co-Chair the IEEE EMC & SI Symposium six times (2009, 2011, 2012, 2013, 2014 and 2015) and an exhibitor 15 consecutive years. She enjoys travelling with her husband Vince, photography, and cheering on the University of Florida Gators!

Dennis Lewis – Boeing

Dennis is Technical Fellow with The Boeing Company. He is a 27-year veteran of The Boeing Company, Dennis has technical and leadership responsibility for its primary RF, Microwave and Antenna Metrology labs. He is a part time faculty member and past chairman of the Technical Advisory Committee for North Seattle College.

He was a distinguished lecturer for the EMC society 2013-2014 and is the general chairman for the 2019 symposium to be held in New Orleans. He enjoys, in his spare time, biking and hiking.

SOCIAL CHAIR

Eriko Yamato – Techdream

Eriko is VP of Sales and Marketing for Techdream. She is originally from Kobe Japan and spent five years in San Francisco during her childhood. After getting her BS in Political Science at Keio University in Tokyo, she worked for a TV station for 5 years producing infotainment programs, sports news, and documentaries. In 2000, she returned to California to pursue her passion in documentary film production at Stanford University where she received her MA in Communication and discovered her other passion: sales and marketing, focusing on EMC, RF and Wireless products. She still enjoys making films and has produced numerous company/product promo, educational, and event videos. Eriko has been active with the EMC Santa Clara Valley Chapter since 2010 and currently serves as the Vice Chair. In her spare time she enjoys hiking and cooking.

COMPANION PROGRAM

Sue Archambeault

Sue is a retired grade school teacher and is very busy with her volunteer work at the local hospital. She enjoys traveling with her husband, making puzzles, and reading.

REGISTRATION CHAIR

Mark Maynard, SIEMIC

Mark is Director of Business Development & Marketing at SIEMIC. He has experience with direct business development, brand development, website, social media, special engineering projects, and negotiate with regulatory standards committees, professional societies, and government agencies for regulatory affairs, compliance testing, and Information Technology Equipment (ITE) and Wireless/Telecom certifications. Previously, he worked in Regulatory Compliance Engineering for twenty years at Dell Inc. with engineering and project management roles in Wireless, Telecom, & ITE Compliance, Environmental Design, and Environmental & Quality Management Systems, obtaining legal market access to 200+ market countries for ITE and wireless/telecom products.

VOLUNTEER COORDINATOR

Stephen Scearce, Cisco

Stephen received his B.S.E.T. and M.S. in Electrical Engineering from Old Dominion University, Norfolk VA in 1996 and 2000 respectively. Stephen started his career working for NASA Langley Research Center in the Electromagnetic research branch High Intensity Radiated Fields team. In 2001 Stephen joined Cisco Systems as an EMC design engineer and has worked in signal integrity and power integrity design for the past 13 years. Stephen currently manages a global team of SI engineers supporting Cisco ASIC and PCB designs.

VOLUNTEER COORDINATOR

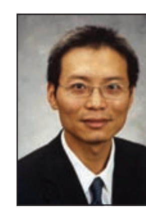
Alpesh Bhobe, Cisco

Dr. Bhobe received his Ph.D. in Electrical Engineering from the University of Colorado at Boulder, Colorado in 2003. He was a Post-Doc at NIST in Boulder, Colorado from 2003-2005. While at the University of Colorado and at NIST his research interest included the development of FDTD and FEM code for EM and Microwave applications. Currently he manages in the EMC Design team at Cisco Systems in San Jose CA.

2015 TECHNICAL COMMITTEE MEMBERS

TECHNICAL PROGRAM CHAIR

Dr. Jun Fan - Missouri University



Dr. Fan is the Director of the Missouri S&T EMC Laboratory. His research interests include signal integrity and EMI designs in high-speed digital systems, dc power-bus modeling, intra-system EMI and RF interference, PCB noise reduction, differential signaling, and cable/connector designs. He likes reading, travel, and music.

TECHNICAL PAPERS CHAIR

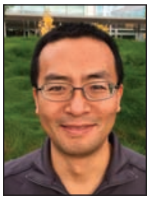
Dr. Chuck Bunting-Oklahoma State University

Dr. Bunting is Associate Dean of Research and Sponsored Programs. Chuck held a Bradley Fellowship and a DuPont Fellowship and in 1994 he was awarded the Ph.D. in Electrical

REALITY Engineering

Engineering from Virginia Tech. From 1994 to 2001 Dr. Bunting was an assistant/associate professor at Old Dominion University in the Department of Engineering Technology where he worked closely with NASA Langley Research Center on electromagnetic field penetration in aircraft structures and reverberation chamber simulation using finite element techniques. He has served as professor of OSU since 2001.

TECHNICAL PROGRAM VICE CHAIRS ON SIPI



Zhiping Yang - Apple Computer

Zhiping is Sr. Principal Power Integrity Engineer / Senior Manager.

Xiaoning Ye – Intel

Dr. Xiaoning Ye is an IEEE senior member, and a Principal Engineer at Intel Corporation. He was TPC co-chair for the IEEE International Conference on Signal and Power Integrity, 2014, an embedded conference of IEEE EMC symposium. He is secretary of the Technical Advisory Committee of EMC society and also serves as an IEEE Distinguished Lecturer for 2014/2015. He enjoys hiking and biking with his family, and learning photography.

TECHNICAL PROGRAM VICE CHAIRS ON EMERGING NEW TECHNOLOGIES

Yihong Qi, DBJ Technologies

Brice Achkir, Cisco Systems

Brice is a Cisco Distinguished Engineer and a Senior Engineering Director in Advanced Technology at Cisco Systems, Inc. Brice has been a leader in translating technical innovations into business opportunities, from the research and development phase through product delivery and support. His focus has been on global impact initiatives, e.g., high-speed architectures and the "internet of everything in the Factory of The Future." Brice has received multiple awards and recognitions as an international thought leader in his areas of expertise. Brice holds many patents relating to high-speed architecture/design electrical and photonic and signal/power integrity. He is active in international standards groups (ITU-T and IPC). Brice holds a B.S. in Applied Physics, an M.S. in Physics, and a Ph.D. in EE. He is an IEEE Fellow and lives in San Jose, California.

TECHNICAL PROGRAM VICE CHAIR ON INDUSTRY PAPERS

Dan Oh, Altera Corporation

SPECIAL SESSIONS CHAIR

Chunfei Ye – Intel

Dr. Chunfei Ye works with Intel Corporation as Senior Staff Engineer and signal integrity technical lead for server platforms. He is responsible for IO signal integrity and package electrical design for Intel server PCH and SOC CPU since 2005. He also managed signal integrity and wireless software tool development teams when he was in Intel Communication Group. Chunfei obtained Ph.D. in Electrical Engineering and B.Sc. in Mathematics. He published more than 50 papers in journals and conferences and holds several patents. He is IEEE Member and IEEE EMC TC 10 (Signal Integrity) Secretary. He served as session chairs for IEEE EMC-SI Symposium for years. Chunfei enjoys fishing, farming and writing.

WORKSHOPS & TUTORIALS CO-CHAIRS

Bruce Archambeault – IBM

See above.

John Maas - IBM

Corporate Program Manager for EMC. John has been involved in EMC since the Dead Sea was just sick, having received his BSEE on clay tablets from the Illinois Institute of Technology in 1981. He is is responsible for IBM's programs and processes for compliance with EMC requirements worldwide. John is Technical Advisor to the US National Committee of the IEC for SC77A and is convenor of IEC SC77B Working Group 10. He is a Senior Member of the IEEE and was chair or co-chair of the Workshops and Tutorials Program for each IEEE International Symposia on EMC since 2007. John is a founding member of the Bag of Dirt Band and enjoys picking the dobro and mandolin.

EXPERIMENTS & DEMONSTRATIONS CO-CHAIRS

Bob Scully – NASA

Bob is an IEEE Fellow. He currently holds a federal GS15 rating, and has been the Johnson Space Center EMC Group Lead Engineer since 2000. He is the technical lead for EMC at the Center, manages the EMI laboratory facility and currently supports multiple programs, including Commercial Crew Development, the International Space Station, and the Orion Program. Bob is also the lead for the Community of Practice for EMC within the Agency. He has over 30 years of experience in aviation. Bob is currently the President of the EMC Society and previously served in all Officer positions for the Technical Activities Committee, TC1, TC4 and, most recently, Vice President of Technical Services. Bob is an Associate Editor for the EMC Society Transactions, and is currently serving as the founder and Chair of the Galveston Bay/Houston EMC Chapter. Bob enjoys hiking, riding motorcycles, stargazing, and playing piano.

Giuseppe Selli - Cisco Systems

Giuseppe received his Laurea Degree from the University of Rome "La Sapienza" in 2002 and his Master and Ph.D. Degrees from The Missouri University of Science and Technology in 2004 and 2007, respectively. He worked on SI for IBM at the TJ Watson Research Center in 2005 and 2006, for Amkor Technology from 2007 to 2011 focusing on packaging and for Cisco system from 2007 until now focusing on systems and packaging. He is currently the Chair of the IEEE EMC Santa Clara Valley Chapter. He is Senior Signal Integrity Engineer at Cisco Systems. He loves to play the accordion; perhaps we will hear him play *La Dolce Vita* during the EMC Musicians segment.

GLOBAL UNIVERSITY CHAIR

Dale Becker, IBM

Chief Engineer Electronic Packaging *Company:* IBM, Poughkeepsie, NY, USA. Dr. Becker is the lead signal and power integrity engineer in IBM Systems and Technology Group. He received his Ph.D. from the University of Illinois at Urbana-Champaign. He was the general chair of the 2014 EPEPS conference and TPC co-chair of the 2014 EMCS embedded conference on SI/PI. He is a Fellow of the IEEE.. His interests include kayaking, golfing, and biking

ENDNOTES

1. Originally published in *Electromagnetic Compatibility Magazine*, IEEE (Volume:2 , Issue: 4). 2013.
2. Leonard Thomas Archives

(the author)

MIKE VIOLETTE
is President of Washington Laboratories and Director of American Certification Body. He can be reached at mikev@wll.com.

IN MEMORIAM

We experienced some sadness during the preparations for this event.

Guy de Burgh passed away on December 21, 2014 after a long battle with cancer. Guy was EMC Technologist at Apple Computer in Cupertino and previously worked at EM Integrity, LLC, Sony Ericsson Mobile Communications, Inc. and Mentor Graphics.

Guy studied at the University of Oxford, garnering an MA in Engineering Science.

He was an effective manager with a calm, caring style and people flourished under his guidance.

Guy enjoyed experiencing the outdoors, was an avid photographer and enjoyed ultimate Frisbee and running. He worked with several EMC Symposia committees over the years, supporting the promotion and logistics of putting the Symposia together. He will be missed.

2015 IEEE Symposium on Electromagnetic Compatibility and Signal Integrity

Santa Clara, California
March 15-20, 2015

Friends and Colleagues,

Caroline Chan
EMC 2015 General Chair

Welcome to Silicon Valley, the land of sunshine and great wine. Did you know that it used to be called Santa Clara Valley before it became the symbol of high tech startups?

This is an unusual year where we have a national symposium in Santa Clara, CA, USA and the International one in Dresden, Germany. Although it is only seven months since the 2014 Raleigh symposium, the size of this symposium is comparable to the International symposium, running from Monday to Friday with the combination of EMC and Signal/Power Integrity topics. We have three unique special events planned for this symposium. Our featured Keynote Speaker is Dr. Thomas H. Lee, graduate of MIT and current electronic engineering professor at Stanford University. Dr. Lee will be summarizing three historical events that have proven the fragility of the Earth's electronics systems which is a subject that greatly affects us all. Our Technical Committee has been working hard in planning an excellent program including new Plenary Sessions with four technical keynote speakers and a Panel of Experts that will offer very informative dialogue about topics relevant to our industry.

While visiting the workshops/tutorials, the high quality Technical paper presentations, which will include unique Industry papers, and then passing through the Special Sessions, don't forget to visit the Exhibit Hall where product show cases and panelists might inspire you to your next innovation.

The Symposium Organizing Committee has planned and designed the EMCSI 2015 Symposium with the goal of ensuring the most enriching technical and professional networking opportunities possible through multiple exhibits, technical programs, companion programs, and social events. We are offering three days of top-rated, peer-reviewed technical papers presented by experts in multi-track sessions and more than two days of practical workshops and tutorials, plus experiments and demonstrations presented by industry professionals.

Also included are collateral industry meetings and a full exhibit hall to learn about the latest offerings in EMC products and services. In addition to the number of regular sessions, special sessions and workshop/tutorial sessions on 'standard EMC' and 'Signal and Power Integrity', there will also be papers on Radio-Frequency Interference and Wireless EMC, Uncertainty Quantification in Computational EM and many more topics! There is certainly something new for everyone, regardless of your interests, within the broad EMC & SI world.

I would also like to extend a welcome to the Santa Clara Valley IEEE EMC Chapter where many of our officers are also volunteering at this conference. If you have a chance, come join us on the second Tuesday of the month for the monthly chapter technical meeting.

Welcome!

Caroline Chan

www.emc2015usa.emcss.org

Daily Schedule

Monday

8:30 AM - Noon

Fundamentals of EMC & Signal Integrity
MO-AM-1

Calibration of EMC Test Facilities and Measurement Instrumentation
MO-AM-2

Product EMC Challenges for Emerging Wireless Technologies
MO-AM-3

Application of Reverb Chambers
MO-AM-4

Lightning Protection of Wind Turbines
MO-AM-5

1:30 PM - 5:30 PM

Fundamentals of EMC & Signal Integrity
MO_PM-1

Testing of Wireless Devices in the Modern World
MO-PM-2

EMC Consultant's Toolkit
MO-PM-3

Smart Grid EMC Update
MO-PM-4

Intentional Electromagnetic Interference (IEMI) Update
MO-PM-5

Tuesday

8:30 AM - 10:00 AM

KEYNOTE PRESENTATION
Dr. Thomas H. Lee
The Carrington Event, H-bombs, Telstar, and the Great Geometric Storm of 1989

10:30 AM - Noon

EMC Management
TU-AM-1

Passive Component Modeling and Measurement I
TU-AM-2

Jitter/Noise Modeling and Analysis I
TU-AM-3

Numerical Modeling and Simulation Techniques I
TU-AM-4

Electromagnetic Environment and ESD
TU-AM-5

1:30 PM - 5:30 PM

Special Session: Radio-Frequency Interference and Wireless EMC
TU-PM-1

Electromagnetic Interference Control
TU-PM-2

High Speed Link Design I
TU-PM-3

SI/PI/EMC Co-Simulation and Co-Design
TU-PM-4

Wednesday

8:30 AM - Noon

Automotive EMC Measurements
WED-AM-1

Passive Component Modeling and Measurement II
WED-AM-2

Jitter/Noise Modeling and Analysis II
WED-AM-3

Power Integrity and Power Delivery Network I
WED-AM-4

Applications of Numerical Modeling
WED-AM-5

1:30 PM - 5:30 PM

Time Domain Emission Measurements and Modeling
WED-PM-1

Capturing Pulsed/Intermittent Signals with Frequency Swept, Frequency Stepped, and Time Domain Scan Methodologies
WED-PM-2

Working EMC Engineer Skills
WED-PM-3

Integrated ESD Device and Board Level Design
WED-PM-4

www.emc2015usa.emcss.org

Santa Clara, California
March 15-20, 2015

Technical Program

Thursday

8:30 AM - Noon

EMC Measurements and Calibration
TH-AM-1

High Speed Link Design II
TH-AM-2

Modeling and Simulation for Large-Scale and Multi-Scale Power Delivery Network
TH-AM-3

Numerical Modeling Approaches
TH-AM-4

2:30 PM - 5:30 PM

Wireless Testing and RF Interference
TH-PM-1

Numerical Modeling and Simulation Techniques II
TH-PM-2

Power Integrity and Power Delivery Network II
TH-PM-3

Special Session: Uncertainty Quantification in Computational EM and Signal/Power Integrity Verification
TH-PM-4 S

Friday

8:30 AM - Noon

Introduction to Medical EMC
FR-AM-1

Basic EMC Measurements
FR-AM-2

Nanotechnology and Advanced Materials Applied to EMC
FR-AM-3

New Opportunities and Challenges for Validation of Computational Electromagnetics Standardization – the Review of IEEE Std 1597.1
FR-AM-4

Conformity Assessment Topics for EMC Laboratories
FR-AM-5

1:30 PM - 5:30 PM

Debugging EMI Test Failures
FR-PM-1

Field Sources and their Application in Computational EMC
FR-PM-2

EMC Risk Management Workshop
FR-PM-3

Crosstalk – Theory, Modeling, Characterization, and Design Optimization
FR-PM-4

IEEE Senior Member Elevation Event

Stacy Lehotzky of IEEE will give a presentation to explain the benefits of being a Senior Member. To be eligible for this special IEEE program you must:

- be engineers, scientists, educators, technical executives, or originators in IEEE-designated fields;
- have experience reflecting professional maturity;
- have been in professional practice for at least ten years;
- show significant performance over a period of at least five of their years in professional practice.

The goal of this presentation is to explain the value of IEEE Senior Membership.

Join us on Tuesday, March 17.

IEEE Senior Member Application Workshop

Need help filling out your applications to be a Senior Member of IEEE? Come to our workshop to prepare your application with our IEEE specialists. We will be completing the forms onsite at EMCSI 2015. The three required references will be provided on location by the local IEEE Section. You must bring your resume.

Join us on Wednesday, March 18.

Professional Development

The IEEE EMC Society is offering both Professional Development Hours (PDHs) and Certificates of Participation to IEEE EMC and SI/PI symposium attendees. A small fee and a completed evaluation form will be required to receive a certificate. In addition, PDH candidates must provide evidence of having attended each session for which credit is desired.

PDH CERTIFICATE OF COMPLETION

PDH credits can be used by licensed professional engineers to document required continuing education for their individual State Board or Certifying Body requirements.

We have expanded choices with this a-la-carte menu, where you may obtain credit for attending any morning or afternoon session, any day of the week. An example is shown below.

	Monday	Tuesday	Wednesday	Thursday	Friday
AM	4.0 hrs	4.0 hrs	4.0 hrs	4.0 hrs	4.0 hrs
PM	4.0 hrs	4.0 hrs	4.0 hrs	4.0 hrs	4.0 hrs

To obtain PDH credits, an attendee must:

- Sign up on your registration form or at the Registration Desk, and pay the processing fee* if required.
- Sign in and out with the volunteer at the door to each chosen paper session or W/T session.
- Complete an evaluation form for each session, morning or afternoon, that credit is desired.
- Submit evaluation forms to the registration desk or scan and email to bob.Scully@ieee.org no later than Monday, March 23, 2015. Any forms received after this date will not be processed.

The total hours attended will be calculated along with the total number of PDH credits earned, and one Certificate of Completion will be awarded by the IEEE showing the total earned PDH credits.

CERTIFICATE OF PARTICIPATION

A Certificate of Participation may be useful for non-licensed professionals or college students to officially document attendance at the Symposium.

To obtain a Certificate of Participation, an attendee must:

- Sign up on your registration form or at the Registration Desk, and pay the processing fee* if required.
- Complete one form listing and describing all paper sessions and W/T sessions attended.
- Submit form to the registration desk or scan and email to bob.Scully@ieee.org no later than Monday, March 23, 2015. Any form received after this date will not be processed.

A Certificate of Participation will then be sent to the attendee from the IEEE.

*There is a modest $20 charge for processing PDH credits and/or CoP certificates; this fee is waived for IEEE EMC Society members only.

Clayton R. Paul Global University

Global EMC University was first offered at the 2007 IEEE EMC Symposium in Honolulu to provide advanced education on a variety of topics that are an important part of EMC engineering. The overwhelming response to this program caused the EMC Society to add it to the technical program every year since 2007. It has continued to receive high praise from those who attend. The Board of Directors had voted to name the Global University in honor of Clayton R. Paul, who dedicated his career to EMC/SI education and was instrumental in setting up the initial Global University. We are pleased to be able to offer Global University once again at the 2015 IEEE EMC Symposium and Signal Integrity in Santa Clara, California.

This year's Global University offers 12 hours of instruction. Eight hours are on basic SI related topics and four hours on traditional EMC topics. The sessions are run in parallel with the traditional technical sessions at the symposium. A broader set of EMC topics will be covered at the International Symposium on EMC in Dresden, Germany on August 16- 22, 2015. Classes are taught by an international panel of educators, who have been selected for this program based on their reputation for excellence in areas of practical importance to EMC and SI engineers and their demonstrated ability to communicate effectively with students who are new to the field.

The targeted audience for GU SI are engineers who have been in the profession approximately 5 years, although past classes have included many veterans wanting to improve their understanding. The overall objective of this sequence of lectures and activities is to provide a comprehensive exposure to the basic concepts and skills that are necessary to be successful in the profession.

OTHER INFORMATION

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

Prerequisites: Engineering or Technology Degree with Electrical Theory

Audience: Engineers, technicians and professionals who want to gain insight into EMC and SI and the application to today's technology.

Note: Attendance is based on those who pre-register for the Clayton R. Paul Global University (on-site registration limited to openings due to cancellations), pay the full symposium registration fee, and an additional registration fee for these special classes.

Fees: $375.00

Classes offered: Six, 2-hour classes offered two each on Tuesday, Wednesday and Thursday.

Class I: Radiated Emissions and Conducted Emissions

Lee Hill, Silent Solutions LLC

Class IIa: Grounding Essentials
Class IIb: ESD

Todd Hubing, Clemson University

Class III: Introduction to Signal Integrity

Jun Fan, Missouri University of Science and Technology

Class IV: Introduction to Power Integrity

Ege Engin, San Diego State University

Class V: SI and EMC Design for High-speed Differential Signaling

Tzong-Lin Wu, NTU

Class VI: SI/PI Issues and Solutions for High-Speed Single-Ended Signaling

Dan Oh, Altera Corp

2015 Social Events

WELCOME RECEPTION

Tuesday, March 17, 6:00 PM – 8:00 PM

Join us in the gorgeous Mission City Ballroom in the Santa Clara Convention Center for an evening of wine tasting, socializing, and live music from the EMC Band!

One ticket to this event is included in all 5-Day technical registrations and the Companion Program registration. All others may purchase a ticket to the Welcome Reception as an add-on to your registration.

An Adult Reception Ticket price: $75.00
A Junior (Age 8 to 17, inclusive) Reception Ticket is: $35.00
Children under age 8 are free, but must be accompanied by a registered adult.

EVENING GALA EVENT

Wednesday, March 18, 6:30 PM – 9:30 PM

Our evening Gala is a must attend event with an awards ceremony and our delicious California menu. This event will be in the Mission City Ballroom in the Santa Clara Convention Center.

One ticket to this event is included in all 5-Day technical registrations EXCEPT student registrations. This is a change from last year, made to keep student registration costs down. Extra tickets to the Gala may be purchased as an add-on to your registration.

An Adult Gala Ticket is: $90.00
A Junior (Age 8 to 17, inclusive) Gala Ticket is: $45.00
Children under age 8 are free, but must be accompanied by a registered adult.

Photo courtesy of Ken Wyatt

EMC SOCIETY BAND

Tuesday, March 17, 6:00 PM – 8:00 PM

EMC Society Musicians will perform at the Welcome Reception! Come see our gifted colleagues share their musical talents!

This is a comeback event that was first featured in Austin at EMC 2009. Veteran EMC Society Band members and newcomers alike are welcome to participate.

If you would like to perform, please contact our fearless bandleader Jeff Silberberg at jeffrey.silberberg@verizon.net. If needed, he can arrange for backup musicians to allow your talent to shine!

Photo courtesy of Ken Wyatt

Social Events

CHAPTER CHAIR TRAINING SESSION AND DINNER

Wednesday March 18, Noon - 2:00 PM

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, and additionally 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 Directors.

A Social Session will precede the lunch, to give the Chapter Chairs the opportunity to socialize with the other Chapter Chairs and their Angels. Lunch 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 lunch, an interactive brainstorming session will conclude the meeting. This session is intended 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.

