AUGUST 2011

IN COMPLIANCE™

THE COMPLIANCE INFORMATION RESOURCE FOR ELECTRICAL ENGINEERS

Recent Changes to GR-1089-CORE

PLUS

EMI
Risk Analysis

Making Real Boards:
The Secrets to Matching Fabricator Impedance Results With Your Own Calculation

An Equivalent Three-Dipole Model for IC Radiated Emissions Based on TEM Cell Measurements

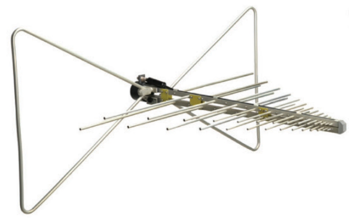
Automating EMC Testing

SPECIAL COVERAGE
2011 EMC Symposium

Wide Variety of Products for Your EMC Testing Needs

Visit us at Booth 118
IEEE EMC 2011
Long Beach, CA

Biconical Antenna



Combilog Antenna

Log Periodic Antenna

Passive Horns up to 40 GHz

Monopole Antenna

Loop Antenna

Active Horn Antenna

Absorbing Clamps

Preamplifiers

Comb Generators up to 34 GHz

LISNs

CDNs

Near Field Probes

Save Time and Money by Shopping From A Single Source

Com-power offers a wide variety of products for compliance testing. We provide quick delivery, the best warranty in our industry, and very reasonable prices.

Competitive Pricing
Fast Delivery
Three-year Warranty

OTHER PRODUCTS INCLUDE:

Spectrum Analyzers & Receivers • Power Amplifiers • Turntables • Masts & Tripods • Product Safety Accessories

Contact us at 714.528.8800 or sales@com-power.com
www.com-power.com

COM-POWER CORPORATION

114 Olinda Drive, Brea, California 92823 • tel 714.528.8800 • fax 714.528.1992 • sales@com-power.com

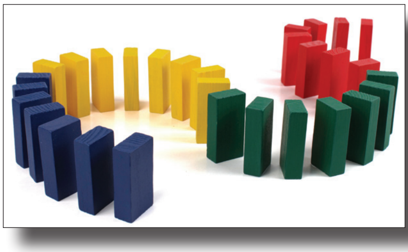
CONTENTS

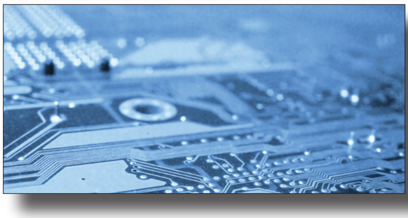
August 2011
Volume 3 • Number 8

DEPARTMENTS

SPECIAL FEATURE:

FEATURES





Letter from the editor

California Dreamin'

I love this time of year. Here at the offices of In Compliance, we're getting ready for the largest international gathering of EMC professionals in our industry. The anticipation of seeing old friends and meeting new friends is beginning to build. And the hustle and bustle of planning for the big event is keeping us on our toes! California, here we come!

Just the other day, one of my colleagues mentioned that this would be our third August issue for In Compliance. I was a little surprised and shook my head in wonder (well, okay maybe a big "What!" fell out) because I really couldn't believe so much time has passed since the introduction of our Premiere Issue at the 2009 Symposium in Austin.

And yet - here we are, two full years into this adventure and a magazine filled with exciting, new things to share. As you leaf through the pages in this, our third August issue, you may notice a different look. It seemed appropriate that as we observe our second anniversary, we would take a close look at our magazine and make improvements for our **25th issue**! We've streamlined things a bit and made things easier to find with colored tabs like the one you see here in the upper left corner. We hope you enjoy the new layout and invite your feedback.

Inside, you'll find a great line-up of articles from a broad range of authors.

Jeffrey Viel brings us special coverage on the new GR-1089-CORE Issue 6. Jeff provides a run down of the changes in Issue 6 and shares the potential impact on previously certified products.

Also new in this issue is the addition of Niels Jonassen's **Mr. Static** columns. We've coordinated efforts with The ESD Association to bring these timeless articles back into the print realm.

Take a walk down memory lane with Joe Tannehill in this month's "**Reality Engineering"** article - Automating EMC Testing, where Joe takes a look back in time to 1984 and shares with us the progression of the automation of EMC testing throughout his career. Dan Hoolihan covers software validation relative to EMC lab assessments in Joe's article and Kimball Williams joins in to write on Computer Assisted Testing.

Don't miss our 2011 EMC Symposium Preview starting on page 34. The 2011 Committee has organized a fantastic event this year!

And one last note, your letters and comments are truly appreciated - and help us deliver the news and information you've come to rely on. We hope you will continue sending your feedback so that we can continue to work at better serving you. Until we meet again.

Lorie Nichols
Editor
editor@incompliancemag.com

IN Compliance Magazine
ISSN 1948-8254 (print)
ISSN 1948-8262 (online)
is published by

Same Page Publishing Inc.
P.O. Box 235
Hopedale, MA 01747
tel: (508) 488-6274
fax: (508) 488-6114

staff

editor Lorie Nichols
lorie.nichols@incompliancemag.com
(978) 873-7777

director of sales Sharon Smith
sharon.smith@incompliancemag.com
(978) 873-7722

director of media services Erin Feeney
erin.feeney@incompliancemag.com
(978) 873-7756

account manager Barbara Kovalchek
barbara.kovalchek@incompliancemag.com
(978) 846-1656

subscriptions

IN Compliance Magazine subscriptions are free to qualified subscribers in North America.

Subscriptions outside North America are $129 for 12 issues. The digital edition is free.

Please contact our circulation department at circulation@incompliancemag.com

advertising

For information about advertising contact:
Sharon Smith at 978-873-7722
sharon.smith@incompliancemag.com

Barbara Kovalchek at (978) 846-1656
barbara.kovalchek@incompliancemag.com

News in Compliance

FCC News

Commission Issues New Rules Against "Spoofing"

With the deceptive use of caller identification information on the rise, the Federal Communications Commission (FCC) has issued new rules to protect consumers from the practice of "spoofing," which involves masking the identification of a caller for malicious purposes.

In a Report and Order issued in June 2011, the FCC now prohibits caller ID spoofing with fraudulent or harmful intent. Under the new rules, violators are subject to up to a $10,000 fine for each violation, or three times that amount for each day of continuing violations, with a maximum fine of $1 million for any continuing violation. In addition, the FCC may assess fines against entities it does not traditionally regulate without first issuing a citation, and can impose penalties more readily than it can under other provisions of the Communications Act.

According to the FCC, callers are still permitted to alter caller ID information as long as their purposes are not harmful or fraudulent. An example might be a domestic violence shelter that may have personal safety reasons for not revealing the actual phone number of the shelter.

The new rules implement the provisions of the Truth in Caller ID Act, passed by Congress and signed into law by President Obama in 2010.

The complete text of the Commission's Report and Order on spoofing is available at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-11-100A1.pdf.

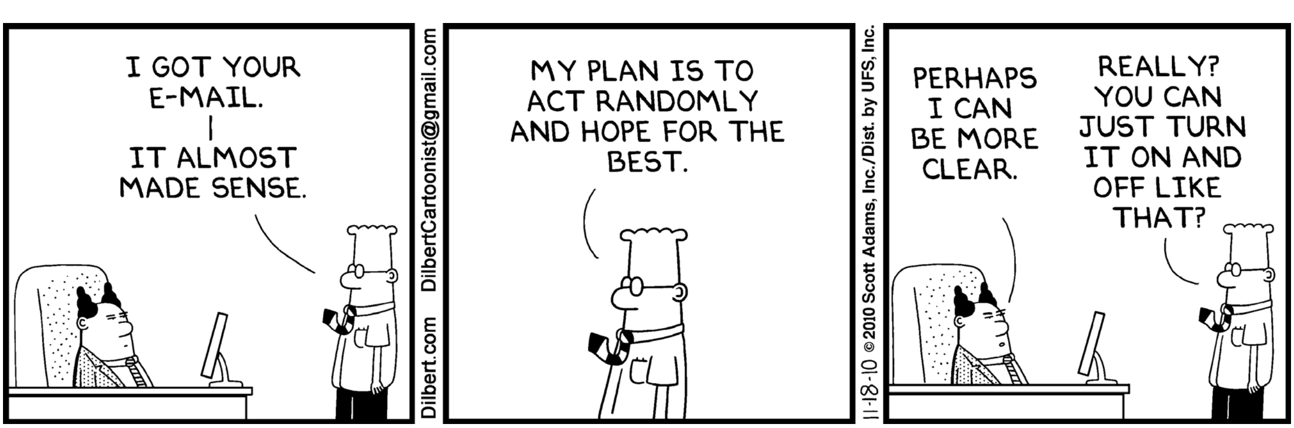
FCC Proposes Major Penalties for Unauthorized Phone Charges

Signaling its commitment to enforce its rules against the practice of "cramming" (the placing of unauthorized charges on a consumer's phone bill), the Federal Communications Commission (FCC) has proposed significant financial penalties against four separate telecommunications companies based in Pennsylvania.

In four separate Notices of Apparent Liability for Forfeiture issued in June 2011, the Commission has proposed a $4.2 million penalty against Main Street Telephone of Blue Bell, PA, a $3.0 million penalty against both VoiceNet Telephone and Cheap2Dial of Harrisburg, PA, and a $1.5 million penalty against Norristown Telephone of Blue Bell, PA, for a total of $11.7 million. According to the FCC, the companies charged thousands of customers for "dial-around" long distance service that they had not ordered. The Commission's investigation revealed that only a small percentage of the affected consumers actually used the services, while the unlawful billing continued for months and, in some cases, years.

The FCC has found that cramming is an "unjust and unreasonable" practice that violates section 201(b) of the Communications Act, and has pledged to take aggressive enforcement action against companies that engage in cramming activities.

The complete texts of the Notices of Apparent Liability for Forfeiture are available at http://transition.fcc.gov/Daily_Releases/Daily_Business/2011/db0701/FCC-11-89A1.pdf (for Main Street), http://transition.fcc.gov/Daily_Releases/Daily_Business/2011/db0701/FCC-11-91A1.pdf (for Voice Net), http://transition.fcc.gov/Daily_Releases/Daily_Business/2011/db0701/FCC-11-90A1.pdf (for Cheap2Dial), and http://transition.fcc.gov/Daily_Releases/Daily_Business/2011/db0616/FCC-11-88A1.pdf (for Norristown Telephone).



News in Compliance

European Union News

EU Commission Updates Ecological Criteria for Personal Computers

The Commission of the European Union (EU) has issued updated ecological criteria for manufacturers of personal computers (PCs) wishing to display the EU's Ecolabel on their products.

The Commission's Decision updating the Ecolabel requirements for PCs was published in June 2011 in the *Official Journal of European Union*. The new criteria update those originally issued by the Commission in 2005, which were valid through June 2011, and are consistent with those of the U.S. Energy Star program.

The specific EU Ecolabel criteria for PCs, and the requirements for the assessment and verification of compliance with the criteria, are laid out in the Annex to the Commission's Decision.

The complete text of the Commission's Decision regarding the use of the EU Ecolabel is available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:151:0005:0014:EN:PDF.

Standards List for In-Vitro Medical Devices Updated by EU Commission

The Commission of the European Union (EU) has published an updated list of standards that can be used to demonstrate compliance with the essential requirements of its Directive 98/79/EC, dealing with in-vitro diagnostic medical devices.

According to the EU's Directive, an in-vitro diagnostic medical device is "any medical device which is a reagent, reagent product, calibrator, control material, kit, instrument, apparatus, equipment, or system, whether used alone or in combination, intended by the manufacturer to be used in-vitro for the examination of specimens, including blood and tissue donations, derived from the human body."

Under the Directive's definition, specimen receptacles are considered to be in-vitro diagnostic medical devices, while products for general laboratory use are not, unless such products are intended to be used for in vitro-diagnostic examination.

The updated list of CEN and Cenelec standards that can be used to support compliance with the Directive was published in June 2011 in the *Official Journal of the European Union*, and replaces all previously published standards lists for the Directive.

The list is available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2011:185:0003:0006:EN:PDF.

Updated Standards List Released for the EU's Directive on the Safety of Toys

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 relating to the safety of toys (88/378/EEC).

According to the Directive, a toy is defined as "any product or material designed or clearly intended for use in play by children of less than 14 years of age." The scope of the Directive includes electric toys that are powered by a nominal voltage up to and including 24 V, and requires sufficient protections for such devices to prevent the risk of electric shock and/or burns.

The most recently updated list of CEN standards for the Directive was published in June 2011 in the *Official Journal of the European Union*, and replaces all previously published standards lists for the Directive.

The revised list of standards can be viewed at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2011:178:0004:0005:EN:PDF.

Updated Standards List Published for EU's 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 June 2011 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 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2011:168:0002:0011:EN:PDF.

News in Compliance

CPSC News

CPSC Opens New Product Testing Center

The U.S. Consumer Product Safety Commission (CPSC) has opened a new state-of-the-art product testing facility in Rockville, MD.

According to the CPSC, the new National Product Testing and Evaluation Center provides 63,000 sq. ft. of office and laboratory space, and house 75 agency scientists and engineers. The new center is equipped with a variety of testing equipment, including an ATV tilt table to measure ATV road stability, and advanced test chambers to conduct mattress flammability testing and carbon monoxide alarm testing.

The CPSC's new testing facility replaces its former testing site in Gaithersburg, MD, which CPSC engineers had occupied since 1975.

The CPSC's new testing facility replaces its former testing site in Gaithersburg, MD, which CPSC engineers had occupied since 1975. The inadequacy of the former facility was among the many deficiencies highlighted in a 2007 report by the *New York Times* about the CPSC's challenges in protecting consumers from unsafe products.

Additional information about the CPSC's new product testing center is available at http://www.cpsc.gov/cpscpub/prerel/prhtml11/11244.html.

CPSC Approves New Safety Rule for Hair Dryers

The U.S. Consumer Product Safety Commission (CPSC) has approved a new rule that strengthens its enforcement efforts against unsafe hand-held hair dryers.

Published in the *Federal Register* in June 2011, the new rule restricts the importation of hand-held hair dryers that do not include integral immersion protection, and gives the CPSC the authority to issue a mandatory recall of any such non-compliant devices.

Current voluntary industry standards require manufacturers of hand-held hair dryers to incorporate a protective mechanism into the device that prevents shock and/or electrocution when the hair dryer comes in contact with water. According to the CPSC, most manufacturers and distributors already comply with these voluntary standards. However, the new rule provides the agency with additional enforcement options to ensure the safety of consumers.

The complete text of the CPSC's new rule regarding hand-held hair dryers as published in the *Federal Register* is available at http://www.cpsc.gov/BUSINFO/frnotices/fr11/hairdryrule.pdf.

GE Recalls Air Conditioning and Heating Units

GE Appliances and Lighting of Louisville, KY has announced the recall of about 91,000 of its GE Zoneline-brand air conditioners and heaters manufactured in China.

The company reports that an electrical component in the heating system can fail, thereby posing a fire hazard to consumers. GE says that it has received four separate reports of smoke and/or fire with the recalled units, with fire extending beyond the units in two instances, resulting in property damage. However, no injuries have been reported.

The recalled air conditioning and heating units were sold by GE authorized representatives and HVAC distributors nationwide from March 2010 through March 2011 for between $1000 and $1200.

More information about this recall is available at http://www.cpsc.gov/cpscpub/prerel/prhtml11/11247.html.

Company Recalls Premium Sewing Machines

Janome America, Inc. of Mahwah, NJ is recalling about 600 sewing machines manufactured in Japan and Taiwan.

Janome reports that the wire inside the sewing machines can short circuit, posing a risk of fire to consumers. The company says that it has received one report of a sewing machine catching fire, but no reports of injuries or property damage.

The recalled sewing machines were sold at sewing machine stores nationwide from September 2010 through April 2011 for about $3000.

Additional details about this recall are available at http://www.cpsc.gov/cpscpub/prerel/prhtml11/11237.html.


Visit us at
Booth 222
IEEE EMC 2011
Long Beach, CA
All you
need in one
small package
Antennas | Probes | Accessories | Preamplifiers | Low-Loss Cables | Recalibration Services
Travel Made Easy
with Next-Day,
On-Time
Delivery
Don't Leave home without it. A.H. Systems provides many models of Portable Antenna Kits, each containing all the necessary Antennas, Current Probes, and Cables to satisfy numerous customer requirements. Excellent performance, portability (compact size and lightweight), along with ease of setup make all of the Antenna Kits your choice for indoor or field testing. Loss and breakage are virtually eliminated as each component has a specific storage compartment within the case. All Antenna Kits are accompanied with a Tripod and Azimuth & Elevation Head, both contained in a Tripod Carrying Case...and dont forget your keys!
ANTENNAS...
and KITS TOO...
Innovation
Quality
Performance
Phone: (818)998-0223 ♦ Fax (818)998-6892
http://www.AHSystems.com
A.H. Systems

News in Compliance

UL Standards Updates

Underwriters Laboratories has announced the availability of these standards and revisions. For additional information, please visit their website at www.ul.com.

Underwriters Laboratories has announced the availability of the following standards and revisions. For additional information regarding the standards listed below, please visit their website at www.ul.com.

Standards and Outlines

UL 102: Interim Sustainability Requirements for Door Leafs
Standard dated June 14, 2011

UL 110: Interim Sustainability Requirements for Mobile Phones
Standard dated June 6, 2011

UL 263: Standard for Fire Tests of Building Construction and Materials
Standard dated June 21, 2011

UL 1963: Standard for Refrigerant Recovery/Recycling Equipment
Standard dated June 1, 2011

UL 2007A: Standard for Shatter Containment Of Lamps For Use In Regulated Food Establishments
Standard dated June 21, 2011

Revisions

UL 8: Standard for Water Based Agent Fire Extinguishers
Revision dated June 13, 2011

UL 69: Standard for Electric-Fence Controllers
Revision dated June 15, 2011

UL 197: Standard for Commercial Electric Cooking Appliances
Revision dated June 24, 2011

UL 248-1: Standard for Low-Voltage Fuses - Part 1: General Requirements
Revision dated June 22, 2011

UL 295: Standard for Commercial-Industrial Gas Burners
Revision dated June 11, 2011

UL 296: Standard for Oil Burners
Revision dated June 15, 2011

UL 489: Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
Revision dated June 30, 2011

UL 514D: Standard for Cover Plates for Flush-Mounted Wiring Devices
Revision dated June 28, 2011

UL 551: Standard for Transformer-Type Arc-Welding Machines
Revision dated June 23, 2011

UL 810A: Standard for Electrochemical Capacitors
Revision dated June 7, 2011

UL 962: Standard for Household and Commercial Furnishings
Revision dated June 3, 2011

UL 1004-1: Standard for Rotating Electrical Machines - General Requirements
Revision dated June 23, 2011

UL 1053: Standard for Ground-Fault Sensing and Relaying Equipment
Revision dated June 15, 2011

UL 1082: Standard for Household Electric Coffee Makers and Brewing-Type Appliances
Revision dated June 17, 2011

UL 1083: Standard for Household Electric Skillets and Frying-Type Appliances
Revision dated June 17, 2011

UL 1247: Standard for Diesel Engines for Driving Stationary Fire Pumps
Revision dated June 28, 2011 **L 1411: Standard for Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances**
Revision dated June 16, 2011

UL 1450: Standard for Motor-Operated Air Compressors, Vacuum Pumps, and Painting Equipment
Revision dated June 7, 2011

UL 1876: Standard for Isolating Signal and Feedback Transformers for Use in Electronic Equipment
Revision dated June 29, 2011

Do you have news that you'd like to share with your colleagues in the compliance industry? We welcome your suggestions and contributions.

Send news items to the editor:

In Compliance Magazine
P.O. Box 235
Hopedale, MA
(508) 488-6274
editor@incompliancemag.com

iNARTE Informer

HEADQUARTERS NEWS

The 2011 Symposium season is upon us. In August we have the IEEE EMCS 2011, in September there is the ESDA EOS/ESD 2011, and then in October the IEEE PSES 2011. This year they are all in California, and all just far enough apart that we will be travelling back and forth for each one.

The important thing to remember for all who plan to attend any of these events is that your symposium registration fee also covers the iNARTE exam proctoring service. Each of the organizers have graciously offered iNARTE exhibition and examination room space and you can register in advance to take any of the iNARTE examinations at any of these events, and at the US domestic application rates. Below are some useful links:

iNARTE Home – www.narte.org

iNARTE Examination Registration - www.narte.org/h/examregform.asp

EMCS 2011 - www.emc2011.org/program/

EOS/ESD 2011 - www.esda.org/symposia.html

PSES 2011 - www.psessymposium.org

Also remember that this year there are new iNARTE certification opportunities to consider:

EMC Design Engineer

www.narte.org/h/emcdesignengineer.asp

MIL-STD EMC Specialist www.narte.org/h/milstdemcspecialist.asp

iNARTE Certification for ESDA Program Managers – www.esda.org/documents/SymposiumProgram2011.pdf (Page 6)

And for all you experienced EMC Design Engineers out there, get your applications submitted and recorded during our introductory Grandfathering period. Applications will be received until December 31st 2011, after that you have up to 12 months to complete the process.

MIL-STD EMC SPECIALIST

The new MIL STD certification program has already started. On June 14th-17th, Washington Laboratories Academy gave a four day course to introduce the new/modified test methods and test article configurations that are now part of MIL-STD 461F. At the conclusion of the tutorials on June 17th, Steve Ferguson proctored the first iNARTE MIL-STD EMC Specialist certification examination. Most attendees did not have enough prior notice of the iNARTE exam to come prepared, but two brave souls took the plunge and both passed. Their certificates will be issued when their remaining application steps have been completed. One of these lucky applicants will get Certificate #00001.

Washington Laboratories Academy will be repeating this event several more times. The current schedule is September 13th -16th, 2011, November 14th-17th, 2011, and March 13th-16th, 2012. Make your reservations as soon as possible, and come prepared with reference materials ready to take the iNARTE open-book exam, (http://www.wll.com/academy.html).

ASIAN REVIEW

This year we attempted to cover all our more active Asian regions in one trip, so 11 flights and three weeks later we have attended APEMC 2011 and met with partners in Japan, Korea, China and Singapore.

Japan continues to be our most responsive country. This year, so far, we have had more than 230 Japanese applicants taking iNARTE certification examinations, and currently almost half our EMC and PSE certificate holders are in Japan. As reported last month, we signed a formal agreement with KEC Japan to introduce the EMC Design Engineer certification program and it will be interesting to see how popular this new certificate becomes there, as compared to the USA.

We have a new Regional Partner in Korea who will be promoting iNARTE Certification for ESD practitioners. Joshua Yoo, President of CORE Insight Inc. provides consulting services and ESD control training. CORE has worked closely with the ESDA for several years and has built an excellent reputation. We were able to spend time with Joshua and his assistant Elly Koo to finalize arrangements for an iNARTE examination session on July 22nd.

On to Hong Kong, where we met with Jerry Lee and Kent Hsu of ATCB-HI Ltd. ATCB acts as the exclusive administrator for iNARTE programs in China and Taiwan. We reviewed progress on the strategic plan prepared last year and established our priorities for the next 12 months. There is interest in EMC, ESD and Product Safety Engineering certification in this region, but applicants are only slowly emerging.

Finally to Singapore, and meetings with Marcus Koh and Yohan Goh of Everfeed Technology Pte Ltd. Everfeed is part of a group of companies having facilities in Malaysia and China, specializing in consultation, solutions and training in ESD

The Chicken Rice Engine Room

control. Marcus has been most successful in recruiting applicants for iNARTE ESD certification from among their customer group and we discussed arrangements for Everfeed to host a special, three day, ESD Association Tutorial and iNARTE examination program later this year.

It was nice to get back after that trip and back to some home cooked meals again. We certainly sampled a few strange things during our travels. Abalone, black pork and horse are all popular on Jeju Island. Hong Kong has everything, but we particularly enjoyed the special roast goose and the spicy fish soup. In Singapore we tried their popular chicken rice and the turtle special with crocodile soup. It was all good, but not exactly what we are used to.

The Turtle and Crock Pot

REGISTER FOR CERTIFICATION EXAMS

The following events offer candidates a chance to take the iNARTE certification examinations without incurring proctoring fees.

IEEE EMCS 2011 – Long Beach, CA. iNARTE workshop on August 15th, examinations on August 19th.

EOS/ESD 2011- Anaheim, CA. iNARTE examinations on September 16th

IEEE PSES 2011 – San Diego, CA. iNARTE examinations on October 13th

Candidates can register in advance at the iNARTE web site to examine at any of the above events for any of the programs that we offer. At the event, candidates can register until the day before the exam, but only for the discipline related to the event. IN

QUESTION OF THE MONTH

Last month we asked:

According to MIL-STD-461F, stepped frequency susceptibility scans shall dwell at each tuned frequency for:

A) 500 ms

B) 1 s

C) A period of time not less than that required for the EUT to respond.

D) The greater of 3 seconds or the EUT response time.

The correct answer is D) The greater of 3 seconds or the EUT response time.

This question this month is:

Select one of the radio frequencies listed below that represents the 19th order intermodulation product frequency for signal frequencies of 3.397 MHz and 12.45 MHz.

A) 12.903 MHz

B) 4.606 MHz

C) 17.002 MHz

D) None of the above

(the author)

BRIAN LAWRENCE began his career in electromagnetics at Plessey Research Labs, designing "Stealth" materials for the British armed services. In 1973 he moved to the USA and established a new manufacturing plant for Plessey to provide these materials to the US Navy. In 1980 he joined the "Rayproof" organization to develop an RF Anechoic Test Chamber product line. As a result of acquisitions, Rayproof merged into Lindgren RF Enclosures, and later into ETS-Lindgren. Following a career spanning more than 40 years in the electromagnetic compatibility field, Brian retired as Managing Director of ETS-Lindgren UK in 2006. Later that year he assumed the position of Executive Director for the National Association of Radio and Telecommunications Engineers, NARTE. Now renamed iNARTE, the Association has expanded its operations and is today an affiliate of RABQSA under the overall banner of the American Society for Quality, ASQ.

FUTURE of EMC Engineering

Printed Circuit Boards of the Future

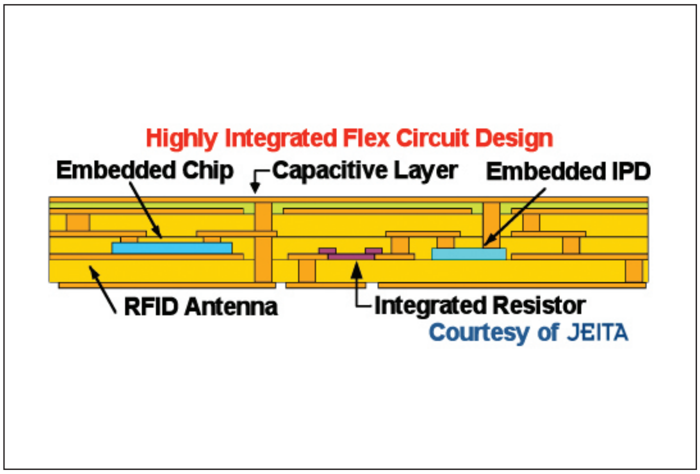
BY MARK MONTROSE

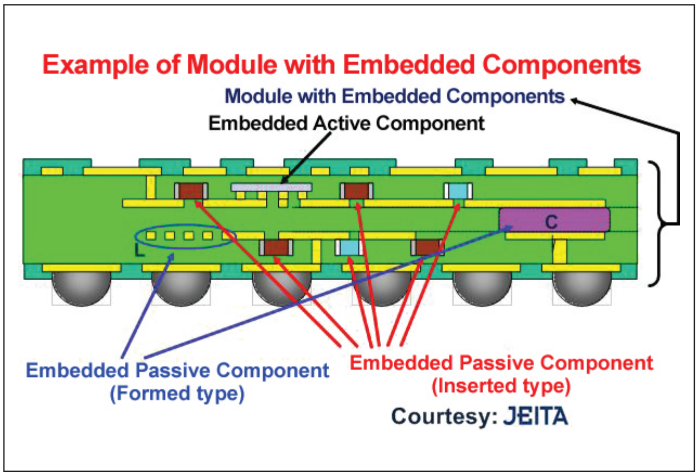
Almost every electrical device has a physical structure that contains transmission lines. We call this structure a printed circuit board (PCB). There are three basic structures-rigid, flex and rigid-flex. Advances in technology mandate smaller, faster and at low cost. The company that can achieve all three elements will be successful.

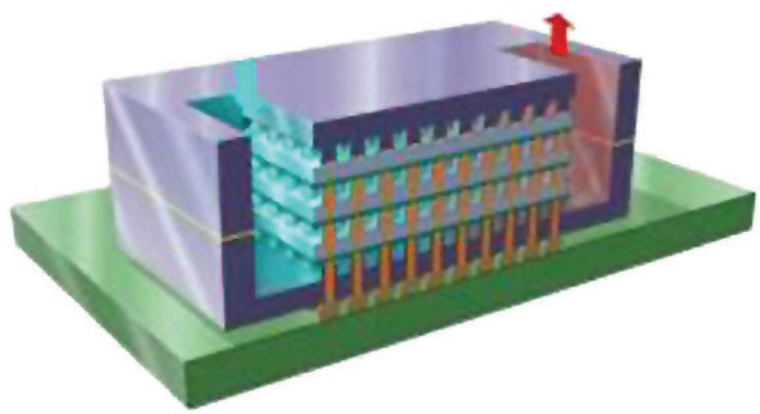
In the future, there will be a point to where the number of active and passive components that can be physically mounted onto a PCB will exceed the available real-estate of the laminate including both top and bottom layers. When this occurs the product must increase in size or features removed. This is a challenge for any designer. PCBs in the future may take on different forms than what we are familiar with today.

To highlight where the future of PCB technology may end up, we can expect the following will become a routine design process. Will advances in PCB technology make more or less work for the EMC engineer?

1. Most high-technology products will be six or more layers using very thing laminates.
2. Discrete actives such as semiconductor dies, or wafers, will be embedded internal to the assembly. Embedding actives minimizes loop area inductance and allows room on both top and bottom for components and interconnects that cannot be embedded.
3. Discrete passives, such as capacitors and inductors will also be embedded along with buried capacitance layers to ensure a high quality power distribution network. Buried resistors have been around for several decades (www.ohmega.com).
4. Transmission lines will be fiber optic and not traditional copper traces. There are now PCBs that contain fiber optic traces which are made by placing glass beads in a trench within a core layer and during manufacturing melted into a fiber optic interconnect. Backplanes are also becoming fiber optic for certain high-speed applications.
5. Three dimensional components will be used with higher number of I/O pins and greater power consumption.







3D-IC with vias and inter layer cooling channels enclosed in a sealed housing (www.PhysOrg.com)

(the author)

MARK I. MONTROSE is an EMC consultant with Montrose Compliance Services, Inc. having 30 years of applied EMC experience. He currently sits on the Board of Directors of the IEEE (Division VI Director) and is a long term past member of the IEEE EMC Society Board of Directors as well as Champion and first President of the IEEE Product Safety Engineering Society. He provides professional consulting and training seminars worldwide and can be reached at mark@montrosecompliance.com.

MR. Static

How Is Static Electricity Generated?

Predicting the level of static build-up is rarely possible.

BY NIELS JONASSEN

Nearly all static-electric phenomena are caused by the interaction between charges located on the surfaces of bodies which might be conductive as well as insulative. A basic question, therefore, is, how do the bodies obtain the charges? We will present a qualitative overview of the physical processes involved in static build up.

INTRODUCTION

Associate Professor Neils Jonassen authored a bi-monthly static column that appeared in *Compliance Engineering Magazine*. The series explored charging, ionization, explosions, and other ESD related topics. The ESD Association, working with *IN Compliance Magazine* is re-publishing this series as the articles offer timeless insight into the field of electrostatics.

Professor Jonassen was a member of the ESD Association from 1983-2006. He received the ESD Association *Outstanding Contribution Award* in 1989 and authored technical papers, books and technical reports. He is remembered for his contributions to the understanding of Electrostatic control, and in his memory we reprise "Mr. Static".

~ The ESD Association

Reprinted with permission from:
Compliance Engineering Magazine,
Mr. Static Column

The title might seem to imply a discussion on developing formulas for quantitatively predicting the magnitude of electrification from material parameters and other physical conditions. Quantitative predictions, however, are rarely possible.

It is important to first stress that charges are never generated. They always exist in atoms—as positive charges on the protons of the nuclei, and as negative charges on the electrons around the nuclei. An electric effect can be seen only when electrons are removed from some of the atoms in one material and transferred to atoms in another (or maybe even the same) material. The electric effect is caused by the attraction between opposite charges and the repulsion between like charges.

We are normally only aware of this effect if the electron-exchanging materials are separated in such a manner that at least part of the charges do not reunite during the separation process. The transfer of electrons between atoms or molecules might occur when two solids—identical or different—contact each other, with electrons crossing the interface in a preferential direction, giving one material a positive and the other a negative excess charge.

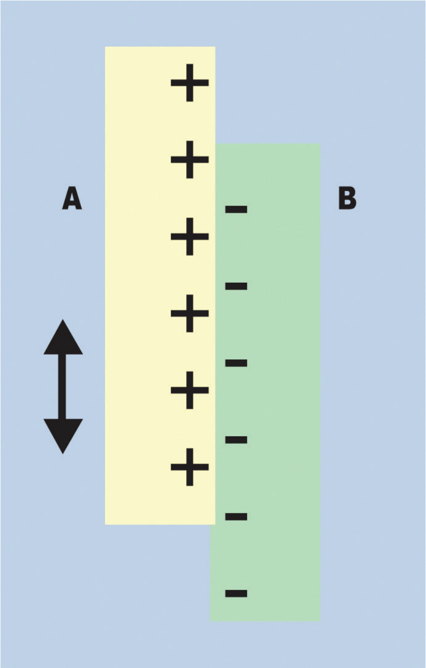


Figure 1: Triboelectrification

The exchange of electrons could also occur when an insulative liquid flows through a tube, when a liquid of almost any type breaks up into droplets of nonuniform magnitude, or when droplets fall through an inhomogeneous field, such as in a thundercloud.

The number of electrons transferred in any charging process is enormous. Here are some examples. If a powder, such as sugar or flour, slides down a tube and sticks to the wall, the charge on each tiny particle could be 10^{-14} to 10^{-13} C, i.e., 100,000 to 1 million electrons have been transferred per particle. A person who has walked across a carpeted floor receives a shock when touching a doorknob that typically has a charge of about 10^{-7} C. Powder sliding down a tube often has a specific charge of about 10^{-7} C•kg–1. A plastic folder rubbed with a piece of cloth or fur typically produces a charge of 10^{-7} C per sheet.

Charging of Solids: Triboelectrification

The most important type of charge separation involves the contact and friction between solids known as triboelectrification. When two solid materials, A and B (see Figure 1), contact and possibly rub against each other, electrons could move across the interface.

Metals. It may be surprising that triboelectrification also happens when the two contacting materials are metals. And even more surprising is that this friction between metals is the only case in which the result of the charge transfer can be accurately predicted. When two metals contact, a voltage difference is established across the interface—the so-called contact potential difference—with a magnitude from a couple of tenths to a few volts.

If the metals are "well-defined" metals, the contact potential difference can be calculated from the work functions, i.e., the energy it takes to remove a loosely bound electron from the metal. It should be stressed, however, that this charge exchange between metals only gives rise to what we normally understand as static electricity when the two metals are separated extremely quickly, such as when a metal powder is blown against a metal surface.

Insulators. It is likely that processes similar to those described for metals could take place during contact between materials of which one or both are insulators. It is, however, difficult to characterize completely an insulating surface. For many materials, especially noncrystalline ones, the energy levels are badly defined and, therefore, the detailed contact processes are not known.

It is conceivable that only electrons located close to the surface can participate in the charging of highly insulative materials. Similar to metals, for some of these materials it is possible to measure the work function for loosely bound electrons. Because the measured values only hold true for materials with well-defined surface states, the practical implication of this is small.

As soon as a surface prepared in vacuum is exposed to ordinary air, the state—including the energy levels of surface electrons—can change considerably. Consequently, charging experiments with insulators can only yield quantitatively predictable results if the surfaces are carefully prepared and the experiments are performed in vacuum. And such experiments might disclose very little about what one could expect to find under more-practical conditions.

Positive end
Plexiglass
Bakelite
Cellulose nitrate
Glass
Quartz
Nylon
Wool
Silk
Cotton
Paper
Amber
Resins (natural and man-made)
Metals
Rubber
Acetate rayon
Dacron
Orlon
Polystyrene
Teflon
Cellulose nitrate
Polyvinyl chloride
Negative end

Table 1: An example of a triboelectric series

Contact Electrification: Triboelectric Series

One of the material parameters influencing the course of a charging process between two solid materials is the permittivity. Scientifically speaking, permittivity is defined as the ratio between corresponding values of the dielectric displacement and the electric field strength. However, in this context, it is more important that permittivity is also a measure of the ability of the material to become polarized.1 If an ion or another small, charged atomic or molecular cluster lands on an insulative surface, it will be bound to the surface by polarization forces. The stronger the forces, the higher the permittivity of the material.

This is the background for Coehn's law, which states that when two materials are in contact with each other, the one with the highest permittivity becomes positive. This law was originally based on a comparison of known values of permittivity and published triboelectric series (i.e., a list of materials arranged in such an order that any material will become positively charged when rubbed against another material that is nearer the negative end of the series). There is no doubt that such a correlation exists, but with quite a few exemptions. And certain groups of materials can even be arranged in a closed series.

Table 1 shows an example of a triboelectric series. Such a series should be used with caution because the order of the materials could vary from series to series. Some series even locate air at the top of the positive end, which is a mistake.

From the relative position of a material in a series, it is possible to predict the sharing of polarity. However, the magnitude of the charges separated by contact and friction between two given materials can only be predicted with a high degree of uncertainty.

The magnitude of the charges often increases with the degree of friction

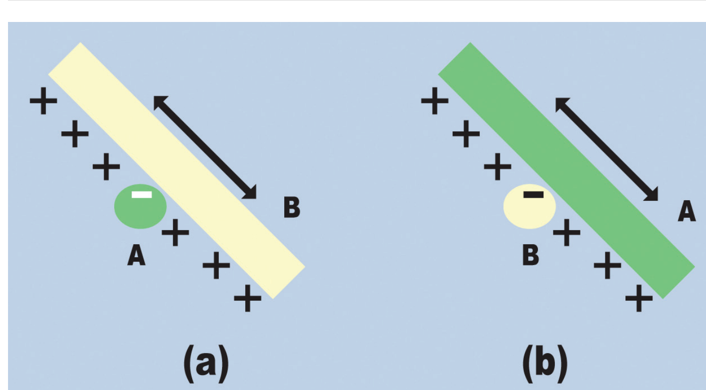


Figure 2: Asymmetrical friction.

MR. Static

If a liquid is flowing through a tube, there is a tendency for the outer charge of the double layer to be given off to the tube and the inner charge to be carried along with the flow.

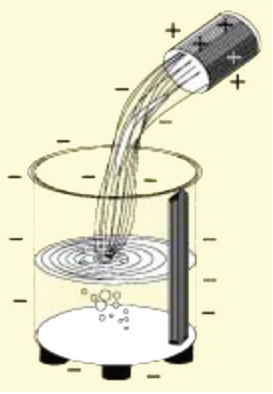


Figure 3: Electrification by flow of liquid

between the surfaces, and the reason for this could be that the rubbing increases the area of contact between the surfaces while the charging process itself is only governed by the energy state of the surfaces, and that charged particles cross the interface at points of sufficient proximity. This, however, is hardly a satisfactory interpretation, because then it wouldn't be possible to explain the fact that two identical surfaces can get charged by rubbing against each other. It could be argued, though, that no two surfaces are ever identical, and that incidental and uncontrollable differences might cause different affinities to charged particles.

Asymmetric Friction

As mentioned earlier, the degree of friction between two materials influences the contact area, and thus the exchange of charges. But the process of friction could have a specific influence of its own. It can be demonstrated that if two identical surfaces—macroscopically speaking—are rubbed against each other in such a way that the contact takes place between a small area of one surface and a larger area of the other, the polarities of the surfaces are likely to change if the roles of the surfaces are interchanged. Figure 2 illustrates this process. Two pieces—A and B—of the same material are rubbed against each other. In Figure 2a, A is stationary and B is being used as the bow on a string. If the bow, B, becomes positive, then, when the roles of A and B are reversed, the bow (in this case A) will again be positive, as seen in Figure 2b. This is asymmetrical friction.

A possible explanation of this phenomenon is that the asymmetry could cause a thermal gradient to develop between the surfaces, thereby inducing already existing charge carriers to move in a certain direction. It is also possible that the charge carriers are produced by a thermal dissociation of the material into charged components.

Other conditions, such as the existence of external electric fields across interfaces, may also play a role in charge exchange between contacting solid materials. This effect can be used in an electrostatic separation process.

Postcontact Processes. Although contact between metals might produce charge transfer, no net charge will remain on the metals after separation unless at least one of the metals is insulated and the separation happens very quickly. If, on the other hand, at least one of the materials is an insulator, both surfaces will be charged immediately after separation. If they are both insulative or if one is an insulated conductor, the charges might remain on the materials even when they are far removed from each other.

During the initial separation, a series of processes could take place that would reduce the magnitude of the charges remaining on the surfaces. Such processes include decay and various types of discharges, ranging from corona discharge to regular sparks.

Charging of Liquids

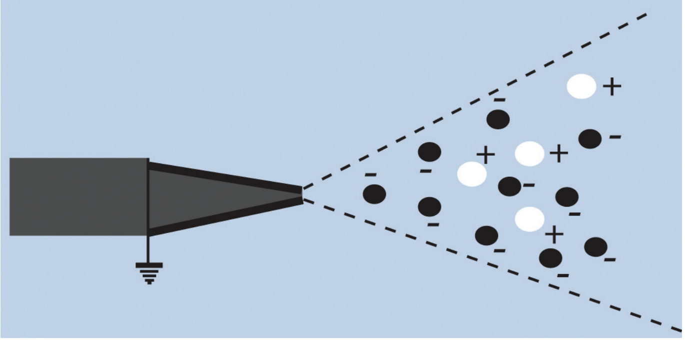
The charging of solid materials by contact and friction is the best known type of static electrification, but it is not the only one. Liquids can also get charged, by flowing through tubes or by spraying, for example. However, the mechanism involved in the charging of liquids is somewhat different from the processes active in solids charging.

It has been demonstrated that phenomena like electrophoresis and capillary electricity in aqueous solutions can be explained if it is assumed that, on the interface between a liquid and a solid, or between a liquid and a gas, an electrical double layer exists in the liquid with a layer of charge close to the surface and a layer of the opposite polarity a short distance into the liquid.

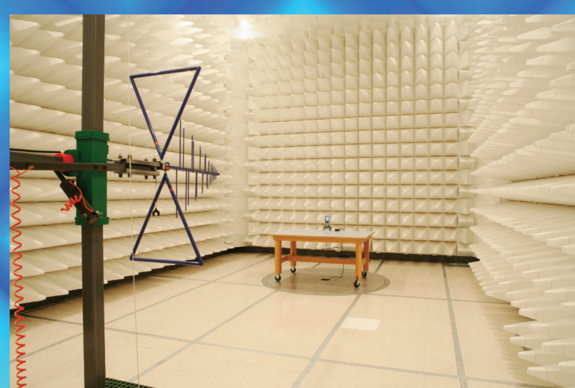
Flow and Spraying. If the surface of a liquid is changed, the electric double layer has to be formed or destroyed. These processes are supposed to have a certain inertia, which implies that it is possible to separate the charges of the double layer by mechanical action on the liquid.

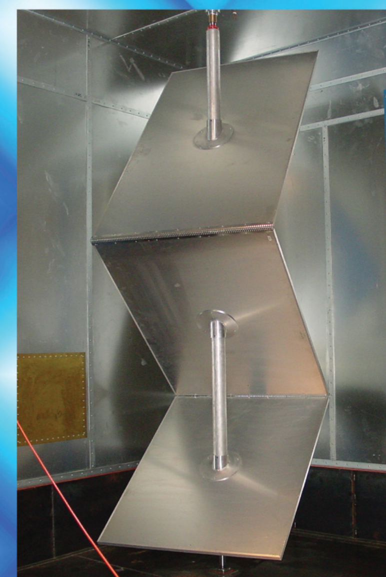
If a liquid is flowing through a tube, there is a tendency for the outer charge of the double layer to be given off to the tube and the inner charge to be carried along with the flow (see Figure 3). The effect of the charging increases with the resistivity of the fluid (and depends on several other

Figure 4: Electrification by spraying of liquid



Facility Solutions For Global EMC





Let Panashield help you with your EMC facility project.
Our experienced personnel will provide technical support to guide you through design, supply and certification.

- EMC Chambers
- RF Shielded Enclosures
- Military Test Chambers
- Avionics Test Chambers
- Free Space Chambers
- Reverberation Chambers
- P3 RF Sliding Doors
- Turnkey Services
- Facility Relocations/Upgrades

Visit us at Booth 322
IEEE EMC 2011
Long Beach, CA

Tel: 203.866.5888 Fax: 203.866.6162
help@panashield.com

www.panashield.com
www.panashield.co.uk

PANASHIELD INC.

MR. Static

It is very rarely possible to accurately predict the level of static buildup one might encounter under certain, even well-defined, working conditions, but there are exceptions.

parameters). Consequently, only highly insulative liquids ($\rho >$ ca. $10^7\ \Omega \bullet m$) will show charging by flow. Water, therefore, will not charge by flow.

It is well known that the breaking up of a liquid into droplets could cause charge separation. This is what happens with waterfall electricity or whenever water is broken into droplets (see Figure 4) where the fine mist, consisting mainly of very small droplets, is predominantly negative and the larger water drops, precipitating more easily, are positive.

Although charging of liquids by flow can only occur with highly insulative liquids, charging by spraying can happen with almost any liquid.

Charging of Powders

Dust and powders can get charged by contact or friction between the particles, especially if the individual particles have different properties, such as varying sizes or differing materials. Such charging could result in the particles sticking together. More common, however, are processes in which a powder is being transported through a system of tubes, and the powder as a whole is being charged by friction with the walls of the tube system. This kind of charging might take place if either the powder, the tubes, or both are insulative.

Charging of Gases

This section could actually be abbreviated to a single phrase: Gases do not charge! But it is not uncommon to find large static charges where gases are used in connection with transport of liquids and solids such as powders. This phenomenon is often interpreted as a charging of the gas itself. This, however, is not the case.

The kinetic energy that might be imparted to a gas molecule in an airflow—even at high velocities—is much lower than the thermal kinetic energies at normal temperatures. It is also much lower than the level required to knock an electron off either the gas molecule itself or the container walls, for instance.

This theoretical prediction is backed by experiments in which filtered air is blown against a solid surface. No charging occurs. The charging observed with ordinary compressed air is caused by liquid or solid impurities of the gas impinging on the target and, therefore, is a case of dust charging rather than gas charging. The polarity of the target charge can be either positive or negative, depending on the nature of the target as well as that of the impurities.

Placing air at the top of a triboelectric list, therefore, makes no sense. Nearly all charging experiments I have done with nonfiltered air impinging on a variety of solid materials have shown a positive charge on the target, which apparently should place air at the negative end of the list. But that, too, is wrong. All experiments with carefully filtered air show no charging, demonstrating that gases do not charge.

Conclusion

It is very rarely possible to accurately predict the level of static buildup one might encounter under certain, even well-defined, working conditions, but there are exceptions. If one is dealing with liquids flowing through tube systems and the resistivities, resistances, capacitances, flow rates, and system geometry are known, then it is certainly possible to calculate fairly accurately the charging currents and equilibrium voltages.

But if one is dealing with the conditions in the electronic industry, little is usually known about the charging conditions. Materials with often-unknown properties are rubbing against each other and exchanging charges at an unknown and unpredictable rate. Sometimes one can measure the end result, but here one should be aware that the measurement itself could interfere essentially with the quantity to be measured.

So we're left with the question: What can we do? Can we do something to prevent charging? The short answer: very little. Can we do something to abate the effects of the charging? The answer: a lot. Abating the effects will be addressed in a future column. IN

Reference

1. Niels Jonassen, "Polarization, for Better or Worse," in Mr. Static, Compliance Engineering 17, no. 5 (2000): 34–40.

(the author)

NIELS JONASSEN, MSC, DSC, worked for 40 years at the Technical University of Denmark, where he conducted classes in electromagnetism, static and atmospheric electricity, airborne radioactivity, and indoor climate. After retiring, he divided his time among the laboratory, his home, and Thailand, writing on static electricity topics and pursuing cooking classes. Mr. Jonassen passed away in 2006.

REALITY Engineering

Automating EMC Testing

(or what did we do with all the time we saved?)

BY JOE TANNEHILL

3 Days, 3 Guys, and Some Graph Paper – The Early Days

I was introduced to commercial electromagnetic interference (EMI) testing in 1984. While working at Intergraph Corp. in Huntsville, Alabama, I got to work in the coolest looking building in town. It was an oversized pool cover that we called 'The Bubble'. The bubble building was on a hillside that allowed the Open Area Test Site (OATS) ground plane to be a bit above the surrounding terrain, free of conductive building materials and large enough for a 10 meter ellipse, though we primarily used it for 3 meter testing.

In those days, Intergraph was producing large rack mounted computer systems that focused on high resolution graphics and the storage required to support the high detail needed for CAD/CAM and geographical mapping. For instance, each rack would contain three phase power distribution, some hard disk drives and a subsystem. Typically we needed racks for the CPU, the graphics processor, storage, and maybe a rack just for managing it all. The main interface was a line printer or alpha numeric monitor that would require at least one systems engineer to type in the boot sequence and all of the commands to get the system to eventually print a capital 'H' pattern to all display and I/O devices. Sometimes this took days to setup and run. All of this would support a separate graphics workstation that could have dual high resolution displays and a large digitizer table. All very cool stuff, but even though it was capable of mapping the world in 3D and color, all we got to see were scrolling Hs.

Once running, it was difficult to shut down and re-start just because it was the end

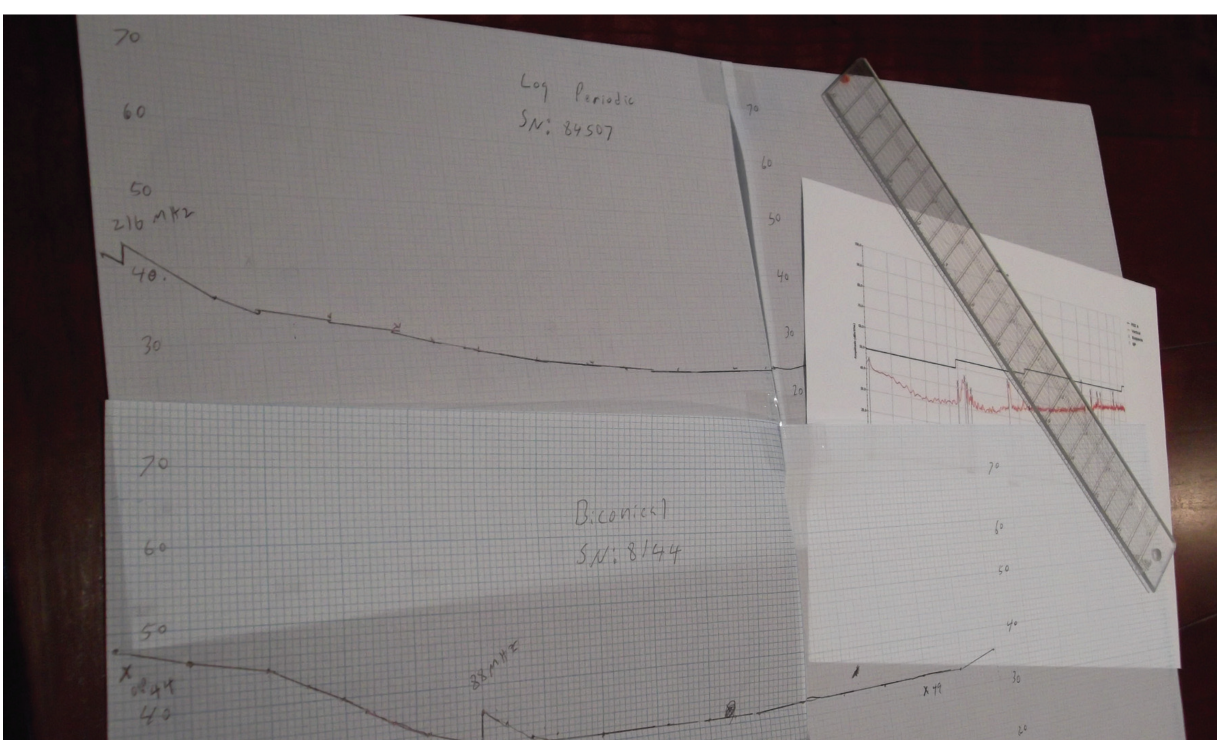


Image courtesy of ETS-Lindgren

'Plotting' along: The two taped sections of graph paper represent biconical and log periodic ranges. They are also serialized since each antenna has to have its own graph. You can see the breaks in the limit lines here as well. Contrast the full range in the automated plot.

of the work day. So, like all EMC guys, our real work did not start till after 5:00 pm on Friday and of course the system *had* to ship out on Monday! After over 26 years, I can see that not much has changed about the demands on the electromagnetic compatibility (EMC) community.

The test methodology was an exercise in consumption of time and money and the outpouring of expletives and sweat. We would have one person drive the spectrum analyzer and one person to record bogeys. Since this was an OATS, we were subject to the ambients found in that area. It was easy to discern most ambients by knowing all of the local licensed transmitters such as radio and TV broadcasts. We could also 'tune in' using the demod on the Quasi Peak adaptor to listen to the emission to determine if it was our EUT or not. So, before the EUT was powered on, we would do a manual scan through the spectrum and record any ambients that we could not identify. This could take over three hours.

After deciding on who was going to work the weekend, we would go through the same scanning technique with the Equipment under Test (EUT) fully operational with one person calling out frequency and amplitude and the other recording them in a table. We would try to cross reference the ambient list but sometimes they would sneak through. Ambients do not matter unless it is close to or over your limit line. To stop a test and shutdown the EUT was the last thing we wanted to do. Sometimes we could use a near field probe to validate the emission was an actual EUT product. Did I mention that we had to test this rack mounted system in multiple azimuths, two polarities and two antenna ranges. To 'go back' to a previous position was a horrifying contemplation!