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 courtesy of Jerry Ramie

FOUNDERS AND PAST-PRESIDENTS LUNCHEON

Thursday March 19, 11:30 AM - 1:30 PM

The Luncheon is open to the Founders of the EMC Society, Past-Presidents of the EMC Society, current members of the Board of Directors, and students. The luncheon is a chance for the old and the new to mix, exchanging experiences of the past, challenges of the future and learning about the EMC profession. A sit down lunch is provided. When making your reservation, please indicate that you plan to attend so there will be seating and food for you.

Photo courtesy of Jerry Ramie

IEEE EMC YOUNG PROFESSIONALS PARTY

Tuesday, March 17th, 8:15 PM -10:00 PM
(after the Tuesday Welcome Reception)

Show off your bowling skills with your fellow EMC Young Professionals. This is a great opportunity to socialize and connect with like-minded individuals in an informal setting.

Tickets are $10 and include bowling, shoe rental, and pizza

Exhibitors List (alphabetically)

3G Metalworx Inc. 824
A.H. Systems, Inc. 419
A2LA - American Association for Laboratory Accreditation. 521
Advanced Test Equipment Rentals 502
AE Techron, Inc. 420
Altair Engineering Inc. 411
Amphenol Canada 831
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ANSI-ASC C63 Committee on EMC 908
Applied Physical Electronics LC 8
AR RF/Microwave. 202
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Avalon Test Equipment Corp. 842
Boonton/Noisecom . . . . TBD (Wireless Telecom Group)
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Electro Magnetic Test, Inc. 1
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Elite Electronic Engineering Inc. 837
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IEEE 2016 EMC Symposium 916
IEEE Antenna and Propagation Society 906
IEEE EMC Society 910
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Interference Technology / ITEM Media 702
Keysight Technologies 618
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Exhibits

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Liberty Calibration Corps 835
MET Laboratories 13
Michigan Scientific Corp. 124
mk-messtechnik GmbH 907
Moss Bay EDA/IBM 808
National Technical Systems (NTS) 901
NEC TOKIN 802
Newtons4th NA. 10
NEXIO 223
Nolato Silikonteknik AB 718
Northwest EMC Inc. 424
NVLAP 926
OnRule. 732
Ophir RF Inc. 610
Orbis Compliance LLC 738
Panashield 708
Pearson Electronics Inc. 9
Reliant EMC . . . . TBD
RF Exposure Lab 807
Rigol Technologies 717
Rohde & Schwarz USA, Inc.. 102
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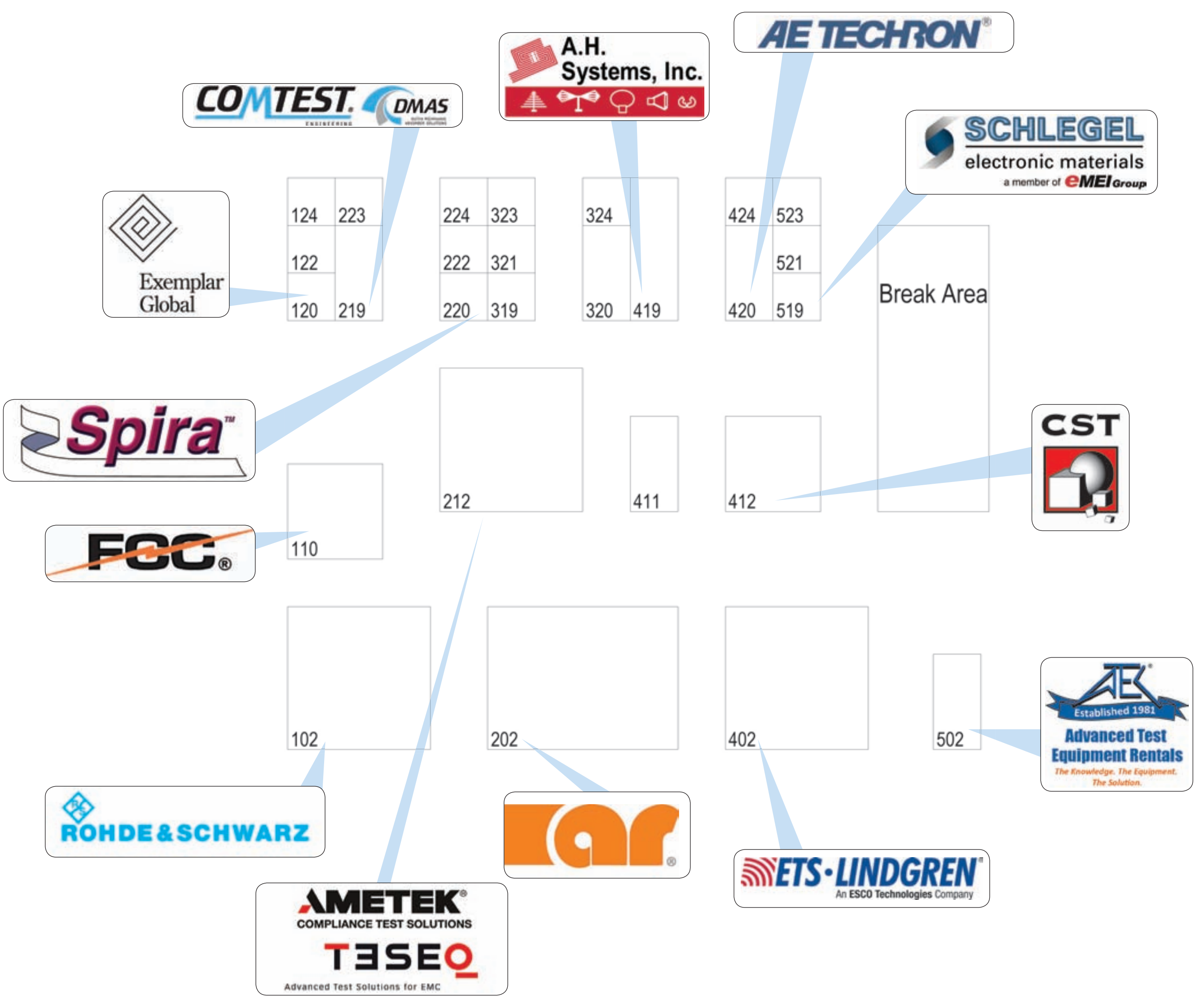

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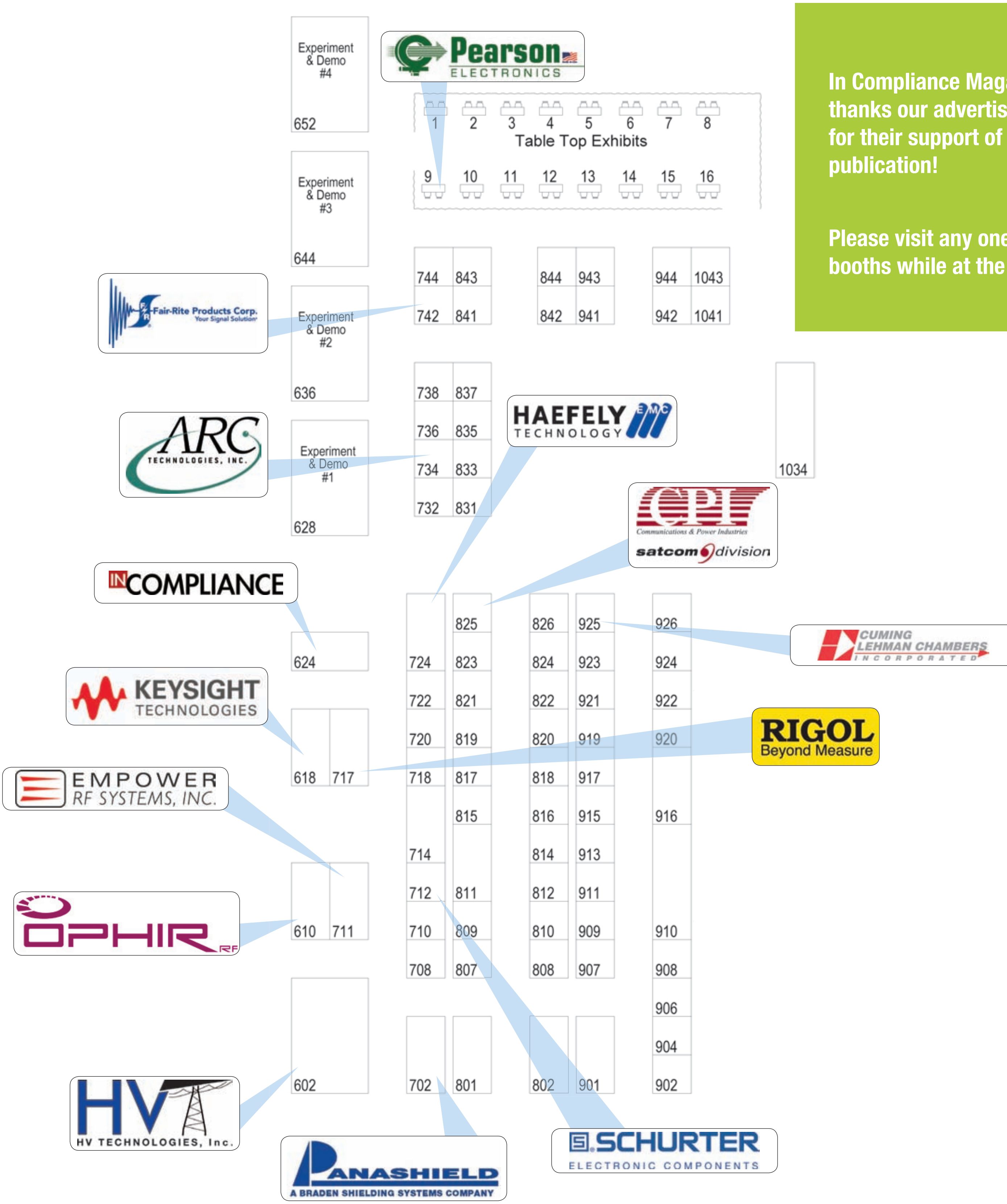

2015 Exhibitor Profiles

Booth 419

Manufacturer
Antennas and Antenna Products

A.H. Systems, Inc. - manufactures a complete line of affordable, reliable, individually calibrated EMC Test Antennas and Current Probes that satisfy FCC, MIL-STD, VDE, IEC and SAE testing standards. Delivering high quality products at competitive prices with immediate shipment plus prompt technical support for the entire product line are goals we strive to achieve at A.H. Systems. We provide rental programs for our equipment and offer Recalibration Services for all our antennas and probes, including others manufactured worldwide. We take pride in providing a fast turn around schedule to help minimize any down time the customer may experience during testing. 100% inventory, NEXT-DAY ON-TIME DELIVERY.

Website: www.ahsystems.com

Booth 502

Equipment Resellers/Rentals

Advanced Test Equipment Rentals (ATEC), A2LA ISO 17025 certified for calibration, supplies complete testing solutions for EMC, Electrical, Power Quality, Environmental and similar testing applications for the Aerospace, Defense, Medical, Telecom and many other industries. ATEC takes pride in serving our customers for over 30 years with invaluable expertise and technical support.

Website: www.atecorp.com

Booth 420

Manufacturer
Power Supllies
Test & Measurement Equipment

AE Techron, Inc. - The audio-bandwidth EMC experts. AE Techron DC-enabled AC amplifiers, power supplies and test systems are designed to meet the rigorous requirements of EMC testing. Their popular 7224 linear amplifier has been recognized by Ford for use in EMC-CS-2009 testing and features a DC to 300 kHz bandwidth. The 3110 Standards Waveform Generator, when combined with one or more AE Techron amplifiers, creates a complete universal audio bandwidth test system for Aviation (DO-160, MIL-STD-461) and Automotive testing (SAE J1113-22, ISO 16750-2, MILSTD1275, GMW3172). Other products offer solutions for power susceptibility and conducted immunity testing found in Telecom (GR 1089 Section 10/ATIS-0600315.2007).

Website: www.aetechron.com

Booth 202

Manufacturer
Antennas and Antenna Products
Test and Measurement Equipment

AR is your one source for RF/Microwave bench top and rack mounted broadband power amplifiers, amplifier modules, complete EMC test systems, EMI receivers, military communications booster amplifiers and more.

Our global company consists of AR RF/Microwave Instrumentation, AR Modular RF, AR Receiver Systems and AR Europe.

AR RF/microwave Instrumentation in Souderton, PA manufactures and distributes products that meet the vast range of EMC and wireless telecommunication standards:

- RF Power Amplifiers, 1 – 50,000 watts, dc – 1 GHz
- Microwave Amplifiers, 1 – 10,000 watts, 0.8 – 45 GHz
- Hybrid Power Modules, 1-6 & 4 – 18 GHz and custom design
- RF Conducted Immunity Test Systems
- Electromagnetic Safety Products
- Radiated Immunity Test Systems
- EMC Test Software, accessories and RF Test accessories

Visit www.arworld.us for more about the product offerings of all AR companies.

Website: www.arworld.us

Booth 734

Manufacturer
Antennas & Antenna Products
Conductive Materials
Shielding Products & Materials
Test/Certification

ARC Technologies, Inc. offers a complete range of absorber products that provide solutions to the diverse RF and EMI problems facing today's military, aerospace, and commercial electronics design engineers. Whether a customer is facing these problems at 50 MHz or 110 GHz, nearfield or farfield, narrowband or broadband, the company has an absorber product or will develop an application-specific product to meet its requirements

Website: www.arc-tech.com

Booth 219

Manufacturer
Anechoic Chambers/Materials
Shielding Products & Materials

Controlled electromagnetic environments
DMAS is a supplier of high performance polystyrene microwave absorbers suited for (semi) anechoic chambers enabling our customers to make the difference. Our product range consists of both hybrid (EMC) and broadband (microwave) absorbers. DMAS polystyrene absorbers are sustainable, environmental friendly and fully compliant with REACH and ROHS.

Comtest Engineering supplies high performance anechoic chambers, reverberation chambers and RF shielded rooms. Comtest is a privately owned, second generation family business and was founded in 1985. We are a professional organization and recognized for quality and flexibility. Our high performance RF shielded doors, mode-stirrer systems and microwave absorbers have been internationally recognized as state of the art products.

The comprehensive turnkey EMC test chamber solutions we offer:

- Anechoic chambers
- Anechoic chamber upgrades
- Reverberation chambers
- RF shielded rooms & doors

Comtest skilled and experienced team is dedicated to satisfy your need to control the electromagnetic environment!

Website: www.comtest.eu

Booth 825

Communications & Power Industries/CPI is the world's leading producer of high power TWT amplifiers, with a proven track record of consistent performance, service and support. For EMC testing, CPI is the only manufacturer of both TWTs and amplifiers. CW and pulsed amplifiers are available from 1 to 95GHz, with power levels exceeding 2 kW. Meet the latest EMC standards with CPI TWT Amplifiers.

Website: www.cpii.com

Booth 412

Software Development/Products

CST is a world leader in computer simulation of radiated emissions and susceptibility. CST EMC STUDIO® is a specialized software package for analyzing EMC at both component and system level. The solvers and tools are built on from the mature technology of CST STUDIO SUITE and CST BOARDCHECK.

Website: www.cst.com

Booth 925

Manufacturer
Anechoic Chambers/Materials
Shielding Products & Materials

Cuming-Lehman Chambers, Inc. (CLCI) is a wholly owned subsidiary of Cuming Microwave, Inc. specializing in the design and construction of anechoic chambers and host facilities "tailor made" to fit your performance needs and personal preferences. Our highly skilled project managers provide CLCI with the capacity to be the total turnkey solution for all of your testing needs.

Products and Services: EMC as well as High Frequency anechoic chambers, host facilities, shielded rooms, doors and door repairs, filters, and Microwave Absorbers, dielectric materials, artificial dielectrics and radomes.

Website: www.cuminglehman.com

Booth 711

Manufacturer
Test & Measurement Equipment

Empower RF Systems is a leader in solid state, power amplifier solutions with frequency coverage up to 6 GHz. Our products utilize latest LDMOS and GaN device technologies and originate from an extensive library of "building block" designs with documented solutions ranging from basic function PA modules to complete, multifunction PA assemblies with embedded software and system controllers. Live demonstrations of industry leading, smallest size high power amplifiers will be underway throughout EMC & SI 2015. Visit us at Booth 711 and see for yourself - 20 to 1000 MHz, 1 kW PA in a 5U chassis and 500W in a 3U chassis, and a 1 to 3 GHz, 1 kW PA in a 5U chassis. The standard hardware and software architecture incorporated in these next generation platforms is truly unique.

Customer specific configurations are also a key element of this product portfolio - stop by to discuss your requirements.

Website: www.empowerrf.com

Booth 212

Manufacturer
Power Supplies
Test & Measurement Equipment
Testing/Certification
Training & Seminars

EM Test, a unit of AMETEK Compliance Test Solutions is a leading supplier of innovative Conducted Transient & RF Immunity, Power Anomaly, and Harmonics & Flicker test and measurement solutions worldwide.

Founded in 1987, EM Test is a gold-label supplier of choice serving customers in the Automotive, IEC, Military, Aerospace, Medical, Telecom, and Component testing industries.

Website: www.ametek-cts.com

Booth 402

Manufacturer
Power Supplies
Test & Measurement Equipment
Software Development/Products
Testing/Certification
Training & Seminars

ETS-Lindgren is an industry leader in the design, manufacture, and installation of systems and components for test and measurement. Our turnkey solutions are used worldwide for EMC/EMI/RFI/EMF/IEMI test and measurement applications as well as for medical, industrial, wireless, and governmental RF shielding requirements. Popular products include antennas; field probes, monitors, and positioners; RF and microwave absorber; shielded enclosures; and anechoic chambers, to name a few. Innovative software offered includes TILE!™ for automated EMC test lab management and EMQuest™ for fully automated 2-

2015 Exhibitor Profiles

and 3-D antenna pattern measurement. Services provided include calibration at our A2LA accredited calibration lab and wireless testing at our CTIA Authorized Test Lab (CATL). Educational offerings include courses on EMC Fundamentals, Wireless/OTA and MIL-STD-461F that feature classroom study and hands-on lab sessions.

Visit us in booth 402 to see our new products: the EMField™ Generator - a unique, integrated solution for radiated immunity testing including IEC/EN 61000-4-3; the EMCenter™ - a flexible platform that reduces system complexity and provides centralized control for making RF measurements; and DuraSorb™ polystyrene hybrid absorber – ideal for MIL-STD-461, ANSI C63.4, CISPR 16 and CISPR 25 test applications as well as for 3 and 5 meter range chambers.

Website: www.ets-lindgren.com

Exemplar Global

Booth 120

Associations Societies Committees
Testing / Certification

Exemplar Global is the world's largest non-profit accredited personnel certification body, offering a wide range of professional certifications, including iNARTE.

iNARTE, now a program of Exemplar Global, has certified qualified engineers and technicians for over 30 years. Current certification fields include Telecommunications, Electromagnetic Compatibility/Interference (EMC/EMI), Product Safety (PS), Electrostatic Discharge control (ESD) and Wireless Systems Installation. More than 16,000 engineers and technicians have met iNARTE's certification requirements of education, training, experience, peer references and examination.

Website: www.narte.org

Fair-Rite Products Corp. Your Signal Solution

Booth 742

Manufacturer
Antennas & Antenna Products
Ferrite/Suppression Products
Shielding Products & Materials

Fair-Rite Products Corporation

. manufactures a comprehensive line of ferrite components in a wide range of materials and geometries for EMI Suppression, Power Applications, and Antenna/RFID Applications. Fair-Rite is the first U.S. soft ferrite manufacturer to receive ISO/TS 16949:2002 certification. We place the highest value on quality, engineering, and service and are dedicated to continual improvement. In addition to our standard product offering, Fair-Rite can provide custom designs and shapes to meet your specific requirements. We have an experienced team of engineers to assist you with new design and technical support. Please visit fair-rite.com to view our new online catalog and find contact information for customer service, applications engineers, local sales representatives, and local distributors.

Website: www.fair-rite.com

FCC®

Booth 110

Manufacturer

Fischer Custom Communications, Inc. is the leading designer and manufacturer of

- Current Monitor Probes
- Bulk Current Injection Probes
- LISN's
- CDN's
- EM Injection Clamps
- TLISN's
- TEM Cells
- CMAD's
- Telecom Surge CDN's

Our calibration laboratory is accredited to ISO/IEC 17025:2005 by A2LA

Web site: www.fischercc.com

HAEFELY TECHNOLOGY EMC

Booth 724

Manufacturer
Test & Measurement Equipment

As a leader in the field of EMC, **HAEFELY HIPOTRONICS** has a full range of conducted immunity test equipment designed to simulate the effects of interference sources on electronic, electrical and telecommunications products. Most prevalent and included in both IEC and EN product standards are the "classic" EMC tests for electrostatic discharge (ESD), electric fast transient/burst (EFT), lightning surge, magnetic fields (MF), and power line quality. Our objective is to provide the best-in-class range of instruments that are flexible enough to be used in many applications including CE Marking, product development, type verification, product safety, component and production testing for IEC, EN, IEEE, ANSI, UL, and other standards.

Website: www.hipotronics.com

HV TECHNOLOGIES, Inc.

Booth 602

Manufacturer
Test & Measurement Equipment

HV TECHNOLOGIES, Inc. (HVT), with our partners: EMC Partner, Prana, Gauss, Montena, Innco Systems, Siepel, and Pontis EMC are focused on providing our clients with top quality, full compliant EMC test instruments. Our staff has been supporting the EMC testing community by designing, producing, and distributing the best in EMC test instruments for over two decades. We cover all aspects of EMC testing for immunity and emissions. When using our products, customers experience the most reliable test instruments with the cleanest most repeatable measurements. This has been possible through innovative product design and the deployment of unique leading-edge technologies. The highest level of support is our main focus and part of every product. Offering Equipment: ESD, Surge, EFT, Lightning, EMI Receivers, Class A amplifiers, Reverberation and Anechoic Chambers, Turntables, Antenna Masts, Hardened Camera EMC Systems, Antennas, EMP Systems… We have the products, delivery, and support you need today and for years to come.

Website: www.hvtechnologies.com

INCOMPLIANCE Magazine

Booth 624

Publisher
Training & Seminars

In Compliance is a leading source for news, information, and resources for electrical engineering professionals. We deliver coverage on the latest standards updates, global compliance news, and engineering developments as well as technical explanations & guidance to over 17,000 electrical engineering professionals worldwide. Discover the latest design practices and testing tips, stay current with important updates, learn fundamental concepts, explore current events, and more!

Visit incompliancemag.com to start exploring and to activate your free subscription.

Website: www.incompliancemag.com

KEYSIGHT TECHNOLOGIES

Booth 618

Manufacturer
Test & Measurement Equipment

Keysight Technologies (formerly Agilent Technologies EMG) is advancing at a rapid pace and EMC testing is necessary to the success of this progress. No longer are the boundaries of EMC testing relegated to open area test sites, C30 laboratories and text books; they are becoming part of our daily lives. Join us in booth 323 along with industry peers to understand how Keysight's design and test solutions contribute to the progress.

Agilent's Electronics Measurement Group is now known as Keysight Technologies, Inc. Currently a wholly owned subsidiary of Agilent Technologies,

Website: www.keysight.com

OPHIR RF

Booth 610

Manufacturer
Test and Measurement Equipment
Product Safety Compliance Equipment
Antennas and Antenna Products

Designer and Manufacturer of High Power, Solid State RF and Microwave Amplifier modules, systems and integrated solutions

Website: www.ophirrf.com

PANASHIELD
A BRADEN SHIELDING SYSTEMS COMPANY

Booth 708

Manufacturer
Anechoic Chambers/Materials
Shielding Products & Materials

Panashield, A Braden Shielding Systems Company, provides EMC facilities servicing commercial and government clients. Our products and services include RF Shielded Enclosures and EMC Chambers for radiated emissions and immunity testing, wireless, antenna measurement, automotive, military and aerospace. For 25 years we have been committed to providing our clients with expertise reflecting current developments and specifications in the global electromagnetic compliance industry.