The 'Real Time Limit Line' was a penciled in line on some graph paper that would alter the FCC Class A limit line to account for cable loss and antenna factor. The line would look like the contour of your factors with the limit line break points at 88 and 216 MHz. A ruler would help for those pesky middle frequencies.

The third person (boss) was required at the end of the testing when all data was captured on multiple sheets of paper. We would sit together with one person reading out loud each emission and amplitude while another person cross referenced the ambient list and the other person looked at the graph paper to see what the delta was. After hours of this, we would have a list of emissions that we would have to determine the final result using a calculator to get the absolute value and delta to the limit. As Kimball Williams mentions in his side bar article, the questioning of data accuracy and integrity was a major factor early Monday morning! If a failure or marginal emission was identified, we would have to crank up the beast, and look for worst case positioning of cables and peripherals then take pictures of it.

The final report would include the six highest emissions with their associated position, polarity, and antenna height along with the photos. We would use a Polaroid camera with a hood on it that would fit over the spectrum analyzer display to provide graphical data of the top six emissions, one at a time. Of course this was raw data, so we would place the display line where the corrected limit line should be. If a failure was found, the whole process was then called a pre-compliance engineering run.

Conducted emissions were similar since we did not have a chamber to block ambient signals from getting onto our power lines.

First Generation Automation

After years of doing it 'that way' we finally bought an HP 9300 computer to run a version of Hewlett Packard EMI software so that we could at least automate the spectrum capture and quasi peak measurements. Though this software was technically accurate and functional, it was not usable for us. We found that it did not

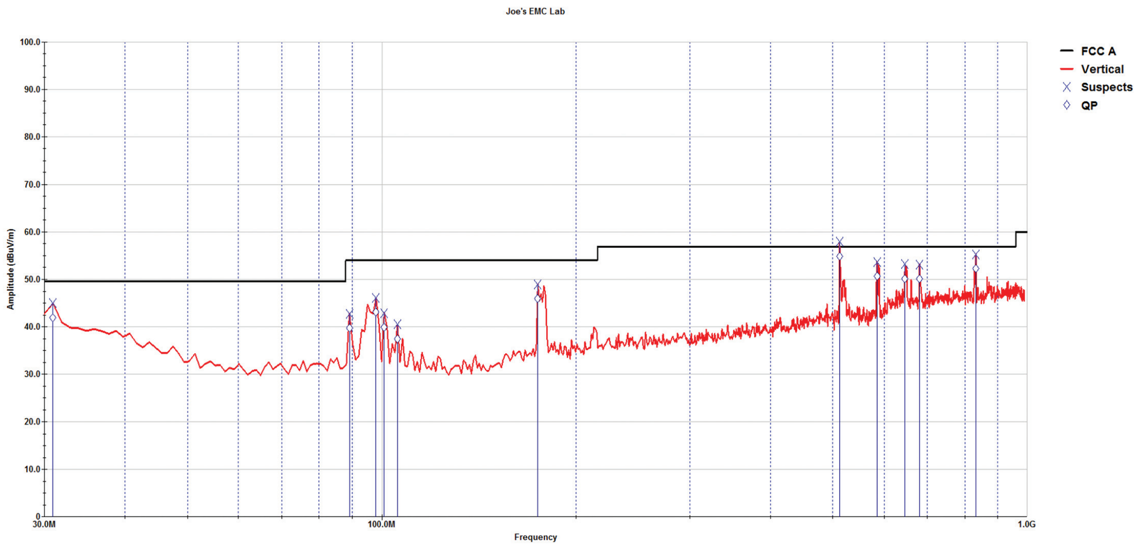


Image courtesy of ETS-Lindgren

All the answers: This graph shows the same range on one sheet of paper compared to the graph paper which needed four sheets. This range also takes advantage of a broadband antenna that does not have a break at 200 MHz. This type of graph can be formatted to show EUT, Client, Date/Time and Comments so that you can see all you need to know about the test and EUT.

REALITY Engineering

have a good method for discriminating against ambients and it was too rigid with its process. At this time (around 1989, I think) we realized we could still use the computer connected to the analyzer to automate some processes. Any time savings was an improvement! Eventually the test time was reduced from as long as one week to about four hours. EUT's also got smaller with less complex setups.

The computer used HP Basic, also known as Rocky Mountain Basic (RMB) operating system. I did not have any programing background but found it to be pretty easy to work with. As I became the resident code monkey on this system, I eventually had to make it work with FCC, VDE, and then CISPR 22 methodology and limits. By the time I left the company in 1997, it was mostly used for CISPR 22 testing.

The basic method that I used was to automatically tune the system from 30 MHz to 1 GHz in 10 MHz spans, then let the power of the HP 8566B analyzer run marker peak, then 'next' marker peak in each 10 MHz to find all peaks in each span. This could be done in the ambient mode and EUT mode. The computer would compare the ambient and EUT lists to provide a list of suspects. The suspects were determined by comparing the frequency and amplitude within something like 2x the resolution BW to see if they were the same. The suspect list erred on the ambient side so it would always provide more suspects for the operator to manually discriminate. The SW would also allow the operator to manually optimize any emission not on the list. The SW would then tune each suspect on the analyzer so that the operator could manually maximize the emission or discard it as an ambient. Once it was maximized, the SW would run the correction factors and determine the delta to the limit and capture the positioner information. At test completion, the SW would sort the emissions by margin to the limit and report the six highest with positioner information for the final report.

The report was a MS word template that had fields for the EUT variables and data. It was a very simple method, but is still effective to this day.

This type of computer/instrument setup spawned many independently developed acquisition programs across the industry known as 'home brew'. Home brew is still used today and is the single largest market share for test software. Much of today's home brew uses LabView.

Test Software Accuracy

The test software accuracy was dependent on raw data plus interpolated correction

Software Validation Relative to EMC Lab Assessments

By Daniel D. Hoolihan

ISO/IEC Standard 17025:2005 – *General Requirements for the Competence of Testing and Calibration Laboratories addresses Software Validation in Clause 5.4.7.2.*

Clause 5.4.7.2 says the following:
When computers or automated equipment are used for the acquisition, processing, recording, reporting, storage or retrieval of test or calibration data, the laboratory shall ensure that:

- *a) Computer software developed by the user is documented in sufficient detail and is suitably validated as being adequate for use;*
- *b) Procedures are established and implemented for protecting the data; such procedures shall include, but not be limited to, integrity and confidentiality of data entry or collection, data storage, data transmission and data processing;*
- *c) Computers and automated equipment are maintained to ensure proper functioning and are provided with the environmental and operating conditions necessary to maintain the integrity of test and calibration data.*

NOTE: Commercial off-the-shelf software (e.g., word processing, database, and statistical programs) in general use within their designed application range may be considered to be sufficiently validated. However, laboratory software configuration/modifications should be validated as in 5.4.7.2, item a.

Most EMC software developed by EMC equipment vendors are considered to be lab software configurations and should be validated as in 5.4.7.2, item a. This is also true of software developed internal to the EMC lab for its use.

Validation usually consists of **manually checking** frequency and amplitude for emissions being measured to assure that the manual-check answer and the software answer are the same.

The validation is similar for immunity testing; if the software says it is generating 3 volts per meter in a radiated immunity test then the manual-check with an electromagnetic field sensor should also indicate that the field is at 3 volts per meter.

In rare instances, an EMC Lab may have two software programs for the same measurement process; in that case, the lab can validate the numbers from program #1 by running program #2.

Software programs for measuring electromagnetic emissions and for controlling electromagnetic immunity-test hardware for subjecting equipment-under-test to both radiated and conducted stresses have enabled EMC labs to test products more efficiently and in a more consistent manner. The danger in the software programs comes from assuming that they are operating correctly in every possible scenario. Software validation is the engineer's way of assuring that the software is doing what is programmed to do.

DANIEL D. HOOLIHAN is the Founder and Principal of Hoolihan EMC Consulting. He is a Past-President of the EMC Society of the IEEE and is presently serving on the Board of Directors. He is presently an assessor for the NIST NVLAP EMC and Telecom Lab Accreditation program. Also, he is the Vice-Chair of the ANSI ASC C63® committee on EMC.

factors. The interpolation was validated to any 'auditor' by having them first do a manual calculation on any frequency, then let the automation do the same thing to show that it is correct. No standard says that you have to do a mathematical interpolation if you only have a graph of factors to eyeball. So interpolation by eye was and is usable though the human factor is involved. For some reason the EMC engineer seems to take the harsher side of the line than the customer. Anytime there was external test data on a EUT, we would do an A to B to compare results. If data is in dispute after the math has been validated, the next step is to look at normalized site attenuation data and antenna calibrations. Dan Hoolihan's side bar article provides an auditor's perspective on automated EMC test software when evaluating a lab for accreditation.

Second Generation Automation

Commercially developed test software is available for almost any test application. Since EMC standards have evolved to include broader frequency ranges and more bandwidths - automation is a requirement! Industry auditors that protect the integrity of the lab affiliations must review software usage as well as lab processes and methodology. Home brew software is at a disadvantage during an audit since the revision control and the developer have to jump through a lot of hoops to show that it is and will be in the future an accurate method of data acquisition. If the person leaves the company someone else has to take over. What was an internal asset that was probably also a hobby now becomes a huge liability.

Commercial software is not scrutinized at the lab level since it is widely accepted and follows industry standards for revision control and development. National Instruments has developed a whole business by providing automation options for almost any industry. Their LabView program can be used as an open platform for controlling instruments of almost any type as long as it can communicate with a computer. Instrument communications have evolved from RS-232 and GPIB to USB and Ethernet. At this time, the communications protocol is not a great improvement in speed or accuracy, but it does reduce the cost of cables and eliminates the need for the GPIB and serial ports.

LabView is powerful but not easy for the typical lab engineer to master and maintain. HP VEE is another instrument centric software program that can be used to automate EMC testing. Like LabView, HP VEE can be used to develop commercial or home brew solutions. Other software is written in C++ which is very powerful, but requires a software engineer to develop and maintain.

Many new instruments are PC computers with an RF section and can provide a lot of internal automation. The drawback to these instruments is that they do not work well with external equipment such as positioners and when it goes out for calibration it is difficult to replace with another device. They would be adequate for bench testing and pre-compliance work. They are most suited for military testing since the instruments have built in military specified bandwidths/sweep times and allow for inclusion of correction factors.

Instrument vendors have developed software to take full advantage of their products. This is a good option if the lab is going to only use that vendor's equipment and has replacements available when calibration time comes around. Other equipment can be used with optional drivers if available.

Immunity/Susceptibility Testing

Immunity/susceptibility testing is even more demanding in respect to the test process. It is nearly impossible to do an EN 55024 immunity calibration or test by hand, much less a 16 point field uniformity test. The leveling algorithms and control injected current while increasing the forward power to a calibrated level is a great benefit of automation.

Benefits of Automating

I am a private pilot and *can* fly hundreds of miles successfully with a compass and a watch. However, with the availability of GPS and autopilots it does not make sense to fly by the old school method just because I can. Technology allows us humans to manage complex, repetitive, mundane, and time consuming tasks so that we can reduce their outputs to our level. Assurance of data integrity is one of the things we love to do, but not at every data point. To answer the question of 'What did we do with all that time we saved'? It seems that our industry and our bosses had no problem filling in that space and there was never a point that I can remember being bored because I finished a task 75% quicker than it would normally take. The benefit of automation is throughput and data integrity. Time saved always seems to take care of itself!

It seems that our industry and our bosses had no problem filling in that space and there was never a point that I can remember being bored because I finished a task 75% quicker than it would normally take.

Future Outlook of EMC Test Automation

It seems that standards committees are always developing more rigorous methods for testing systems to be compatible with the electromagnetic environment (EME). Since the EME is likely to become more occupied with intentional and un-intentional sources, the requirements to measure and control them will need to change as well. Test methods must adapt to emulate the environment. We are still using a quasi-peak measurement that was developed to quantify the annoyance of interference on an AM radio. Now we need to be able to coexist with impulsive sources that are common to cell phones and other frequency hopping devices. Power systems use switching that can couple over to other

REALITY Engineering

Computer Assisted Testing (CAT)

By Kimball Williams

If you are not a 'cat' person, you might not appreciate the full advantages of computer assisted testing. I say 'assisted' because the bulk of the critical elements involved in testing remain in the preparation and setup of each test element. To date no one has found a way to 'automate' that. What has been accomplished is to take the repetitive drudgery out of the detail of equipment adjustment, data reading and data recording. Along with removing this drudgery, computer assisted testing has removed most of the conditions that, in the past, resulted in the introduction of human errors in the process.

My early experimentation with software control of testing began in1980 with a dual floppy drive desk top computer running Basic programs driving a rack of receivers (see accompanying photo) to make EMC emissions measurements. Previous to this, my technician and I would set up each test, tune each frequency range searching for a 'peak' in the meter (Yes, a meter with a dial and pointer!), write down the reading and proceed to the next range and repeat the process. To perform one scan from 10 KHz to 1 GHz by this method then plot the data consumed an eight hour day.

Our first scan with a single antenna with receivers under computer control produced a completed plot in less than 20 minutes. I recall my technician asking; "What do I do with the rest of my career?" With this quantum leap in test time, the design engineers realized that EMC was no longer just the final test their design had to pass. EMC was now a viable development tool. We began hiring technicians to keep up with the demand for test services.

The increased confidence from having the computer take the data, apply the antenna and cable loss factors, as well as store both the raw and the final data, removed much of our early debates with development engineers about "How confident are we in the data?" By careful use of test 'master' artifacts (comb generators) and the use of statistical process control (SPC) to track system stability, questions about the reliability of the test equipment have almost disappeared completely. The ability to have the system also take data and place it into a final report ensures that nothing is inadvertently altered or changed while it is being 'handled' by humans.

However, in my opinion, the greatest advantage with a well implemented computer assisted test system is the ability to free up the test technician to act as an intelligent pair of eyes, watching the test as it progresses and asking; "Do I believe this?" With EMC testing, more than any other, there is so much that can happen to fool us into believing that a computer drawn data chart 'must be right' when there is something fundamentally not right about the test. Our only defense against this is the computer between our ears, and a good sense of skepticism. A well developed computer aided test control system provides that freedom of action.

KIMBALL WILLIAMS is a Technical Fellow for Denso Americas based in Southfield, Michigan, acting as the engineering lead for the EMC laboratory. He received his BSEE degree from Lawrence Technological University in Southfield, Michigan. Prior to joining Denso Americas, he was the Principal Designated Engineer for Underwriters Laboratories for 3 years. He began his EMC career in earnest as the Principal EMC Engineer for Eaton Corporation, where he remained for 26 years. He is a Past-President of the IEEE EMC Society and is presently serving on its Board of Directors.

devices via capacitive and inductive paths that will radiate above the 'conducted' frequency range but may meet the 'radiated' range limits and sensitive electronics need to be able to work in proximity to them.

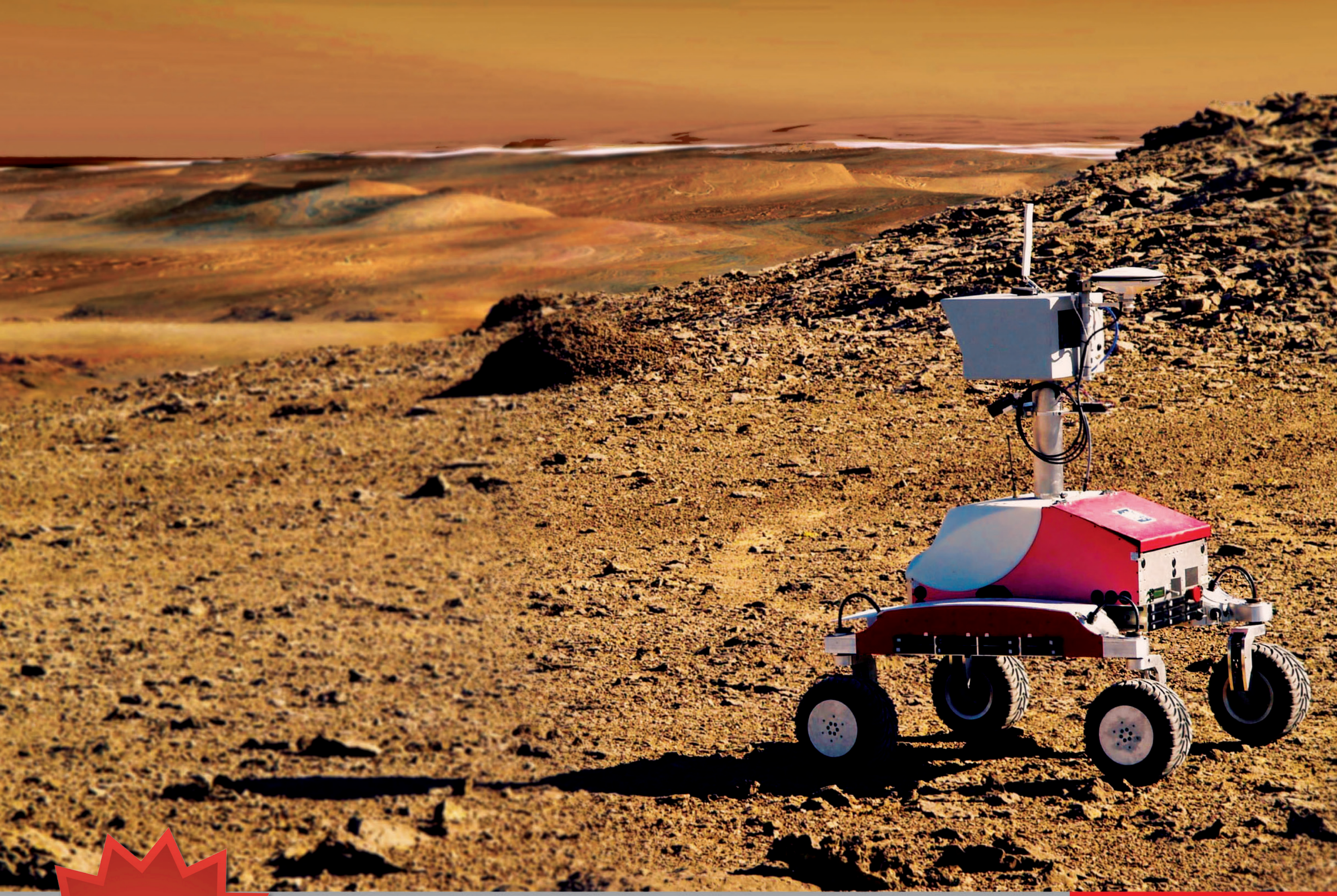
This would certainly require new detection circuits similar to the demod circuits of the wireless electronics we use. Test frequency ranges and limit lines will also change. The automation will have to use multiple testing or multiple detection during the same test in order to make it feasible.

I do not think the manufacturers of the measurement instruments should design their internal computers for automation but more for signal processing. Automation software will have to adapt to the instrument capabilities and focus on control and data reduction so that us humans can interpret and communicate the complex data that the instruments will provide.

Interpreting and communicating the data means that we can display the data in terms that will indicate its compatibility to the EME. Test reports are required by standards to have a lot of information in them, but the end customer of the report typically only looks at the graphs, then the tables. So the graphs and tables will need to be very informative and relevant. IN

(the author)

JOE TANNEHILL has been working in the EMC field for over 27 years, starting with Intergraph Corp. in Huntsville, Alabama testing and designing graphics workstations and associated computing components. From there he worked at Gateway 2000 and at Dell designing laptop, desktop and enterprise systems. In 2005, Joe took a detour to the Department of Defense world working for Raytheon in Sudbury, Massachusetts where he was a design consultant with MIT's Draper Labs. Longing for the heat of Texas he moved back to Austin to work with Motion Computing and then at ETS-Lindgren in his present position as an EMC engineer managing and supporting TILE! EMC test software, including organization of the annual TILE! Users Group meeting. This year's meeting will be held on August 17 in Long Beach, California during the IEEE EMC Symposium. Joe is the inventor of two EMC related patents. He may be reached at joe.tannehill@ets-lindgren.com.



wll.com/academy • 301 216 1500

WASHINGTON LABORATORIES ACADEMY

DOMESTIC & INTERNATIONAL RADIO APPROVALS: ALL YOU NEED TO KNOW

Presented with American Certification Body, Elite Electronic Engineering and TUV Rheinland

September 20-22, 2011 **Marriott Suites, Downers Grove, IL**

Join us for a comprehensive overview of methods and requirements for EMC and Radio Regulations – All You Need to Know! This Washington Labs Academy Seminar will cover international standards and methods of evaluation and certification requirements for equipment with specific focus on radio regulation compliance.

Included is an update on FCC Rules and policies and EU R&TTED

- Learn the latest FCC and Industry Canada Rules and Regulations
- Interact with the experts on FCC and IC interpretations
- Understand the requirements of the R&TTE Directive
- Discover routes for moving your product globally and into emerging markets
- Interact and exchange with your colleagues in the industry

SPECIAL FEATURE

Updates from the FCC, IC, TCB Council, R&TTECA and ECANB
The training will feature critical updates on regulations and policies from the FCC, IC and TCB Council training workshop. The training will also feature critical updates from the latest R&TTE and EMC Notified Body group meetings.

WHO SHOULD ATTEND

Engineers, program managers, test technicians and regulatory personnel working in EMC, Radio and telecommunications testing and Regulatory Compliance for North America and Europe as well as test, design and development engineers and technicians will benefit from receiving the latest in critical updates on test methodology.

LOCATION

Chicago Marriott Suites Downers Grove
1500 Opus Place
Downers Grove, IL

WHAT YOU'LL LEARN

Techniques and Methods: As technologies evolve, measurement and certification of devices are constantly evolving and creating challenges for the electronics industry. Keeping abreast of these changes and the nuances of the regulations is critical for speeding electronic and radio products' time-to-market. Fierce competition from rival developers and test labs creates additional pressure to design and test the devices for compliance with the regulatory requirements and getting it right the first time.

Co-Location and Multiple Transmitters: It is increasingly common to find multiple-transmitter devices; the challenge to certify these devices creates issues dealing with co-located radios, radiation hazards, electromagnetic compatibility (EMC) and certification strategies.

Confidence and Experience: Our Lecturers have a wealth of experience and information in the field of product testing and certification and will share their perspective and insight on the regulations and evolving requirements for electronic and radio frequency systems. The goal of this seminar is to present the latest information on the evolving requirements and to give attendees better understanding of the processes and procedures for approving equipment.

SPECIAL FEATURE: (Day Three Only)

Global Regulatory Product Approvals
The latest information on meeting international requirements for electronics devices. This one-day special session will provide an overview of Global Regulatory Requirements for Telecom/Radio/Wireless products. The focus will be on the country-Specific Requirements for the "BRIC" Countries (Brazil, Russia, India, China, Korea) as well as Asia-Pacific and South America

REGISTRATION

For more information or to register today please visit http://wll.com/EMC_Chicago.html or call 301/216-1500

SEMINAR OVERVIEW

Days 1 and 2:
FCC, Canada and the EU

- FCC rules and regulations overview
- TCB applications and certifications
- FCC submissions process
- LTE, WiMAX, 3GPP
- Modular Approvals and integration of modules
- MIMO and Co-location of transmitter devices
- RF Exposure (SAR & MPE)
- FCC KDB and PBA process
- R&TTECA Updates

Day 3:
International Approvals

- Overview of Global Regulatory Requirements
- Telecom/Radio/Wireless
- Product Safety & EMC Summary
- Country-Specific Requirements
- BRIC Countries (Brazil, Russia, India, China, Korea)
- Japan Approvals
- Requirements for Asia Pacific Countries
- Additional Global Markets

EXPERT INSTRUCTION

Our guest lecturers are from ACB, Inc., Elite Electronic Engineering and TÜVRheinland

Dennis Ward is senior applications examiner and Technical Director for ACB, Inc. in the US and has been involved in many aspects of EMC, wireless and product conformance for over 30 years. He has worked as Director of Laboratories and has consulted on numerous products for world-wide approval, including cellular, 3G, Wi-Fi, Spread Spectrum, Digital Transmission Systems, Wireless Access Points.

Dan Crowder is Elite's Certification Department Supervisor and FCC/CE Mark Team Leader. His specialized area of knowledge includes transmitter certification and testing for US and foreign markets, FCC testing and regulations, CE Marking and international compliance regulations. He is involved in standards development including participation on ANSI committees. He is a member of the TCB Council, IEEE EMC Society and is an iNarte® Certified EMC Engineer.

Bill Holz has 25 years of experience in international regulatory services. He joined TÜVRheinland's International Approvals division in 2008. Holz is considered one of the foremost experts in the rules and pitfalls of navigating complex international regulatory procedures.

JOIN US FOR OUR NEXT SEMINAR!

Domestic and International Radio Approvals:
All You Need to Know

November 7 - 11, 2011 Newark, CA

COURSE OUTLINE

Tuesday September 20 (FCC)

8:00 am	Registration
8:30 am	Introduction and overview of course FCC Technical Rules FCC TCB Applications
Noon:	Lunch
1:00 pm	FCC Modular Approvals FCC Practices and Practicalities TCB Council Training Permissive changes Questions and answers
5:00 pm	End

Wednesday, September 21 (FCC, IC and CE)

8:30 am	FCC RF hazards RF Exposure Requirements FCC Submissions and KDBs Industry Canada Certification requirements
Noon:	Lunch
1:00pm	Canada and the US IC Modular approvals & Permissive Changes R&TTE Compliance and CE Marking ECANB and R&TTECA Questions and answers
5:00 pm	End

Thursday, September 22 (International Approvals)

8:30 am	Overview
9:00 am	Eastern Bloc and South American The BRIC Countries Brazil and South America Russia and the Eastern Block India and the Southeast Asia
Noon:	Lunch
1:00 pm	Asia China, Taiwan, Korea, Japan Emerging Markets Question and Answers
5:00 pm	End

FEE/REGISTRATION

Take one, two or all three days!

Domestic & International Radio Approvals: All You Need to Know

Registration Fees:

Days 1-2 (only): US$895 per student

Day 3 (only): $495

Days 1-3: $1200

Discounts! 10% discount for additional student from same organization.

Fee includes: Lecture notebook, copy of the standard, lunch, breaks, and completion certificate.

Payment in advance via check, VISA or MasterCard (preferred credit cards) or bank transfer (ask for transfer details).

Dear Readers,

Register at www.emc2011.org

The Long Beach Convention & Entertainment Center sets the stage for this year's ***IEEE EMC Society International Symposium on Electromagnetic Compatibility***.

Join *IN Compliance Magazine* and nearly 2000 EMC Professionals from around the world as we gather to share the latest information on EMC, offer our talents to help educate newcomers to the challenging field of EMC, and network with fellow EMC Society members and those interested in keeping current with the most up to date requirements and methodologies.

Benefits of Attending

- Hear top-rated, peer reviewed, technical papers presented by experts in multi-track sessions over a three-day period.
- Attend two days of practical, peer reviewed workshops and tutorials.
- See experiments and demonstrations presented by EMC experts that reinforce the concepts presented in the Fundamentals of EMC Tutorial and Global EMC University.
- Visit exhibitors and see their newest test equipment, modeling software, and measurement systems.
- Check out the latest in services, information, and components in the Exhibit Hall.
- Renew friendships, forge new friendships, and network with industry gurus.
- Share fun-filled social events with family and special friends.

Experience, too, downtown Long Beach, California, which is both large enough and compact enough for IEEE EMC 2011 to virtually "own" the city. The Long Beach Convention & Entertainment Center is located in the heart of downtown Long Beach and is within walking distance to first-class accommodations, shopping, dining, attractions, and sightseeing along picturesque bays and 5 1/2 miles of sandy beach. A pedestrian promenade links hotels, shops, restaurants and attractions with the Pacific Ocean. There is also a transit bus service, called the Passport, which has complimentary service throughout downtown.

In this Symposium Preview section, we bring you special coverage of the 2011 Symposium and encourage you to attend this annual event. It's a great opportunity to learn from industry experts, share information and experiences with peers, reconnect with friends and have a little fun too!

We hope you'll join us at this year's most well known international EMC gathering.

Meet Two Celebrated Authors!

You'll have the rare opportunity to meet two well known experts in the fields of electromagnetic compatibility and signal integrity – Henry Ott and Howard Johnson, both gifted and experienced educators.

MR. HENRY OTT
will be chairing and presenting in the Tutorial Session on the Fundamentals of EMC. Mr. Ott is considered by many to be one of the nation's leading EMC educators, and has over 40 years experience in the field of EMC. He is the author of the popular book **Electromagnetic Compatibility Engineering**.

DR. HOWARD JOHNSON
will be chairing and presenting in a Special Session on signal integrity titled High-Speed Connectors. Dr. Johnson is a foremost authority on signal integrity, and has over 30 years of experience. He is the author of the popular book **High-Speed Digital Design: A Handbook of Black Magic**.

Join these engaging and informative authors and speakers at EMC 2011 in Long Beach. Register to attend their sessions. Purchase their books and attend a book signing with the authors.

(chairman's welcome)

Dear EMC Community,

You are cordially invited to take part in the IEEE EMC Society's International Symposium on Electromagnetic Compatibility (ISEMC) in Long Beach, California this August. We have a beautiful location right in downtown Long Beach at the Long Beach Convention and Entertainment Center. Long Beach is located at the southern end of Los Angeles county, and boasts weather that cannot be beat. As it is said, "it never rains in southern California"!

The treasure of 2011 ISEMC is the Technical Program. We have planned a diverse range of technical sessions, meetings, experiments, demonstrations, professional development, and society awards. We are pleased to be offering some Special Sessions on EMC in Space, co-chaired by Ray Perez and Jim Lukash. Global EMC University is back again, now in its fifth year. We have a wide range of Workshops and Tutorials offering a wealth of information on basic EMC, measurements and testing, reverberation chambers, modeling, electronic vehicles and transportation, standards, and more. This year, our Visual Presentations of the Poster Papers will be located in the foyer outside of the meeting rooms. Meetings with the authors will have a dedicated time not conflicting with paper presentations

We have a rare opportunity this year to meet two well known experts in the field who are both gifted and experienced educators. Mr. Henry Ott will be chairing the Tutorial Session on the Fundamentals of EMC, and Dr. Howard Johnson will be chairing a Special Session on Signal Integrity. Henry Ott is considered by many to be the nation's leading EMC educator, and has over 40 years experience in the field of EMC. Howard Johnson is a foremost authority on signal integrity, and has over 30 years of experience. He is also an engaging and informative author and speaker.

For our companions, we have something different this year – a raffle! – everything from lovely jewelry to local artist items to cuddly animals! For every tour purchased, 5 free tickets will be given and, to everyone registered for the Companion Program, 10 free raffle tickets will be given. The Companion Program will feature a breakfast every morning in the Companion Suite, and spouses will again be invited to join their registered companions for breakfast.

Given the wealth of beaches, museums, and local attractions, five distinctive tours have been chosen to enhance your companion's visit. In addition to these, we have arranged for a post symposium trip on Saturday to Catalina Island, which is just 22 miles off the coast from Long Beach. Catalina Island has long been the home of fishermen and traders, smugglers, miners, and militia. More recently, Santa Catalina Island has served as the location for the filming of over 500 motion pictures, documentaries, television programs and commercials. The history of this island is truly unique, and is a fitting place to wind up your week at 2011 ISEMC.

Ray Adams

Join us at 2011 ISEMC, and you will return technically enriched, professionally updated, personally refreshed, and ready to solve any EMC challenge.

Ray Adams

General Chair
2011 IEEE International Symposium on Electromagnetic Compatibility

The free Internet Café is open during Exhibit Hall hours only.

Tuesday . . . . 9:30 am to 5:30 pm
Wednesday . . . . 9:30 am to 5:30 pm
Thursday . . . . . 9:30 am to 12:30 pm

(Symposium-at-a-Glance)

Day	7 AM	8 AM	9 AM	10 AM	11 AM	Noon	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM
Sunday								Registration Open					
Sunday		Exhibitor Set Up											
Sunday		EMC Society Board of Directors Meeting											
Monday	Speakers' Breakfast			Break		Lunch			Break				
Monday	Registration Open												
Monday		Workshops and Tutorials					Workshops and Tutorials						
Monday		Exhibitor Set Up											
Monday									Chapter Chair Training			Chapter Chair Dinner (til 8:30 PM)	
Monday				Wine Tasting & Beach Tour									
Monday	Companion Suite Open												
Tuesday	Speakers' Breakfast			Break		Lunch			Break				Welcome Reception @ Aquarium of the Pacific (until 10 PM)
Tuesday	Registration Open												
Tuesday		Technical Paper Sessions		Meet Poster Paper Authors			Technical Paper Sessions						
Tuesday			Poster Paper Sessions 1: Set Up Display, 9 to 10 AM; Meet the Author, 10 to Noon, Atrium Room 102A; Display, Noon to 5 PM, Room 102A										GOLD Intro & Ice Cream @ Aquarium (8 to 9:30)
Tuesday			Exhibit Hall Open										
Tuesday			Experiments & Demos					Experiments & Demos					
Tuesday		Global EMC University					Global EMC University						
Tuesday			Junior Technical Program										
Tuesday	Companion Suite Open												
Tuesday		Hollywood Tour											
Wednesday	Speakers' Breakfast			Break		Lunch			Break			Gala Evening Event on the Queen Mary (until 10:30 PM)	
Wednesday	Registration Open												
Wednesday					Founders Luncheon								
Wednesday				GOLD Follow-up Session		HAM Radio Lunch							
Wednesday		Technical Paper Sessions					Technical Paper Sessions						
Wednesday			Exhibit Hall Open										
Wednesday			Experiments & Demos					Experiments & Demos					
Wednesday		Global EMC University					Global EMC University						
Wednesday			Junior Technical Program										
Wednesday	Companion Suite Open												
Wednesday		Los Angeles Shopping, Arts & Historical Tour											
Thursday	Speakers' Breakfast			Break		Awards Luncheon							
Thursday	Registration Open												
Thursday		Technical Paper Sessions						Technical Paper Sessions					
Thursday			Exhibit Hall Open										
Thursday			Experiments & Demos							EMC 2011 Wrap-Up Meeting (to 5:45 PM)		EMC BOD Meeting (until 9:30 PM)	
Thursday		Global EMC University							Global EMC University				
Thursday		Junior Technical Program @ Aquarium of the Pacific											
Thursday	Companion Suite Open												
Thursday		Santa Monica Famous Fun Tour											
Friday	Speakers' Breakfast			Break		Lunch			Break				
Friday	Registration Open												
Friday		Workshops and Tutorials					Workshops and Tutorials						
Friday						JPL Technical Tour							
Friday	Companion Suite Open												
Friday		Getty Museum Architectural Tour											
Saturday		Post Symposium Catalina Island Adventure											

(Technical Program Overview)

Workshops and Tutorials

provide an opportunity to learn the basics in EMC from the experts in industry and academia.

Workshops provide an interactive format to share the subject topic with the workshop facilitator. The EMC areas to be covered include the popular series on introduction to EMC to contemporary industry topics facilitated by the EMC Society Technical Committees, Standards Working Groups and others.

Tutorials are set up in a classroom format with the lecturer providing instruction on their area of expertise.

Join these engaging and informative authors and speakers. Register to attend their sessions:

Mr. Henry Ott - will be chairing and presenting in the Tutorial Session on the Fundamentals of EMC on Monday, August 15th.

Dr. Howard Johnson - will be chairing and presenting in a Special Session on signal integrity titled High-Speed Connectors on Wednesday, August 17th.

Monday, August 15

8:30 AM – Noon

- MO-AM-1 Fundamentals of EMC
- MO-AM-2 Application of Reverberation Chambers
- MO-AM-3 Low Frequency EMC including Power Quality in Relation to Renewables, Energy Efficient Devices, Electrical Vehicles and Smart Grid
- MO-AM-4 Addition of ESD and Lightning Requirements and Testing to MIL-STD-461
- MO-AM-5 Introduction to EMI Modeling Techniques

1:30 – 5:30 PM

- MO-PM-1 Fundamentals of EMC
- MO-PM-2 EMC Aspects of Smart Grid
- MO-PM-3 Hot Topics in EMC Measurements: Site validation, Time Domain and Antenna Characterization
- MO-PM-4 How to Break Down Complex Systems Into Realistic, Solvable and Accurate Models
- MO-PM-5 Fundamentals of Signal Integrity

Friday, August 19

8:30 AM – Noon

- FR-AM-1 EMC Leadership Training
- FR-AM-2 Transportation System EMC
- FR-AM-3 Basic EMC Measurements
- FR-AM-4 Advanced Antenna and Probe Topics
- FR-AM-5 EMC and Wireless Devices

1:30 – 5:30 PM

- FR-PM-1 EMC Consultant's Toolkit
- FR-PM-2 Transportation System EMC
- FR-PM-3 Relationships between Transfer Impedance and Shielding Effectiveness
- FR-PM-4 Predicting Cosite Interference

Technical Papers

are provided on Tuesday to Thursday during multiple concurrent sessions.

The papers represent the latest in technology as presented by industry, government and academia. All papers have been peer reviewed and accepted by the EMC Society's Technical Committees. The Technical Papers will be given in two formats: oral presentation sessions and poster paper sessions. Read below for the details.

The Presentation of Technical Papers and Special Sessions are aligned according to technical topic areas associated with the IEEE EMC Society Technical Committees. The Presentation of Papers Sessions schedule is developed in mid-May. Please check www.emc2011.org for updates.

Presentation of Papers Sessions

The Presentation of Papers Session is an oral briefing with charts on a digital projector of the speaker's technical paper in a theatre style room setup. We have 185 papers being accepted by the committee. The Session Chair will moderate the meeting between speaker presentations, and questions and answers with the attendees and speakers.

Special Sessions (Invited Papers)

are presented on Tuesday, Wednesday, and Thursday.

These Special Sessions may tend to be more of a tutorial nature covering all the basics or updates of that area. The final Special Sessions schedule is developed in mid-May. Please check www.emc2011.org for updates.

Tuesday, August 16

8:30 AM – Noon

- **TU-AM-1** Antennas 1
- **TU-AM-2** Signal Integrity 1
- **TU-AM-3** EBG Technologies and IC
- **TU-AM-4** Electrostatic Discharge 1
- **TU-AM-5** Nanotechnology and Advanced Materials

1:30 – 5:30 PM

- **TU-PM-1** Antennas 2
- **TU-PM-2** Signal Integrity 2
- **TU-PM-3** PCB and Filters
- **TU-PM-4** Cavities and Enclosures
- **TU-PM-5** Special Session: Solving Large EM Problems
- **TU-PM-6** Special Session: EMC in Space

Wednesday, August 17

8:30 AM – Noon

- **WED-AM-1** Emissions 1
- **WED-AM-2** Signal Integrity 3
- **WED-AM-3** Shielding Theory
- **WED-AM-4** Topics in HPEM
- **WED-AM-5** Cables and Coupling

1:30 – 5:30 PM

- **WED-PM-1**Emissions 2
- **WED-PM-2**Signal Integrity 4
- **WED-PM-3** Electromagnetics
- **WED-PM-4** Transients and Material Characterizations
- **WED-PM-5** Special Session: Signal Integrity for High Speed Connectors
- **WED-PM-6** Special Session: EMC in Space
- **THU-AM-6** Special Session: EMC in Space

Thursday, August 18

8:30 AM - Noon

- **THU-AM-1** Reverberation
- **THU-AM-2** Electromagnetic Band Gap Filters
- **THU-AM-3** EMC in Circuits and Devices
- **THU-AM-4** Electrostatic Discharge 2
- **THU-AM-4** Information Leakage
- **THU-AM-5** Special Session: Full Channel Characterization and Link Path Analysis for High-Speed Interconnect
- **THU-AM-6** Special Session: EMC in Space

2:30 - 5:30 PM

- **THU-PM-1** Immunity
- **THU-PM-2** Signal Integrity 5
- **THU-PM-3** PCB Simulations
- **THU-PM-4** Information Leakage
- **THU-PM-5** EMC Environment
- **THU-PM-6** EMC Management

(Accomodations)

Hotel	Distance From Convention Center	Transportation Options	Room Rate	Reservation Cutoff Dates	Cancellation Policy	Early Departure Fee (after check in)	Internet
HOST HOTEL **Hyatt Regency Long Beach** 200 South Pine Ave Long Beach,CA 90802 (562) 491-1234 www.hyattregencylongbeach.com	50 Steps	Walk	$179	7/12/2001	72 Hrs Prior One Night + Tax	$50	$5 per day
Westin Long Beach 333 E. Ocean Blvd Long Beach,CA 90802 (562) 436-3000 www.westin.com/longbeach	0.4 Mile Two Blocks North and Three Blocks East	Passport Bus or Walk	$169	7/14/2001	72 Hrs Prior One Night + Tax	One Night + Tax	Complimentary Wireless
AVIA Long Beach 285 Bay Street Long Beach,CA 90802 (562) 436-1047 www.aviahotels.com/hotels/longbeach	0.2 Mile Two Blocks West	Walk	$165	7/13/2001	72 Hrs Prior One Night + Tax		Complimentary Wireless
Hilton Long Beach 701 W. Ocean Blvd Long Beach,CA 90831 (562) 983-3400 www.longbeach.hilton.com	0.7 Mile Two Blocks North and Six Blocks West	Hotel Shuttle to CC 7AM - 9AM and 5PM - 7PM or Passport Bus	$169	7/12/2001	72 Hrs Prior One Night + Tax	$125	$9.95 per day $24.95 per week
Renaissance Long Beach 111 E. Ocean Blvd Long Beach,CA 90802 (562) 437-5900 www.renaissancelongbeach.com	0.2 Mile Two Blocks North	Walk	$169	7/22/2001	Prior to 6PM day of scheduled arrival One Night + Tax		Lobby 2Hr Free per day $12.95 per day in room
Courtyard by Marriott 500 E. 1st Street Long Beach,CA 90802 (562) 435-8511 www.courtyard.com/lgbcy	0.6 Mile Four Blocks North and Seven Blocks East	Passport Bus or Walk	$139	7/25/2001	Prior to 6PM day of scheduled arrival One Night + Tax		Complimentary Wireless

The City of Long Beach offers complimentary transportation on its popular Passport Bus which services the downtown hotels and the Long Beach Convention & Entertainment Center. Service is provided on a continuous basis from the hours 9:00 AM to midnight, seven days a week. *Subject to change.*

Visit http://www.lbtransit.com for more information

(Social Events)

Welcome Reception

AT THE AQUARIUM OF THE PACIFIC

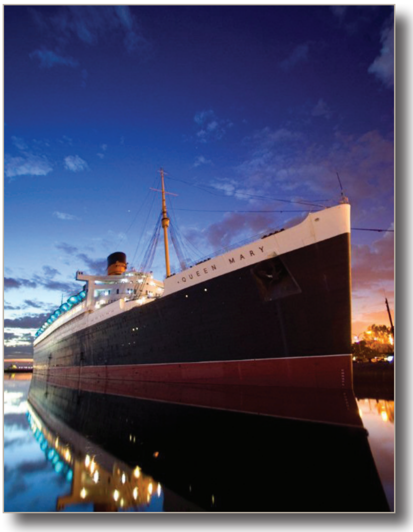
Tuesday, August 16th 7:00 PM – 10:00 PM

Join your fellow attendees for a private journey of discovery through the world's largest ocean at the Aquarium of the Pacific in Long Beach, California. Explore our exhibits and discover sunny Southern California and Baja, the frigid waters of the North Pacific, and the colorful reefs of the Tropical Pacific. Come face-to-face with, and even touch, the ocean's ultimate predators in Shark Lagoon. And, hand feed lorikeet birds. With a special evening of fantastic food and amazing exhibits, you will have an experience to last a lifetime!

This event is included in all Full, 5 Day Technical Registrations and Companion Program Registrations. All others may purchase a ticket to the Welcome Reception for $60 (includes two drink coupons) as an add-on cost to your registration.

The Aquarium is a 10 minute walk from the Convention Center. There is a limited, free, Long Beach Shuttle Service to the Aquarium, every 10 minutes from 9:00 AM to midnight on Passport Bus C, boarding directly in front of the Convention Center.

Gala Evening Event



ON THE QUEEN MARY

Wednesday, August 17th 6:00 PM – 10:00 PM
6:30 PM – 8:00 PM Dinner
5:15 PM – 10:30 PM roundtrip shuttle service, Convention Center to Queen Mary

Step back in time for an elegant evening on the 'High Seas' and experience what travel was like on board an authentic steamship filled with original art deco fixtures that will bring you back to the '30s.

Casting an impressive figure against the Long Beach, California skyline, the Queen Mary offers visitors the chance to experience firsthand one of the world's most renowned and remarkable ocean liners. From the time of her Maiden Voyage in 1936, the Queen Mary was regarded as the only way to travel by the elite of high society, carrying some of the world's most preeminent movie stars, business moguls, politicians, and royalty across the Atlantic. Drafted into service as a troop carrier, the elegant ship was painted grey from top to bottom so she could travel the seas unseen, and was deemed the Grey Ghost due to her camouflage appearance. During World War II she carried over 750,000 soldiers across more than 500,000 miles of ocean and played a significant role in the success of the Allied Forces. After the war, the Queen Mary was restored to her former glory and reentered passenger service until she was retired to her new home in Southern California in 1967.

Stop for a photo with a Hollywood Star before you make your way to the Bow for a cocktail overlooking the stunning Long Beach Skyline. As you proceed to the stern for dinner, take your time perusing the historic original photos of Hollywood stars, dignitaries, and troops. Spend the rest of the evening enjoying the glorious California sunset, music, and the company of old friends and new acquaintances. Ahhhh...it's the good life!

This event is included in all full 5 day Technical Registrations. All others may purchase a ticket to the Gala for $95 (includes two drink coupons) as an add-on cost to your registration.

photos courtesy of Destinations Magazine

(Social Events)

New for 2011!

IEEE EMC SYMPOSIUM GOLD EVENT
Tuesday, August 16th 8:00 PM – 9:30 PM

The IEEE EMC Society is excited to invite you to the first ever IEEE EMC Symposium Graduates of the Last Decade (GOLD) Event. If you graduated from your first professional degree program within the last ten years, then you are eligible to register for the EMC symposium GOLD Event. The first ten years after graduating from your first professional degree can be very challenging. It is common for young and recent graduates to be searching for employment, planning their professional growth and career development, and changing their life status.

Come and join us for a fun evening where you will learn more about GOLD, have an opportunity to enter in a raffle and take part in an ice cream social following the welcome reception. This is a great opportunity for you to meet other young professionals, exchange contacts, discuss stories of work (and perhaps find out how similar the stories are, no matter where you work) and your hobbies. You will also have the opportunity to mingle with members of the EMC Society Board of Directors. If volunteering is your thing, we have a number of volunteer opportunities in GOLD EMC.

Not enough? Also join us on Wednesday during our first GOLD session where you will hear from some remarkable speakers in the EMC field. I hear they will be offering guidance on how to get ahead at work, how to market yourself and much more. Meanwhile, make our Facebook (GOLDEMC email: GOLDEMC@gmail.com) page one of your favorites and follow us as we bring you to the next event. See you there!

Join K3SJS and W3IA

HAM RADIO LUNCH
Wednesday, August 17th Noon – 1:30 PM

You are invited to the HAM Radio Lunch for an opportunity to share past stories and interesting information. Please join Jo (K3SJS) and Tom (W3IA) Chesworth and Ed Hare from the ARRL. You will be able to buy a lunch inside the convention center for $12 and bring it to our meeting. We ended up last year with several "talking" ideas. More information to follow.

So we may have a head count and contact information, please call Jo at (814) 466-6559 or email jo@7ms.com.

CHAPTER CHAIR DINNER
Monday, August 15th 6:30 PM – 8:30 PM

This Dinner is a chance for the EMC Society Chapter Chairs or their representatives to gather and share what they have been doing for the past year.

FOUNDERS LUNCHEON
Wednesday, August 17th 11:30 AM – 1:30 PM

The Founders Luncheon is open to the founders of the EMC Society, members of the Board of Directors, and students.

Recognition Event

AWARDS LUNCHEON
Thursday, August 18th 12:30 PM – 2:00 PM

The Exhibit Hall will be closed starting at 1:00 PM, and the technical program will be on break during the Awards Luncheon. The Awards Luncheon will be the last formal opportunity to gather and network with family of EMC professionals from acemedia, industry, government, military, and retired. The event will start off with a catered sit-down served meal. Afterwards, the EMC Society will take time to recognize members and non-members for their contribution to the society and professional excellence.

For those with a Full Technical Registration (member, non-member, life members, retired, unemployed or student) the Awards Luncheon is free. All others may purchase a ticket for $45 to the Awards Luncheon as an add-on cost to your registration.

(Social Events)

Technical Tour

JET PROPULSION LABORATORY (JPL) TECHNICAL TOUR
Friday, August 19th Noon – 6:30 PM

The technical tour begins in the von Karman auditorium where attendees will get an overview / history of JPL and watch the movie Journey to the Planets and Beyond. From there, the visitors will enjoy the von Karman museum, which exhibits models of spacecraft, touch-screen monitors, and items such as meteorites from the comet Vesta and a moon rock. Two facilities that are often visited on a tour of JPL are the Spacecraft Assembly Facility and the Space Flight Operations Facility. The Spacecraft Assembly Facility is where the JPL technicians and engineers assemble the spacecraft. The Spacecraft Assembly Facility is a clean room facility. It is a class 10,000 room, which means per cubic foot there are 10,000 or fewer dust particles. Technicians and engineers wear "bunny suits" to keep the spacecraft from coming in contact with hair and skin. The Space Flight Operations Facility is where JPL has the Deep Space Network. Developed and managed by JPL, the Deep Space Network monitors radio transmissions to determine the health and precise location of each spacecraft, as well as data from the instruments aboard.

The JPL tour is scheduled for 2 PM on Friday, August 19, 2011. The tour is limited to 80 people at a cost of $25.00 per person ($35.00 after July 17, 2011) and is available on a first come basis. The tour length is estimated to be 2.5 hours. Buses will depart the convention center at noon for JPL, so be there on time. Snacks will be provided on the return trip. For more information on JPL, visit their website at www.jpl.nasa.gov. The list of names is required to be provided to JPL three weeks prior to the tour, so register early or you may miss a great tour. Also, everyone is required to show a current photo ID or valid passport to gain entrance to JPL; there will be no exceptions.

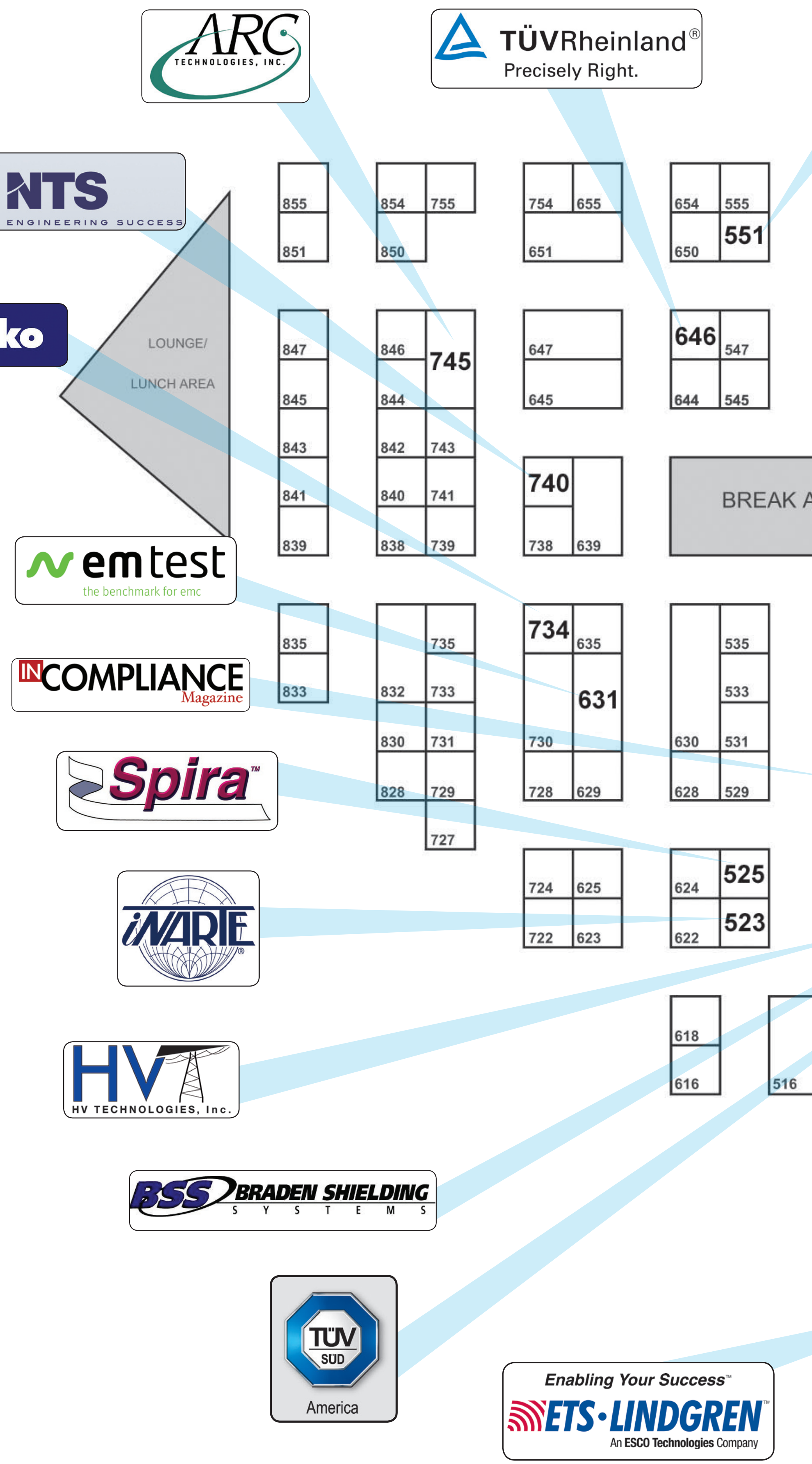
PostConference Tour

CATALINA ISLAND ADVENTURE
Saturday, August 20th 8:15 AM – 5:15 PM

Your one-hour boat ride will take you 22 miles across the sea to Catalina. Next, experience one of the island's many exciting and exclusive tours, like the Glass Bottom Boat or Casino Tour! These tours give you an inside look at the island's natural history and beauty, don't forget your camera! Once you've done your activity, head to the boardwalk for a group lunch and then roam the town buying souvenirs and taking in the relaxation island style!

Contact the Tour Manager, Melina Patrick, at (562) 980-7566 (or email Melina@ctc4u.com) to book your tour. Make sure you mention that you are an IEEE Conference Attendee!