Website: www.panashield.com

Pearson ELECTRONICS

Booth 9

Manufacturer
Test & Measurement Equipment

Pearson Electronics, Inc. manufacturers Precision Wide Band Current Probes used for accurate measurements of EMI, surge, lightning, pulse and other complex current wave shapes. New from Pearson Electronics is the Powerline Ripple Detector which greatly simplifies the measurement of injected ac ripple on an ac power bus required in MIL-STD-461 CS101.

Website: www.pearsonelectronics.com

RIGOL Beyond Measure

Booth 717

Manufacturer

Rigol Technologies USA is transforming the Test and Measurement Industry. Our premium line of products includes Digital and Mixed Signal Oscilloscopes, Spectrum Analyzers and RF Signal Generators, Arbitrary Waveform Generators, Sensitive Measurement Products and Data Acquisition Systems.

Our test solutions combine uncompromised product performance, quality, and advanced product features; all delivered at extremely attractive price points. This combination provides our customers with unprecedented value for their investment, reduces their overall cost of test, and helps speed time to completion of their designs or projects.

Rigol's Headquarters is in Beijing China with a new state of the art R&D and Production Facility in Suzhou. Rigol has two International subsidiaries located in Beaverton, OR, United States and Munich, Germany. Some 400 employees are serving our customers in more than 60 countries and regions worldwide.

Website: www.rigolna.com

2015 Exhibitor Profiles

ROHDE&SCHWARZ

Booth 102

Manufacturer
Antennas & Antenna Products
Test & Measurement Equipment
Software Development/Products

For more than 80 years, **Rohde & Schwarz** has stood for quality, precision and innovation and is one of the world's largest manufacturers of electronic test & measurement, communications and broadcasting equipment.

Rohde & Schwarz offers a broad range of EMC, EMI, EMS and EMF test equipment for pre-compliance and full compliance measurements, providing accurate results across a wide frequency range. Rohde & Schwarz also provides customers with complete turnkey systems, significantly enhancing productivity and product performance by enabling precise results when measuring complex waveforms.

For more information, visit www.rohde-schwarz.us/en/products/test_and_measurement/emc_field_strength/products.

Website: www.rohde-schwarz.us

SCHLEGEL electronic materials

a member of eMEI Group

Booth 519

Manufacturer
Conductive Materials
Shielding Products & Materials

Schlegel Electronic Materials (SEM) invented highly conductive fabric over foam shielding gaskets in 1987, marking a major breakthrough for the electromagnetic interference shielding of electronic enclosures and has become the pre-eminent manufacturer of electromagnetic interference (EMI) shielding products.

SEM offers a full range of EMI shielding products including gaskets, I/O backplane shielding gaskets, Conductive Tapes, DYNASHEAR, DYNAGREEN, Greenshield, (Halogen Free line) Conductive FR Foams, Elastomers, EPDM Hybrid gaskets, SHIELDED CANS, ORS-II for ETHERNET applications, Transformers and Be Cu Finger stock. These enable the computer, telecommunications, military and medical, and Electronics Industries to meet global requirements for electromagnetic compatibility (EMC). NOW you can get your THERMAL INTERFACE MATERIALS through Schlegel EMI!!!

The company's world-renowned EMI shielding gaskets are available in hundreds of profiles and unique designs, with attachment options that include mechanical self-attaching, clip, rivet, and a variety of pressure-sensitive adhesives.

Website: www.schlegelemi.com

SCHURTER ELECTRONIC COMPONENTS

Booth 712

Manufacturer
Cords / Cord Sets
Connectors
Ferrite / Suppression Products
Filters
Passive Electronic Components
Product Safety Compliance Equipment
Shielding Products & Materials
Test & Measurement Equipment
Testing / Certification

SCHURTER continues to be a leading partner of the electronics and electrical industries for passive and electromechanical components such as: fuses, circuit breakers, connectors, EMC products and input systems. Our products ensure clean and safe supply of power, as well as ease of use. Our EMC capabilities and expertise ensure that we provide products and services that prevent appliances from interfering with one another through unwanted electrical or electromagnetic effects. EMC products include power entry modules with filters, single phase block filters, 3-phase block filters, DC filters, suppression chokes, pulse transformers and EMC services.

Website: www.schurterinc.com

Spira

Booth 220

Manufacturer

Spira Manufacturing Corporation has been serving the EMC community with quality engineered EMI/RFI shielding products for over **35 years**! We are AS9100/ISO-9001 certified and offer the finest most reliable EMI/RFI shielding gaskets in the market. Spira's strength lies in our exceptional products, on-time delivery, superior customer service, and technical support.

Spira's patented EMI/RFI and environmental gaskets offer excellent solutions for both cost-sensitive and high-performance applications. The unique spiral design offers extremely low compression set, long life and high shielding. Gaskets available in: groove or surface mount, EMI and Environmental protection, Honeycomb Filters, Connector-Seal Gaskets, O-Rings, Die-Cut Gaskets, and custom configurations.

Our shielded honeycomb filters offer the performance of a welded panel at the price of aluminum. Flexi-Shield is soft, durable and offers a rain/wind/dust seal like elastomers.

Our new Connector-Seal gaskets provide the best EMI & Environmental seal on the market! Visit our website for more info, free samples and an EMI Educational seminar.

Website: www.spira-emc.com

AMETEK COMPLIANCE TEST SOLUTIONS / TESEQ

Advanced Test Solutions for EMC

Booth 212

Manufacturer
Antennas & Antenna Products
Power Supplies
Test & Measurement Equipment
Software Development/Products
Testing/Certification
Training & Seminars

Teseq Inc., a unit of AMETEK Compliance Test Solutions, offers the world's most comprehensive range of EMC systems for immunity and emissions testing. This includes the Milmega and IFI RF amplifiers.

We take great pride in our world-class research and development program, backed by state-of-the-art global manufacturing. Teseq Inc. is the only pulsed immunity manufacturer in North America with an ISO 17025 accredited calibration lab.

Website: www.ametek-cts.com

2015 Exhibitor Show Stoppers

A.H. Systems, Inc.

Booth 419

Stop by and say Hi!

Find out the latest information about our antenna manufacturing and testing services. We manufacture a complete line of affordable, reliable, individually calibrated EMC Test Antennas and Current Probes that satisfy FCC, MIL-STD, VDE, IEC, and SAE testing standards. Delivering high quality products at competitive prices with immediate shipment plus prompt technical support for the entire product line are goals we strive to achieve at A.H. Systems.

We really take pride in providing a fast turn around schedule to help minimize any down time you may experience during testing.

We stock over 95% of our inventory, and provide NEXT-DAY ON-TIME DELIVERY.

At our facility, we calibrate most other brand antennas, as well as our own antennas in accordance with SAE, ANSI, IEEE, and CISPR specifications.

We have the solution to your EMC testing requirements. Looking forward to seeing you at our booth 419.

Advanced Test Equipment Rentals (ATEC)

Booth 502

Largest selection of EMC test equipment you can rely on, in-stock and available, with friendly and knowledgeable service you can trust. Advanced Test Equipment Rentals is A2LA ISO 17025 certified for calibration and specializes in the application of transient immunity for surge, EFT/burst, ring wave, dips and interrupts, harmonics and flicker, and ESD. ATEC supplies complete testing solutions for EMC applications in military/defense, telecom, commercial CE, aerospace, and automotive markets. No other rental company has the breadth and depth of our inventory and the expertise to match your test needs with the right equipment.

- IEC 61000
- MIL-STD-461
- DO160 Sect 22
- Automotive ISO 7637
- Telcordia GR-1089
- Medical IEC60601-1-2
- DO160 HIRF
- Indirect Lightning Strike
- Harmonics & Flicker
- and many more…

You can depend on ATEC's knowledge and expertise for your EMC test equipment needs, as do the many accredited EMC test labs in North America. ATEC is the official EMC test equipment supplier for technical sessions at EMCSI 2015. Also, visit ATEC at booth #502.

Order now! (800) 404-ATEC (2832) or www.atecorp.com .

AE Techron, Inc.

Booth 420

COME GET YOUR FREE BOWL-A-RAMA TICKETS

After the huge success last year, we are looking forward to our new Bowl-A-Rama event, with good company and good times for all! Stop by our booth to get your free ticket for this fun event.

3110 UNIVERSAL SIGNAL SOURCE

You'll also have the chance to try out our 3110 Controller, a part of our line of radiated and conducted test solutions. The 3110 is a universal audio bandwidth signal source; it comes preprogrammed with the waveform or pulse sequences needed for DO 160 Section 18 and 19, Boeing, Airbus, MIL STD 461 CS101 and CS109, ISO 11452-10, CS 2009.1 and more.

The 3110 also has an Arbitrary Standards creator, able to produce uSecond bursts or multiple segment waveform sequences lasting hours. Please come by and see how easy it is to create your own standard.

7224 AUDIO BANDWIDTH STANDARD AMPLIFIER

Don't forget to check out the AE Techron 7224 amplifier, a DC to 300 kHz solution that is recognized by Ford for EMC-CS-2009 testing. The 7224 can provide continuous DC at 13.5 volts while simultaneously producing high-frequency AC in excess of 200 kHz—all within a 2U package that weighs just 41 lbs!

At AE Techron, we have over 20 years of experience developing amplifier and power conversion solutions for the toughest of problems in the audio bandwidth. Stop by and see what solutions we have for you!

AR RF/Microwave Instrumentation

Booth 202

Stop by booth #202 for free demo's of some exciting new products.

Many view this event as a show of EMC test equipment, but for AR it is about innovation. See our MultiStar line of products including our DSP EMI Receiver, Multitone Tester, and Field Analyzers. These products feature amazing speed and incredible accuracy and save you time and money. We've also introduced a line of .7 to 6 GHz single band Class A and Class AB amplifiers for EMC and wireless applications with output powers exceeding 200 watts. Setting us apart is our quest for higher and higher output powers up to 50,000 watts at the lower RF frequencies, 4000 watts from 80-1000 MHz, 3000 watts from 1-2.5 GHz and 1200 watts from .7-4.2 GHz. In additional we have developed new dual band solid-state Class A amplifiers that cover.7 -18 GHz in one package. Not stopping there, AR is introducing a new line of electromagnetic safety monitors and sensors for numerous applications.

While you're in the booth, ask about our new partnership with MVG EMC for supplying EMC turnkey solutions.

Don't forget to test your AR knowledge and be entered into our daily prize drawings. There are 3 chances to win each day!

Comtest Engineering/ DMAS

Booth 219

Controlled Electromagnetic Environments

DMAS is a supplier of high performance polystyrene microwave absorbers suited for (semi) anechoic chambers enabling our customers to make the difference. Our product range consists of both hybrid (EMC) and broadband (microwave) absorbers. DMAS polystyrene absorbers are sustainable, environmental friendly and fully compliant with REACH and ROHS.

Comtest Engineering supplies high performance anechoic chambers, reverberation chambers and RF shielded rooms. Comtest is a privately owned, second generation family business and was founded in 1985. We are a professional organization and recognized for quality and flexibility. Our high performance RF shielded doors, mode-stirrer systems and microwave absorbers have been internationally recognized as state of the art products.

The comprehensive turnkey EMC test chamber solutions we offer:

- Anechoic chambers
- Anechoic chamber upgrades
- Reverberation chambers
- RF shielded rooms & doors

Comtest skilled and experienced team is dedicated to satisfy your need to control the electromagnetic environment!

Comtest Engineering
www.comtest.eu
info@comtest.eu

DMAS
www.dmas.eu
info@dmas.eu

CST of America, Inc.

Booth 412

CST will be presenting the latest developments of CST STUDIO SUITE® 2015 at booth #412.

The sooner potential EMI and EMC issues are discovered, the easier it can be to mitigate them. By simulating the behavior of virtual prototypes using CST STUDIO SUITE, engineers can model emissions and susceptibility even before constructing a physical device. Signal traces, cable harnesses, connectors, vents and seams can all potentially give rise to EMC/ EMI problems. CST STUDIO SUITE includes both specialized solvers and general purpose full-wave solvers for simulating a wide range of structures to efficiently.

Many EMC/EMI issues arise from the interaction between several components in a system. For example, fields can couple from a package to a heatsink, and then radiate from the heatsink and out through seams in the enclosure. Complex coupling paths such as these can often be simulated most efficiently by combining several methods. CST's System Assembly and Modeling (SAM) framework allows multiple solvers can be combined for a hybrid simulation, while bi-directional transient co-simulation allows complex cables and cable harnesses to be implemented in a 3D model.

Visit the CST booth to learn more about the latest tools for EMC simulation in CST STUDIO SUITE 2015.

2015 Exhibitor Show Stoppers

Cuming-Lehman Chambers Inc.

Booth 925

Cuming-Lehman Chamber Incorporated (C-LCI) specializes in the design and construction of anechoic chambers and host facilities tailor made to fit your performance needs and personal preferences. Our experienced staff and highly skilled project managers provide C-LCI with the capacity to be the total turnkey solution for all of your testing needs.

From the formulation of an advanced material in our laboratory to the construction of a host facility in the field, we are the world's leading authority on the development of technology and products for the RFI/EMI Absorber, Radar Cross Section Reduction and Anechoic Chamber markets.

Core Capabilities

- 3M, 5M, 10M EMC; MIL STD; Compact Ranges; Near Field; Antenna Measurement Chambers
- Shielded Enclosures, (welded, modular or "stick built" construction).
- Retrofits & Relocations
- Refurbishments and relocations
- Large Shielded Doors
- Turntables, Antenna Masts, Controllers
- Specialty Boxes
- Microwave absorbers
- Host facilities (Certified Star Building Systems)
- CCTV's & Intercom Systems
- Ramps, Ladders, Lifts, Platforms & Cranes
- Lighting – LED, Fiber Optic
- Filters
- HVAC Systems
- Fire Detection / Protection Systems
- Antenna Mounts
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Keysight Technologies

Booth 618

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Booth 610

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Booth 212

Come visit our booth to see Teseq's new products and powerful amplifiers from IFI and MILMEGA. Check out the new MILMEGA AS0104-800/400, developed for automotive radar pulse testing. This amplifier can produce its full rated power CW and allows calibration with a standard field probe and testing by substitution without any scaling. This unique amplifier features low harmonics even at saturation; and because testing is done at the same power level as the calibration, it can still be used to test at saturation. The AS0104-800/400 also covers the full range from 1 to 4GHz and can therefore be used for more general testing and not just the radar pulse.

For the first time in the US, EM Test is displaying its new product highlights alongside its sister brands like the new PFM 200N100 for dropout testing to car manufacturer specifications.

Serving the global EMC community, with test equipment, test systems as well as end-to-end solutions, especially for fast-evolving technology sectors that demand rapid, reliable results in compliance with current standards, Teseq's test systems are guaranteed to be standards compliant. Its systems accelerate product development as well as deliver immediate and reliable results.

Our user-friendly application software enables the use of convenience features that enhance efficiency and provide low-cost and customized solutions. The company also offers a worldwide network of experts to provide customers with rapid responses and effective communication. Together, under AMETEK Compliance Test Solutions (CTS), we now operate nine internationally recognized accredited calibration laboratories for calibration services around the globe.

TECHNICALLY Speaking

The Pitfalls of Pass/Fail Testing

Product Safety Newsletter - January/February 1990

BY RICHARD NUTE

You're at your desk when the phone rings. It's one of your production lines; they're having failures with a part or a test that is critical to the safety of the product. They've shut down the line. You drop everything, and head to the line to investigate.

As you walk to the line, your mind is filled with both questions and hope.

What are you going to do when you get there? Will you be able to get the line back up and running? Is it a true failure, or did they make a mistake? You hope it's a mistake, or interpretation error. Or, maybe it's not a problem at all; you hope they're being overzealous and over-cautious. And, you hope that whatever it is, they've caught them all before they've been shipped to the field so that you don't have to consider a product recall.

The first thing you want to do is to see the failure for yourself. This will answer all your questions. You hope. If it is a true failure, you hope the cause is obvious and the fix is easy.

Already, you feel the pressure. You've been here before; if you can't fix it in a few minutes, the manufacturing manager will have you and a bunch of others in his office. They'll be looking to you for instructions as to how to proceed. And, they'll want those instructions fast!

The pressure is on! You've gotta find the root cause, and fast! Once you've identified the root cause, the pressure is off you and onto the manufacturing folks who will deal with the problem. So, you're hoping this will be easy.

Here's one scenario:

When you get to the line, they show you damage to the power cord jacket adjacent to the strain-relief mechanism. It's a strange mark, neither a cut nor a bum, but something of a cross between the two.

Is the damage acceptable or not?

You decide a pull-strength test is probably appropriate. So, you apply 35 pounds. At about 30 seconds, the jacket separates.

Clearly not acceptable. You do have a problem.

You look at other units. Some have damage, some don't. The ones that have damage are not uniform. The damage varies from barely discernible to quite extensive. Now you're faced with the question: How bad is bad?

This should be easy: Test a number of units at 35 pounds for one minute. Then, relate the degree of damage to breakage.

But, it doesn't work. Some severely damaged units which should have broken do not break! What is going on here? The problem seems to have shifted from one which should have been easy, to one which seems to have no bounds. How are you going to get control of this situation?

Here's another scene:

When you get to the line, they explain that about half of the units are failing the hi-pot test.

You check the hi-pot tester and find that it's both calibrated and working properly. You watch the operator do the test and, again everything is okay. The units are truly failing the hi-pot test: You do have a problem.

It only takes a few minutes more to isolate the particu1ar part in the primary circuit that is the culprit. Let's say, for discussion, the part is a fan motor. And, it is certified by several certification houses. So, you know that the fan was successfully hi-pot tested as a part of the fan manufacturer's production process.

Why do some of the fans, all of which passed the manufacturer's hi-pot test, fail our hi-pot test? What is going on here? The problem should have been easy, but some are okay, and some are not. How are you going to get control of this situation?

Let's step out of the woods, and look at the forest from afar. What is common to these two scenarios?

In both scenarios, we are dealing with some units failing, and some units passing a requirement specified in a third party test standard. The test process is pass-fail; tested units, by definition, must fit in one category or the other.

Often, our thinking is driven by the standards and by the pass-fail certification submittal process. We tend to think only in terms of pass-fail. So, when we appear at the production line, our concern is for the failed units, and not for the passed units. Pass-fail thinking and testing is appropriate and acceptable when qualifying a product to a standard. Pass-fail thinking and testing is an appropriate and acceptable process for a certification house. But, pass-fail testing is seldom appropriate and acceptable for the manufacturer. And, it doesn't work for problem solving.

Your objective is to find what is causing the failures, not to segregate the bad from the good.

The failed units are bad, but we don't necessarily know how bad. The passed units are good, but we don't know how good.

When we perform pass-fail testing, we don't measure the actual performance of each unit.

When we perform a pull test at 35 pounds, and the unit fails, we don't know the pull value that it will pass. When we perform a hi-pot test, and the unit fails, we may not note the voltage at which it failed.

More importantly, for a unit that passes, how good is it? If it passes a 35-pound pull test, will it pass a 50-pound pull test? If it passes a 1000-volt hi-pot, will it pass a 1500-volt hi-pot? If it passes 1500, will it pass 2000?

TECHNICALLY Speaking

Exactly how good is it? If we test to failure, we have a measure of the performance of the particular unit.

Are the units marginal, or is there a clear distinction between the units that measure above 35 pounds and the units that measure below 35 pounds? Is there a clear distinction between the units that measure above 1000 volts hi-pot and the units that measure below 1000 volts hi-pot?

The answer to this question quickly narrows the scope of the problem. Here's an example:

If, in investigating the power cord jacket damage, we pull the power cord to failure, we learn that some cords, regardless of the extent of jacket damage, fail at or around the ultimate strain-relief strength of 125 to 150 pounds. Others, depending on the extent of jacket damage, fail between 30 and 50 pounds. We examine the measurement data and note that only one brand of cord fails as a function of jacket damage.

Presto! The scope of the problem is now defined, and the issue can be handed off to the manufacturing folks.

Imagine how many pass-fall tests would be necessary before you finally discovered that the problem occurs in only one brand!

Measuring the performance of a strain-relief mechanism on a number of production units need not sacrifice the unit; upon failure, the unit probably can be repaired at relatively little expense com¬pared to the time to understand and put bounds on the problem.

On the other hand, hi-pot testing to failure may be very expensive to repair. So, you may not want to subject a number of units to a test-to-failure. Let's look at some other techniques for investigating hi-pot failures. Remember, the objective is to find the root cause for the production-line hi-pot failure.

The hi-pot test tests insulations. It tests, simultaneously, both air and solid insulations -- which always exist in parallel, and often exist in series.

While some may argue, I believe it is seldom that solid insulation fails at potentials below about 2000 volts rms.

Since every construction employs air as insulation, when a hi-pot failure occurs, there is a good likelihood the breakdown is in air. (Note that, in the event a breakdown occurs across the surface of an insulator, the "thing" that breaks down is the air, the arc in the air at the surface of the insulator burns the insulator resulting in carbon tracks on the surface.)

The air that breaks down is likely that of a series "circuit" of air and solid insulation. The two insulations in series constitute two capacitors in series. The voltage across each insulation is inversely proportional to the value of the individual capacitances. Where the distance in the air portion of the series is very small (about 0.5 mm or less), the air is a candidate for breakdown during the hi-pot test.

One method of finding the hi-pot failure is to take the unit apart, one piece at a time. Each time you remove a part, you hi-pot that part by itself, and you repeat the hi-pot test on the remaining pans. These two tests will tell you when have removed the pan that caused the failure.

Okay. You've found that the hi-pot failure is occurring in the fan. But you don't stop there. You've got to find the particular insulation that is breaking down. You should continue taking things apart.

You're looking for about 0.5 mm in series with a thin, solid insulation. Maybe the magnet wire to rotor shaft, where the wire can be spaced a fraction of a millimeter from the metal shaft giving you the air-solid series construction.

You may get a low-energy arc through the air, from the shaft to the magnet wire. It may or may not trip your hi-pot tester, depending on how sensitive you've set the trip. The arc current is limited by the impedance of the capacitance of the solid insulation portion of the series-connected insulations.

The problem with either corona or the low-energy arc is the very high temperatures in the arc. The temperature is high enough to burn the solid insulation part of the two insulations. (In switches, the arc temperature during the opening process is high enough to melt the metal at the ends of the arc!)

You may not get a complete punch-through of the solid insulation because there isn't enough energy in the arc to burn all of the series solid insulation. However, with repeated testing, more of the solid insulation is burned away, the hole gets deeper, and successive hi-pot tests trip at lower and lower voltages. When the solid insulation finally has a carbon path all the way through, it is shorted out, and all that is left is the air. This now breaks down consistently at the same relatively low voltage compared to the initial breakdown. But, it doesn't go to zero because there is always some air between the two conductors.

Yet another technique is to use a high-voltage insulation resistance meter to find the fault as you take the fan apart. Some insulation resistance meters include a switch-selectable voltage source; you want one that goes to at least 1000 volts. The insulation resistance meter is a low-current, high voltage source that will make a small, continuous arc that doesn't do much damage. The meter tells you what's happening.

When I evaluate a prototype product, I like to measure the value required to break the unit rather than simply test for pass-fail. In this way, I know how weak or how strong the unit is. I also know what the weakest link is. Then, I take it out and test the remaining parts to failure, and again determine the weakest link.

Pull on the strain-relief until it fails. Run the hi-pot test voltage up until it fails. Increase the 25-amp ground continuity test until it fails. Pull on the handle until it breaks. Increase the impact test until the enclosure breaks.

Later, should a problem arise on the production line, I can guess at what might be the problem, and can quickly test for it. I either know what the problem part is likely to be, or I know what it is not likely to be.

Finding a problem with pass-fail testing requires lots and lots of testing and, consequently, a long time. Finding a problem by measuring the magnitude at which both "passed" and "failed" units fail only requires a few units and, consequently, a short time.

Pass-fail thinking and testing does not tell you how good or how bad, or how strong or how weak. If you don't know how good or how strong, then you don't know how close you are to failing. If you don't know how close you are to failing, then you run the risk of some units failing in production or, worse yet, in the field.

The "passed" ones often can tell you more than the "failed" ones---if you know what breaks, and what it takes to break it.

Measurement is the answer.

Run the unit to failure. Then, measure the magnitude of the force that causes failure. Now, you know how good, how bad, how strong, or how weak.

Pass-fail testing necessarily must be the kind of test in a standard. Pass-fail testing necessarily must be the process of a certification house. But, for you, every pass-fail test should be changed into one of measurement. When you make the measurement and get a value, the value proves whether you pass or fail. If you perform a pull test on a strain-relief and find that it fails at 125 pounds, you have proved that it passed the 35-pound test. If you fail a hi-pot test at 4100 volts, you have proved that it passed the 1500-volt test.

Don't just know your product passed the test; know how good your product is. It gives you power.

(the author)

RICHARD NUTE
is a product safety consultant engaged in safety design, safety manufacturing, safety certification, safety standards, and forensic investigations. Mr. Nute holds a B.S. in Physical Science from California State Polytechnic University in San Luis Obispo, California. He studied in the MBA curriculum at University of Oregon. He is a former Certified Fire and Explosions Investigator.

Mr. Nute is a Life Senior Member of the IEEE, a charter member of the Product Safety Engineering Society (PSES), and a Director of the IEEE PSES Board of Directors. He was technical program chairman of the first 5 PSES annual Symposia and has been a technical presenter at every Symposium. Mr. Nute's goal as an IEEE PSES Director is to change the product safety environment from being standards-driven to being engineering-driven; to enable the engineering community to design and manufacture a safe product without having to use a product safety standard; to establish safety engineering as a required course within the electrical engineering curricula.

EMC Education

The View from the Chalkboard

BY MARK STEFFKA

This month's edition can best be titled "If I knew then what I know now"! Normally I use this space to present topics that I feel are important items in EMC education. This past semester was interesting because a number of students in my undergraduate EMC course shared with me their thoughts on why they felt having a background in EMC would be beneficial to them in their future careers.

I also know that many of you have had opportunities to attend various EMC symposiums and conferences over the years and/or have been a participant at some the EMC education (single or multiday) events that are held. Perhaps you attended some of those because were new to EMC, or maybe were looking for those one or two items that could help you with an immediate challenge you had in your work. Some of the comments I have received include how helpful it is to know the characteristics "real" components and how those characteristics may cause unanticipated and undesired effects, how and why wiring can (unknowingly) become effective antennas, and what are the causes and effects of common mode current.

Because of the feedback from my students, and knowing that you may have similar thoughts after attending an EMC event, I thought that I would provide YOU an opportunity to tell me what you think is important and what you would like see in EMC educational opportunities.

So – I would like to know how you think those of us in EMC education can meet your needs for the types of information on topics that are most relevant to you. We have prepared some "thought starter" questions here – and welcome your additional comments and requests. (Specifically, if you have specific ideas for upcoming "View from The Chalkboard" topics – let me know that, too!)

To help you provide this information to me, I would like to ask if you would complete a short on-line survey with your thoughts and comments (the survey is located at: www.incompliancemag.com/chalkboard).

So, if you would, please think about the following and then let me know your thoughts on:

- What do you wish you would have been taught about EMC during your formal academic schooling?
- What is / are the MOST important thing(s) about EMC that you have learned "on the job" that you think should be included in every formal EMC course or educational event?
- What advice do you have for a person who is new to EMC?
- What was best engineering related professional development event you've ever attended (EMC related or other), and why was it the best?

Looking forward to your suggestions, thoughts, and comments!

(the authors)

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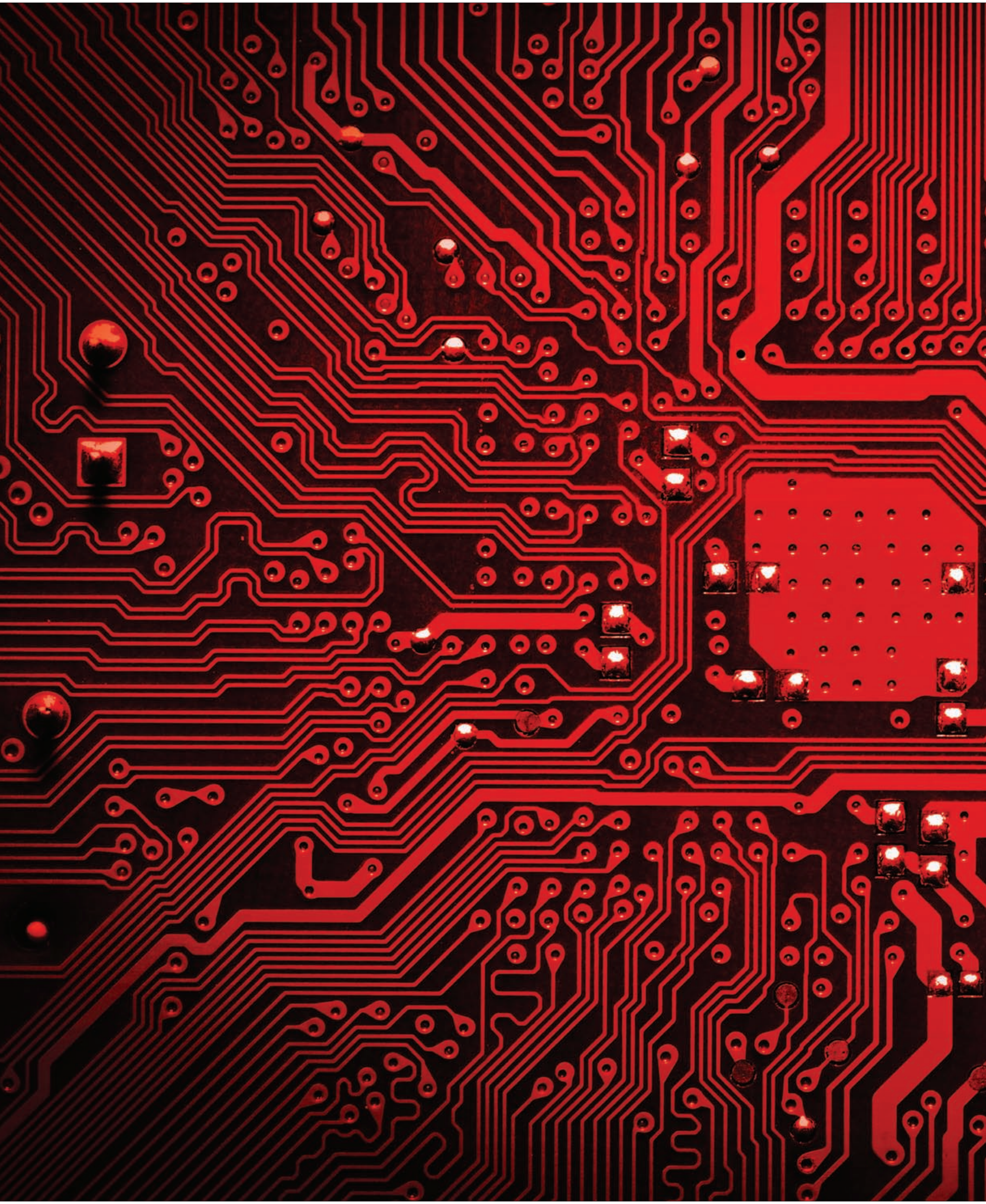
Mr. Steffka is the author and/or co-author of numerous technical papers and publications on EMC presented at various Institute of Electrical and Electronics Engineers (IEEE) and Society of Automotive Engineers (SAE) conferences. He has also written about and has been an invited conference speaker on topics related to effective methods in university engineering education. He is an IEEE member, has served as a technical session chair for SAE and IEEE conferences and has served as an IEEE EMC Society Distinguished Lecturer. He holds a radio communications license issued by the United States' Federal Communication Commission (FCC) and holds the call sign WW8MS. He may be reached at msteffka@umich.edu.



EMI and Signal Integrity

How to Address Both in PCB Design

BY WILLIAM D. KIMMEL, PE AND DARYL D. GERKE, PE

Let's do a comparison of EMI (electromagnetic interference) design and signal integrity. EMI focuses on the associated specifications and testing requirements and interference between neighboring equipment. Signal integrity addresses the degradation of signal quality to the point where erroneous results occur. But the overlap in design techniques at the board level is considerable. Note that the IEEE EMC Society has a subcommittee devoted to signal and power integrity.

We consider signal integrity to be EMI at the circuit board level. Our experience is that a circuit board that is well designed for signal integrity is generally pretty good for EMC as well. Let's take a closer look at these issues, and see where they differ and where they overlap.

DIFFERENT FOCUS, SIMILAR TECHNIQUES

With signal integrity, the focus is on printed circuit board and associated interconnections between circuit boards. The objective is clean signals along with adequate operating margins (timing, supply voltage, and environmental variations). This has become a major factor with the increasing serial I/O speeds, headed to 100 GHz. The key concerns are signal reflections, crosstalk, ground bounce and power decoupling. The solutions are careful circuit layout and attention to timing. The interference levels of interest are millivolts and milliamps.

EMC focuses on the entire system, including printed circuit boards, enclosures and cables and power supply. The objective is to pass relevant EMC test requirements and to make sure it works in its intended application. The key concerns are emissions, immunity, and mutual compatibility of equipment, including digital and analog circuits, motor controls, relays, etc. The remedial solutions are careful circuit layout, grounding and shielding, filters and transient protection. The relevant signal levels are microvolts and microamps for emissions, and kilovolts and amps for immunity.

The common area is at the circuit board and local interconnect area. Even here, there are some clearly different aspects of interest. First, note that the key signal levels of concern are very different. For signal integrity, the key factor is to keep noise levels substantially below the signal levels, so our noise margins are in the millivolt range for digital circuits. But, for EMI, emission levels must be kept in the microvolt and microamp range, typically three orders of magnitude lower than acceptable internal noise levels. For immunity, external levels may well be in the kilovolt and amp range, again, orders of magnitude higher than logic levels and analog circuit levels.

This means that parameters entirely acceptable with signal integrity can be grossly higher than that needed for emissions and grossly lower than needed for immunity.

Parasitic coupling paths are more critical for EMI, but signal losses are more critical for signal integrity.

Let's see how these factors affect board design.

GROUND IMPEDANCE

Ground impedance is at the root of virtually all signal integrity and EMI problems; low ground impedance is mandatory for both. This is readily achieved with a continuous ground plane, and exceedingly difficult with traces, as would be used in a two layer board. We'll deal with multilayer boards, where it is feasible to implement a ground plane.

Ground impedance is an important issue for both signal integrity and especially for high frequency emissions in EMI. A ground plane serves well as a signal return, provided the ground is continuous under the signal path. But, even with a continuous return path, there will be enough voltage drop across ground to generate a common mode voltage. This is not significant for signal integrity, but is the primary cause of common mode voltages which, left unchecked, will escape as an EMI emitter via the signal or power ground conductor.

Here, we note that common mode currents are purely parasitic. They contribute nothing to the desired signal but can be difficult to block as EMI emitters. Differential mode currents are the normal signal path, and are more of an issue with signal integrity than with EMI. These considerations are driven by the loop area; inductive impedance of the signal/return loop is proportional to the loop area, as is the antenna efficiency (a consideration for radiated emissions and immunity). But signal/ground loop areas on a multilayer circuit board are small, providing the return path in ground is continuous, and is usually not a problem with EMI.

Copper thickness is not an important factor. At high frequencies, skin effect dominates, so currents are squeezed to the surface, rendering extra thickness irrelevant.

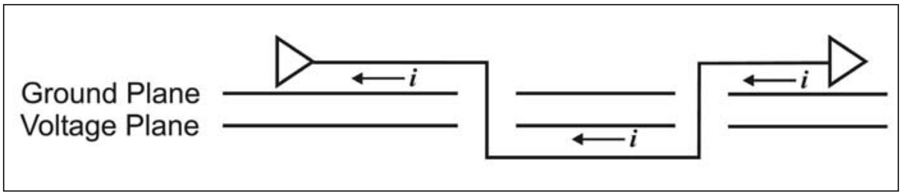


Figure 1: Return current path is discontinuous when switching reference planes

In fact, the principal problem with ground impedance is the discontinuities that occur in the signal return path, and that has major impact on characteristic impedance control.

IMPEDANCE CONTROL

At higher frequencies, characteristic impedance control becomes necessary for signal integrity and, to a lesser extent, for EMI control. Now we are operating well into the GHz range, and impedance control requires meticulous care just to maintain signal integrity. For EMI, it is usually sufficient to minimize overshoot and undershoot, especially with signals leaving the circuit board.

The biggest problem with maintaining impedance control is the signal path discontinuities, including return path on ground plane:

1. The ideal signal path has a continuous copper plane immediately underneath. In such a case, impedance control is confined to proper terminations, usually at the load end. For slower signals, where EMI control is the predominant issue, source termination is often an appropriate choice, as it also limits the emission currents from leaving the driver chip. Source termination does slow the signal, which may not be acceptable for highest speeds.

2. The worst discontinuity occurs if the signal changes reference planes from a ground plane to a voltage plane, as illustrated in Figure 1. Clearly, ground to voltage vias can't used to provide a return path, so the only option is to insert decoupling capacitors at the perimeter in order to provide a low impedance high frequency return path across the boundary. Unfortunately, this is not a fully acceptable solution at high frequencies, but will be reasonably good for lower frequency signal paths.

3. A lesser discontinuity occurs if the signal is transitioning from one ground plane to another. Here, the return path from plane to plane must be made continuous and impedance control effected. Typically, this is handled by inserting ground to ground vias around the perimeter of the signal via, and controlling the keepout, pad size and via size and length in order to match impedances.

4. The least problem of layer changing occurs when the signal transitions from one side of the ground plane to the other (see Figure 2). Since we haven't changed reference planes, there is no issue with ground vias, so the impedance discontinuity is minimal.

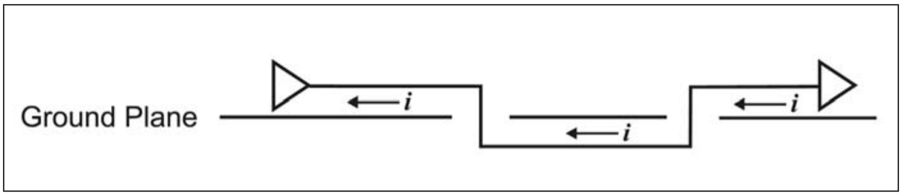
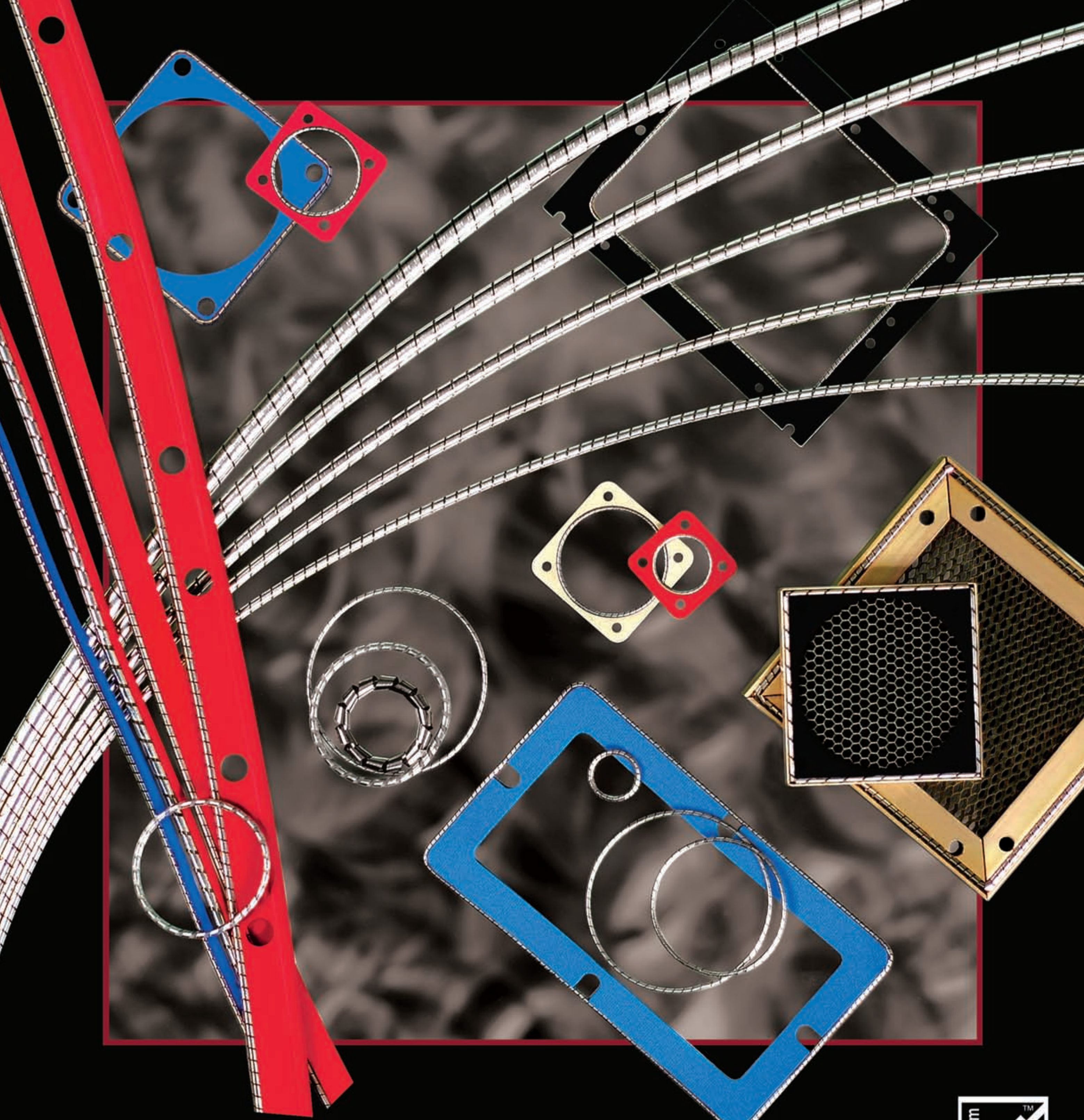


Figure 2: Return current past discontinuity is minimized when keeping same reference plane



For highest speed signal integrity, you will need to minimize the impedance discontinuity by controlling the via size and length, and the diameter of the keepout.

4. Cuts in plane, as shown in Figure 3, shows a discontinuity in the signal return current path. The return path has to go around the gap in the plane, raising the characteristic impedance at the gap, and energizing the opening as a slot antenna. This can occur when a portion of the plane is stolen to accommodate another trace, at a split plane boundary, or at a connector cutout.

5. Signal path at mandatory discontinuities. This assumes that impedance control needs to be maintained across the boundary. Most notably, this will occur at the circuit board to connector boundary (see Figure 4), and is especially noticeable when the impedance of the cable doesn't match the impedance at the circuit board. In such a case, an impedance matching network needs to be placed at the boundary. This is handled by controlling the copper parameters at the boundary. Larger cutouts increase inductance while leaving more copper at the boundary increases capacitance.

PCB LAYOUT

For both EMI and signal integrity, good layout starts by identifying critical traces. In both cases, most of the problems lie with a very few of the traces. You don't have the time or real estate to treat all the traces, so you concentrate on the few. But the critical traces are typically different for signal integrity and EMI.

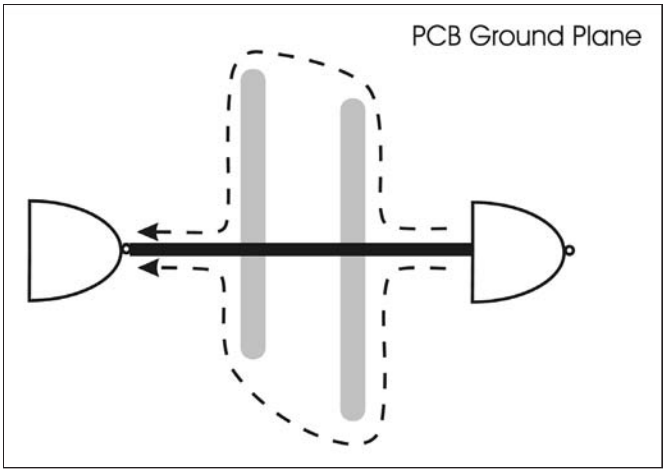


Figure 3: Signal return path is disrupted by cut in ground plane

For signal integrity, the problem is limited to the relatively few high speed signal traces. High speed serial data are the leader, and design will concentrate on the signal/return path and adjacent metallic members. For EMI, the problem concentrates on those lines entering or leaving the circuit board. The primary emitters are those that carry high speed clock and data lines, along with the parasitic coupling to slower lines, power lines and especially ground lines. The primary receptors are low level analog input lines for RFI and digital lines for transients.

Once these lines are identified, you can place the chips on board to facilitate good routing. The simpler the path for critical traces, the easier it is to maintain signal integrity and EMI control.

DECOUPLING

Starting with the supply voltages, the voltage tolerances are basically a signal integrity issue. This does not show up at the EMC level except to the extent that external interference corrupts voltage at the power supply or on-board regulators. The big difference lies with the demand for decoupling. Clock noise that shows up on the power rails and sneaks out the power cable will be an emission problem even if amplitudes are in the microvolt range, but won't be a problem for signal integrity until it reaches the millivolt range. So decoupling demands for EMI are a thousand times more demanding than for signal integrity.

The chip manufacturer recommends decoupling capacitors as needed for Vcc droop. This means that the target frequencies for signal decoupling are at the clock frequency and below, while the frequencies for emissions are at the clock harmonics, typically ten times the clock frequency or even higher.

Thus, the demands for decoupling for emissions are substantially higher than with signal integrity. This doesn't mean more capacitance, it means less inductance. At modern computer speeds, your high frequency harmonics are inevitably operating above the series resonant frequency of the typical decoupling capacitor. Just add one to two nanohenry of lead length in each decap and you will find that the impedance is too high for effective filtering. If the impedance is above one ohm, you should look for better

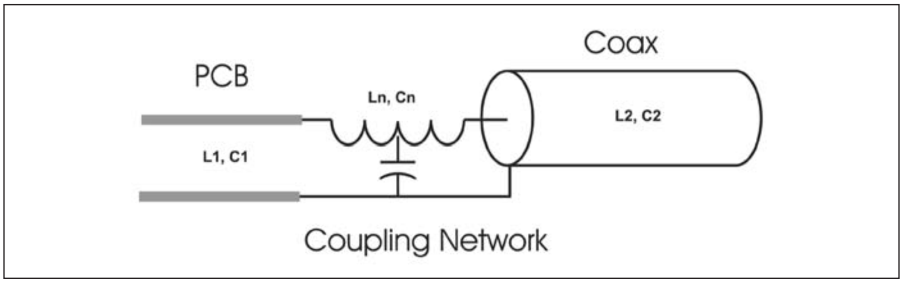


Figure 4: PCB to coax impedance matching

filtering, or more decaps in parallel. The good news is that at higher frequencies, the interlayer capacitance of multilayer boards becomes the dominant factor above a couple hundred MHz.

CROSSTALK

Crosstalk can be an issue for both signal integrity and EMI. Crosstalk is unintended coupling to adjacent metallic members, usually to an adjacent signal, power or ground path.

Crosstalk includes field coupling from one line to an adjacent line. It is a major issue with cables that will usually need to be addressed, but may also be a problem with adjacent trace coupling at the circuit board level. Any coupling from very high speed signal lines can degrade signal quality (we see signal speeds well into the GHz range, and we hear 100 GHz is just around the corner), whether to an adjacent trace or any other metallic element on the circuit board. For EMI, crosstalk becomes a problem with I/O lines coupling energy to/from clock lines or sensitive on-board lines. Often, this problem can be eliminated by separating these lines. The spacing in between need not be wasted, but can be used for less critical lines. In both cases, increased spacing is beneficial, as coupling falls off with the square of the distance.