Cost per person $125 Includes: Bottled Waters, Roundtrip Boat Transportation, Tour, and Lunch
This is a tour that will involve moderate walking throughout the day! Terminal is about 15-20 minutes walking distance from the Convention Center: The Long Beach Passport Bus can provide free transportation.



Stop by to visit our valued supporters.

A.H. Systems, Inc. 222
Advanced Test Equipment Rentals . . 445
Agilent Technologies 223
AR RF/Microwave Instrumentation . . 111
ARC Technologies, Inc. 745
Braden Shielding Systems, LLC. 424
Com-Power Corporation 118
CST of America, Inc. 339
Curtis Industries/Filter Networks . . . 234
EM Test USA 631
ETS-Lindgren 311
Fair-Rite Products Corp. 327
HV TECHNOLOGIES, Inc.. 423
IN Compliance Magazine 429
iNARTE, Inc. 523
Leader Tech. 551
National Technical Systems 740
Nemko USA/Canada. 734
Panashield, Inc. 322
Pearson Electronics, Inc. 325
Rohde & Schwarz 217
Spira Manufacturing Corporation . . . 525
TÜV Rheinland of North America . . . 646
TÜV SÜD America Inc. 422


LEADER TECH a HEICO company
ATEC Advanced Test Equipment Rentals Rentals Made Easy.
CST
Curtis Industries
FILTER NETWORKS
Fair-Rite Products Corp. Your Signal Solution www.fair-rite.com
Pearson ELECTRONICS
A.H. SYSTEMS
Agilent Technologies
PANASHIELD INC.
ROHDE&SCHWARZ
ar
LOUNGE/ LUNCH AREA
AREA
554 455 550 451 454 355 450 351 354 255 350 251
546 447 445 446 347 444 345 346 247 344 342 340 241 338 239
339 143 141 238 139
144 142 140 138 136 134 130 128 126 124 122 120 118 116
534 435 532 433 530 431 429 331 334 235 332 233 330 231
234 135 232 133 230 131
426 327 424 325 422 323 227 322 223 222 127 123
425 423 522
417 317 217 119
311 111

(Exhibits)

(Exhibitor Profiles)

A.H. Systems, Inc.
Booth 222

- Manufacturer
  - Antennas and Antenna Products

A.H. Systems 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.

Tel: +1 818 998 0223
sales@AH Systems.com
www.ahsystems.com

Advanced Test Equipment Rental
Booth 445

- Equipment Reseller/Rentals

Advanced Test Equipment Rentals (ATEC) supplies complete testing solutions for EMC, Defense, Telecom, Power Quality, Environmental and similar testing applications. Celebrating 30 years in business, ATEC maintains an accredited on-site lab and takes pride in serving our customers with invaluable expertise and technical support. ISO 9001 and HUBZone certified.

Tel: +1 888 544 ATEC
rentals@atecorp.com
www.atecorp.com

Agilent Technologies
Booth 223

- Manufacturer
  - Test and Measurement Equipment

Agilent offers EMI measurement solutions for EMC compliance and precompliance testing. The Agilent MXE EMI receiver is fully compliant with CISPR 16-1-1 2010 and includes X-Series signal analysis and graphical measurement tools that make it easy to diagnose EMI problems. To ensure successful compliance testing, MXE-identical measurements can be made—at a fraction of the price—with any X-Series signal analyzer and the EMC measurement application. Agilent Solutions Partners offer a single point of contact to purchase a complete EMC solution that meets MIL-STD and commercial specifications, combining Agilent's products with value-added integration, software, probes, antennas, chambers, and more.

Tel: +1 800 829 4444
www.agilent.com/find/emc

rf/microwave instrumentation

AR RF/Microwave Instrumentation
Booth 111

- Manufacturer
  - Antennas and Antenna Products
  - Test and Measurement Equipment

AR RF/Microwave Instrumentation is a manufacturer and distributor of high power broadband amplifiers from DC – 45 GHz, 1 – 50,000 watts and beyond. Our amplifiers are well suited for radiated and conducted immunity testing and equally suitable for general laboratory testing. Available are a full line of complementary test accessories including antennas, directional couplers, field monitoring equipment, power meters and EMC test software. We also offer EMI receivers, RF conducted immunity test generators and EMC/RF test systems.

Tel: +1 215 723 8181
info@arworld.us
www.arworld.us

ARC Technologies, Inc.
Booth 745

- Manufacturer
  - Ferrite/Suppression Products

ARC Technologies is the leading supplier of microwave absorbing materials for commercial and defense applications. While providing a complete range of standard absorber products, ARC Technologies also offers dielectric materials, composites, radomes, and radar absorbing structures (RAS). The company's Wave-X family of products is an effective solution for EMI and SAR suppression due to their unique formulations. No matter the problem you are facing ARC Technologies has a product or will develop an application specific product to meet your specifications.

Tel: +1 978 388 2993
Fax: +1 978 388 6866
sales@arc-tech.com www.arc-tech.com

Braden Shielding Systems, LLC
Booth 424

- Manufacturer
  - Anechoic Chambers/Materials
  - Ferrite/Suppression Products
  - Filters
  - Shielding Products and Materials
  - Test and Measurement Equipment
- Testing/Certification

Braden Shielding Systems, LLC designs, fabricates, installs and test 3, 5 and 10m anechoic chambers, reverb chambers and shielded enclosures.

Tel: +1 918 624 2888
Fax: +1 918 624 2886
info@bradenshielding.com
www.bradenshielding.com

(Exhibitor Profiles)

Com-Power Corporation
Booth 118

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

Com-Power is a leading supplier of EMC test instrumentation. We are a resource for EMC engineers looking for a wide selection of products and unique solutions. Our products are well suited for an accredited EMC laboratory for compliance testing and also for performing pre-compliance EMC testing and debugging at the factory. The Com-Power product line includes antennas up to 40 GHz, Comb Generators, LISN, CDNs, power amplifiers for conducted immunity, directional couplers, near field probes, preamplifiers and much more. All our products are calibrated to the latest test standards and are usually available from stock for immediate delivery. For added confidence, we offer the industry's best three year warranty. Please visit our website for additional details and product specifications. All products can be ordered directly from Com-Power or from distributors listed on our website.

Tel: +1 714 528 8800 Fax: +1 714 528 1992
sales@com-power.com www.com-power.com

CST of America, Inc.
Booth 339

- Software Development/ Products

CST is a world leader in computer simulation of radiated emissions and susceptibility. CST MICROWAVE STUDIO(R) TLM solver (Microstripes) and CST CABLE STUDIO(TM) provide powerful features for complex EMC analysis including coupled simulations which allow for large system analysis and installed performance studies. Many years of in house expertise support the tools and give customers confidence in our simulation results. Contact us for free technical support and samples.

Tel: +1 508 665 4400 Fax: +1 508 665 4401
info@us.cst.com www.cst.com

Curtis Industries/Filter Networks
Booth 234

- Manufacturer
  - Connectors
  - Filters
  - Passive Electronic Components

Curtis Industries/Filter Networks is a specialized manufacturer of standard and custom EMI/RFI Filter devices, Terminal Block and associated subsystems. We are ISO 9001:2008 and ITAR registered. Curtis Industries' innovative engineering solutions impact New Product Introduction (NPI), PCB Assembly, Cable Assemblies, System Integration, Testing, Supply Chain Logistics and Order Fulfillment. Our manufacturing core competencies focus on a range of markets including Aerospace, Communications, Industrial Controls, Medical, Military, Networking and Telecommunications. We create superior quality, budget conscious solutions for complex challenges.

Tel: +1 414 649 4200 Fax: +1 414 649 4279
cfrederick@curtisind.com www.curtisind.com

EM Test USA
Booth 631

- Manufacturer
  - Test and Measurement Equipment

EM Test is the world's leading supplier of EMC test instruments to virtually all industries. Our testers provide a wide range of capability from ESD, Surge, and Fast Transients to the special requirements of the automotive, military, telecom, and avionics manufacturers. From test pulses, conducted RF or AF, programmable AC/DC sources, Harmonic and Flicker analyzers to special couplers, probes and cables--we have it all. Multiple software releases per year insure all EM Test instruments are up-to-date with the latest standards and requirements changes, and all software is Windows 7 compatible.

Tel: +1 603 769 3477 Fax: +1 603 769 3499
m.hopkins@emtest.com www.emtest.info

ETS-Lindgren
Booth 311

- Manufacturers
  - Anechoic Chambers/Materials
  - Antennas and Antenna Products
  - Filters
  - Product Safety Compliance Equipment
  - Shielding Products and Materials
  - Test and Measurement Equipment
- Software Development/Products
- Training and Seminars

ETS-Lindgren is a global leader in the design, manufacture, and installation of systems and components for the detection, measurement and management of electromagnetic, magnetic and acoustic energy. We provide turnkey solutions for EMC/EMI/RFI/EMF/IEMI test and measurement applications as well as medical, industrial, wireless, and governmental RF shielding requirements. Popular products include antennas; field probes, monitors, and positioners; RF and microwave absorbers; 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- 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).

Tel: +1 512 531 6400 Fax: +1 512 531 6500
info@ets-lindgrn.com www.ets-lindgren.com

This year there will be 131 exhibitors in the Symposium exhibit hall.

When you visit the show floor, please stop by to visit the fine companies who support In Compliance magazine. Tell them we sent you!

(Exhibitor Profiles)

Fair-Rite Products Corp. Booth 327

- Manufacturers
  - Antennas & Antenna Products
  - Ferrite/Suppression Products
  - Shielding Products & Materials

Fair-Rite Products Corp. 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 US 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 www.fair-rite.com to view our new online catalog and find contact information for customer service, applications engineers, local sales representatives, and local distributors.

Tel: +1 888 324 7748/ +1 845 895 2055
Fax: +1 845 895 2629
ferrites@fair-rite.com www.fair-rite.com

HV Technologies, Inc. Booth 423

- Manufacturer
  - Test and Measurement Equipment
  - Testing/Certification

HV Technologies, Inc. is the exclusive North American distributor of the EMC-PARTNER brand of transient generators of ESD, EFT, SURGE, and VDI covering CE Mark, Avionics, MIL-SPEC, Smart Grid and Telecom applications. Precision, repeatability, and reliability is guaranteed by patented solid state high voltage switching technology and fiber optic triggering. Visit us to learn about the world's only AA battery powered 30kV ESD simulator, the latest accessories for Airbus ABD 0100.1.2 G, the all new solution to the Voltage Spike of Airbus ABD 0100.1.8, and the new modular CE Mark transient generator, TRA3000, allowing the user to add or remove capabilities when and as needed.

Tel: +1 703 365 2330 Mobile: +1 703 980 4330
revesz@hvtechnologies.com
www.hvtechnologies.com

IN Compliance Magazine Booth 429

- Publishers

IN Compliance Magazine offers in-depth coverage of worldwide regulatory compliance issues for manufacturers of electronic products. Monthly technical features focus on designing and testing products to comply with domestic and international requirements. Major topics include EMC, Product Safety, Telecommunications, ESD, and Environmental Issues.

Tel: +1 508 488 6274 Fax: +1 508 488 6114
editor@incompliancemag.com
www.incompliancemag.com

Our advertisers offer many reasons to visit their exhibit booths this year.

See a preview of what's to come — check out pages 52-56 in our all new Show Stoppers section!

iNARTE, Inc. Booth 523

- Associations/ Societies/ Committees

iNARTE, a non-profit organization, offers Certification Programs to validate the credentials of professional Engineers and Technicians in EMC/EMI disciplines. The purpose of iNARTE EMC Certification is to foster technical excellence in EMC engineering. Our programs establish competency criteria for EMC/EMI work. Our Certification benefits the individual practitioner and the entire EMC community by establishing a standard of excellence and recognition for those that achieve it.

Tel: +1 800 89 NARTE/ +1 252 672 0200
Fax: +1 252 672 0111
inarte@narte.org www.narte.org

Leader Tech Booth 551

- Manufacturer
  - Anechoic Chambers/Materials
  - Conductive Materials
  - Ferrite/Suppression Products
  - Shielding Products and Materials

Leader Tech is a world-leading innovator and manufacturer of EMI shielding products for circuit boards, electronic enclosures and interconnect cables. The company's core product offerings include standard and custom circuit board shields, beryllium copper fingerstock gaskets, conductive elastomers, advanced RF absorber materials and EMI/RFI ferrites. Leader Tech is a wholly owned subsidiary of HEICO Corporation, a successful and growing technology-driven aerospace, defense and electronics company. HEICO Corporation is a New York Stock Exchange listed company (NYSE: HEI and HEI.A) and has been ranked as one of the 200 "Best Small Companies" and 200 "Hot Shot Stocks" by Forbes.

Tel: +1 813 855 692 Fax: +1 813 855 3291
sales@leadertechinc.com
www.leadertechinc.com

National Technical Systems Booth 740

- Software Development/Products
- Testing/Certification
- Training and Seminars

NTS is the largest independent provider of EMC services in North America with 8 locations to provide you with world-class product compliance services. Our state-of-the-art labs offer EMC, Product Safety, Wireless and Telecommunications engineering and compliance testing. Our expert engineers and test technicians take the time and put forth the effort to understand your business, your needs and your goals and combines this knowledge with our own compliance and testing expertise to help you create successful products.

Tel: +1 800 270 2516
Fax: +1 818 591 0899
info@nts.com www.nts.com

(Exhibitor Profiles)

Nemko USA/CAN
Booth 734

- Testing/Certification
- Training and Seminars

Nemko contributes to a safer world by sharing knowledge and safeguarding products, environment, people and systems. Nemko creates value for the customer by providing fast and reliable global market access.

Tel: +1 760 444 3500 Fax: +1 760 444 3005
Bruce.Ketterling@Nemko.com www.nemko.com

Panashield, Inc. Booth 322

- Manufacturer

Panashield designs, supplies, installs and certifies the following: RF Shielded Enclosures; EMC Chambers, Compact, 3meter, 5meter, 10meter; Military 461E and DO160 Avionics Test Chambers; Free Space Simulation Chambers; Reverberation Chambers; CISPR 25 Chambers for Automotive Testing; P3 RF Sliding Doors; Turnkey Services; Facility Relocations; Upgrades to existing facilities.

Tel: +1 203 866 5888 Fax: +1 203 866 6162
girard@panashield.com www.panashield.com

Pearson Electronics, Inc. Booth 325

- Manufacturer
  - Test and Measurement Equipment

Pearson Electronics manufacturers Precision Wide Band Current Probes used for accurate measurements of EMI, surge, lightning, pulse and other complex current wave shapes. The model 3525 has a 6 decade flat transfer impedance,10 Hz to 10 MHz, for EMI measurements. Other probes can measure current as low as 10 microamps (20dBμA) and frequencies as high as 200 MHz. Lightning and surge currents with amplitudes up to 500 kiloamps can be viewed with low sensitivity designs. A typical measurement is an 8x20, or 10x350, microsecond single shot pulse. We maintain a wide variety of clamp-on and toroid current probes in stock for immediate delivery.

Tel: +1 650 494 6444 Fax: +1 650 494 6716
sales@pearsonelectronics.com
www.pearsonelectronics.com

Rohde & Schwarz Booth 217

- Manufacturer
  - Antennas and Antenna Products
  - Test and Measurement Equipment
- Software Development/Products

Rohde & Schwarz is a leading manufacturer of EMC, communication, signal analysis and signal generation equipment. We cover all EMC requirements in Automotive, Military and Commercial sectors. Established over 75 years ago, Rohde & Schwarz has a global presence and international service network with ISO registrations and accreditations. It has approximately 7400 employees and achieved a net revenue of €1.3 billion (US $1.6 billion) in fiscal year 2009/2010. You trust our EMI test receivers; in addition we lead the world in turnkey EMI and EMS test systems. You can count on us for expert support committed to all your EMC applications.

Tel: +1 888-TEST-RSA Fax: +1 410 910 7801
customer.support@rsa.rohde-schwarz.com
www.rohde-schwarz.com

Spira Manufacturing Corporation
Booth 525

- Manufacturer
  - Shielding Products and Materials

Spira Manufacturing Corporation has been serving the EMC community with quality engineered EMI/RFI shielding products for over 30 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.

Tel: +1 818 764 8222 Fax: +1 818 764 9880
sales@spira-emi.com www.spira-emi.com

TÜVRheinland® Precisely Right.

TÜV Rheinland® of North America
Booth 646

- Testing/Certification
- Training and Seminars

TÜV Rheinland® is a leading provider of international testing and certification services, with expertise in product assessment as well as EMC, electrical and telecommunications safety testing. Our 10-, 5- and 3-meter anechoic and semi-anechoic EMC laboratories can accommodate large and small products. Also offering CE Marking and other services to ensure worldwide market access and acceptance, TÜV Rheinland's expert services give companies a competitive advantage selling their products to global markets. Be sure to stop by booth # 646, or visit our http://www.us.tuv.com.

Tel: +1 888-743-4652 (Toll free)
+1 203 426 0888 (International)
Fax: +1 203 426 4009
info@tuv.com www.us.tuv.com

Choose certainty. Add value.

TÜV SÜD America Inc.
Booth 422

- Testing/Certification
- Training and Seminars

TÜV SÜD America offers EMC testing and certification services for the aerospace, commercial, and automotive industries. Our NVLAP, A2LA, and AEMCLRP-accredited laboratories can perform testing to EN, MIL-STD-461, RTCA/DO-160, GM, Ford, Honda, Nissan, Toyota, Hyundai, Fiat, and many other test specifications. Additionally we provide HIRF, environmental, mechanical and electrical safety testing and certification services.

Tel: +1 734 455 4841 Fax: +1 734 455 6590
info@tuvam.com www.TUVamerica.com

(Show Stoppers)

Our advertisers have agreed to participate in a new feature in our EMC Symposium Preview -- the Show Stopper section. And so, we bring you a new opportunity to learn about what's new and what you have to look forward to when you stop by their booths for a visit in Long Beach this year.

Advanced Test Equipment Rentals

find us at **Booth 445**

Since 1981, Advanced Test Equipment Rentals (ATEC) has shown its commitment to providing quality customer service by meeting our customer's equipment rental needs. ATEC supplies complete testing solutions for EMC, Defense, Telecom, Power Quality, Environmental and similar testing applications. Our custom solutions, flexible rental terms, and quality customer support differentiates us from our competitors as a complete solution for all test and measurement needs.

Celebrating 30 years in business, ATEC has become the leading experts in EMC test applications and have accrued the largest inventory of EMC equipment in the industry.

As a leading provider of test and measurement equipment, Advanced Test Equipment Rentals has established solid relationships with industry leading manufacturers worldwide. As a result, our company is able to provide a wide variety of equipment from the unique and unusual to the most cutting-edge products on the market today.

Please visit Advanced Test Equipment Rentals, booth #445, to meet our friendly and knowledgeable staff and enter our raffle for a chance at winning a fabulous prize. We hope to see you at EMC 2011!

Agilent Technologies

find us at **Booth 223**

Visit Agilent Technologies at Booth 223 to see EMI measurement solutions for EMC compliance and precompliance testing. The new Agilent MXE EMI receiver is fully compliant with CISPR 16-1-1 2010 and includes X-Series signal analysis and graphical measurement tools that make it easy to diagnose EMI problems. To ensure successful compliance testing, MXE-identical measurements can be made with any X-Series signal analyzer and the EMC measurement application. Agilent Solutions Partners offer a single point of contact to purchase a complete EMC solution that meets MIL-STD and commercial specifications, combining Agilent's products with value-added integration, and more. Agilent Technologies is the world's premier measurement company. Agilent is committed to providing innovative measurement solutions that enable its customers and partners to deliver the products and services that make a measurable difference in the lives of people everywhere.

AR

find us at **Booth 111**

What has AR done for you lately? Stop by Booth #111 and see!

We've exceeded old power limits with our new 16kw, 10 kHz - 225 MHz amplifier and are breaking down barriers with our new dual band solid-state amplifiers. These amplifiers offer the reliability of solid-state from 1 -18 GHz in one package. Our new DSP EMI Receiver covers 20 Hz to 18 GHz and features amazing speed and incredible accuracy.

A new family of solid-state microwave amplifiers provides power up to 500 watts covering 1 – 2.5 GHz; making them excellent replacements for traveling-wave tube amplifiers. We're giving you more power in our 0.8 – 4.2 GHz solid-state microwave amplifiers – up to 1200 watts! There will be live demonstrations of our EMC test software, EMI receiver, conducted immunity test systems and more.

Don't forget to test your AR knowledge and be entered into our daily prize drawings. There are 4 chances to win each day!

ARC Technologies

find us at **Booth 745**

ARC Technologies is the leading supplier of microwave absorbing materials for commercial and defense applications. While providing a complete range of standard absorber products, ARC Technologies also offers dielectric materials, composites, radomes, and radar absorbing structures (RAS). The company's Wave-X family of products is an effective solution for EMI and SAR suppression due to their unique formulations. No matter the problem you are facing ARC Technologies has a product or will develop an application specific product to meet your specifications.

(Show Stoppers)

CST of America

find us at **Booth 339**

CST will be presenting the latest developments of CST STUDIO SUITE at booth #339.

Bi-directional transient Field/Cable co-simulation

In many applications, such as lightning strike as well as other EMC susceptibility and emission scenarios, it is necessary to include in the 3D model an accurate representation of the often complex cable bundles which can be both inside and outside of any shielding enclosure. Due to the large aspect ratio which can exist between the enclosures (e.g. a car, a plane) and the cross sections of the individual conductors in the cable, this can be a very challenging problem. The improved integration of the TLM solver of CST MICROWAVE STUDIO® (CST MWS), formerly known as CST MICROSTRIPES, enables the bi-directional transient co-simulation with CST CABLE STUDIO (CST CS). which is an. Stop by at our booth to learn more about this effective way to meet the challenge of different scale in simulation.

Braden Shielding Systems

find us at **Booth 424**

Braden Shielding Systems provides complete packages for all your EMC needs. With more than 5,000 chambers worldwide, we have the experience, knowledge and capabilities to provide our customers with the finest shielded enclosures available. We welcome you to visit out booth #424 at the IEEE 2011 International Symposium on Electromagnetic Compatibility.

Com-Power Corporation

find us at **Booth 118**

Com-Power Corporation is a supplier of a wide variety of EMC Test Equipment. Our product line includes Antennas, Preamplifiers, Comb Generators, LISNs, CDNs, Power Amplifiers and much more. If you are planning to set up an EMC lab or looking for a solution, please come and meet with us. Save time and money by shopping from one single source. We will have samples of our latest products on hand. Come check out our Comb Generators for quick EMC site verification. In addition, we will be conducting a raffle drawing every day for a chance to win our Near Field Probe kit. Use the Probes to find the EMC noise source and impress your customers and colleagues. VISIT US IN BOOTH 118. See you there!

Curtis Industries/Filter Networks

find us at **Booth 234**

Be sure to visit Curtis Industries/Filter Networks' new trade show booth at EMC 2011. We are introducing two new product lines: the F7000 Filter Series along with the F3760 Series 3-phase line.

The F7000 Series features high frequency power line filters that utilize the patented X2Y technology. Typical applications for this filter include computers, telecommunications, AC & DC motors, power supplies, Tempest equipment, AC to DC converters, hospital equipment and more.

The New Curtis F3760 Series 3-phase filter product line is High Current, 760VAC, great for motors, variable speed drives, and many other applications.

Curtis Industries/Filter Networks is a specialized manufacturer of custom and standard Terminal Block and EMI/RFI Filter devices and subsystems. We are ISO 9001, UL and ITAR registered. Our manufacturing core competencies focus on a range of markets including Aerospace, Communications, Industrial Controls, Medical, Military, Networks and Telecommunications.

We create superior quality, budget conscious solutions for complex challenges. See you in August!

EM Test USA

find us at **Booth 631**

For information about innovative state of the art equipment for conducted EMC, you'll need to visit EM Test's booth 631 at the IEEE EMC Symposium in Long Beach. From generators and couplers that can handle ***1GBIT/s telecom lines*** for Surge, Ringwave and EFT testing, to a broadband, programmable AC/DC source for DO-160 Section 16, Airbus, Boeing and Mil-Std704 requirements, EM-Test has the solution for your testing needs.

Not only do we have products for testing to all the standard IEC tests for conducted immunity (Surge, Burst, Dips & Interrupts, ESD, Conducted RF and Harmonics/Flicker) we have the instruments you need to meet virtually all automotive industry test standards including ISO, SAE and world-wide vehicle manufacturers standards. Additionally, we supply instruments for EMC testers for emerging technologies such as solar panel and hybrid vehicle standards as well as for Surge Protective Components.

In business since 1987, EM Test is an international company with several fully accredited 17025 calibration labs plus sales offices and distributors around the world providing local support, training and service. We look forward to seeing you in Long Beach...

(Show Stoppers)

ETS-Lindgren

find us at **Booth 311**

You Haven't Seen the Show until You've Seen Booth 311!

Featuring six new products, programs and attendee giveaways, ETS-Lindgren's booth is a "must see" destination while you're in Long Beach for the IEEE EMC Symposium.

Free samples of a new flexible EMC absorber, FlexSorb™ -- the absorber that "Bends Without Breaking" -- will be available to the first 250 visitors.

Also being featured is a new sales program, Antennas-2-Go™, that ships 10 of our most popular antennas from stock. Protecting those antennas during shipping and storage will be easier with a new expanded line of rugged cases on display. Keeping them properly calibrated will be simplified with a new Calibration Services Plus!™ program that offers enhanced calibration services at ETS-Lindgren's A2LA accredited lab.

The new release of TILE! 5.0™ – the premier EMC lab management software – offers a smoother graphical interface and more user capability. (TILE! users – don't forget to attend the annual TUG meeting on Wednesday morning!). And to improve your skills in the lab, representatives of ETS-Lindgren's ETS-U will be on-hand to discuss their EMC Fundamentals Course.

For those who lost their luggage or just need a clean T-shirt, ETS-Lindgren is also giving away Antenna and TILE! T-shirts to the first 250 people who stop by the booth and complete a 3-minute survey. Food service and other giveaways will be available at select times during the show.

Fair-Rite Corporation

find us at **Booth 327**

Fair-Rite Products Corp has been busy!

We have recently expanded our *Power/Inductive Materials and Components* line for transformer, inverter and inductor applications. We now offer THREE new materials, 95, 97 & 98 in industry standard shapes and sizes. Our expanded line provides low losses and optimum use of given volume of ferrite material for power/inductive designs up to 750Khz. The added shapes permit simplified construction of common mode EMI filters without toroidal winding complexity.

Additionally, Fair-Rite has also created a High Frequency Toroid Kit for inductive applications operating at a frequency of 1MHz and above. The kit contains eight sizes in four materials from a 6mm OD to 61mm OD. The materials are selected for optimized performance over a specified frequency range for power conversion and low loss applications. These toroids and materials can be utilized for broadband transformers and high frequency chokes as well. The toroid shape offers an ideal geometry for potential users to evaluate material relative to their electrical requirements.

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.

HV TECHNOLOGIES, Inc.

find us at **Booth 423**

Why Come By Our Booth?

Learn more about the latest innovations in transient test solutions from EMC-PARTNER. Some new products since last year's Symposium:

CE MARK Applications:

- 200 Amps per Phase EFT and SURGE
- DC Interrupts to 100 Amps
- TRA3000 Modular CE Mark Transient Generator
- ESD3000 Still the only AA Battery Powered ESD Simulator

AVIONICS Lightning & Voltage Spike:

- Airbus ABD0100.1.2 G specific lightning waveforms WF2, WF3, WF5A
- Airbus ABD0100.1.8 Voltage Spike on Power Line up to 2kV
- Larger Cable Bundle Couplers

GREEN ENERGY Smart Grid & Solar:

- Solar Panel Insulation -- MIG1203SOLAR tests panels from 30cm up to 2.5m
- Complete Solutions to C37.90, C62.41, Impulse specs of C63.16 and more

Have a transient impulse test application not listed above? Drop by our booth and review it with us. We offer hundreds of products and most likely have your transient test solution.

iNARTE

find us at **Booth 523**

Visit us at booth #523 to get the latest information on our new certification programs and our new organization. Since EMCS 2010, iNARTE has become formally affiliated with RABQSA, which makes us a part of the overall ASQ organization. Information about RABQSA and how this affiliation will impact upon iNARTE activities will be available at the show. This year we have introduced two new EMC certification programs; EMC Design Engineer and MIL-STD EMC Specialist. The examination elements required for these new certifications will be offered on Friday August 19th, together with

(Show Stoppers)

our regular examination programs. The EMC Design Engineer program will be launched in three phases; Engineer, Senior Engineer and Master Engineer. Phase one is available now and is intended for Design Engineers who are undergraduates, recent graduates and engineers with less than two years of EMC related work experience. The Senior Engineer and Master Engineer phases will follow later this year. During this introductory period of the program, we are offering Grandfather Certification as Master EMC Design Engineer to experienced practitioners recognized by the EMC community. Registrations for examinations, application forms for all disciplines, and most importantly, applications for Master EMC Design Engineer during the Grandfathering period will be available at the iNARTE booth.

IN Compliance Magazine

find us at **Booth 429**

Stop by to see us at Booth 429 this year - we're not only giving away free subscriptions, but for our subscribers we have a free gift!

IN Compliance is the leading monthly magazine in the EMC industry -- keeping you informed with news and technical articles through our print version as well as digital and bi-monthly newsletters.

Check out our ad on page 57. And be sure to stop by to see why we're EMC fit to a T!

Leader Tech

find us at **Booth 551**

New - Expanded Line of Conductive Elastomers

Stop by Leader Tech's Exhibit (Booth 551) for information on our expanded line of Conductive Elastomers! This all new product offering provides engineers with a highly customizable and cost-effective gasketing solution that delivers a shielding effectiveness of up to 110 dB across wide temperature variations and environmental conditions.

Leader Tech's high-performance gasketing material is manufactured using proprietary formulations of both silicone and fluorosilicone rubber that is embedded with highly conductive fillers including: silver plated copper, silver plated aluminum, silver plated glass and nickel coated graphite. The company offers a wide assortment of gasket profiles as well as unlimited variations of extruded, molded, sheet stock, and die-cut finishes.

For samples or additional technical information, just stop by our booth and speak with one of our engineers.

National Technical Systems

find us at **Booth 740**

Visit NTS at the IEEE EMC Symposium - WBooth 740

NTS is recognized worldwide as an industry leading provider of Electromagnetic Compatibility (EMC) engineering, and compliance testing services.

NTS operates more EMC testing laboratories than any other company in North America with locations from coast to coast and in Europe. We offer the broadest range of capabilities to test your products for compliance with applicable EMC regulatory requirements all over the world.

Our EMC and EMI Subject Matter Experts can offer your company integrated design, analysis, testing and evaluation services, reducing your product development costs and accelerating your time to market. We operate modern, world class facilities staffed by highly experienced EMC engineers and technicians, all trained in the usage of modern test and measurement equipment. Not only does NTS have the most EMC testing laboratories across North America, we also operate a network of A2LA accredited labs, certified for testing to an enormous array of standards.

Our Program Managers and EMC/EMI Subject Matter Experts will work closely with you and your team, conducting technical design reviews to determine your exact challenges, needs and requirements. For more information, visit NTS on the web at www.nts.com or stop by Booth 740 at the IEEE EMC Symposium to speak with one of our experts.

Panashield Inc.

find us at **Booth 322**

Panashield looks forward to seeing old and new friends in Long Beach. Drop by and visit us at Booth 322. See our new absorber products, new lighting options and new shielding effectiveness measurement systems. We have new staff (the Newbies Pam and Dave) to meet with you and discuss your chamber requirements. Don't forget to participate in our raffle!

Panashield provides the highest quality EMC turnkey facilities with on-time and on-budget performance. Servicing commercial and government clients worldwide with complete facilities, upgrades to existing facilities, and relocations. Products & Services include the design, installation and certification of RF Shielded Enclosures, Chambers for EMC, Automotive, Military, Avionics, Aerospace, Wireless, Antenna Measurement, Free Space Simulation, and Reverberation Chambers. We also offer our patented P^3 RF Sliding Doors for new and existing facilities.

(Show Stoppers)

Pearson Electronics

find us at **Booth 325**

Pearson Electronics manufacturers Precision Wide Band Current Probes used for accurate measurements of EMI, surge, lightning, pulse and other complex current wave shapes. We will be demonstrating the performance of several probes to assist with various measurements required by the MIL-STD-461 specification. The Pearson model 3525 will be compared to other passive EMI probes to demonstrate its efficiency and its 6 decade flat transfer impedance, 10 Hz to 10 MHz, one of the best in the industry. This probe is a great choice to meet the 30 Hz to 10 kHz frequency requirement for CE101. We will also be demonstrating other current probes and injection clamps to assist with CS115 and CS116 requirements. The Pearson's wide band frequency response and ability to inject and measure fast rise times make the Pearson probe an ideal choice for these requirements. We look forward to seeing you at booth 325.

Rohde & Schwarz

find us at **Booth 217**

Rohde & Schwarz is one of the world's leading manufactures of test & measurement, communications and broadcasting equipment. EMC and EMI test equipment and systems from Rohde & Schwarz determine the causes and effects of electromagnetic interference. With decades of in-field EMC and EMI measurement experience, Rohde & Schwarz's broad EMC & field strength test equipment product portfolio provides accurate results across a wide 3 GHz to 67 GHZ frequency range. Rohde & Schwarz not only offers EMC, EMI, EMS and EMF test equipment for pre-compliance and full-compliance measurement, but it also provides customers with complete turnkey systems. Rohde & Schwarz test solutions significantly enhance productivity and product performance by enabling precise results to be achieved when measuring complex waveforms.

For more information, go to http://www.rohde-schwarz.us/en/products/test_and_measurement/emc_field_strength/products/

Spira Manufacturing Corporation

find us at **Booth 525**

Newest InSpiration in EMI shielding!

- Come by booth #525 for an **EMI Educational DVD** by one of the leaders in EMI Shielding (FREE while supplies last!) "EMI Shielding Gasket Selection, Testing & Effective Use." It covers the requirements to select the proper EMI gasket to last the LIFE of a system and explains the importance of choosing a compatible gasket and joint surface to avoid corrosion. It also details and evaluates the accuracy of Shielding Effectiveness Test Methods and introduces a more effective Transfer Impedance Test Method.
- We have samples of our newest products including Spira's Front-**Mount Environmental Connector-Seal Gaskets** - providing the BEST environmental seal and EMI shielding combination for flange mounted connectors.
- Also see our **Honeycomb Fan Filters** and ask us about our patented blending process that makes them the best on the market and cost effective too.
- We're happy to answer any application questions regarding Spira's gaskets – the best EMI gasket on the market when you need excellence by design and expert technical assistance.
- And don't forget your **FREE boomerang** – Spira has something for everyone!!

All products manufactured in California. www.spira-emi.com/whatsnew

TÜV SÜD America

find us at **Booth 422**

Our EMC Services + Your Product = Worldwide Acceptance.

Need EMC testing and certification services? Do the math and see that TÜV SÜD America is the answer for turning complex regulatory issues into international solutions.

Our EMC services unit is a leading provider of EMC testing solutions. We offer In-Situ Testing, Aerospace and Defense Testing including MIL-STD-461E, RTCA/DO-160E, EUROCAE/ED-14E, Def-Stan 59-41, Multiple-Burst and Multiple-Stroke Lightning, and HIRF testing up to 9500 Volts/meter. We provide Medical EMC Services specializing in FDA IEC60601, GM and Ford AEMCLRP-accredited Automotive EMC testing. We also test to U.S., European, Asian OEM, and international standards, along with supplying eMarking services to the European vehicle directives. Our labs are accredited by NVLAP and A2LA for virtually all U.S., FCC, European, and Asian standards, and we are a Notified Body for Europe.

Stop by Booth 422 at the IEEE EMC Symposium to enter to win an iPod Shuffle and find out how TÜV SÜD America can assist you in getting your product to market fast.

Recent Changes to GR-1089-CORE

Released in May of 2011, GR-1089-CORE Issue 6 Electromagnetic Compatibility (EMC) and Electrical Safety requirements for Network Telecommunications Equipment has undergone a number of technical changes. We look at its substantial modifications and the potential impact on previously certified products.

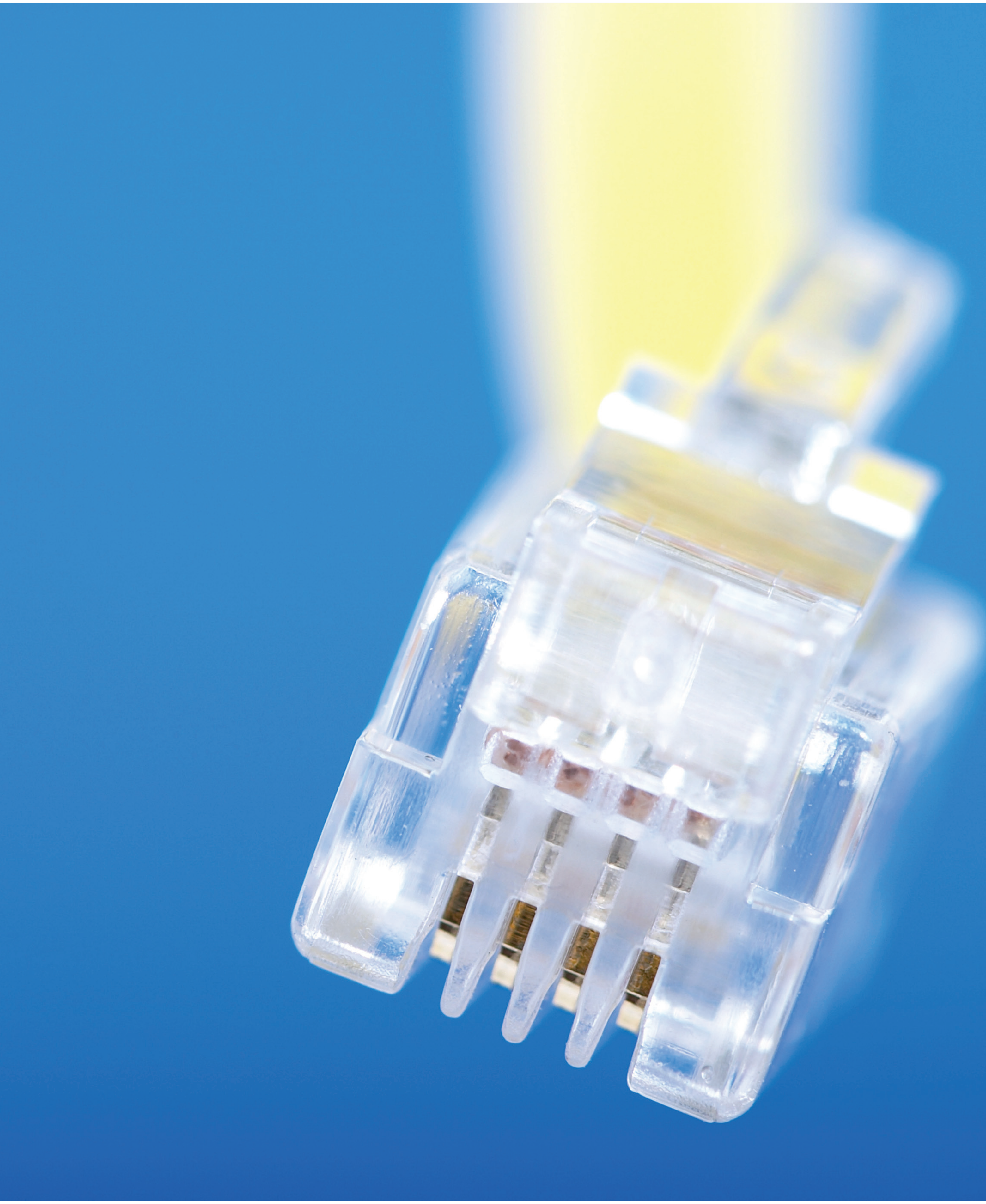
BY JEFFREY VIEL

APPLICATION GUIDELINES FOR EQUIPMENT PORTS

Appendix B now defines two additional classifications for type 3 and 5 ports traditionally reserved for ports directly connected to metallic outside plant (OSP) lines. Intra-cell site cable ports directly connected to metallic OSP cables and located only at cell site or other locations that posses tall antennas are now classified as port type 3a/5a. The definition is further expanded by stating that this cable type has limited exposure as it is routed outdoors in relatively short distances, and that AC power fault conditions are not a significant threat. The greatest threat to type 3a/5a ports is due to Ground Potential Rise (GPR).

The second new classification is defined for short reach OSP cables. Cables that are deployed in short durations less than 500 feet due to functional design constraints are now classified as port type 3b/5b. Due to the short routing distances, type 3b/5b ports also have limited exposure to lighting and power fault conditions, and the greatest threat is posed mostly by near strike lightning.

Type 4 ports, which are traditionally reserved for customer premise or non-central office intra-building environments, now includes port type 4a for customer-side Optical Network Terminals (ONT's) and Intelligent Network Interface Devices (iNID's). These ports do not connect to metallic OSP lines and are intended to electrically or optically isolate ports from the network. Plain Old Telephone Service (POTS), Ethernet, and coaxial lines fall under port type 4a. However, coax lines are still tested as type 4 ports.

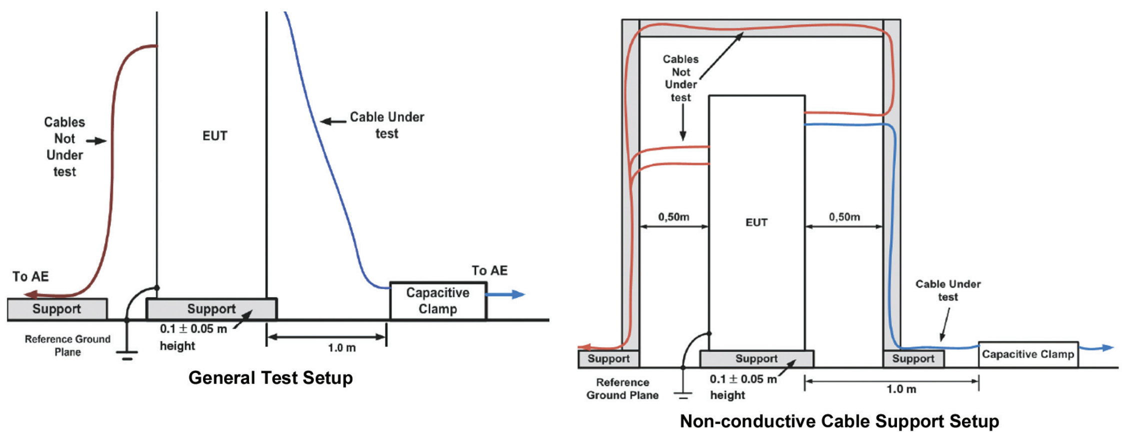


Type 8 ports, or DC power ports, includes two additional classifications. DC power routed to antennas or equipment located at the top of antennas is now classified as port type 8a. Type 8b covers DC power ports located in Intra-cell site environments. The test application chart for equipment ports located in GR-1089-CORE Appendix B has been updated to include these new port type classifications.

and results shall be deemed valid even where discharges are not observed. Additionally, Section 2.1.4.1 Test Methods Normal Operation states that if service effecting responses occur during testing, testing shall be repeated with longer intervals between discharges as referenced in the latest EN 61000-4-2 Version 2008 Test Standard.

Under the Electrical Fast Transients (EFT) Test Methods and Procedures Section, a statement has been added by test similarity, and will require conformance to the higher test level if they are intending to sell products in Europe. Another subtle difference noticed between the IEC test method and GR-1089 is the proposed test setup. Two illustrations have been included in issue 6 to address cable dressing during the test as shown in Figure 1. In these drawings, GR1089 depicts the coupling clamp positioned 1 meter from the EUT regardless of how long the cable under test is. This methodology is suggested by the standard of testing

Figure 1: Suggested EFT test setup illustrations per GR1089 Issue 6



ELECTROSTATIC DISCHARGE AND ELECTRICAL FAST TRANSIENTS

Section 2 continues to define the Electrostatic Discharge (ESD) and Electrical Fast Transient (EFT) requirements for network telecommunications equipment. A few minor technical changes were observed regarding ESD testing. The first was found under Requirement R2-2 which provides details regarding test methodology on performing contact discharge tests to non-conductive surfaces. R2-2 clarifies when performing contact discharge tests to non-conductive surfaces that produce arc discharges to surrounding conductive surfaces is not considered a valid test. Testing shall be repeated using air discharges at these locations, that permits the use of special software and firmware if it can be demonstrated that the EUT is configured and operated in a manner which is consistent with normal operation. This section has also been updated with special instructions regarding power ports, and using the capacitive coupling clamp versus the CDN method described in the latest version of IEC 61000-4-4. However, the CDN method is considered equivalent.

The EFT test levels, repetition rate, burst rate and burst period remains unchanged, which are consistent with IEC 300-386. However, GR-1089 still specifies the test levels for outside plant and central office intra-building ports (types 1 and 2) at 250 volts where EN 300-386 tests at 500 volts. The difference in screening levels for EFT prevents a product manufacturer from claiming CE mark compliance for each, but tends to deviate from the referenced IEC standard. IEC 61000-4-4 states that unless specified by the product manufacturer, the length of cable between the EUT and the coupling clamp shall be 0.5 m, ±.05 m. The IEC's general laboratory test setup for EFT shown in Figure 2 suggests that for high entry or top fed ports, the coupling clamp shall be elevated such that no greater than one meter separation between the clamp the EUT exists. This requires installing an elevated groundplane and coupling clamp near the top of the cabinet. This may lead to incompatibility issues between GR and IEC if not addressed properly. For products that are being certified to EN 300-386 and GR-1089 I6 concurrently, it is recommended that the IEC method be observed as intended.

> Another major change observed in Issue 6 is that Section 3.2.1.3 Radiated Magnetic Field Emissions Requirement has been removed.

RADIATED EMISSIONS

In accordance with Section 3.1.4 FCC Part 68 and ACTA, technical criteria has been replaced with a statement regarding consolidated testing. GR1089 Issue 6 permits and encourages simultaneous testing to multiple standards such as FCC, EN 300-386, and GR1089. Consolidated test results are allowed in test reports. Traditionally, this has been common practice for global certification of telecommunications equipment and is expected to simplify the reporting requirements.

There has been a major change to the GR-1089 radiated emissions electric field requirements in Issue 6. R3-2[8] has been revised to state that radiated emissions electric field testing is performed from 30 MHz to 10 GHz intentional and unintentional radiators versus the previous 10 kHz to 10 GHz requirement in GR1089 Issue 5. However, the 3 and 10 meter limit levels have not changed for this new limited test range. The validity of the 10 kHz to 30 MHz test range has been in question for many years due to a number of reasons ranging from near field effects, correlation issues between an open area test site and shielded anechoic chambers and, more importantly, the actual need to measure radiated fields in this range. Emissions contributions in this frequency range are generally cable related and not emitted from the equipment enclosure. As GR-1089-CORE already quantifies conducted emissions from each cable type in this range, the elimination of this test frequency range is expected to be of limited risk.

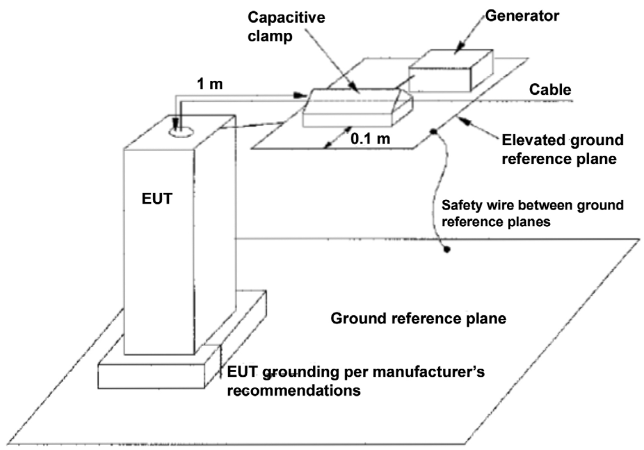


Figure 2: General laboratory EFT test setup per IEC 61000-4-4

RADIATED MAGNETIC EMISSIONS

Another major change observed in Issue 6 is Section 3.2.1.3 Radiated Magnetic Field Emissions Requirement has been removed. The radiated magnetic emissions test was exclusive to GR-1089-CORE and was not an EN 300-386 OR FCC requirement. Therefore, this test requirement deletion has no impact on consolidated product certification. Traditionally, the radiated magnetic emissions limit was simply based on the conversion from electric field to magnetic field using the decibel equivalent of 377 ohms free space impedance of a plane wave, or -51.5 dB. These measurements were performed in two orthogonal axes and were useful in determining the magnetic component of the product emissions, but the results were of little use. Typically, if the product met the radiated electric field requirement they would meet the magnetic field requirement by default. Therefore, removal of this test requirement is considered to be of low risk to future product certification.

CONDUCTED EMISSIONS

Exclusive conducted emissions tests for analog voiceband leads previously, specified in GR-1089-CORE Issue 5 (Section 3.2.3.2), and conducted emissions for telecommunication leads (Section 3.2.3.3) have also been removed. However, they have been combined under the conducted emissions requirements for telecommunication ports in Issue 6. As similarly stated in Issue 5, all telecom ports require conducted current emissions measurements from 10 kHz to 30 MHz.

RF IMMUNITY

In regard to RF immunity testing, Table 3-11 Frequencies of Key Interest has been updated. Television channel 2 (55.25 MHz), channel 11 (199.25 MHz), and channel 52 (699.25 MHz) have been excluded. However, additions to police/fire radio (481, 816, and 4965 MHz) have been added. Cell phone frequencies have been changed from 825 MHz to include 701, 711, 713, 781, 787.5, 791, 805.5, 1732, and 2310 MHz. PCS now includes 914 MHz in addition to 1800 MHz. In summary, GR1089 Issue 6 has specified 26 key frequencies versus 18 specified in Issue 5.

LIGHTNING AND AC POWER FAULT

Section 4 has undergone a variety of technical and formatting updates, including a new table (Table 4-2) which lists surge applicability based on port type. The table also provides a test surge description, test conditions, connections, and application information. The 23 newly listed surges appears daunting in size at first glance, but this is a consolidation of all first level lightning criteria into one table for quick and easy reference.

INTRA-BUILDING LIGHTNING

In regard to the first level intra-building lightning test criteria, GR-1089 now permits that either one surge can be applied to 3 samples or 5 five surges applied to one sample to ease the burden on vendors. However, using extended interval times between surges may be required when testing only one sample. R4-7 [233] states that all Ethernet ports shall be tested. However, type 2 Ethernet ports shall only be subjected to longitudinal (differential) surges. The use of either the 2/10 microsecond or the 1.2/50 microsecond waveform with stress levels between 800 and 1500 volts is still permitted.

GR-1089 has defined the double exponential impulse waveform and how to characterize its rising edge and duration times in Appendix A. This was traditionally performed between 10% and 90% of the rising edge, and between 0% of the rising edge and 50% of the falling edge for establishing the duration for both voltage and current waveforms as depicted in Figure 3. This holds true for most of the waveforms required in this new issue except for the 1.2 µs / 50 µs and the 10 µs / 700 µs combination waveforms, which only use this for current measurements. For the voltage component of these waveforms, they are characterized using 30% to 90% of the rising edge exclusively as shown in Figure 3. This methodology aligns with IEC 61000-4-5 as well as IEC 60060-1.

FIRST LEVEL SURGES

There have been several changes to the first level surge test requirements as follows:

GR-1089 now permits that either one surge can be applied to 3 samples or 5 five surges applied to one sample to ease the burden on vendors.

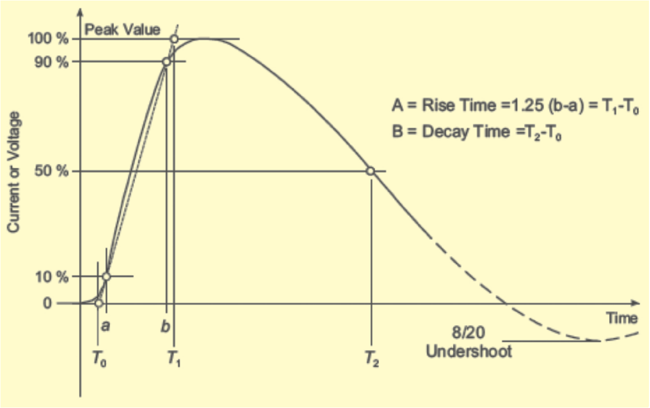


Figure 3: Double exponential voltage and current waveform measurements

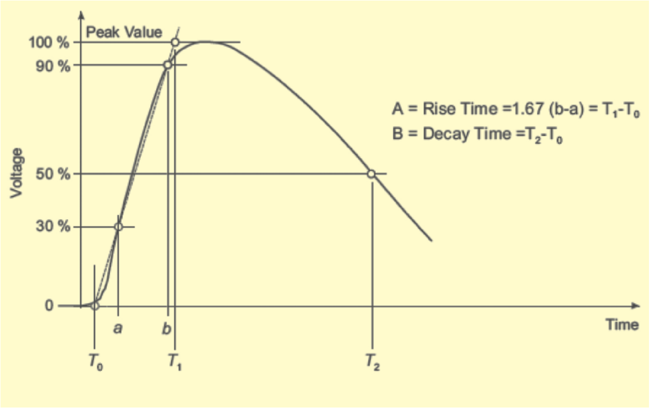


Figure 4: Voltage measure-ments for the 1.2/50 µs, and 10/700µs double exponential waveforms

Surge 3 "Gas tube interaction test applicable for types 1, 3, 3b, 5b, and 5 ports" requires 4000V 10/700us V 5/310us A (ITU-T K.44 generator circuit schematic provided).

Surge 4 "Inductive kick test for OSP interfaces applicable for port types 1, 3, and 5.(???) 2500V 500 A 2/10us" is not required for ports solely intended for installation in GR487 or GR950 style enclosures. However, product labeling is required when the exclusion of Surge 4 is observed.

Surge 7 "High lightning exposure test for remote OSP interfaces" requires the 10/250 uS waveform be between 400V 50 A and 4kV 500 A.

CELL SITE INTER-STRUCTURE

Section 4.6.1.3 is a new test procedure which describes the withstand criteria for ports located within a cell site inter-structure. This section is intended for port interfaces which are deployed between separate structures, cabinets, buildings, and H frames within a cell site to mitigate potential GPR damage. Two separate test options are provided:

Option A: Isolation test – 1500 V AC 50/60 Hz 60 seconds

- 2120 VDC 60 seconds
- 10 2400V spikes 1.2/50 us

Option B: Surge Test

Types 3a, 5a or 8b ports

3a, 5 a ports are subjected to select intrabuilding surge tests (8 – 14.1)

3a, 52 and 8b ports are also subjected to 2.5 kV 5kA longitudinal surge (23 per Table 4-2).