OTHER SIGNAL PATH ISSUES

In addition to crosstalk, other losses may come into play, with series resistance and shunt dielectric loses being the major issue.

Signal path losses would include series resistance in the conductive path and shunt conductance in the dielectric. For the most part, these losses are not a problem at the circuit board level, unless you are using a high resistance signal path, such as conductive epoxy (which is rarely used). These losses become much more of a problem at the cable level, especially with signal integrity, where losses track directly with eye diagram shrinkage, to the point of signal failure. For EMI, the problem is a bit less noticeable. But obviously, if the signal strength is weakened, it takes less external interference to create data errors.

Imbalance is an extension of crosstalk, becoming increasingly significant for differential signals as serial data speeds increase. Balance loss will occur with unequal coupling paths, as mentioned above, and will also show up due to unequal propagation times from driver to receiver. This is much more of an issue with signal integrity than with EMI.

Coupling to off-board elements is primarily an EMI issue, where coupling between elements on adjacent circuit boards may be significant. A typical case is where clock noise from a high speed microprocessor chip capacitively couples to an adjacent circuit board, then propagates to the outside world from there. A similar situation occurs if an internal cable is routed too close to this same chip. This situation is increasingly being handled by on-board chip shielding. This problem rarely occurs with signal integrity issues.

ANALYTICAL SOFTWARE

Let's take a look at analytical software, clearly, a topic of significant interest. Any modeling that reduces hardware redesign effort is like money in the bank. So what is the status?

Our observation is the modeling for signal integrity is much more developed than for EMI. It is a much simpler task to model the signal path, with consideration limited to the signal path/return, plus coupling to adjacent metallic members. The EMI predictions are much more complex, as it involves consideration of many more circuit board coupling paths and common mode noise generation, both of which are difficult to identify, much less quantify. Additionally, calculations need to consider enclosure and cable shielding effectiveness, which involves identifying all the relevant parameters and quantifying them. In actuality, almost all of the modeling is directed at emissions. (We've seen almost nothing on modeling of immunity issues.) The bottom line is, consider yourself as doing well if your predictions are good within 20 dB, or a factor of 10. Well, that is better than nothing, but it still leaves a lot to be done by test and redesign.

SUMMARY

Signal integrity has become an increasingly important part of EMI design. Good circuit board design is very important in both cases, but the emphasis is different. Most notably, signal integrity is primarily concerned with the critical high speed signal lines, and EMC is primarily concerned with the lines entering the circuit board.

(the authors)

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CISPR 11: An Historical and Evolutionary Review

BY DANIEL D. HOOLIHAN

Editor's Note*—This article was originally published in 2010 in* In Compliance Magazine*, and has been updated to include recent progress on the development of Edition 6.0 of CISPR 11.*

CISPR is the International Special Committee on Radio Interference which was founded in 1934. The International Standard for electromagnetic emissions (disturbances) from industrial, scientific and medical (ISM) equipment is CISPR 11. The official title of the standard is "Industrial, Scientific, and Medical Equipment – Radio-Frequency Disturbance Characteristics – Limits and Methods of Measurement." The premiere edition of the standard was released in 1975 and the current edition (fifth edition) was released in 2009. The standard includes both limits and methods of measurement for conducted-emissions and radiated-phenomena. This article traces the history and development of the content of the standard over the last 40 years.

FIRST EDITION—1975

The title of the Premiere Edition was "Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific, and Medical (ISM) Radio-Frequency CISPR Subcommittee B (Interference from Industrial, Scientific, and Medical Apparatus)." It summarized the technical content of a number of CISPR publications, recommendations and reports over a period of eight years, from 1967 to 1975.

The frequency range covered by the first edition of the standard was 150 kHz to 18 GHz. The terminal voltage limits were quoted in millivolts and covered the frequency range 150 kHz to 30 MHz. Terminal voltage limits from the first edition are reproduced in Table 1.

The radiated limits were quoted in microvolts per meter for the frequency range 0.150 MHz to 1000 MHz. They were quoted at antenna-measurement distances of 30, 100, and 300 meters from the equipment or 30 meters or 100 meters from the boundary of the users' premises. Limits of radiation in microvolts/meter and decibels (uV/m)]

Frequency Range - MHz	Limits in mV for microwave ovens with RF power of 5 kW or less	Limits in mV for all other ISM equipment
0.15 – 0.20	2	3
0.20 – 0.50	2	2
0.50 – 5.0	1	1
5.0 – 30.0	2	1

Table 1: Terminal voltage limits, CISPR 11, First Edition (Table I)

from the first edition is recreated in Table 2.

There was a special limit for radiation from microwave equipment used for heating and medical purposes in the frequency range from 1-18 GHz; it was 57 dB above a picowatt effective radiated power (ERP), referred to a half-wave dipole.

Methods of measurement quoted CISPR Publications 1, 2, and 4 for quasi-peak measuring sets. Measurement of the radio-frequency voltage on supply mains (AC voltage lines) was conducted with a V-network with an intrinsic impedance of 150 ohms.

Magnetic field measurements are made with a balanced loop antenna below 30 MHz. For signals greater than 30 MHz, an "electric aerial" would be used as per CISPR Publications 2 and 4. The center of the "aerial" would be 3 meters above the ground.

Above 1 GHz, the "receiving aerial" was to be made with a directive aerial of small aperture capable of making separate measurements of the vertical and horizontal components of the radiated field. The height of the aerial had to be the same as the height of the approximate radiation center of the equipment under test.

SECOND EDITION—1990

The second edition of CISPR 11 was released in 1990, and it contained numerous changes from the original 1975 edition, as well as two amendments.

In this edition, ISM Equipment was divided into two groups and two classes. Group 1 equipment included all ISM equipment that used RF energy only for internal functioning of the equipment, while Group 2 equipment included ISM equipment used for external treatment of material and similar processes. Class A equipment is equipment suitable for use in all establishments other than domestic buildings, while Class B equipment is equipment suitable for use in domestic surroundings.

The frequency bands for conducted emissions were stated as covering 150 kHz to 30 MHz. The second edition included new separate limits for Class A and Class B equipment. The Class A equipment limits in dBuV are shown in Table 3.

The Class B equipment Limits in dBuV are shown in Table 4.

Frequency Range - MHz	On a Test Site, at a distance from the equipment of 30 m	On a Test Site, at a distance from the equipment of 100 m	Not on a Test Site, at a Distance of 30 m from the boundary of user's premises	Not on a Test Site, at a Distance of 100 m from the boundary of user's premises	Not on a Test Site, at a Distance of 300 m from the equipment
0.15 – 0.285	-	50 uV/m			
(34 dBuV/m)	-	50 uV/m			
(34 dBuV/m)	-				
0.285 – 0.49	-	250 (48)	-	250 (48)	-
0.49 – 1.605	-	50 (34)	-	50 (34)	-
1.605 – 3.95	-	250 (48)	-	250 (48)	-
3.95 – 30	-	50 (34)	-	50 (34)	-
30 – 470	30 (30) – In TV Bands				
500 (54) – Outside TV Bands	-	30 (30)*	50 (34)**	200 (46)	
470 - 1000	100 (40) – In TV Bands				
500 (54) – Outside TV Bands	-	100 (40)*			
500 (54)**	-	200 (46)			

* - Compliance with these limits is required only for the TV channels in use at any time at the site

** - Limits for use outside the TV channels in use at the time at the site

Table 2: Limits of radiation, CISPR 11, First Edition (Table II)

Electromagnetic radiation disturbance limits in dBuV/m for Group 1 equipment in Edition 2 are shown in Table 5.

There were additional limits for radiated emissions for Group 2 equipment.

In the frequency range 1 GHz to 18 GHz, the limit for radiation disturbance power was 57 dB above a picowatt (effective radiated power), referred to a half-wave dipole in the narrow frequency range 11.7 GHz to 12.7 GHz.

The standard used statistics for compliance conclusions. Clause 6.1 stated "it cannot be shown that equipment in series production fails to meet the requirements of this publication without a statistical assessment of compliance being carried out."

In the General Measurements Requirements clause, the standard provided for the measurement of Class A equipment either on a test site or *in situ* as determined by the manufacturer. However, the standard mandated that Class B equipment be tested and measured in a testing laboratory only.

Measuring equipment used by a testing lab had to comply with CISPR 16. Receivers needed both average and quasi-peak capability. An artificial mains network (LISN) was needed for conducted emissions, and it was a 50 ohm-50 microhenry network. Antennas used included a loop antenna below 30 MHz and a balanced-dipole antenna from 30 MHz to 1000 MHz. Measurements were made in both horizontal and vertical polarizations. Class A equipment was measured with the center of the antenna three meters above ground while, for Class B equipment, the center of the antenna had to be adjusted to between one and four meters.

The testing laboratory had to meet special provisions for measuring radiated emissions, including a minimum-sized ground plane, and an area free of reflecting structures and also large enough to allow for the appropriate separation of the equipment under test and the receiving antenna.

Amendment 1 to the second edition was released in March of 1996. It changed some conducted emission limits, especially for Class A equipment. Amendment 2 was also released in March of 1996 and it contained limits for induction cooking appliances for both conducted limits and radiated magnetic field limits. Amendment 2 also modified radiation limits for Group 2 equipment.

Frequency - MHz	Group 1 – Quasi-Peak	Group 1 -Average	Group 2 – Quasi-Peak	Group 2 - Average
0.15 - 0.50	79	66	100	90
0.50 - 5.0	73	60	86	76
5 - 30	73	60	90 decreasing with logarithm of frequency to 70	80 decreasing with logarithm of frequency to 60

Table 3: Class A limits for conducted emissions, CISPR 11, Second Edition

Frequency Band – MHz	Quasi-Peak	Average
0.15 – 0.50	66 decreasing with logarithm of frequency to 56	56 decreasing with logarithm of frequency to 46
0.50 – 5	56	46
5 – 30	60	50

Table 4: Class B limits for conducted emissions, CISPR 11, Second Edition

Frequency Band MHz	Group 1 – Class A – 30 meters	Group 1 – Class B – 10 meters	Group 1 – Class A – 30 meters from wall
0.15 – 30	X	X	X
30 -230	30	30	30
230 – 1000	37	37	37

Table 5: Electromagnetic radiation disturbance limits, CISPR 11, Second Edition

The third edition of CISPR 11 was also developed by CISPR Subcommittee B and was released in 1997. It replaced the second edition and its two amendments.

THIRD EDITION—1997

The third edition of CISPR 11 was also developed by CISPR Subcommittee B and was released in 1997. It replaced the second edition and its two amendments.

The main content of CISPR 11 standards are based on the original CISPR Recommendation No. 39/2, entitled "Limits and Methods of Measurement of Electromagnetic Disturbance Characteristics of Industrial, Scientific, and Medical (ISM) Radio-Frequency (RF) Equipment." The Recommendation states "The CISPR, considering a) that ISM RF equipment is an important source of disturbance; b) that methods of measuring such disturbances have been prescribed by the CISPR; c) that certain frequencies are designated by the International Telecommunication Union (ITU) for unrestricted radiation from ISM equipment, recommends that the latest edition of CISPR 11 be used for the application of limits and methods of measurement of ISM equipment."

The third edition of the standard reorganized the first Clause, changing it from "Scope and Object" to "General," and comprised of two Sub-clauses, "Scope and Object," and "Normative References."

Clause 6 of the second edition was renumbered as Clause 11 in the third edition, and Sub-clause 6.1, "Equipment in series production," was replaced with Sub-clause 11.2, "Equipment in small scale production."

A new Sub-clause 5.4, "Provisions for Protection of Specific Sensitive Radio Services," was added in Clause 5, "Limits of Electromagnetic Disturbance."

Clause 7 in the second edition became Clause 6 in the third edition; Clause 8 became Clause 7, Clause 9 became Clause 8, Clause 10 became Clause 9, and Clause 11 became Clause 10.

Annexes A – D remained the same in the third edition as in the second. Two new annexes were added, Annex E, "Safety-Related Service Bands," and Annex F, "Sensitive Service Bands."

The classification of equipment remained the same from the second to the third edition, that is, Group 1 and Group 2, and Class A and Class B.

With respect to the limits of electromagnetic disturbance, Class A equipment could still be tested either at a testing laboratory or *in situ*, while Class B equipment had to be measured in a testing laboratory.

The limits for conducted emissions on the power leads were measured from 150 kHz to 30 MHz using a 50-ohm/50-uH network. The limits remained the same for Class A and Class B equipment from the second edition of the standard, except that another category was added for Class A-Group 2 equipment for mains supply currents in excess of 100 amps per phase when using the CISPR voltage probe. The limits for this special case are shown in Table 6.

However, new limits were added in Table 2c in the standard ("Mains terminal disturbance voltage for inductive cooking appliances") for Group 2-Class B equipment for both domestic and commercial cooking appliances.

Table 3 in the standard ("Electromagnetic radiation disturbance limits for group 1 equipment") had a major change, as the measurement distance for Group 1-Class A equipment was changed from 30 meters to 10 meters with a corresponding increase in limits of 10 dB (assuming an inverse distance fall-off of the radiated electromagnetic field).

Clause 5.2.2 of the third edition also introduced the concept of measuring products at shorter distances than the specified measurement distances for radiated disturbances. For example, it allowed Group 2-Class A equipment to be measured at a distance of between 10 and 30 meters instead of 30 meters. Also, it allowed Group 1 and 2-Class B, equipment to be measured at

Frequency Band – MHz	Class A – Group 2 Equipment Limit - dBuV	Class A - Group 2 Equipment Limit - dBuV
	Quasi-Peak	Average
0.15 – 0.50	130	120
0.50 – 5.0	125	115
5.0 - 30	115	105

Table 6: Special case limits for conducted emissions, CISPR 11, Third Edition

antenna distances between three and 10 meters. However, it stated that "in case of dispute, Class A-Group 2 equipment shall be measured at a distance of 30 meters; Class B-Group 1, Class B-Group 2, and Class A-Group 1 equipment shall be measured at a distance of 10 meters."

Tables 3a and 3b were added in the third edition to cover Group 2 induction cooking appliances for Class B and Class A, respectively. Table 3a ("Limits of the magnetic field induced current in a 2-m loop antenna around the device under test") was intended to use the Van Veen Loop Method measurement method as per CISPR 16-2. Table 3b ("Limits of the magnetic field strength") is measured at a three meter antenna distance with a 0.6 meter loop antenna as described in CISPR 16-1.

Table 4 in the standard ("Electromagnetic radiation disturbance limits for Group 2-Class B equipment measured on a test site") added a new column of requirements, that the quasi-peak magnetic field (measured at three meters) will not exceed 39 dBuAmp/meter decreasing linearly with the logarithm of the frequency to 3 dBuAmp/meter from 150 kHz to 30 MHz.

Table 5 in the standard changed the measurement distance from 30 meters to 10 meters and increased the limits by 10 dB from the limits found in the second edition.

Table 6 was added to the third edition of CISPR 11. It was entitled "Electromagnetic radiation disturbance peak limits for Group 2-Class B ISM equipment producing CW-type disturbances and operating at frequencies above 400 MHz." Table 7 ("Electromagnetic radiation disturbance peak limits for Group 2-Class B ISM equipment producing fluctuating disturbances other than CW and operating at frequencies above 400 MHz") and Table 8 ("Electromagnetic radiation disturbance weighted limits for Group 2-Class B ISM equipment operating at frequencies above 400 MHz") were also added.

Clause 5.4 ("Provisions for protection of specific sensitive radio services") was added to the third edition. It referenced a new Annex F which gave examples of bands to be protected.

The same general measurement conditions existed as in the previous edition which is that Class A

The fourth Edition of CISPR 11 was published in March 2003. The fourth edition superseded the third edition (1997), along with its first amendment (1999) and its second amendment (2002).

equipment could be measured at a test lab or *in situ*. Class B equipment had to be measured on a test site (in a test lab).

For equipment on a turntable, the distance to the antenna was measured from the center of the turntable. For equipment not on a turntable, the distance to the antenna was measured from the edge of the equipment. Paragraph 6.5.6 ("Single and multiple-zone induction cooking appliances") was added to the third edition.

Amendment 1 to the third Edition added requirements for ISM lighting apparatus operating in the frequency bands of 915 MHz, 2.45 GHz, and 5.8 GHz. It also added IEC 60705:1999 ("Household microwave ovens – methods for measuring performance") to the normative standards. It also added new words in Clause 5.2.2 (discussed earlier) and it added a new Table 5 ("Electromagnetic Radiation disturbance limits for Group 2 – Class A equipment"). All new wording was added to Clause 5.2.3 by Amendment 1. In Clause 6.2.1, it added the requirement that "for measurements at frequencies above 1 GHz, a spectrum analyzer with characteristics as defined in CISPR 16-1 shall be used." Additionally, in Clause 6.2.4, it added the words "for measurements at frequencies above 1 GHz, the antenna used shall be as specified in CISPR 16-1." Also, Clause 6.5.4 ("Microwave cooking appliances") was added by Amendment 1.

An important (and somewhat controversial) Sub-clause was added by Amendment 1 in Clause 7.1.3 ("Radiation measurements [9 kHz to 1 GHz]"). It added two sentences that impacted the third edition and subsequent editions. The first sentence said "for the test site measurements, an inverse proportionality factor of 20 dB per decade shall be used to normalize the measured data to the specified distance for determining compliance." Also, it added the parenthetical sentence, "care should be taken in measuring a large test unit at 3 meters at a frequency near 30 MHz due to near-field effects." It deleted a key sentence from the second edition that said "at the closer measurement distance the electromagnetic disturbances measured shall not exceed the limit values specified in Clause 5." In Sub-clause 8.2 it added the sentence "the distance between the receiving antenna and the EUT shall be 3 meters." Sub-clauses 8.3 ("Validation and calibration of test site") and 8.4 ("Measuring Procedure") were completely rewritten. Finally, Amendment 1 added Figure 5 ("Decision tree for the measurement of emissions from 1 GHz to 18 GHz of Class B-Group 2 ISM equipment operating at frequencies above 400 MHz").

Amendment 2 replaced "spark erosion equipment" with "electro-discharge machining (EDM) and arc welding equipment." It also made additional editing changes to a number of Sub-clauses.

FOURTH EDITION—2003

The fourth Edition of CISPR 11 was published in March 2003. The fourth edition superseded the third edition (1997), along with its first amendment (1999) and its second amendment (2002).

There were a limited number of changes in the fourth edition from the third edition. The first two sentences in Clause 4 were changed to read "the manufacturer and/or supplier of ISM equipment shall ensure that the user is informed about the class and group of the equipment, either by labeling or by the accompanying documentation. In both cases, the manufacturer/supplier shall explain the meaning of both the class and the group in the documentation accompanying the equipment."

Clauses 7.1 and 7.2 were interchanged from the third edition.

Clause 6.2.5 ("Artificial Hand") was added to the fourth edition, as well as Figure 6 ("Artificial Hand, RC Element"). The concept of an artificial hand was introduced to simulate the effects of the user's hand during the conducted emission measurements

The definitions of Group 1 ISM equipment, Group 2 ISM equipment, Class A equipment, and Class B equipment remained basically the same as the third edition.

With respect to limits of electromagnetic disturbance, Class A equipment could once again be measured either in a testing laboratory or *in situ* (as preferred by the manufacturer). However, the fourth edition continue to require Class B equipment to be measured in a testing laboratory.

The limits of terminal disturbance voltage (conducted emissions) gives the manufacturer two choices: 1) meet the average limit with an average detector and the quasi-peak limit with a QP detector; or 2) meet the average limit when using a QP detector. This was the same as stated in the third edition.

For radiated disturbances from 150 kHz to 1000 MHz, the limits stayed basically the same as those found in the third edition. Measurements were allowed at closer distances than the specified distances under certain considerations. In case of dispute, however, Class B (Group 1 and Group 2) and Class A (Group 1) were to be measured at a distance of 10 meters, while Class A (Group 2) were to be measured at a distance of 30 meters. Receivers used for the measurements were expected to meet the criteria of CISPR 16-1. Requirements for the artificial mains network (LISN) remained the same as those in the third edition, that is, a 50 ohm/50 microhenry V-Network as specified in CISPR 16-1. The antennas used for measuring CISPR 11 products were also expected to meet CISPR 16-1 requirements. In a testing laboratory, the antenna must be raised and lowered from one to four meters in the frequency range 30 MHz to 1000 MHz. For measuring products *in situ*, the antenna's center must be fixed at two meters above the ground.

Amendment 1 to the fourth edition was released in 2004. Primarily, Amendment 1 replaced Table 6 in the fourth edition with a new table that addresses Group 2 (Class A and Class B) ISM equipment producing CW type disturbances and operating at frequencies above 400 MHz.

Amendment 2 added CISPR 16-4-2:2003 to the Normative References. It also added a new Table 2c for Mains Terminal disturbance voltage for induction cooking appliances. It also modified Clauses 6.5.4 ("Microwave Cooking Appliances") and 6.5.6 ("Single and multiple-zone induction cooking appliances") to more closely match the IEC Product Standard. Amendment 2 also added Clauses 6.6 ("Recording of test-site measurement results"), 6.6.1 ("Conducted Emissions"), and 6.6.2 ("Radiated Emissions"). Also, Clause 11.4 ("Measurement Uncertainty") was added, stating that "determining compliance with the limits in this standard shall be based on the results of the compliance measurement, not taking into account measurement instrumentation uncertainty." However, results of measurements of emissions from ISM equipment were supposed to reference the measurement uncertainty considerations contained in CISPR 16-4-2.

FIFTH EDITION—2009

Released in 2009, the fifth edition of CISPR 11 is the current edition of the standard. It continues the long-standing practice of Group 1 and Group 2, Class A and Class B equipment classifications. The limits stated in the fifth edition are similar to the limits found in the fourth edition.

Table 7 presents a side-by-side comparison of the table of contents for the first edition and the fifth edition of CISPR 11, which clearly shows the growth in the length and complexity of the standard over a period of 35 years.

Clause 6 in the fifth edition represents a major overhaul from that in the fourth edition. Its Main Clause and Sub-clause headings are as follows:

Clause 6 – Limits of Electromagnetic Disturbance
- 6.1 – General
- 6.2 – Group 1 Measured on a Test Site
- 6.3 – Group 2 Measured on a Test Site
- 6.4 – Group 1 and Group 2 Class A Measured *in situ*

CISPR 11 – Edition 1 – 1975	CISPR 11 – Edition 5 - 2009
Foreword	Foreword
Preface	Introduction
1 – Scope	1- Scope
2 – Object	2 – Normative References
3 – Definitions	3 – Terms and Definitions
4 – Limits of Interference	4 – Frequencies Designated for ISM Use
5 – Methods of Measurement	5 – Classification of ISM Equipment
6 – Safety Precautions	6 – Limits of Electromagnetic Disturbance
Appendix A – Precautions to be taken in the use of a Spectrum Analyzer	7 – Measurement Requirements
Appendix B – Propagation of Interference from industrial RF equipment at frequencies between 30 MHz and 300 MHz	8 – Special Provisions for Test Site Measurements (9 kHz to 1 GHz)
Appendix C – Artificial Mains Networks for currents between 25 amps and 100 amps	9 – Radiation Measurements – 1-18 GHz
	10 – Measurements in situ
	11 – Safety Precautions
	12 – Assessment of Conformity of Equipment
	13 – Figures and Flowcharts
	Annex A (Informative) – Examples of Equipment Classification
	Annex B (Informative) – Precautions to be taken in the use of a Spectrum Analyzer (see 6.3.1)
	Annex C (Normative) – Measurement of Electromagnetic Radiation disturbances in the presence of signals from radio transmitters
	Annex D (Informative) – Propagation of Interference from industrial radio frequency equipment at frequencies between 30 MHz and 300 MHz
	Annex E (Informative) – Recommendations of CISPR for protection of certain radio services in particular areas
	Annex F (Informative) –Frequency Bands allocated for safety-related radio services
	Annex G (Informative) – Frequency Bands allocated for sensitive radio services
	Bibliography

Table 7: Comparison of the first and fifth editions of CISPR 11

The CISPR 11 standard for measuring disturbances (emissions) from ISM equipment has been in existence for 40 years. It has grown from a simple document to a complex document involving a number of types of products.