SECOND LEVEL LIGHTNING

In regard to the second level lightning surge criteria defined in Section 4.6.3, Table 4-3 now combines port type 1,3, and 5 with type 7 requirements into one table. However, there have been no technical requirement changes to these port types.

FIRST LEVEL AC POWER FAULT

Within the first level AC power fault criteria defined in Section 4.6.4, Table 4-4 has removed Tests 8 and 9 and tailored many of the test conditions. For the most part, the levels are slightly less severe than in GR1089 Issue 5.

SECOND LEVEL AC POWER FAULT

A number of changes to the second level power fault test levels are shown in Table 4-5. The most substantial is that the maximum test voltage level has been limited to 425 V versus 600 V, but can be run at 600 V with manufacturer's approval. Current remains at the same level as specified.

ENCLOSURES SUITABLE FOR FUSING

GR-1089 Issue 6 has revised the requirements for equipment enclosures suitable for fusing. Requirement R4-55 [196] per GR0189 Issue 5 has been changed to R4-51 [196], which now states enclosures shall not contain vents or openings that would allow for ejection of molten metal, flames, or similar hazards when internal fusing occurs. No ventilation or opening were permitted in Issue 5.

R4-57 [198] per GR1089 Issue 5 requirement, which stated that the enclosure shall be capable of withstanding a 12-gauge shotgun blast without penetration of the enclosure wall by any pellets, has been removed.

SECTION 9 BONDING AND GROUNDING

The most substantial change made in Section 9 of GR-1089 Issue 6 was that the embedded power sources defined rating has been reduced from >20 VA to >15 VA. This change has been reflected throughout the section, including short circuit testing which now states that a power source less than or equal to 15 VA need not be tested for short circuits. This has changed from 20 VA in issue 5. In addition, short circuit testing also states that all equipment that has been listed by an NRTL through standards such as UL60950 or UL1459 need not be tested for short circuits. This has changed from discrete equipment assemblies only as stated in Issue 5.

SECTION 10 DC POWER PORT CRITERIA

Section 10 has been updated to reference the new ATIS 0600315 test standard (formerly ANSI T1.315). The new ATIS document specifies that all transient voltage measurements are now specified to be made between 10% and 90% of the corresponding rising or falling edge of the waveform, which aligns with the IEC 61000-4-5 waveform characterization method.

In most cases, these transients are performed with a DC coupled audio amplifier while supplying the EUT with full load power. To verify this prior to testing, ATIS has provided 4 optional waveform verification methods which range from (1) open circuit, (2) with EUT in circuit, (3) resistive/capacitive load in circuit, or (4) purely resistive load in circuit. Although the fast rise

GR-1089 Issue 6 has revised the requirements for equipment enclosures suitable for fusing.

and fall times are easiest to meet in an open circuit condition, additional tests are required to verify impulse current (100 amperes), as well as the amplifier's slew rate in accordance with IEC-61000-4-11. However, any of the four optional verification methods are acceptable.

Another subtle change that was noticed was the ATIS 0600315 under voltage transient shown in Figure 5. The waveform's fall time was relaxed to ≤ 12 microseconds from the 10 microseconds previously required by ANSI T1.315.

Among these changes, the noise returned by network equipment measurement specified by ATIS 0600315.2007 is no longer required per GR-1089 Issue 6. The wide band noise frequency test is still required by GR-1089, but with a relaxed limit requirement. This test measures the electrical noise (Vc) fed back from telecommunications equipment within any 3 kHz band ranging from 10 kHz to 20 MHz. For -48 VDC powered equipment, the limit (expressed in mV rms) 1.0 * square root of Ic (rated input current) or 1 ampere, whichever is greater, was changed to state that Ic or 10 amperes is now the maximum input current, whichever is greater. This change can substantially relax the wideband noise frequency emissions requirement for equipment operating at marginal loads.

There has also been a slight modification to the measurement circuit provided in ATIS 0600315 shown in Figure 6. The illustration provided in GR-1089-CORE Issue 6 (shown in Figure 7) introduces a high impedance transducer between the measurement equipment and the measurement capacitors to normalize the circuit impedance to at least 600 ohms. Notes provided in this revised section also state the capacitors are only used for voltage isolation and can be excluded if a differential probe is used.

In regard to the noise immunity test levels in Section 10, they have not changed for -48 VDC equipment except that voice frequency noise immunity is only reserved for products that include analog voice band ports.

WIRELESS PRODUCTS PERFORMANCE REQUIREMENTS

Appendix F has been added in Issue 6 to address the minimum performance parameters for wireless products that must be monitored during immunity testing.

- Output RF Power

  In general terms, the forward power transmit levels shall remain within the manufacturers specified levels and tolerances, or ± 1 dB.

- Frequency

  The transmit frequency and bandwidths shall remain within FCC tolerable limits during and following testing.

- Integrity

  The transmitted modulated signal shall not lose any of its baseband information. Output power can be

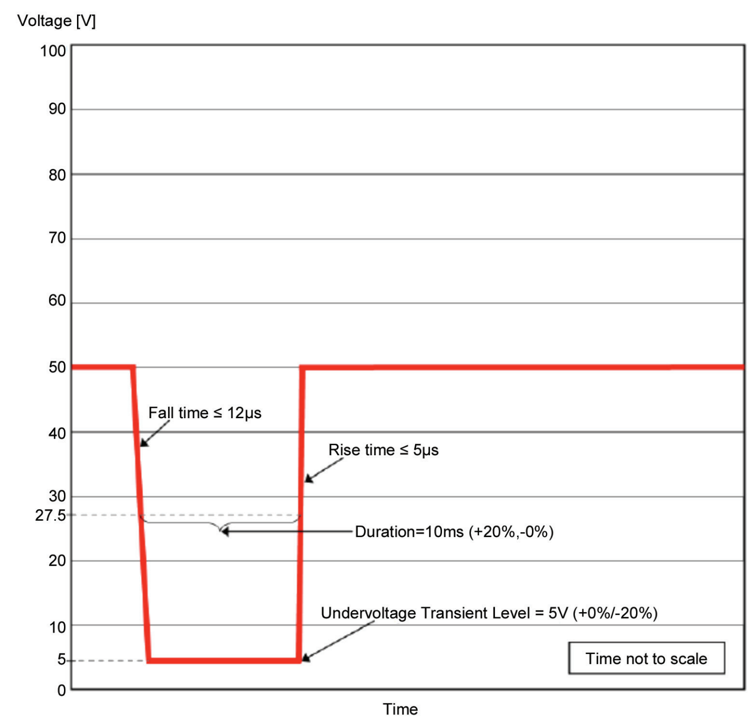


Figure 5: ATIS 0600315 under voltage transient

The wide band noise frequency test is still required by GR-1089, but with a relaxed limit requirement.

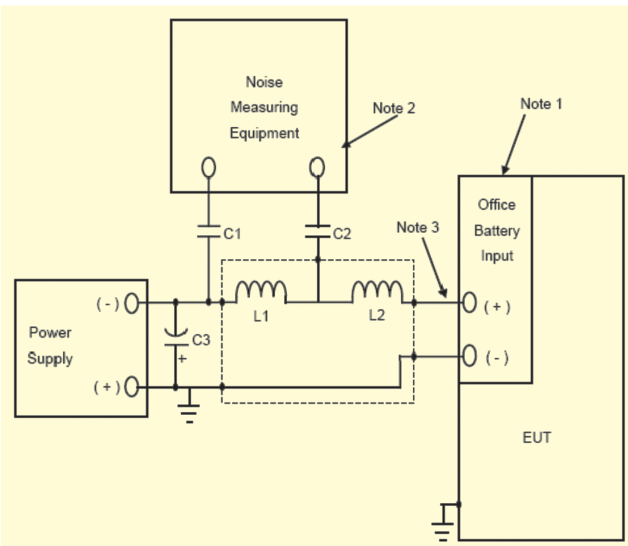


Figure 6: ATIS 0600315 noise return circuit

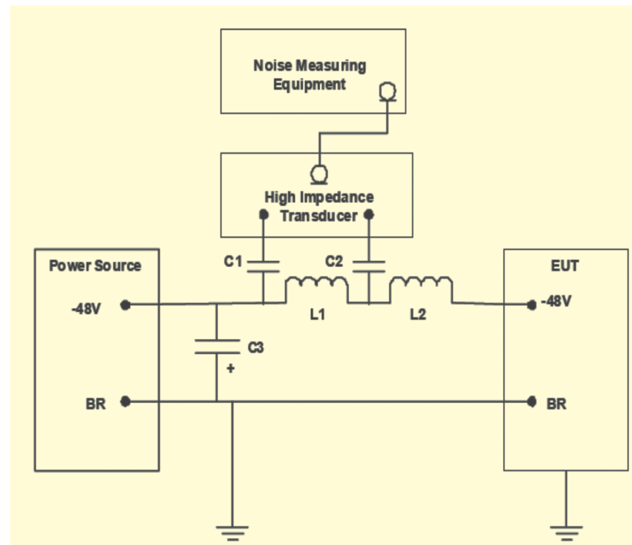


Figure 7: GR-1089-CORE Issue 6 noise return circuit

sampled and demodulated to monitor performance.

- Data error rate

  Data error shall be within the manufacturer's stated tolerance, not to exceed 1 %.

In summary, there have been a variety of technical changes which are intended to improve the electromagnetic and electrical safety certification process of network telecommunication equipment. However, these changes are still being evaluated by the RBOCs and have not yet been officially approved. For products intended to be sold to Verizon, Quest, and AT&T, GR1089 Issue 5 shall continue to be utilized until further notice. IN

REFERENCES

ATIS 0600315 (2007) *Voltage levels for DC Powered equipmentused in the Telecommunications environment.*

ANSI T1.315 (2001) *Voltage levels for DC Powered equipmentused in the Telecommunications environment.*

GR-1089-CORE Issue 5 (August 2009) *Electromagnetic Compatibility and ElectricalSafety - Generic Criteria for Network Telecommunications Equipment.*

GR-1089-CORE Issue 5 (May 2011) *Electromagnetic Compatibility and Electrical Safety - Generic Criteria forNetwork Telecommunications Equipment.*

ETSI EN 300 386 V1.4.1 (2008-04) *Electromagnetic compatibility and Radio spectrum Matters (ERM); Telecommunication network equipment; ElectroMagnetic Compatibility (EMC) requirements.*

61000-4-5 Second edition (2005-11) *Testing and measurement techniques – Surge immunity test.*

47 CFR Part 16 (2008) *Federal Communications Commission regulations of intentional and unintentional electromagnetic emitters.*

(the author)

JEFFREY VIEL

is the EMI/EMC engineering manager for National Technical Systems Boxborough, Massachusetts operations. He is an electrical engineer with over 15 years experience working in the EMI engineering industry. Jeffrey is considered a subject matter expert in multiple fields relating to electromagnetic interference design, and compatibility including lightning/power cross, shielding, bonding and grounding, and power quality filtering. He is also former sergeant in the U.S. Marine Corps, and long term member of IEEE, and SAE International, and an active member on several NTS/EMC related technical boards. Jeffrey currently provides technical training, product design consultation, EMI mitigation, test procedure development, and test/engineering staffing services to NTS clientele.

EMI Risk Analysis

The reliability of electronic technologies (including the software and firmware that runs on them) can become critical when the consequences of errors, malfunctions, or other types of failure include significant financial loss, mission loss, or harm to people or property (i.e. functional safety).

BY KEITH ARMSTRONG

Electromagnetic interference (EMI) can be a cause of unreliability in all electronic technologies [1], so must be taken into account when the risks caused by malfunctioning electronics are to be controlled.

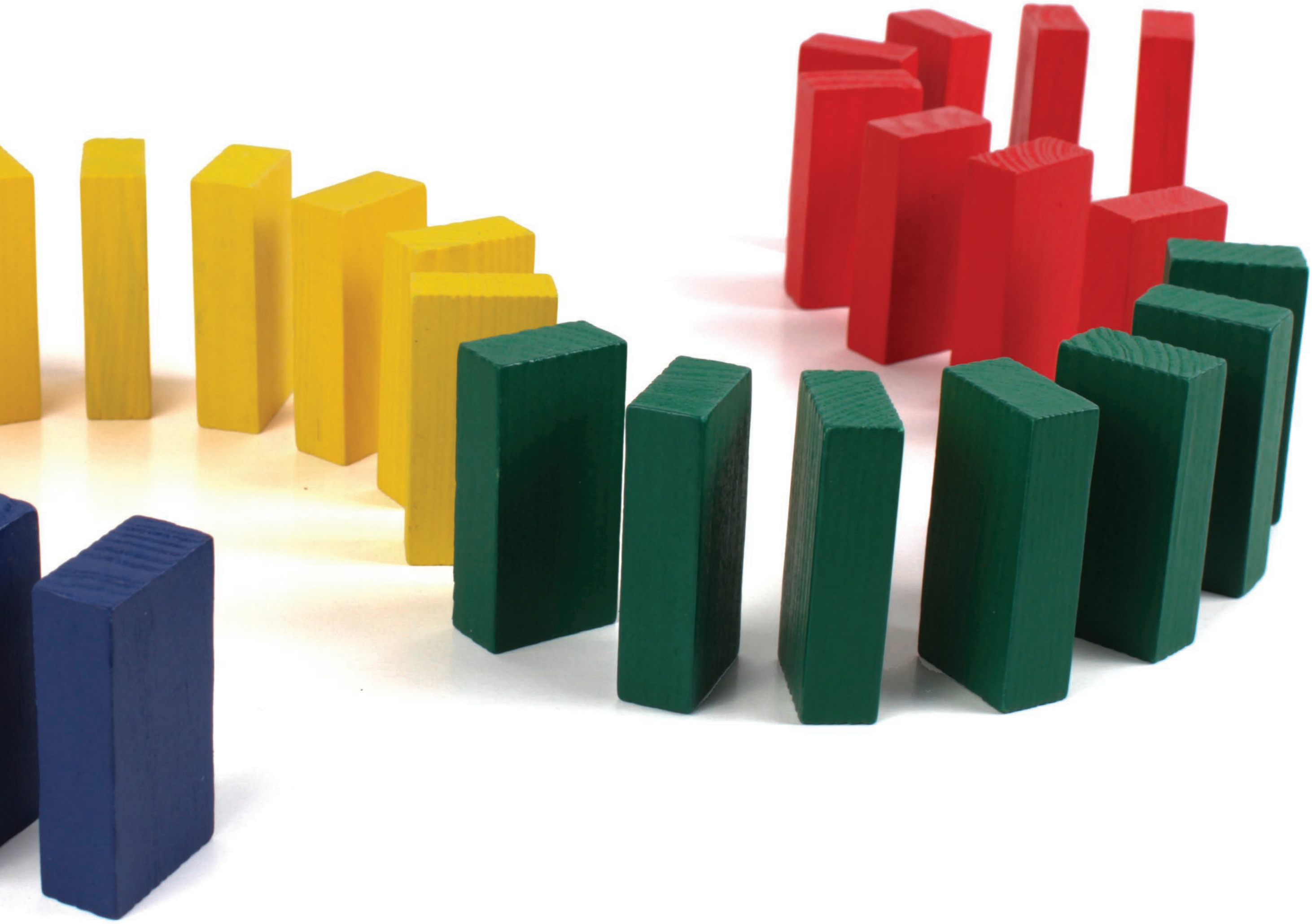
Most EMC engineers believe that the normal EMC tests do a good job of ensuring reliable operation, and indeed they do make it possible to achieve normal availability (uptime) requirements. However, the levels of acceptable risk in safety-related applications are generally three or more orders of magnitude more demanding, and applications where (for example) mission or financial risks are critical can be as demanding as safety-related applications, sometimes more so.

Unfortunately, most functional safety engineers leave all considerations of EMI to EMC engineers, with the result that – at the time of writing – most major safety-related projects do little more to control EMI than insure that the items of equipment used pass when tested to the relevant immunity test standards. As a result, safety risks due to EMI are not yet being effectively controlled.

The challenge for engineers is to demonstrate adequate confidence in the reliability of their designs in the operational electromagnetic environment (EME).

The solution [2] is to use well-proven EMC design techniques plus risk assessment that shows the overall design achieves acceptable risk levels, all verified and validated by a variety of techniques (including EMC testing).

This article only addresses the issue of how to take EMI into account when performing a Risk Analysis.



THE NATURE OF THE PROBLEM

"High reliability", "mission-critical", "safety-critical", or security applications might need to have a meantime to failure (MTTF) of more than 100,000 years (corresponding to Safety Integrity Level 4 (SIL4) in IEC 61508 [3], see Figures 1 and 2).

Mass-produced products (e.g. automobiles, domestic appliances, etc.) also require very low levels of safety risk because of the very large numbers of people using them on average at any one time.

It is usually very difficult to determine whether a given undesirable incident was caused by EMI, and the resulting lack of incidents officially attributed to EMI has led some people to feel that current EMI testing regimes must therefore be sufficient for any application. Indeed, it is commonplace to read words such as "….passes all contractual and regulatory EMC tests and is therefore totally immune to all EMI."

However, as Ron Brewer says in [4]: "*… there is no way by testing to duplicate all the possible combinations of frequencies, amplitudes, modulation waveforms, spatial distributions, and relative timing of the many simultaneous interfering signals that an operating system may encounter. As a result, it's going to fail.*"

Prof. Nancy Leveson of MIT says, in [5]: "*We no longer have the luxury of carefully testing systems and designs to understand all the potential behaviors and risks before commercial or scientific use.*"

The IET [6] states: "*Computer systems lack continuous behavior so that, in general, a successful set of tests provides little or no information about how the system would behave in circumstances that differ, even slightly, from the test conditions.*"

Finally, Boyer et al [7] say: "*Although electronic components must pass a set of EMC tests to (help) ensure safe operations, the evolution of EMC over time is not characterized and cannot be accurately forecast.*" This is one of the many reasons why any EMC test plan that has an affordable cost and duration is unlikely to be able to demonstrate confidence in achieving better than 90% reliability. The reasons for this are given in [4], [8], [9], section 0.7 of [10], and [11].

Since the confidence levels that are needed for functional safety compliance (for example) are a *minimum* of 90% for SIL1 in [3], 99% for SIL2, 99.9% for SIL3 and 99.99% for SIL4, it is clear that more work needs to be done to be able to demonstrate compliance with [3] and similar functional safety standards (e.g. [12] [13] and others such as IEC 61511 and IEC 62061), as regards the effects of EMI on risks.

> A HAZARD is anything with potential to do HARM, and the hazard level is derived from the type of harm and its severity.

The best solution at the time of writing is to use well-proven EMC design techniques to reduce risks, and to verify and validate them using a number of different methods, including immunity testing. Risk assessment is a vital part of such an approach, as required by [3]. Unfortunately, neither the IEC's basic publication on Functional Safety [3], nor the basic IEC publication on "EMC for Functional Safety" [2], describe how to take EMI into account during risk assessment; although [10] – a practical guide based on [2] – does cover this.

This article is concerned with how to include EMI issues as part of a risk assessment (whether the risks are safety or other, e.g. financial), and is based on [10] and a paper I presented in 2010 [14]. I have also presented papers on assessing lifetime electromagnetic, physical and climatic environments [15], appropriate EMC design techniques [16], and verification and validation methods (including testing) [17].

As Prof. Shuichi Nitta says in [18]: "*The development of EMC Technology taking account of systems safety is demanded to make social life stable.*" I hope this article makes a contribution to this essential work, but there is much more yet to be done!

RISK ASSESSMENT

Most readers of *IN Compliance* will be very familiar with EMC, but perhaps not (yet) with Functional Safety, so a brief introduction to hazards and risks is probably a good idea.

What are "hazards" and "risks"?

A HAZARD is anything with potential to do HARM, and the hazard level is derived from the type of harm and its severity. For example, a bladed machine can cause harm by cutting skin, flesh, or even bone. We say it has a cutting hazard and define its severity as being either minor, serious, or deadly (other classifications are possible) depending on the maximum depth of cut and the respective parts of the anatomy.

A hazard has a probability of occurrence. The RISK is the product of the hazard level, its probability of occurrence, and a factor that takes into account the observation that, when they occur, not all hazards result in the same harm; for example if there is the possibility of avoidance or limitation. (Risk level = {Hazard level} × {Probability of the hazard occurring} × {Possibility of hazard avoidance or limitation}).

Other multiplying factors can also be applied, and often are. We may decide that a safety risk level should vary according to social factors, such as the type of person (for example, small children, pregnant women, healthy adults, etc.).

We could also consider a financial hazard to be the loss of a defined amount of money, and the financial risk to be the amount of the money multiplied by the probability of losing it.

EMI does not affect the hazards themselves but can affect their probability of occurrence, which is why EMI must be taken into account when trying to achieve acceptably low risk levels.

> To insure that risks are not too high requires using hazard analysis and risk assessment.

Nothing can ever be 100% reliable; there is always some risk. To insure that risks are not too high requires using hazard analysis and risk assessment, which takes the information on a system's environment, design, and application and – in the case of [3] – creates the Safety Requirements Specification (SRS) or its equivalent in other standards.

Using hazard analysis and risk assessment also helps avoid the usual project risks of over- or under-engineering the system.

The amount of effort and cost involved in the risk assessment should be proportional to the benefits required. These include: compliance with legal requirements, benefits to the users and third parties of lower risks (higher risk reductions), and benefits to the manufacturer of lower exposure to product liability claims and loss of market confidence.

Risk assessments are generally applied to simple systems

Modern control systems can be very complex and are increasingly often "systems of systems". If they fail to operate as intended, the resulting poor yields or downtimes can be very costly indeed. Risk assessment – done properly – is a complex exercise in which competent and experienced engineers apply at least three different types of assessment technique to the entire system under review.

To risk-assess a complex system is a large and costly undertaking, but not usually necessary because the usual approach (e.g. [3]) is to insure the safety of the overall control system by using a much simpler and separate "safety-related system" that can be risk-assessed quite easily. Safety-related systems often use "fail-safe" design techniques – when an unsafe situation is detected, the control system is overridden and the equipment under control brought to a condition that prevents or mitigates the harms that it could cause.

For many types of industrial machinery, the safe condition is one in which all mechanical movement is stopped and hazardous electrical supplies isolated. The safe condition might be triggered, for example, by an interlock with a guard that allows access to hazardous machinery.

Such a fail-safe approach is, of course, useless in many life-support applications or anywhere where continuing operation-as-usual is essential, such as "fly-by-wire" aircraft. However, even in situations where a guard interlock or similar fail-safe techniques cannot be used – and the control system is too complex for a practicable risk assessment – it is still generally possible to improve reliability by means of simple measures that can be cost-effectively risk-assessed.

A typical approach is to use multiple (redundant [19]) control systems with a voting system so that the majority vote is used to control the system. Alternatively, control might be switched from a failing control system to another that is not failing (e.g. the Space Shuttle uses a voting system based on five computers [20]).

Specifying the acceptable risk level

For each identified hazard, the level of risk that is specified should be at least broadly acceptable. UK Health and Safety publications [21] and [22] provide very useful guidance on this, and on what may be tolerable under some circumstances.

Acceptable risk levels are culturally defined and not amenable to mathematical calculation. They must be specified before the design process starts. The engineering principle of establishing an acceptable risk level and then designing to achieve it is enshrined in the functional safety standards ([3], [12], [13], and others) and helps:

- manufacturers maximize their return on investment over the short, medium, and long terms by reducing their exposure to lawsuits and having a valid defense in case of a lawsuit,
- engineers and organizations abide by the IEEE's ethical guidelines [23].

Acceptable risk levels for functional safety are generally provided by "Risk Charts" (or "Risk Graphs"), e.g. Annex D in Part 5 of [3], Annex D of [12], Section 7.4.5 of Part 3 of [13].

Reducing the risk from an identified hazard is performed by what [3] calls a "Safety Function". [3] applies a SIL specification to each safety function,

IEC 61508's SILs for "on demand" safety functions...

Safety Integrity Level (SIL)	Average probability of a dangerous failure of the safety function, "on demand" or "in a year*"	Equivalent mean time to dangerous failure, in years*	Equivalent confidence factor required for each demand on the safety function
4	$\geq 10^{-5}$ to $<10^{-4}$	$>10^4$ to $\leq 10^5$	99.99 to 99.999%
3	$\geq 10^{-4}$ to $<10^{-3}$	$>10^3$ to $\leq 10^4$	99.9 to 99.99%
2	$\geq 10^{-3}$ to $<10^{-2}$	$>10^2$ to $\leq 10^3$	99% to 99.9%
1	$\geq 10^{-2}$ to $<10^{-1}$	>10 to $\leq 10^2$	90 to 99%

* Approximating 1 year = 10,000 hrs of operation

"Failure" includes any error, malfunction or fault that causes a hazard

Figure 1: Safety systems that operate "upon demand"

IEC 61508's SILs for "continuous" safety functions...

Safety Integrity Level (SIL)	Average probability of a dangerous failure of the safety function per hour	Equivalent mean time to dangerous failure, in hours	Equivalent confidence factor required for every 10,000 hours of continuous operation
4	$\geq 10^{-9}$ to $<10^{-8}$	$>10^8$ to $\leq 10^9$	99.99 to 99.999%
3	$\geq 10^{-8}$ to $<10^{-7}$	$>10^7$ to $\leq 10^8$	99.9 to 99.99%
2	$\geq 10^{-7}$ to $<10^{-6}$	$>10^6$ to $\leq 10^7$	99% to 99.9%
1	$\geq 10^{-6}$ to $<10^{-5}$	$>10^4$ to $\leq 10^5$	90 to 99%

"Failure" includes any error, malfunction or fault that causes a hazard

Figure 2: Safety systems that operate continuously

chosen according to the rules in [3] to achieve the specified risk level for the particular hazard being risk-reduced. So, for example, a safety-related system might provide three safety functions at SIL 2 and two safety functions at SIL 3.

Developed from Tables 2 and 3 of Part 1 of [3], Figures 1 and 2 show the reliability ranges covered by SILs. Examples of safety functions that operate on-demand include the braking system of an automobile and guard interlocks in industrial plant. Examples of safety functions that operate continuously, include the speed and/or torque control of automobile and other types of engines, and the motors in some machines and robots.

There is no requirement for a safety function to employ electronic technologies. In many situations mechanical protection such as bursting discs, blast walls, mechanical stops, etc., and management (such as not allowing people nearby during operation), etc., and combinations of them, can help achieve a safety function's SIL.

A SIL 3 specified safety function requiring, say, 99.95% reliability, could be achieved by employing three independent protection methods, each one of which achieves just 99.65%. All three, two, just one, or none of these protection devices or systems could use electronic technology. (Note that 99.95% reliability is seven times tougher than 99.65%.)

The most powerful EMC design technique for achieving a SIL is not to use any electronic or electromechanical technologies in the safety-related system!

A philosophical point

Many EMC test professionals, when faced with the information on hazards and risks above, say that because there is no evidence that EMI has contributed to safety incidents, this means the EMC testing done at the moment must be sufficient for safety. However, anyone who uses this argument is either poorly educated in matters of risk and risk reduction, or is hoping the education of their audience is lacking in that area [24].