Clause 7 added a new Sub-clause 7.1 ("General") and a new Sub-clause 7.7 ("Recording of Test Site Measurement Results").

Clause 12 ("Assessment of Conformity of Equipment") added a new Sub-clause 12.1 ("General") and then the next three Sub-clauses were the same as Sub-clauses 11.1–11.3 in the fourth edition.

Clause 13, titled "Figures and Flowcharts," is new to this edition, as is Annex E.

The entire fifth edition was written to provide a more transparent structure. Table 17 in the standard was added with a title of "Electromagnetic Radiation Disturbance Limits for Class A (Group 1) Equipment Measured *in situ*." It specifically addresses equipment with input power greater than 20 KVA.

An Amendment 1 to the fifth edition was released in 2010. It created a new subset of equipment, "Small Equipment." Small Equipment is defined as "equipment, either positioned on a table top or standing on the floor which, including its cables, fits in a cylindrical test volume of 1.2 meters in diameter and 1.5 meters above the ground plane."

Using this definition, Tables 4, 5, 9, 10, and 11 in the standard were modified to allow testing of Class A and B products meeting the "Small Equipment" definition to be tested at a three meter test distance. The limit at three meters would be extrapolated from the typical test distance of 10 meters using an inverse-distance fall-off assumption (free-field).

TOWARD THE SIXTH EDITION—2015

Since the release of Amendment 1 to the fifth edition of CISPR 11 in 2010, Subcommittee B of CISPR has been working on the sixth edition of the standard. At its most recent meeting in Frankfurt Germany in October 2014, Subcommittee B made significant progress on the merging of several new elements into CISPR 11 toward the release of a Final Draft International Standard (FDIS). This FDIS is scheduled for National Voting beginning in April 2015.

New elements or supplements found in the FDIS for CISPR 11 are expected to include:

- Emission requirements for grid-connected power converters (GCPCs)
- Use of the amplitude probability distribution (APD) method and associated limits for the assessment of fluctuating RF disturbances in the range above 1 GHz
- Alignment of emission requirements for disturbance sources generating fluctuating disturbances with those from sources generating continuous wave (CW)-type disturbances
- Emission requirements for GCPCs with greater than 20 KVA rated throughput power.

The FDIS will also include general maintenance items to address other issues in the fifth edition of the standard.

SUMMARY AND CONCLUSIONS

The CISPR 11 standard for measuring disturbances (emissions) from ISM equipment has been in existence for 40 years. It has grown from a simple document to a complex document involving a number of types of products. It has grown from measuring products at a larger distance (100 meters and 30 meters) for Class A equipment to measuring them at three meters. Class B equipment measurement distances have shrunk to three meters, the distance used in the U.S. since the release in 1979 of FCC's rules on computer emissions. This steady erosion of the "laws of physics" for Class A products is worrisome and a trend to reverse this erosion is overdue in the engineering field of EMC and the EMC standards arena.

(the author)

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Advances in Data Transmission Speeds for RJ45 Jack Connectors

Traditional Connectors and Their Application Throughout the Industry are Changing for the Better

BY BRETT D. ROBINSON AND MICHAEL RESSO

For many decades, RJ45 jack connectors have been used for low-cost, high volume applications throughout industrial, commercial, military and medical fields. The registered jack (RJ) is a standardized physical network interface for connecting telecommunications or data equipment to a service provided by a local exchange carrier or long distance carrier. It was introduced by the Bell System under a 1976 order by the Federal Communications Commission (FCC) that ended the use of protective couplers provided exclusively by the telephone company. The modular jack was then chosen as the main candidate for ISDN systems.

Historically, the biggest design problem for RJ45 jacks was to solve crosstalk coupled from adjacent lines. The problem (at least at lower frequency rates) was solved simply by isolation techniques within the connector, or split pair wiring of the Category Cable itself. Newly designed (Femto dielectric) flex core material incorporates a unique strip-line technology that allows data transmission paths to be differentially paired. This allows data packets to be easily driven over a copper line at ranges from 125 MHz all the way up to 20.0GHz.

The RJ45 jack has played a critical role in data transfer, from an integrated circuit (IC) all the way through to the receiver end. However, commercial and military applications require higher data rates, pushing RJ 45 signal rise times and clock speeds faster than any time in history.

Compliance requirements for radiated and conducted emissions now require broader measurement bandwidths. New bandwidth requirements now range from 10kHz ~ 26.5GHz, depending on whether the device is intended for use in military applications (MIL-STD-461), avionics (RTCA-DO-160), medical devices (IEEE802.11/IEC 60601) or commercial electronics (FCC part 15 and the EU's EMC Directive 2004/108/EC). Since the transmission speeds going through an RJ45 jack have approached the effective radiating length of $\lambda/4$ (frequency in wavelength, GHz), its radiated emission characteristics become a primary point of interest for issues involving electromagnetic compatibility (EMC) and electromagnetic interference (EMI).

CROSSTALK

Crosstalk is usually described in the context of culprit versus victim. In high-current, low-impedance circuits, crosstalk is a direct result of mutual inductance between current loops of the connector and cable wiring/shielding practices. Further, crosstalk from mutual capacitance, associated with high-voltage and high-impedance networks, is usually negligible.

However, in the case of the standard RJ45 jack (especially in high-density connectors), the culprit and victim relationships are in very close proximity to each other, which raises mutual inductance and thus the susceptibility to crosstalk. The signal and return arrangement of a standard RJ45 jack causes two current loops to overlap. So, some amount of crosstalk will be experienced on all lines, and the mutual inductance and crosstalk from line to line becomes even greater. In a transmission line, impedance matching is necessary to minimize RF reflections and to allow the connector to deliver the amplitude signal required to maximize power at the load. The effect is a maximum amount of signal being transmitted and a minimum amount of data being reflected back as loss.

To simplify this last statement, the strip-line flex technology within RJ45 jacks in use today creates an extremely low impedance path, creating an insertion loss/isolation greater than 52.78dBm. This virtually eliminates the possibility for crosstalk within the connector and creates an edge-coupled line surrounded by a ground plane, reducing stray voltage and current expenditures. This can be expressed as:

Voltage **V** = 5Vrms
Impedance **Z** = 0.13180747 Ohms
thus Power Level **L** = 52.78dBm

This advantage is not directly due to differentially-paired signal lines. Rather, this design approach minimizes electronic crosstalk and electromagnetic interference. This results in both noise emission and noise acceptance, so it can achieve a constant, known characteristic impedance. Normally, single-ended signals in other types of RJ45 jacks are resistant to interference only when the lines are balanced and terminated by a differential amplifier of some type, wire-wound magnetics or a balun.

CROSSTALK ANALYSIS USING S-PARAMETERS

As a foundation for understanding how to characterize a linear passive physical layer device such as an RJ-45 jack, a brief discussion of multiport measurements is in order. The four port device shown in Figure 1 is an example of what a real-world structure might look like if we had two adjacent printed circuit board (PCB) traces operating in a single-ended fashion. Let's assume that these two traces are located within relatively close proximity to each other on a backplane, and that some small amount of coupling might be present. Since this example involves two separate single-ended lines, this coupling creates an undesirable effect we call crosstalk.

The matrix on the left side of Figure 1 shows the 16 single-ended s-parameters that are associated with these two lines. The matrix on the right shows the 16 single-ended time domain parameters associated with these two lines. Each parameter on the left can be mapped directly into its corresponding parameter on the right through an inverse fast fourier transform (IFFT). Likewise, the right-hand parameters can be mapped into the left-hand parameters by a fast fourier transform (FFT).

If these two traces were routed close together as a differential pair, then the coupling would be a desirable effect and it would enable good common mode rejection that provides EMI benefits.

Once the single-ended s-parameters have been measured, it is desirable to transform these to balanced s-parameters to characterize differential devices. This mathematical transformation is possible because a special condition exists when the device under test is a linear and passive structure. Linear passive structures include PCB traces, backplanes, cables, connectors, IC packages and other interconnects. Utilizing linear superposition theory, all of the elements in the single-ended s-parameter matrix on the left are processed and mapped into the differential s-parameter matrix on the right. Much insight into the performance of the differential device can be achieved through the study of this differential s-parameter matrix,

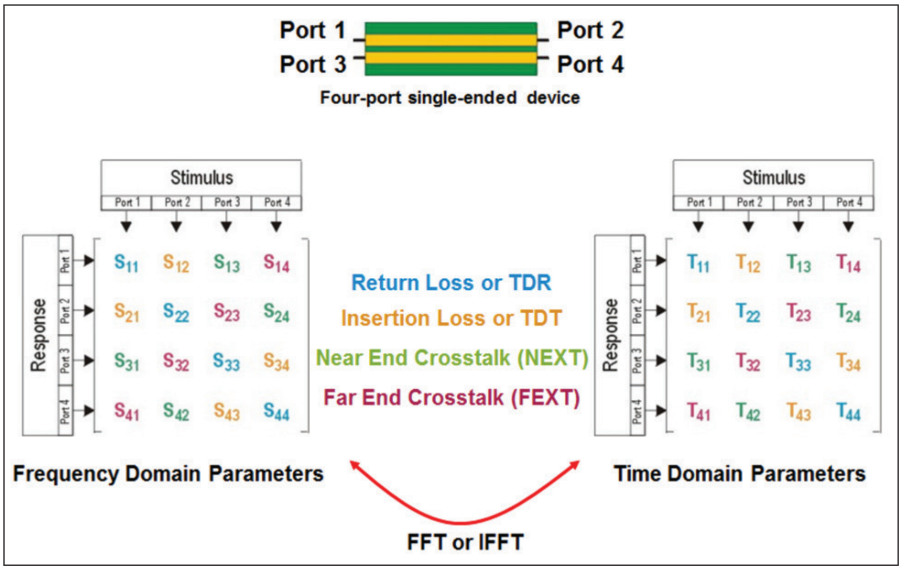


Figure 1

including EMI susceptibility and EMI emissions.

Interpreting the large amount of data in the 16-element differential s-parameter matrix is not trivial, so it is helpful to analyze one quadrant at a time. The first quadrant in the upper left of Figure 2 is defined as the four parameters describing the differential stimulus and differential response characteristics of the device under test. This is the actual mode of operation for most high-speed differential interconnects, so it is typically the most useful quadrant that is analyzed first. It includes input differential return loss (SDD11), forward differential insertion loss (SDD21), output differential return loss (SDD22) and reverse differential insertion loss (SDD12).

Note the format of the parameter notation SXYab, where S stands for scattering parameter (or S-Parameter), X is the response mode (differential or common), Y is the stimulus mode (differential or common), A is the output port and B is the input port. This is typical nomenclature for frequency domain scattering parameters. The matrix representing the 16 time domain parameters will have similar notation, except the "S" will be replaced by a "T" (i.e. TDD11).

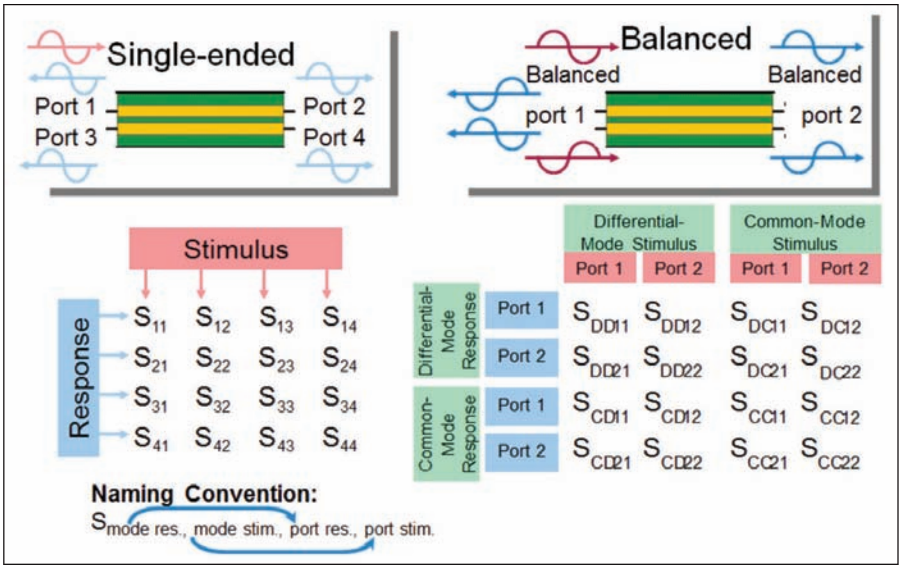


Figure 2

The fourth quadrant is located in the lower right and describes the performance characteristics of the common signal propagating through the device under test. If the device is designed properly, there should be minimal mode conversion, and the fourth quadrant data will be of little concern. However, if any mode conversion is present due to design flaws, then the fourth quadrant will describe how this common signal behaves.

The second and third quadrants are located in the upper right and lower left of Figure 3, respectively. These are also referred to as the mixed mode quadrants. This is because they fully characterize any mode conversion occurring in the device under test, whether it is common-to-differential conversion (EMI susceptibility) or differential-to-common conversion (EMI radiation). Understanding the magnitude and location of mode conversion is very helpful when trying to optimize the design of interconnects for gigabit data throughput.

Differential pairs mentioned earlier in this article technically include: 1) twisted-pair cables, shielded twisted-pair cables, and twin-ax; and 2) strip-line differential pair routing techniques onto "specialized" flex circuit boards.

Generally, a receiving device located at the end of any cable/harness connection reads the difference between the two signals. Since the receiver ignores the wires› voltages with respect to ground, small changes in the ground potential between the transmitter and receiver do not affect the receiver›s ability to detect the signal.

EMI/RFI interference tends to affect both TX and RX wires together. Because the data packet information is sent in the form of bit rates, utilizing differently paired wires, the technique improves the resistance

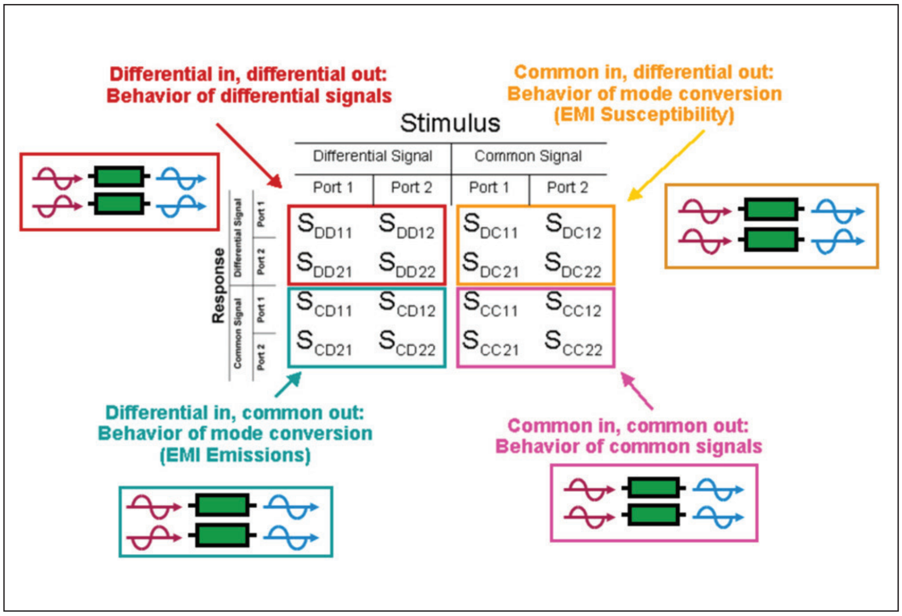


Figure 3

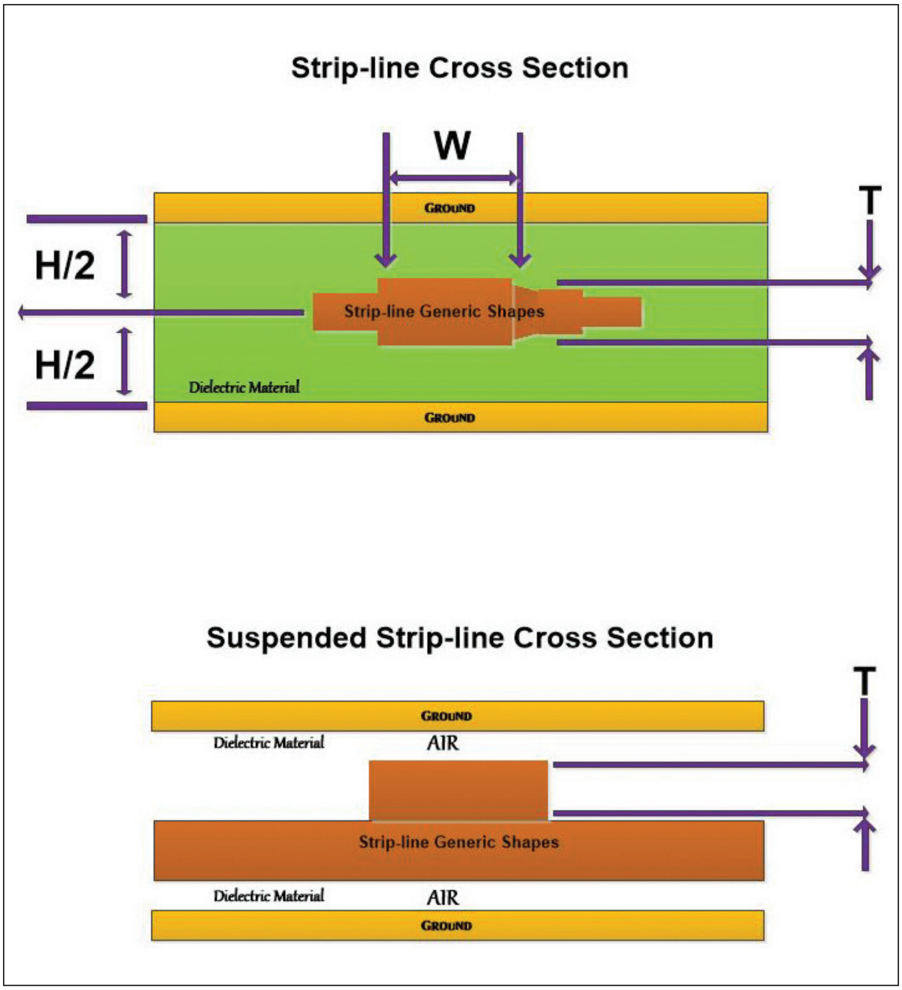


Figure 4

to electromagnetic noise ratio compared with use of only one wire and an un-paired reference (ground). What is then needed is a high speed RJ45 jack which can be used for analog data, as well as digital data signaling, just as in any other Ethernet shield over twisted pair.

DESIGNING THE RJ45 FOR HIGH SPEED DATA TRANSFER

A genuine high speed RJ45 jack and its corresponding interconnection system must have a well-designed base platform from which to start. To begin, it should utilize properly plated copper conductors to ensure a path of least resistance, thus lowering the induced currents and voltages expended dramatically. Utilizing the patent pending flex material, along with differentially paired strip-line components allows for higher transmission data rates the standard ceramic capacitors, inductors, or resistors soldered onto some form of FR4 flex material.

Many RJ45 Jack connectors produced today simply provide magnetically balanced, single-ended lines, in combination with common mode capacitive circuits. However, at much higher frequencies, this can diminish their transmission data rate capabilities. By implementing low pass, femto-dielectric constant materials, the strip-line flex circuit can be balanced differentially to provide the much needed insertion loss/isolation requirements.

COMMON STRIP-LINE DESIGN MODELS

Generally speaking, strip-line transmission lines are fully contained within a substrate, sandwiched between two chassis ground planes. In this implementation, it was performed by closely surrounding the strip-line circuit in a 360 degree manner with chassis ground, as shown in the strip-line cross section model depicted in Figure 4.

> When a conductor is filled with a voltage “charge” and then an external “potential” is applied across it, electrons distribute themselves across the length of the conductor. This forces all of the electrons to lose energy in all directions simultaneously across the conductor’s path.

(It is important to note that special low loss dielectric flexible materials must be used for the strip-line flex development, especially since the dielectric material chosen will directly affect transmission line impedance.)

THE INTUITIVE EXPLANATION

There is an old physics truism that everyone seems to have forgotten when designing electronic circuitry and cables, that is, that electrons tend to flow down the path of least resistance. When a conductor (in our case a plated copper wire) is filled with a voltage “charge” and then an external “potential” is applied across it, electrons distribute themselves across the length of the conductor. This forces all of the electrons to lose energy in all directions simultaneously across the conductor’s path. This same physics can be applied to multiple conductors that parallel to the current flow, the only difference being the different rates proportional to the conductivity of each conductor’s base material. (See Figure 5)

The biggest RJ45 jack design problem was to solve crosstalk coupled from adjacent lines and in the cable components themselves. The basic problem associated with coupled noise or crosstalk is that it increases as the signals for these components have higher and higher data transmission speeds. The historic approach was to just increase spacing between the lines or to add-in ferrites (also known as magnetics) to create needed signal isolation needed, but that alone does not protect the remaining transmission lines in the RJ45 jack from picking up unwanted noise within the jack itself.

However, the application of strip-line flex design techniques provide the important signal and data transmission advantages over conventional design approaches. Strip-line flex design works by incorporating a conductor sandwiched by dielectric material between a pair of ground planes. Traditionally, strip-line was usually made by etching circuitry onto a ceramic/copper substrate that had a ground plane on each opposite face, in order to achieve two opposing ground planes. Today, strip-line design techniques typically use “soft-board” flex technology.

Strip-line design is a transverse electromagnetic (TEM) transmission line media, just like coax, which means that it is non-dispersive. Further, strip-line filter and coupler lines, via shape and spacing, always offer better

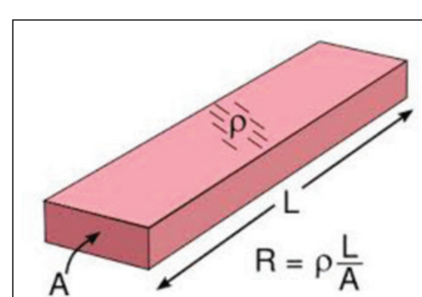


Figure 5

S-Parameter Terms

TDD = Time domain differential

SDD = Frequency (signal) domain differential

RLCG = R=Ohms/m, L= H/m inductance, C = F/m capacitance, G = S/m conductance

S-parameters measurements are taken in magnitude and angle, because both the magnitude and phase of the input signal (angle) are changed by the network being measured.

(This is why they are sometimes referred to as complex scattering parameters).

The four S-parameters mentioned here actually contain eight separate numbers: the real and imaginary parts (or the modulus and the phase angle) of each of the four complex scattering parameters.

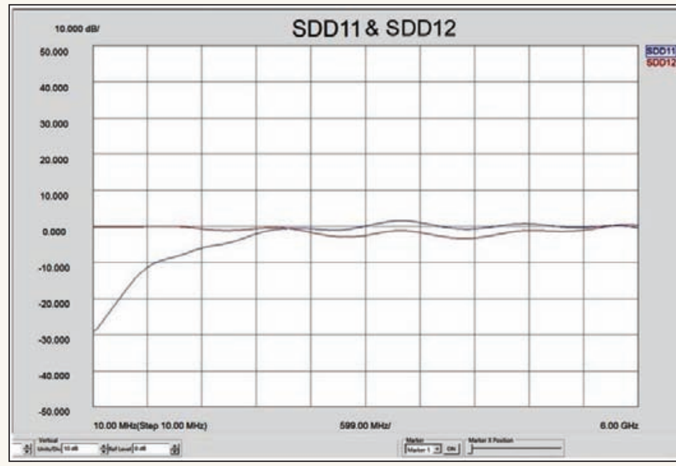
How much gain (or loss) you get is usually more important than how much the signal has been phase shifted.

S-parameters depend upon the network and the characteristic impedances of the source and load used to measure it, plus the frequency measured at (kHz, MHz, GHz).

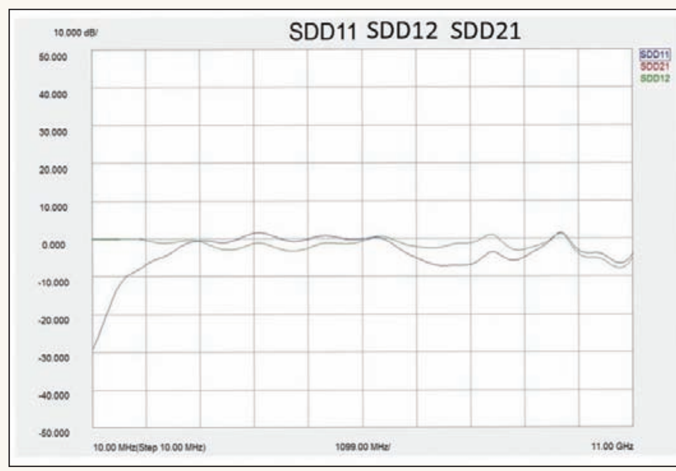
$S_{11} = b1 / a1$, $S_{12} = b1 / a2$, $S_{21} = b2 / a1$, $S_{22} = b2 / a2$

The transmitted and the reflected wave will have changes in amplitude and phase from the incident wave. Generally, the transmitted and the reflected wave will be at the same frequency as the incident wave.

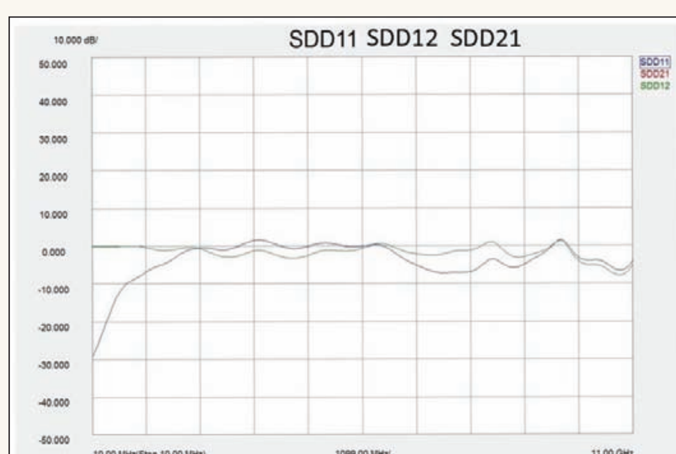
S- Parameter data for the RJ45 jack, along with its mated twin-ax cables



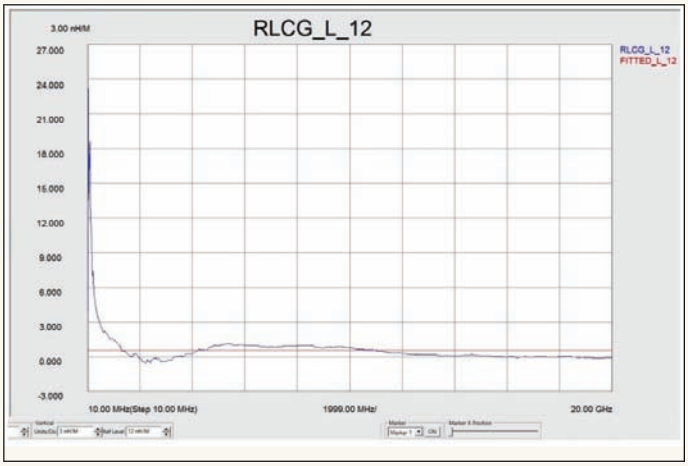
Test Data #1—Measured from 10 MHz to 6GHz (Note: SDD11 & 12 frequency domain RJ45 jack was de-imbedded from test fixture.)



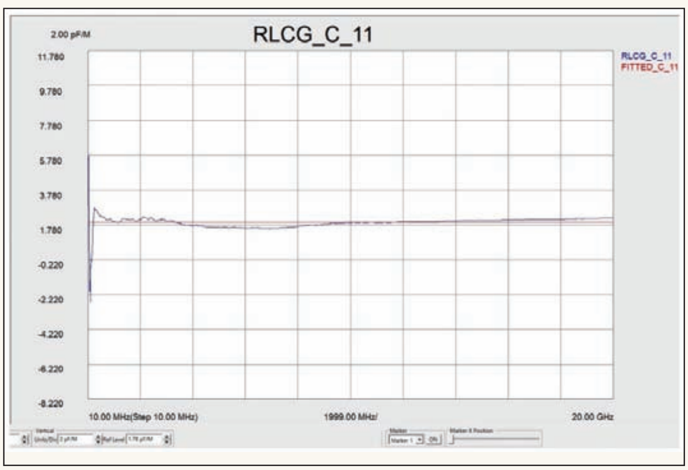
Test Data #2—Measured from 10 MHz to 11GHz (Note: SDD11, 12, 21 frequency domain RJ45 jack was de-imbedded from test fixture.)



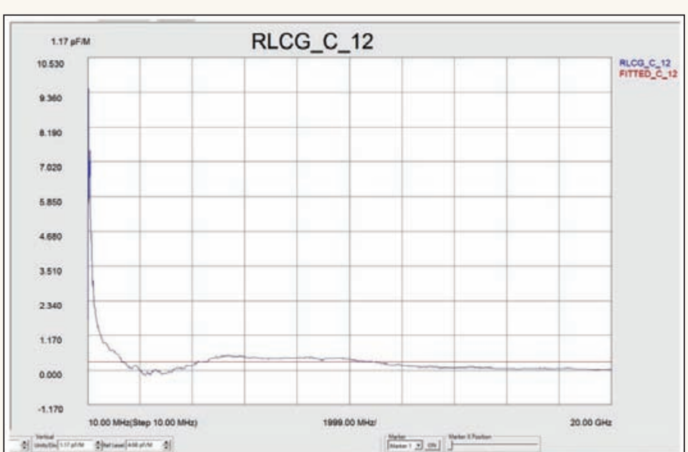
Test Data #3—RLCG cable measurement S-11 (inductance of the cable)



Test Data #4—RLCG 30 meter twin-ax cable measured from 10 MHz to 20GHz (S11 and S12—inductance of the cable)



Test Data #5—RLCG 30 meter twin-ax cable measured from 10 MHz to 20GHz (S11—capacitance of the cable)



Test Data #6—RLCG 30 meter twin-ax cable measured from 10 MHz to 20GHz (S12—capacitance of the cable)

bandwidth than their counterparts using micro-strip or magnetics since, unlike other methods, the roll-off of strip-line is quite symmetrical. Another advantage of strip-line is the superior isolation between adjacent traces can be achieved with a "picket-fence" of grounds surrounding each transmit and receive line, keeping them spaced at less than 1/4 wavelength apart from each other.

COMPARABLE ENERGY USE

Power saving tests were performed in real-time using a DC ammeter and BERT tester as a source. We took a traditional RJ45 jack with ferrites, measured its contribution to a known data transmission circuit, and compared the mA readings with those contributed by a high-speed data RJ45 jack featuring strip-line flex design. The traditional, magnetically-loaded RJ45 added 0.212mA to the PCB's overall power consumption, compared with just 0.031mA for the high-speed RJ45 jack. This represents a power savings of 0.181ma with the high-speed jack.

CONCLUSION

An RJ45 jack with integrated strip-line flex is backward compatible with older connector systems, so that upgrading or refurbishing of legacy data systems becomes much more affordable. In addition, the strip-line flex design allows for greater power savings compared with conventional connectors and PCBs. Strip-line flex technology integrated into the RJ45 jack allows the connector to be same size and format as original connector while enhancing the connector's ability to perform throughput at higher data rates, without the need for magnetics. This approach also leaves more room on the PCB for additional components, since fewer components are required for higher speeds and signal integrity isolation.

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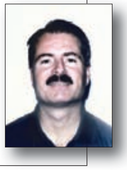

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New CCC Regulations in China

Recent Changes Promises to Streamline the Certification Process

BY PAUL WANG

The Chinese government is implementing a series of reforms in various industries, including the process of certifying product for sale there. The purpose of these reforms is to open the certification and testing market, accelerate the certification process, and reduce the burden on manufacturers and importers seeking access to China's vast and lucrative marketplace. The Certification and Accreditation Administration of the People's Republic of China (CNCA) has announced several changes in its certification requirements for different product categories, and those changes are now in effect.

GENERAL CHANGES

The China Compulsory Certification (CCC) scheme requires manufacturers to obtain approval for their products before they can be legally marketed in China. CCC testing and certification can only be performed by certification bodies that have been approved by the CNCA. CNCA regulations serve as a general guide for certification bodies in China, and CNCA-approved certification bodies like CQC, ISCCC, CESI, CCAP, CCCF and CVC had previously issued their own detailed regulations which may differ from one another in some respects.

There are 21 product types in the current CCC category and each product category has its own set of requirements. The new regulations published in 2014 cover most product categories, and generally include the following changes:

- Certification mode varies depending on the classification levels assigned to the manufacturer's factory
- Type test can be conducted in manufacturer's own lab
- Initial factory inspection can be arranged after obtaining CCC certification
- There are fewer requirements for critical components

FACTORY CLASSIFICATIONS

Factories are now classified into different levels according to the following factors:

- Initial factory inspection and follow up inspection result
- Market survey results
- Reputation or product quality accident

CQC (a CNCA-approved certification body) has listed the factory level classification factors as follow:

- Class A
    - No serious failure found in initial factory inspection or in follow-up inspections within the past two years
    - No test failure during or after certification test
    - No non-conformances identified in the national or state market survey within the past two years

Post-certification audits can consist of follow-up inspection, on-site sampling and tests or market sampling and tests. Certification bodies will determine the extent of post-certification audit activities based on the assigned factory levels. Follow-up inspection frequency depends on the assigned factory Class level, with better factories likely to require fewer follow-up inspections.

    - No product quality accident within the past two years

- Class B: Factories other than Class A, C and D

- Class C
    - Initial factory inspection and follow-up inspection failure caused by product quality, which has been corrected and verified through on-site inspection
    - Product quality disqualification, but not a cause for certificate suspension or withdrawal
    - Other negative factors, including product information or input from the manufacturer

- Class D
    - Failure of initial factory inspection and follow-up inspection
    - Failure of post-certification product testing
    - Refusal to conduct inspection or post-certification testing
    - Serious quality issues that may result in certificate suspension or withdrawal
    - Non-conformance in the state or national market survey
    - Suspension or withdrawal of product certification for other reasons
    - Other negative factors, including product information or input from the manufacturer

Some certification bodies have a different number of factory classifications (for example, three class levels instead of four). Generally, however, a new factory will be initially categorized at a middle level, and moved to a higher or lower level based on the factors mentioned above. A manufacturer's factory classification level may affect a number of other certification factors, including certification mode, factory inspection frequency and product series classification

CERTIFICATION MODES

Certification mode involves the sequence of the CCC certification process, including the required factory inspection. Under the new regulations, most product categories now permit the awarding of a CCC certificate without waiting for the initial factor inspection to be conducted. For many manufacturers, this means receiving certification once the results of type testing have been approved.

As an example, Class I and Class II information technology, audio, video and telecom equipment (per GB 4943/ IEC 60950) can now be certified upon the conclusion of type testing, with factory inspections to be conducted following certification. For equipment and devices other than Class I and Class II, certification can also be issued following successful type testing, with factory follow-up inspections to follow.

Generally, the first factory inspection must be completed within three months after the issuance of the CCC certificate. This means that any corrective actions identified during type testing must be addressed within that time as well.

Post-certification audits can consist of follow-up inspection, on-site sampling and tests or market sampling and tests. Certification bodies will determine the extent of post-certification audit activities based on the assigned factory levels. In addition, follow-up inspection frequency depends on the assigned factory Class level, with better factories likely to require fewer follow-up inspections.

For some product categories like automotive parts, fire protection devices, and security protection devices, an initial factory inspection must still be completed in advance of product certification.

TYPE TESTS CAN BE CONDUCTED IN MANUFACTURER'S OWN LAB

Manufacturers can choose to have required type testing performed at their own testing laboratories or at the factory's testing laboratories. Such testing laboratories must be accredited to the requirements of ISO/IEC 17025, "General requirements for the competence of testing and calibration laboratories," and owned by the manufacturer or the factory. There are two options to conduct the test:

- *Testing on Manufacturer's Premises (TMP)*: Testing is conducted by the test engineer from the authorized CCC test lab.

- *Witness Manufacturer's Testing (WMT)*: Testing is conducted by the manufacturer and witnessed by the authorized CCC test lab engineer.

Note that, in utilizing these options, manufacturer will still be responsible for the cost of travel expenses and witness fees for the representative from the authorized CCC testing laboratory. Further, TMP or WMT accreditation require periodic auditing by the certification body. Finally, the capacity of the laboratory may be too limited to conduct all aspects of the required testing. In these cases, remaining tests will still need to be conducted by the CNCA-approved testing laboratory.

OTHER CHANGES

Other CCC regulatory changes cover the following issues:

- *Critical Component Requirements*—Some EMC-related components were removed from the original list of critical components requiring testing. In addition, voluntary certification marks may be accepted for some critical components, which means that, if the component is outside of CCC category, the manufacturer can provide evidence of a voluntary certification mark to avoid component level test.
- *Self-Made Components*—Self-made components that come under a CCC category may be tested as part of the end product, rather than requiring a separate CCC certificate first. For example, if the end product is a server, and the manufacturer also produces the server power supply that will only be used in the server, the power supply does not require separate certification.
- *Product Series Classification*—The new regulations clarifies the product series identification for group application. For example, displays should be grouped by screen size, power supplies should be grouped by power ratings, etc. Factories with higher level classification may have more flexibility for group application.
- *Other Issues*—There are also some minor changes in the new regulation. Specifically, OEM/ODM agreements need to signed by the applicant, the manufacturer and the factory. Also, "factory quality control capability self-declaration" needs to be submitted in advance of the actual factory inspection.

PREPARING FOR THE CHANGES

For new factories…

If your factory maintains an ISO 9001-certtified quality control system and the product consistency is stable, you can take the advantage of the new regulation and apply for the new certification mode, that is, conduct the factory inspection after CCC certification. This is a good change especially for new factories located outside of China, since it may save a minimum of two to three months compared with the original process. On the other hand, your factory must be well prepared for the inspection, since an inspection failure may delay the release of the CCC certificate. Of course, if you have doubts about the ability of your factory to pass inspection, you can also choose to pursue the original certification route, and have the initial factory inspection conducted first.

For existing factories…

Regulations applicable to existing factories will be updated as new or existing products are recertified. The main challenge here is to maintain complete and accurate records of factory inspection results, and to work toward elevating your factory classification level according to the factory classification requirements. The benefit of obtaining Class A factory classification means fewer factory inspections, reduced inspection scope and more flexibility regarding group applications.

For factories with test labs…

You can expand your test lab capabilities to conduct WMT or TMP testing. This is good for companies that manufacturer large equipment that is difficult to ship or complicated to configure. But the test lab capability must cover all related GB standards to avoid the need to ship samples to a separate testing laboratory for additional testing. Testing fees may also be less compared with the cost of testing products in China-based testing laboratories, but you will still incur witness fees and travel expenses related to WMT or TMP testing. If you have multiple models to be certified, you can apply for this test mode and conduct witness test at one time. If the test sample is easy to ship, testing in China-based testing laboratories may still be a good choice.

Update component list…

If you have an alternate component to be replaced or added, and if that component has been removed from the new regulation, you can simply apply to update to the new regulation and the component will be removed. If your component has a valid voluntary certificate, you can also apply for a new regulation update and avoid verification testing.

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Chair Measurements of Electrostatic Fields and ESD Events in Proximity to a Static Control Safe Workstation

Characterizing Chairs for Use with Static Control Safe Workstations

BY BOB VERMILLION AND DOUG SMITH

A long standing debate exists within the electrostatic discharge (ESD) control community regarding the use of an ANSI/ESD S1.1-2013 wrist strap as a suitable replacement for static control flooring in combination with ANSI/ESD STM12.1-2013 seating (chair) and ANSI/ESD STM9.1-2014 footwear. This brief article will present a summary of testing in which we measured ESD events related to a chair's proximity of 12 inches from an ANSI/ESD S4.1-2006 work surface.

According to NASA-STD 8739.6, "Implementation Requirements for NASA Workmanship Standards," the relative humidity (RH) range within an ESD control area shall be between 30% and 70%. The first phase of our testing was performed at 50%+/-3% RH and the second phase was performed at 30% RH.

Photo 1: ESD safe chair and conventional (i.e., non-ESD) chair

To represent actual conditions of an ESD safe work surface, computer interfaced “hands free” ESD sensing instruments were placed 12 inches from the edge of the work station. Through this series of tests, it became clear that voltages for both ESD safe and non-ESD chairs were less than +/-200 volts when the user was connected to a wrist strap.

The ESD safe chair results were compared with a standard (non-ESD) conference room chair as illustrated in Photo 1. In our tests, a person would sit down and stand up from both types of chairs wearing a wrist strap on an ESD safe mat, followed by the same test using the same chairs placed on an insulative carpet. Photo 2 illustrates the different ESD readings from the non-ESD chair and the ESD chair. It is clear from Photo 2 that the Non-ESD chair is insulative and the ESD chair is static dissipative per ANSI/ESD STM 12.1 at 50% RH.

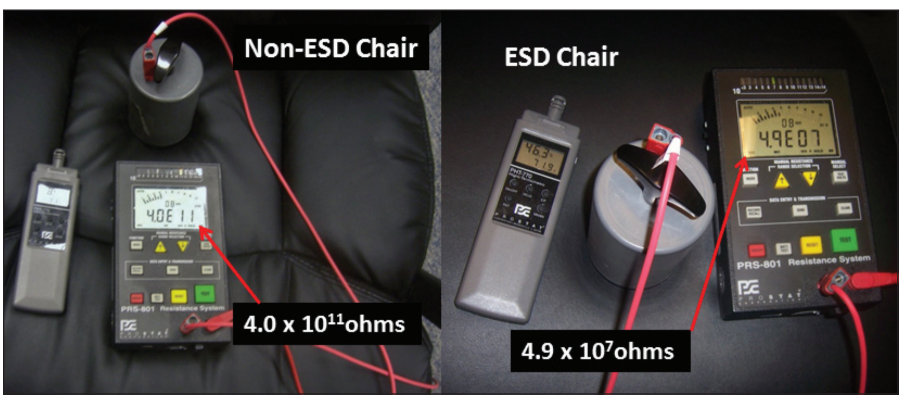


Photo 2: ESD readings from the non-ESD chair and the ESD safe chair

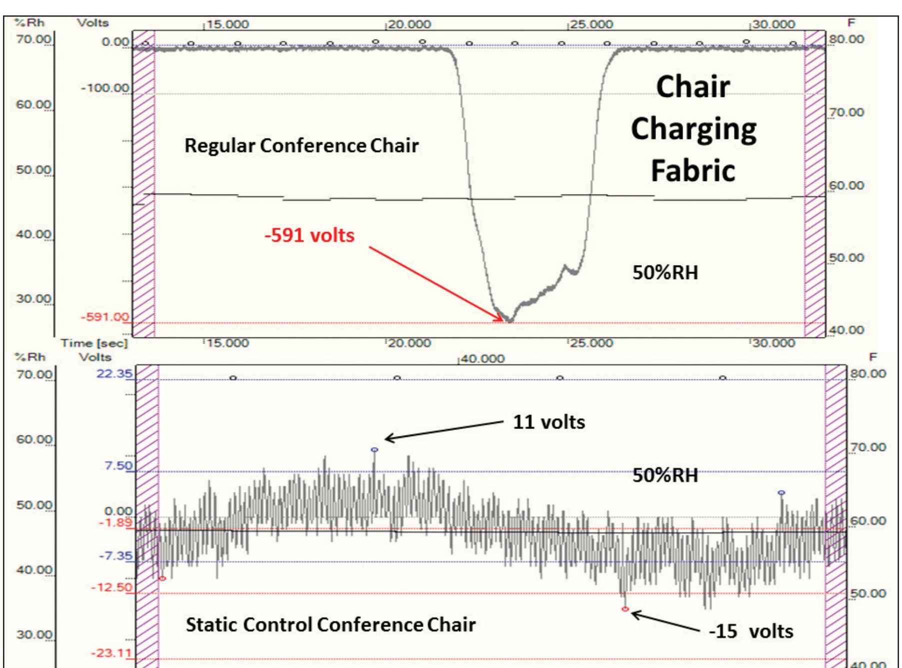
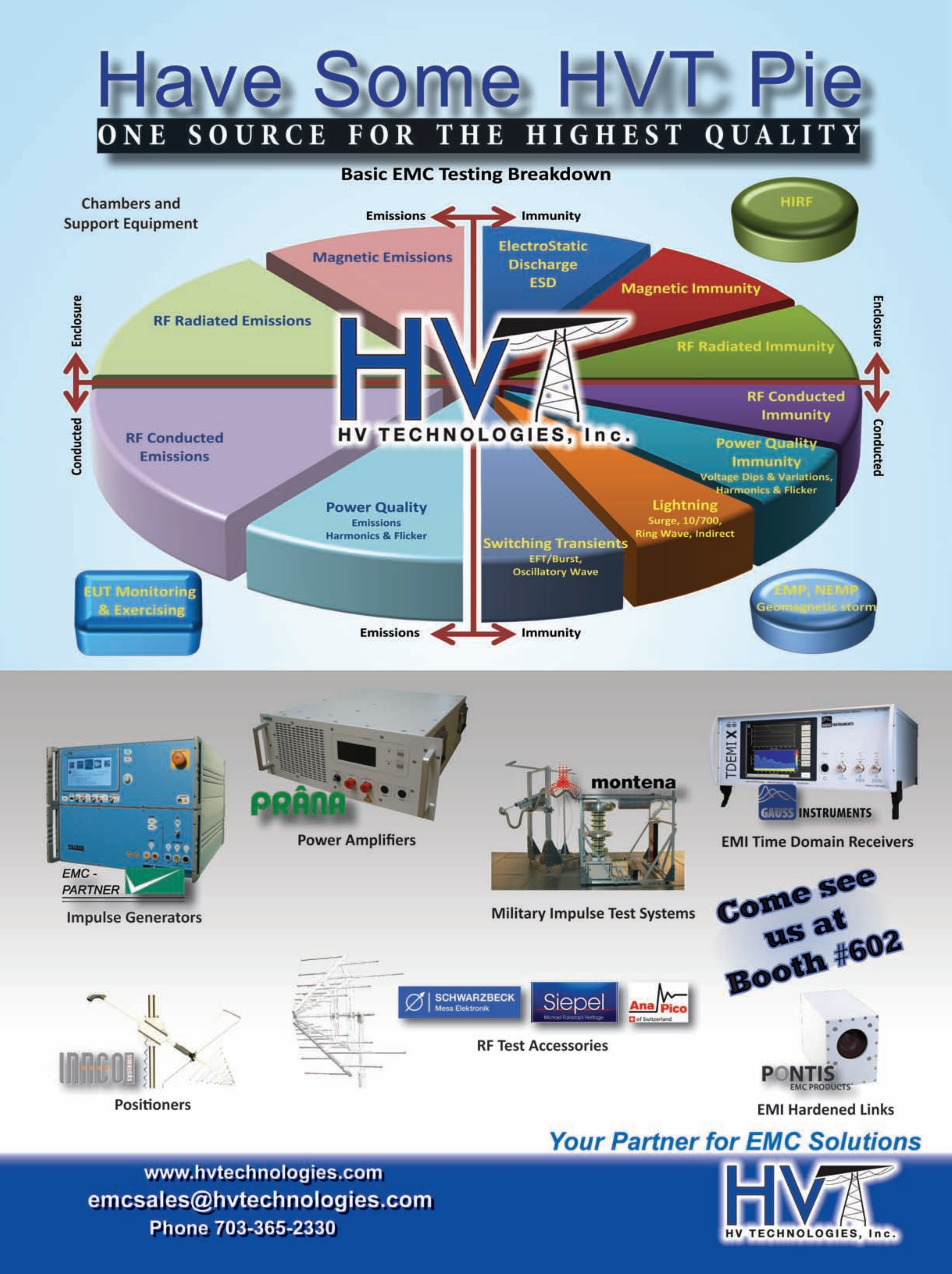


Figure 1: Relative charging of non-ESD chair and ESD safe chair

As a baseline for comparison, the non-ESD chair charged at 50% RH to -591 volts, while the ESD chair charged to a peak of -15 volts (see Figure 1). A limit of <200 volts is called out in ANSI/ESD S20.20-2014 (Table 3 of the standard) under ANSI/ESD STM4.2. Some organizations that handle Class 0A (<120 volts) ESD sensitive devices mandate not more than +/-100 volts at the ESD safe work station.

To represent actual conditions of an ESD safe work surface, computer interfaced “hands free” ESD sensing instruments were placed 12 inches from the edge of the work station as illustrated in Photo 3 (page 84). Testing took place in the following manner:

1. Test ESD safe and non-ESD Chair per ANSI/ESD STM12.1 for resistance mapping at <1.0 x 10^9 ohms.
2. Test ESD safe chair on a static control floor mat after standing up and sitting down while wearing a wrist strap (Chair is pushed back into the workstation).
3. Test non-ESD chair on a static control floor mat after standing up and sitting down while wearing a wrist strap (Chair is pushed back into the workstation).
4. Test ESD safe chair on an insulative carpet after standing up and sitting down while wearing a wrist strap (Chair is pushed back into the workstation).



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5. Test non-ESD chair on an insulative carpet after standing up and sitting down while wearing a wrist strap.
6. ESD event antenna affixed to non-ESD chair to measure ESD during standing up and sitting down at 30% RH.

Through this series of tests, it became clear that voltages for both ESD safe and non-ESD chairs were less than +/- 200 volts when the user was connected to a wrist strap. Table 1 illustrates the findings.

As can be seen in Figures 2 and 3, neither the ESD safe chair nor the non-ESD chair produced higher electrostatic fields at 50% RH. The electrostatic field meter did measure voltages greater than the proximity field antennas. As shown in Table 2, the ESD safe chair

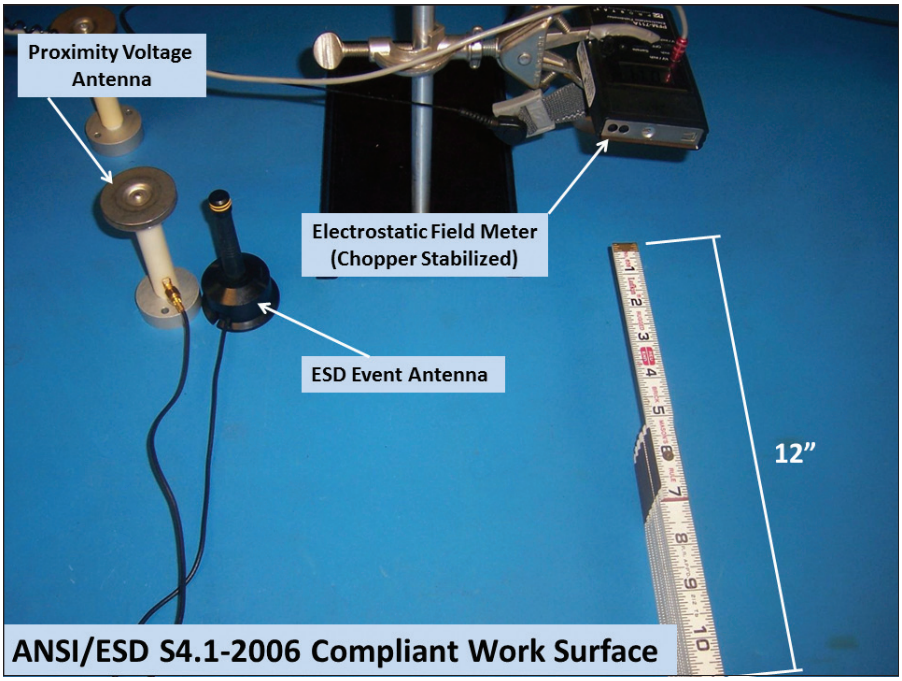

Photo 3: ANSI/ESD S4.1-2006 compliant work surface

ESD Chair on ESD Mat			Non-ESD Chair on ESD Mat			ESD Chair on Carpet			Non-ESD Chair on Carpet		
Test 1	Proximity Voltage	Time	Test 1	Proximity Voltage	Time	Test 1	Proximity Voltage	Time	Test 1	Proximity Voltage	Time
ESD Chair	-0.1	14:35	Reg. Chair	0.1	14:36	ESD Chair	-0.1	14:57	Reg. Chair	-0.1	14:36
	0.1	14:48		1.0	14:10		-2.0	14:15		-23.0	14:56
	-0.1	14:20		6.0	15:30		0.8	15:39		33.0	14:56
Average	0.0	50%RH	Average	2.4	50%RH	Average	-0.4	50%RH	Average	3.3	50%RH
Median	-0.1		Median	1.0		Median	-0.1		Median	-0.1	
Minimum	-0.1		Minimum	0.1		Minimum	-2.0		Minimum	-23.0	
Maximum	0.1		Maximum	6.0		Maximum	0.8		Maximum	33.0	
St. Dev.	0.1		St. Dev.	3.2		St. Dev.	1.4		St. Dev.	28.2	
ESD Chair on ESD Mat			Non-ESD Chair on ESD Mat			ESD Chair on Carpet			Non-ESD Chair on Carpet		
Test 2	Field Meter Voltage[1]	Time	Test 2	Field Meter Voltage	Time	Test 2	Field Meter Voltage	Time	Test 2	Field Meter Voltage	Time
ESD Chair	-14.0	14:46	Reg. Chair	-51.0	15:04	ESD Chair	-32.0	14:47	Reg. Chair	-55.0	2:58
	21.0	14:46		11.0	15:04		21.0	14:47		21.0	2:58
Average	3.5	50%RH	Average	-20.0	50%RH	Average	-5.5	50%RH	Average	-17.0	50%RH
Median	3.5		Median	-20.0		Median	-5.5		Median	-17.0	
Minimum	-14.0		Minimum	-51.0		Minimum	-32.0		Minimum	-55.0	
Maximum	21.0		Maximum	11.0		Maximum	21.0		Maximum	21.0	
St. Dev.	24.7		St. Dev.	43.8		St. Dev.	37.5		St. Dev.	53.7	

Table 1: Results at 50% RH, 73.4°F

[1]1 volt/in increments 0 to ±1,999 Volts

did not produce ESD events which were negligible at 0 volts. The non-ESD chair did produce ESD events when an operator was grounded but only at a peak of 9 volts. As shown in Figure 3, for each ESD event, there was a corresponding low electrostatic field.

In short, at 50% RH when an operator is wearing an ANSI/ESD S1.1-2013 wrist strap, the occurrence of high level electrostatic fields and ESD events measured at 12” were within acceptance levels for many organizations.

What happens with a non-ESD chair at 30% RH, 74°F using an ESD antenna connected to an oscilloscope?

The test set up shown in Photo 4 (page 86) represents a person without a wrist strap. A coaxial cable (50 ohms) is interfaced with a 6” stiff wire as an extension of the center conductor through the BNC (Bayonet Neill–Concelman). The 6” length tunes the antenna to about 500 MHz, the bandwidth of the scope used. An insulative chair may generate radiation and this would be picked up by the wire antenna.

Non-ESD Chair on Carpet		
Chair	ESD Volts	Time
Non-ESD Chair	8.0	14:36
Non-ESD Chair	9.0	14:51
Non- ESD Chair	8.0	14:56
Average	8.3	
Median	8.0	
Minimum	8.0	
Maximum	9.0	
St. Dev.	0.6	50%RH

ESD Chair on Carpet		
Chair	ESD Volts	Time
ESD Chair	0.0	14:36
ESD Chair	0.0	14:51
ESD Chair	0.0	14:56
Average	0.0	
Median	0.0	
Minimum	0.0	
Maximum	0.0	
St. Dev.	0.0	50%RH

Table 2

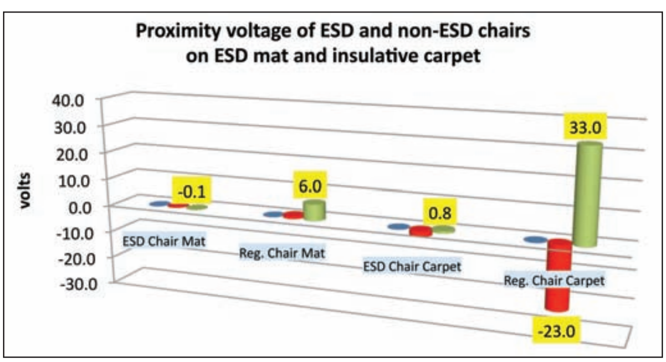

Figure 2: Proximity antenna voltage of ESD safe and non-ESD chairs on ESD mat and insulative carpet. Note: Red = negative voltage, Blue and Green = positive voltage.

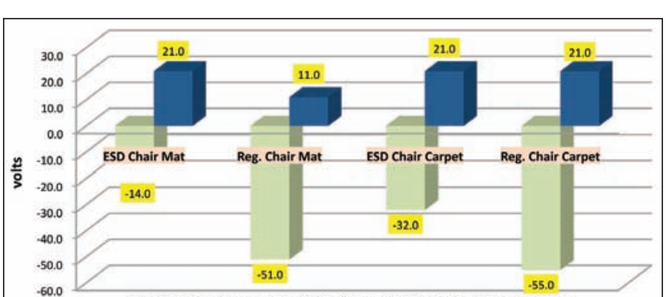

Figure 3: Electrostatic chopper stabilized field meter voltage of ESD safe and
non-ESD chairs on ESD mat and insulative carpet.
Note: Blue = positive voltage, Green = negative voltage

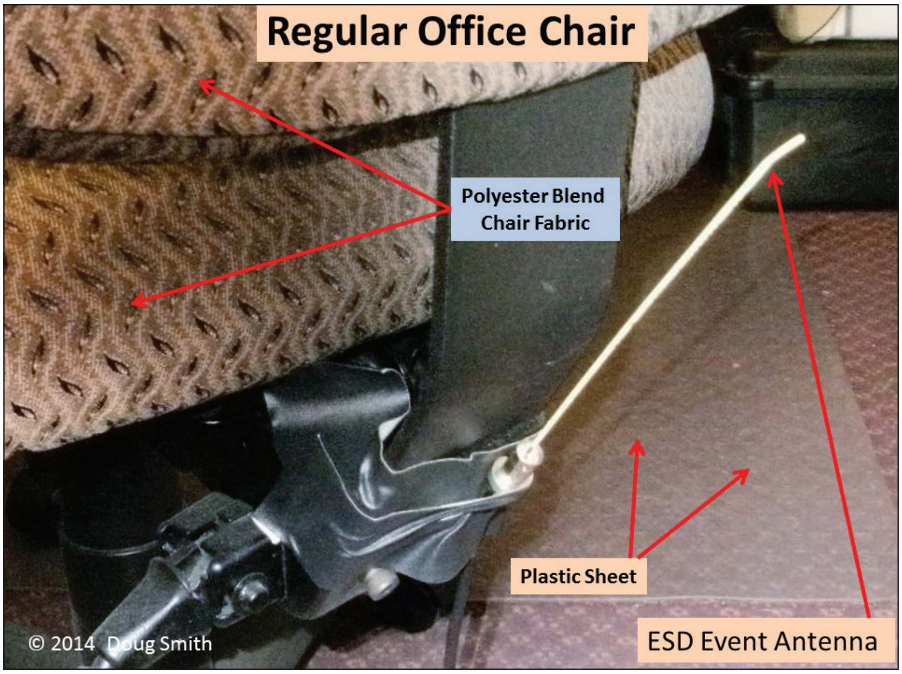

Photo 4: Non-ESD office chair

An operator stood up and sat down while allowing the chair to move a distance of 12" on a wool rug and plastic protective chair runner. Unlike the previous test, the operator is ungrounded, a factor which can certainly influence the readings.

Consequently, the reader can see from Figure 6 that the electrical signal from the stiff wire antenna goes off the scale of +/-400mV. This occurs from foam compression and expansion of the cushioning in the non-ESD chair, inducing a spark between two metal pieces of the chair that are not in contact but form a spark gap.

The foam compression and expansion causes the charge on the surface of the seat of the chair to move and

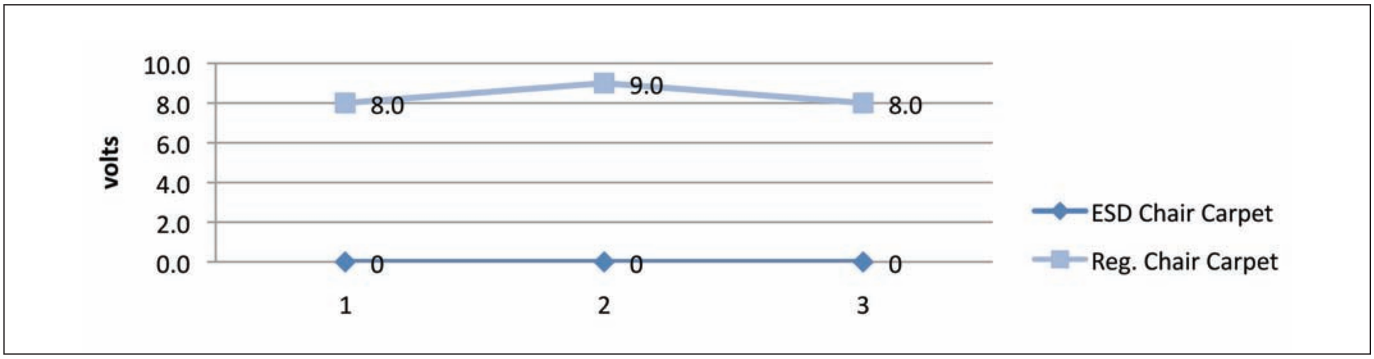

Figure 4: ESD voltage of ESD and non-ESD chairs on insulative carpet (ESD Chair over mat = No ESD events with person wearing wrist strap; non-ESD Chair over mat = Low ESD events with person wearing wrist strap)

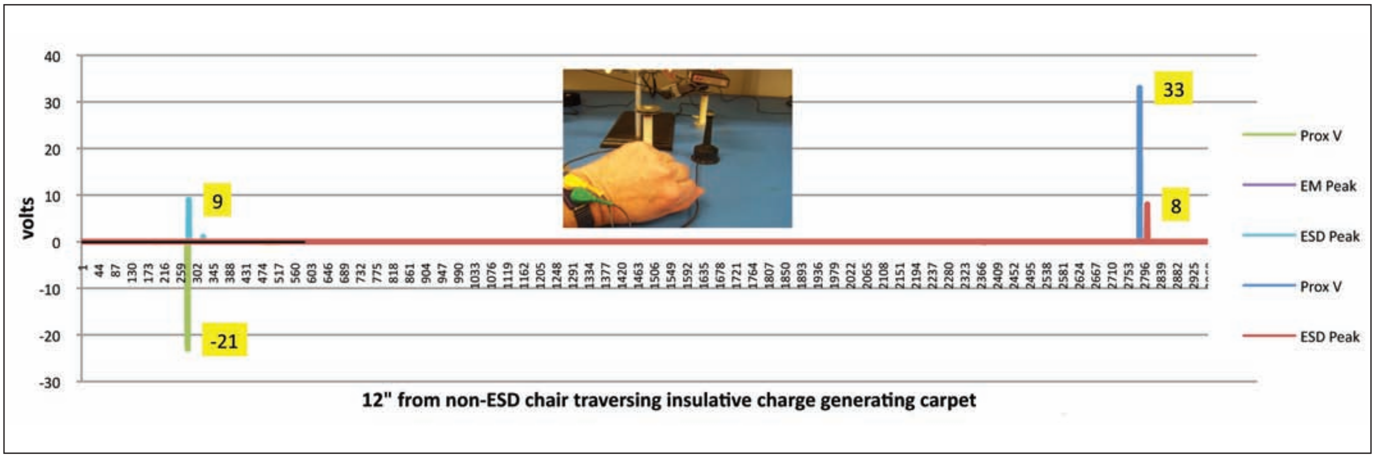

Figure 5: ESD event and voltage with operator wearing wrist strap

the moving charge induces a spark within the chair. Thus, in mission critical aerospace systems, such as a satellite assembly, or in proximity to very sensitive devices like GMR disk drive heads, the induced voltages and currents from the fields radiated from the chair into nearby equipment could be catastrophic.

In a repeat test, the vertical scale was increased from 100 mV/div to 500 mV/div so the waveform would remain visible on the screen. The voltage recorded from the antenna was about 1.3 volts peak into 50 Ohms due to radiation from the chair as illustrated in Figure 7.

At -1.3 volts (20 NS per division), the radiation could damage exposed disk drive heads and possibly other sensitive components. Radiated EMI is known to create soft errors and lock ups in equipment.

Organizations should specify a chair that does not promote radiated EMI/RFI due to ESD. In addition, standards work in this area is needed.

In conclusion, both testing series indicate more work needs to be done in conducting tests at 30% RH or below to determine if similar findings can be secured at low RH conditions.

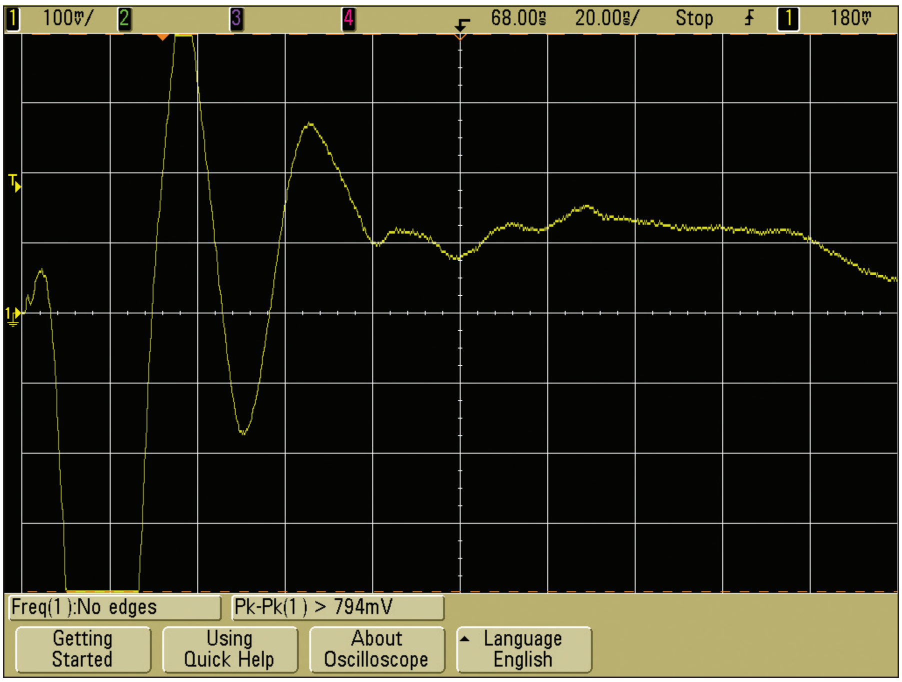

Figure 6

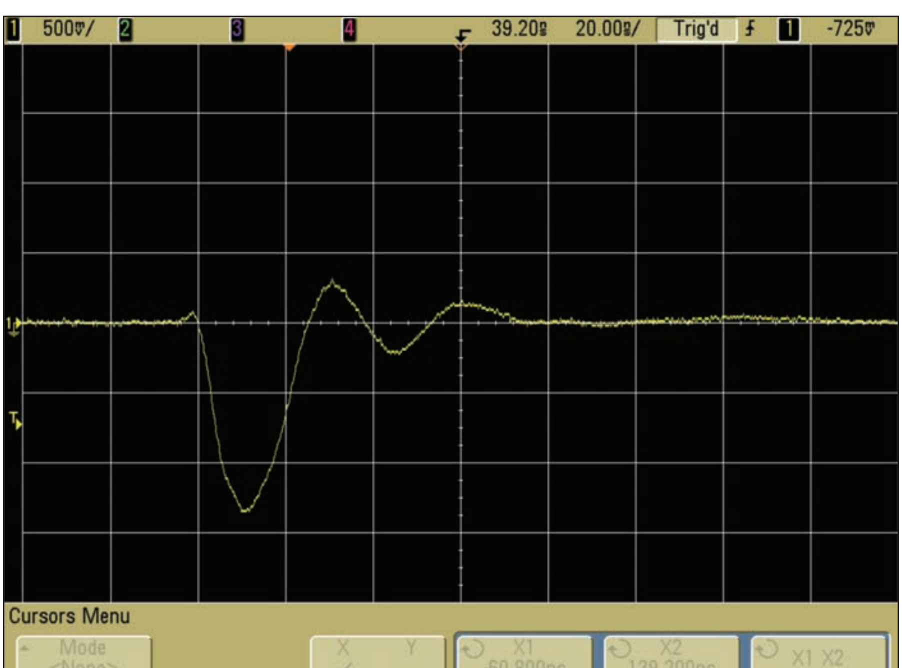

Figure 7

(the authors)

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BUSINESS News

Keysight Technologies Introduces Lower-cost Receiver for Electromagnetic Interference Compliance Testing of Electronic Products Up to 3.6 GHz

Keysight Technologies, Inc. announced that its N9038A MXE EMI receiver is now available with a frequency range of 20 Hz to 3.6 GHz. The affordable pricing of this new option addresses the needs of commercial manufacturers that perform compliance testing in their own facilities and do not require measurements at higher frequencies. The MXE EMI receiver is compliant with CISPR 16-1-1 for commercial products and MIL-STD-461 for military systems. With the new option, test engineers can configure the MXE with a frequency range of 20 Hz to 3.6, 8.4, 26.5, or 44 GHz. More information is available at is available at www.keysight.com.


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Rohde & Schwarz Presents Growing Oscilloscope Portfolio at Embedded World 2015

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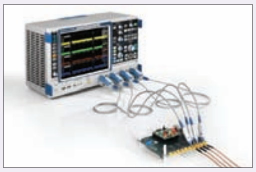
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The fourth edition of IEC 60601-1-2:2014 introduces new EMC requirements and tests for medical equipment and systems. TÜV Rheinland strongly encourages medical device makers to determine how they will transition to the new revision that introduces significant technical changes, including new immunity and risk analysis requirements. New devices must comply by April 2017 in the U.S. For more information about TÜV Rheinland’s testing services, visit www.tuv.com/us.

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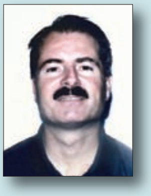

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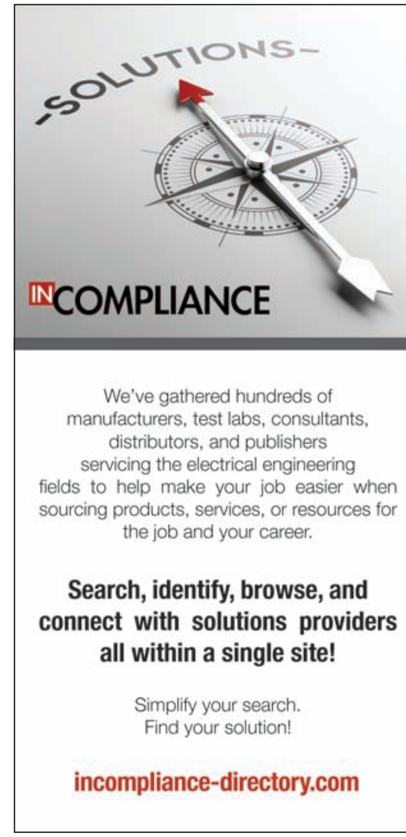
PRODUCT Showcase



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