The assumption that because there is no evidence of a problem, there is no problem, was shown to be logically incorrect in the 19th Century [25]; its use by NASA led directly to the Columbia space shuttle disaster [26]. Redmill [27] affirms: *"Lack of proof, or evidence, of risk should not be taken to imply the absence of risk."*

EMI problems abound [28], but it is unlikely that incidents caused by EMI will be identified as being so caused, because:

- Errors and malfunctions caused by EMI often leave no trace of their occurrence after an incident.
- It is often impossible to recreate the EM disturbance(s) that caused the incident, because the EM environment is not continually measured and recorded.
- Software in modern technologies hides effects of EMI (e.g. EMI merely slows the data rate of Ethernet™ and blanks the picture on digital TV, whereas its effects are obvious in analogue telecommunications and TV broadcasting).
- Few first-responders or accident investigators know much about EMI, much less understand it, and as a result the investigations either overlook EMI possibilities or treat them too simplistically.
- Accident data is not recorded in a way that might indicate EMI as a possible cause.

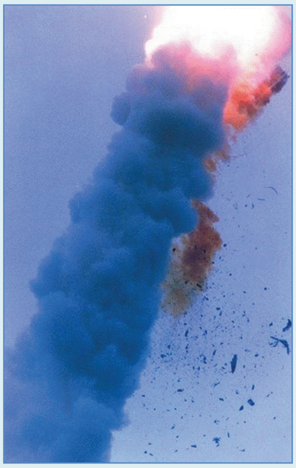
If a thorough risk assessment shows EMI can cause financial, mission or safety hazards, then undesirable incidents due to EMI *will occur*. If the probability of the incidents caused by EMI is higher than acceptable risk levels, their rate should be reduced until they are at least acceptable (i.e. risk reduction).

Hazards can be caused by multiple independent failures

It is often incorrectly assumed that only single failures need to be considered (so-called: "single-fault safety"). However, the number of independent failures that must be considered as happening simultaneously depends upon the required level of safety risk (or degree of risk reduction) and the probabilities of each independent failure occurring.

Not all failures are random

Many errors, malfunctions, and other faults in hardware and software are reliably caused by certain EMI, physical or climatic events, or user actions (for example, corrosion that degrades a ground bond or a shielding gasket after a time, an over-voltage surge that sparks across traces on a printed circuit board, etc.).



Ariane V

Self-destructed
37 seconds into launch
June 4, 1996

Cost : $500 million

A software module from Ariane IV was re-used on Ariane V. It contained a bug that had not been a problem for Ariane IV's higher latitude launch sites, but triggered the self-destruct when Ariane V was launched from a more equatorial site.

Figure 3.: A systematic failure for Ariane V [29]

These are "systematic" errors, malfunctions, or other types of faults. They are not random, but may be considered "built-in" and so *guaranteed to occur* whenever a particular situation arises. An example is shown in Figure 3.

UK Health and Safety [30] found that over 60% of major industrial accidents in the UK were systematic, i.e., were "designed-in" and so were bound to happen eventually.

Not all failures are permanent

Many errors, malfunctions, or other types of failure can be intermittent, for example:

- poor electrical connections (a very common problem that can create false signals)
- transient interference (conducted, induced, radiated)
- "sneak" conduction paths caused by condensation, conductive dust, etc.

The operation of error detection and correction techniques, microprocessor watchdogs, and even manual power cycling can cause what would otherwise have been permanent failures to be merely temporary ones.

"Common-Cause" errors, malfunctions and other failures

Two or more identical units may be exposed to the same conditions at the same time, for example:

- ambient under- or over-temperature
- power supply under- or over-voltage
- EM disturbances (conducted, induced, radiated, continuous, transient, etc.)
- condensation, etc.

This can cause the units to suffer the same systematic errors, malfunctions, etc., which are known as "common-cause" failures.

So, using multiple redundant units [19] – a very common method for improving reliability to random errors, malfunctions or other types of failures – will not reduce risks of systematic failures if identical units, hardware, or software are used to create the redundant system.

Risk assessments need multiple techniques, and expertise

No one risk assessment technique can ever give sufficient "failure coverage", so at least three and probably more different types should be applied to any design:

- at least one "inductive" or "bottom-up" method, such as FMEA [31] or Event-Tree
- at least one "deductive" or "top-down" method, such as Fault Tree Analysis [32] or HAZOP
- at least one "brainstorming" method, such as DELPHI or SWIFT

No risk analysis methods have yet been developed to cover EMI issues, so it is necessary to choose the methods to use and adapt them to deal with EMI. Successful adaptation requires competency, skills, and expertise in both safety engineering and real-life EMI (not just EMC testing).

Devices can fail at two or more pins simultaneously

EMI can cause two or more pins on a semiconductor device, such as an integrated circuit (IC), to change state simultaneously. An extreme example is "latch-up" – when all output pins simultaneously assume uncontrolled fixed states. This is caused by high temperatures, ionizing radiation, and over-voltage or over-current on any pin of an IC. The presence of any one of the three causes increases an IC's susceptibility to latch-up due to the other two.

However, traditional risk analysis methods (e.g. FMEA) have often been applied very simplistically to electronics, for example I have seen (so-called) FMEA-based risk assessments on safety-critical electronics conducted by a major international manufacturer of automobiles that simply went through all of the ICs one pin at a time and assessed whether a safety problem would be caused if each pin was permanently stuck high or low. Also, this was the only failure mode identification method applied.

It should never be assumed that an operator will always follow the Operator's Manual, or would never do something that was just "too stupid."

Reasonably foreseeable use/misuse

It should never be assumed that an operator will always follow the Operator's Manual, or would never do something that was just "too stupid."

Assessing reasonably foreseeable use or misuse requires the use of "brainstorming" techniques by experienced personnel, and can achieve better "failure coverage" by including operators, maintenance technicians, field service engineers, etc., in the exercise.

THE TWO STAGES OF RISK ASSESSMENT

When creating the SRS (or equivalent), the system has not yet been designed, so detailed risk analysis methods such as FMEA, FMECA, etc., cannot be applied. At this early stage, only an "Initial Risk Assessment" is possible, but there are many suitable methods that can be used and many of them are listed in 3.7 of [10].

During the design, development, realization, and verification phases of the project, detailed information becomes available on all of the mechanics, hardware and software. Appropriate risk analysis methods (such as FMEA) are applied to this design information – as it becomes available – to guide the project in real-time and to achieve the overall goals of the Initial Risk Assessment.

As the project progresses the Initial Risk Assessment accumulates more depth of analysis, eventually (at the end of the project) producing the "Final Risk Assessment" – a very important part of a project's safety documentation. But it can only be completed when the project has been fully completed, and its real *engineering* value lies in the process of developing it during the project to achieve acceptable risk levels (or risk reductions) while also saving cost and time (or at least not adding significantly to them).

INCORPORATING EMI ISSUES IN RISK ASSESSMENTS

The reasonably foreseeable lifetime EM environment is an important input to an EMI risk analysis process, as it affects the risk level directly. Because exposure to other environmental effects like shock, vibration, humidity, temperature, salt spray, etc., can degrade EM characteristics (and also faults, user actions, wear, and misuse), their reasonably foreseeable lifetime assessments are also important inputs.

Many foreseeable environmental effects can occur simultaneously, for example:

- Two or more strong radio-frequency (RF) fields (especially near two or more cellphones or walkie-talkies, or near a base-station or broadcast transmitter).
- One or more radiated RF fields plus distortion of the mains power supply waveform.
- One or more radiated RF fields plus an ESD event.
- A power supply over-voltage transient plus conductive condensation.
- One or more strong RF fields plus corrosion or wear that degrades enclosure shielding effectiveness.
- One or more strong RF fields plus a shielding panel left open by the user
- Conducted RF on the power supply plus a high-impedance ground connection on the supply filter due to loosening of the fasteners that provide the bonding connection to the ground plane due to vibration, corrosion, etc.
- Power supply RF or transients plus filter capacitors that have, over time, been open-circuited by over voltages, and/or storage or bulk decoupling capacitors that have lost much of their electrolyte due to time and temperature.

Hundreds more examples could easily be given, and all such reasonably foreseeable events and combinations of them must be considered by the risk assessment.

Intermittent contacts, open or short circuits, can cause spurious signals just like some kinds of EMI, and are significantly affected by the physical/climatic environment over a lifetime. One example of this kind of effect is contact resistance modulated by vibration. This effect is called "vibration-induced EMI" by some.

EMI and intermittent contacts can – through direct interference, demodulation and/or intermodulation [11] – cause "noise" to appear in any conductors that are inadequately protected against EMI (perhaps because of a dry joint in a filter capacitor). "Noise" can consist of degraded, distorted, delayed or false signals or data, and/or damaging voltage or current waveforms.

The good news is that one does not have to wade through all of the possible combinations of EMI and environmental effects, faults, misuse, etc.

When a "top down" risk analysis method is used, it should take into account that significant levels of such noise can appear at any or all signal, control, data, power, or ground ports of any or all electronic units – unless the ports are adequately protected against foreseeable EMI for their entire lifetime, taking into account foreseeable faults, misuse, shock, vibration, wear, etc. (For radiated EMI, the unit's enclosure is considered a port.)

The noises appearing at different ports and/or different units can be identical or different, and can occur simultaneously or in some time-relationship to one another.

When a "bottom-up" risk analysis method is used, the same noise considerations as above apply, but in this they can appear at any or all pins of any or all electronic devices on any or all printed circuit boards (PCBs) in any or all electronic units – unless the units are adequately protected against all EMI over their entire lifetime taking into account foreseeable faults, misuse, etc., as before.

Similarly, the noises appearing at different pins or different devices, PCBs or units can be identical or different, and can occur simultaneously or in some time relationship.

It is often quite tricky to deal with all possibilities for EMI, physical, climatic, intermittency, use, misuse, etc., which is why competent "EMC-safety" expertise should always be engaged on risk assessments, to help insure all reasonably foreseeable possibilities have been thoroughly investigated.

If the above sounds an impossibly large task, the good news is that one does not have to wade through all of the possible combinations of EMI and environmental effects, faults, misuse, etc. There are design approaches that will deal with entire classes of EMI consequences and risk analysis techniques that determine if they are a) needed, and b) effective.

For example, at one design extreme there is the "EMI Shelter" approach: a shielded filtered enclosure with a dedicated uninterruptible power supply and fiber-optic datacommunications is designed and verified as protecting whatever electronic equipment is placed within it from the nasty outside environment for its entire life, up to and including a number of direct lightning strikes, earthquakes, flooding and nearby nuclear explosions if required. Several companies manufacture such shelters.

Door interlocks and periodic proof testing insure it maintains that protection for the required number of decades. Nothing special needs to be done to the safety system that is placed inside it. Of course, [3] (or whatever other functional safety standard applies) will have many requirements for the safety system, but EMI is taken care of by the EMI shelter. Validation of the finished assembly could merely consist of checking that the shelter manufacturer's installation rules have been followed.

If the EMI shelter solution does not seem appropriate for your project, then how about a different extreme: error detection and fail-safe. It is possible to design digital hardware to use data with embedded protocols that detect any possible interference, however caused. When such interference is detected, the error is either corrected or the fail-safe is triggered. Designing sensors, transducers and analogue hardware to detect any interference is not as immediately obvious as it is for data, but can be done.

Safety systems have been built that used this technique alone and ignored all immunity to EMI, but unfortunately they triggered their fail-safes so often that they could not be used. So, some immunity to EMI is necessary for adequate availability of whatever it is the safety system is protecting. Since passing the usual EMC immunity tests often seems to be sufficient for an acceptable percentage of uptime, this is probably all that needs to be done.

CONCLUSIONS

Any practicable EMC testing regime can only take us part of the way towards achieving the reliability levels required by the SILs in [3] or similar low levels of financial or mission risk.

Risk assessment is a vital technique for controlling and assessing EMC design engineering, but since no established risk analysis techniques have yet been written to take EMI into account, it is necessary for experienced and skilled engineers to adapt them for that purpose.

I hope that others will fully develop this new area of "EMI risk assessment" in the coming years. IN

REFERENCES

1. Van Doorn, Marcel,"Towards an EMC Technology Roadmap," *Interference Technology's 2007 EMC Directory & Design Guide* (2007): 182-193, www.interferencetechnology.com.

2. IEC/TS 61000-1-2, Ed.2.0, 2008-11, "Electromagnetic Compatibility (EMC) – Part 1-2: General – Methodology for the achievement of the functional safety of electrical and electronic equipment with regard to electromagnetic phenomena," IEC Basic Safety Publication (2008), http://webstore.iec.ch.

3. IEC 61508 (in seven parts), "Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems," IEC Basic Safety Publication, http://webstore.iec.ch.

4. Brewer, Ron, "EMC Failures Happen," *Evaluation Engineering Magazine* (December 2007), www.evaluationengineering.com/features/2007_december/1207_emc_test.aspx.

5. Leveson, Nancy, "A New Accident Model for Engineering Safer Systems," *Safety Science*, Vol. 42, No. 4, (April 2004):. 237-270, http://sunnyday.mit.edu/accidents/safetyscience-single.pdf.

6. IET, "Computer Based Safety-Critical Systems" (September 2008), www.theiet.org/factfiles/it/computer-based-scs.cfm?type=pdf.

7. Boyer, Alexandre et al, "Characterization of the Evolution of IC Emissions After Accelerated Aging," *IEEE Trans. EMC*, Vol. 51, No. 4 (November 2009): 892-900.

8. Armstrong, Keith, "Why EMC Immunity Testing is Inadequate for Functional Safety," 2004 IEEE International EMC Symposium Santa Clara, CA (August 9-13, 2004) ISBN 0-7803-8443-1, pp 145-149. Also: *Conformity* (March 2005) www.conformity.com/artman/publish/printer_227.shtml.

9. Armstrong, Keith, "EMC for the Functional Safety of Automobiles – Why EMC Testing is Insufficient, and What is Necessary," 2008 IEEE International EMC Symposium Detroit, MI (August 18-22, 2008) ISBN 978-1-4244-1699-8 (CD-ROM).

10. "EMC for Functional Safety", T*he IET*, Ed. 1 (August 2008) www.theiet.org/factfiles/emc/emc-factfile.cfm or www.emcacademy.org/books.asp.

11. Armstrong, Keith "Why Increasing Immunity Test Levels is Not Sufficient for High-Reliability and Critical Equipment," 2009 IEEE International EMC Symposium Austin, TX (August 17-21, 2009), ISBN (CD-ROM): 978-1-4244-4285-0.

12. "Medical devices – Application of risk management to medical devices," *ISO 14971* Ed. 2, www.iso.org

13. Draft "Road Vehicles – Functional Safety," ISO 26262 (10 parts), www.iso.org.

14. Armstrong, Keith, "Including EMC in Risk Assessments," 2010 IEEE International EMC Symposium Fort Lauderdale, FL (July 25-31, 2010), ISBN: 978-1-4244-6307-7 (CD-ROM).

15. Armstrong, Keith, "Specifying Lifetime Electromagnetic and Physical Environments – to Help Design and Test for EMC for Functional Safety," 2005 IEEE International EMC Symposium Chicago, IL (August 8-12, 2005), ISBN: 0-7803-9380-5.

16. Armstrong, Keith, "Design and Mitigation Techniques for EMC for Functional Safety," 2006 IEEE International EMC Symposium Portland, OR (August 14-18, 2006), ISBN: 1-4244-0294-8.

17. Armstrong, Keith, "Validation, Verification and Immunity Testing Techniques for EMC for Functional Safety," 2007 IEEE International EMC Symposium Honolulu, HI (July 9-13, 2007), ISBN: 1-4244-1350-8.

18. Nitta, Shuichi, "A Proposal on Future Research Subjects on EMC, From the Viewpoint of Systems Design," *IEEE EMC Society Newsletter*, Special 50th Anniversary Section: "The Future of EMC and the EMC Society" Issue 214 (Summer 2007): 50-57, http://www.emcs.org.

19. Redundancy (Engineering), http://en.wikipedia.org/wiki/Redundancy_(engineering).

20. *IBM and the Space Shuttle*, www-03.ibm.com/ibm/history/exhibits/space/space_shuttle.html.

21. "Reducing Risks, Protecting People – HSE's Decision-Making Process", *The UK Health & Safety Executive*, ISBN:0-7176-2151-0, www.hse.gov.uk/risk/theory/r2p2.pdf.

22. "The Tolerability of Risk from Nuclear Power Stations," *The UK Health & Safety Executive*, www.hse.gov.uk/nuclear/tolerability.pdf.

23. *IEEE Ethical Code of Practice*, The IEEE, http://temp.onlineethics.org/codes/IEEEcode.html.

24. Armstrong, Keith, "Absence of Proof Is Not Proof of Absence," *The EMC Journal*, Issue 78 (September 2008): 16-19, from the archives at www.theemcjournal.com.

25. Anderson, Anthony, *Presentation to the 20th Conference of the Society of Expert Witnesses at Alexander House*, Wroughton, UK (May 16, 2008) www.sew.org.uk, www.antony-anderson.com.

26. Petrowski, Henry, "When Failure Strikes," *New Scientist* (July 29, 2006): 20, www.newscientist.com/channel/opinion/mg19125625.600-the-success-that-allows-failure-to-strike.html.

27. Redmill, Felix, "Making ALARP Decisions," *Safety-Critical Systems Club Newsletter* Vol. 19 No. 1 (September 2009): 14-21, www.safety-club.org.uk.

28. "The First 500 Banana Skins," *Nutwood UK* (October. 2007), from www.emcacademy.org/books.asp (or read on-line at www.theemcjournal.com).

29. "Ariane V," http://en.wikipedia.org/wiki/Ariane_5.

30. "Out of Control – Why Control Systems Go Wrong and How to Prevent Failure," *The UK Health & Safety Executive*, ISBN: 0-7176-2192-8, www.hse.gov.uk/pubns/priced/hsg238.pdf.

31. IEC 60812:2006, *Analysis Techniques for System Reliability – Procedure for Failure Mode and Effects Analysis (FMEA)*.

32. IEC 61025:2006, *Fault Tree Analysis (FTA)*.

ACKNOWLEDGMENT

Many thanks to Doug Nix of Compliance InSight Consulting, Inc., for improving my text.

(the author)

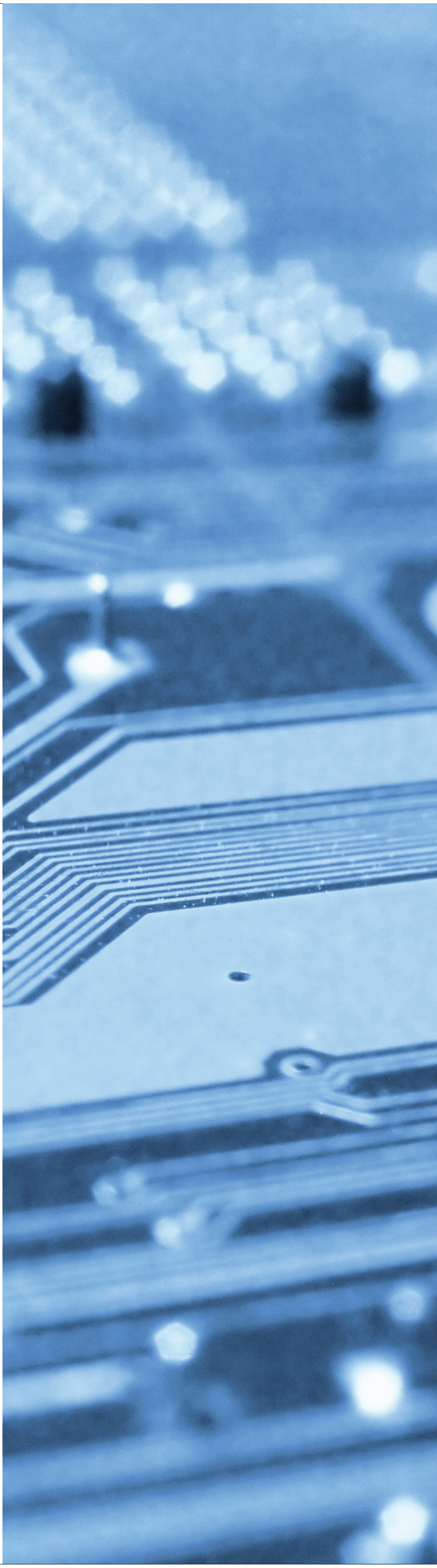
KEITH ARMSTRONG

After working as an electronic designer, then project manager and design department manager, Keith started Cherry Clough Consultants in 1990 to help companies reduce financial risks and project timescales through the use of proven good EMC engineering practices. Over the last 20 years, Keith has presented many papers, demonstrations, and training courses on good EMC engineering techniques and on EMC for Functional Safety, worldwide, and also written very many articles on these topics. He chairs the IET's Working Group on EMC for Functional Safety, and is the UK Government's appointed expert to the IEC committees working on 61000-1-2 (EMC & Functional Safety), 60601-1-2 (EMC for Medical Devices), and 61000-6-7 (Generic standard on EMC & Functional Safety).

Making Real Boards

The secrets to matching fabricator impedance results with your own calculations

BY PATRICK CARRIER

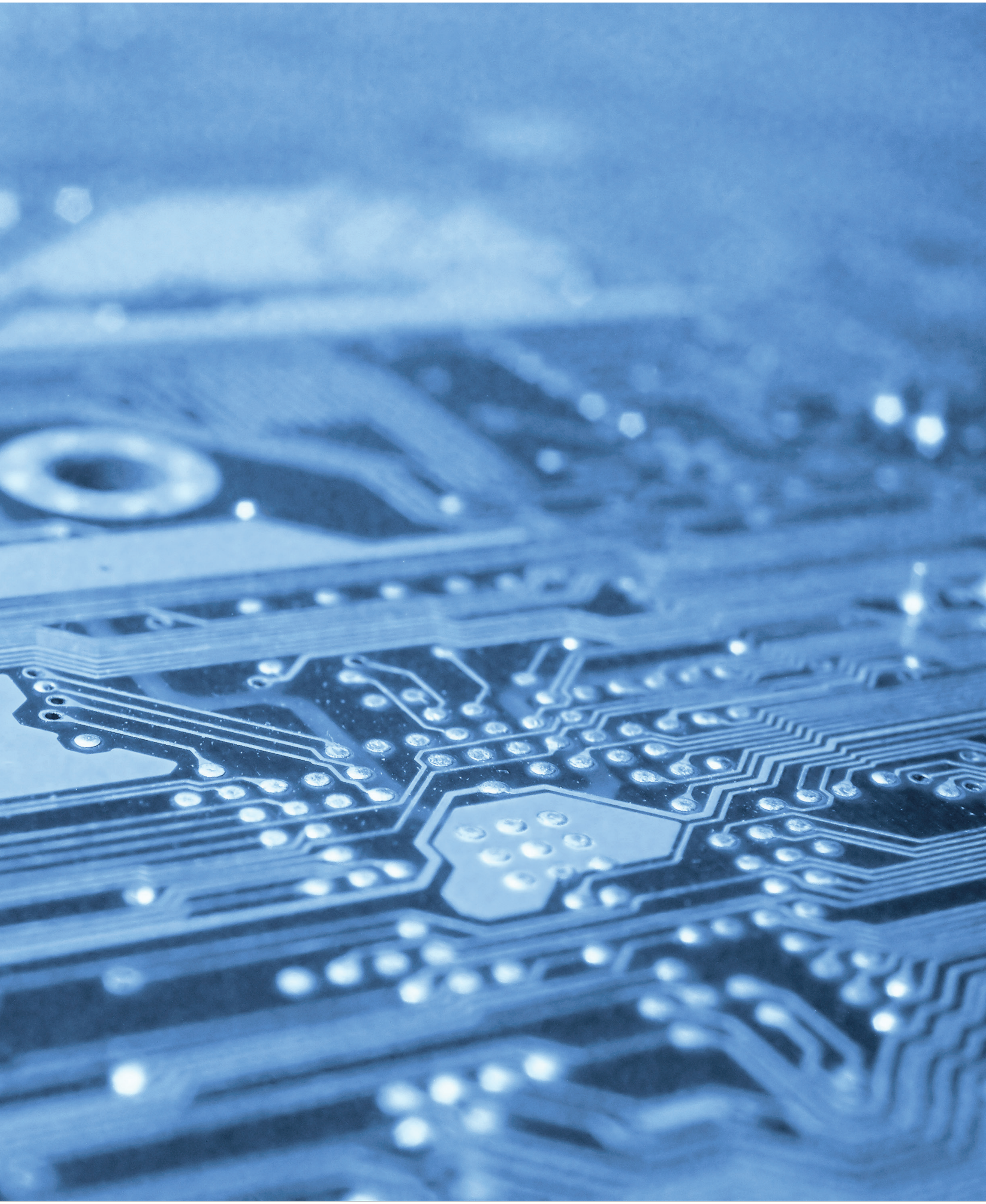


The board stackup is probably the most essential piece for ensuring a successful PCB design. Modern high-speed busses require controlled-impedance traces, and whether you are using a simulation tool, a simple calculator, or the back of a napkin, you need to understand your manufacturing process to correlate your impedance calculations. This ensures that your trace widths and dielectric heights match what will actually be manufactured, and eliminates last-minute design changes.

IMPEDANCE DETERMINATION

Impedance is what drives the dielectric thicknesses and trace widths in the board. Figure 1 shows the three main factors in determining trace impedance: trace width (W), height above the reference plane (H), and dielectric constant (Er). Trace impedance goes up as H goes up, and impedance goes down as W and Er go up. Impedance numbers can be calculated by using formulas or calculator tools, but the most accurate data will be generated from a field solver. Signal integrity simulation tools such as HyperLynx from Mentor Graphics have built-in field solvers, and can be used to generate stackup geometry numbers for a given impedance.

When determining W and H, you can typically begin with a W of 4 mils, as that usually is the minimum manufacturable trace width on ½-oz. copper without incurring extra cost. This is usually the starting point for determining layer height. Since the highest impedance is obtained by using the minimum trace width and maximum dielectric height, the



dielectric height is set by the highest impedance needed for the layer using a 4-mil trace width. For instance, if the maximum impedance needed on a given layer is 60 ohms, the dielectric height for that layer would be set to about 5 mils, since a 4-mil trace with a 5-mil dielectric height will be 60 ohms (given an Er of about 3.6).

In doing these calculations, it is imperative to use the correct value for dielectric constant, as that is where most discrepancies between your calculations and the board fabricator's calculations can differ. Most important is the fact that Er can vary with different dielectric thicknesses due to variations in glass and resin content. Typical values for FR4 material range between 3.5 and 4.5, so it is important to talk to your board manufacturer to get the right values. More often than not, smaller dielectric thicknesses are used in a design, and these typically have lower dielectric constants. For FR4, most people just use an Er of 4. This means that their trace widths and dielectric heights get designed for an impedance lower than what will actually be manufactured, since the dielectric constant is most likely lower (and, if you recall from above, as Er goes down, impedance goes up).

BOARD MATERIAL VARIATION

Another aspect of real PCB fabrication that can cause you to shoot for too low of an impedance target is failure to take into account the variation of glass/resin content around the traces. When multiple PCB layers are pressed together, the resin tends to flow into the spaces around the traces, creating a resin-rich area around the traces that will have a lower dielectric constant. As such, it is important to model that lower Er when modeling your board stackup. Figure 2 shows an example of this in the HyperLynx Stackup Editor, where an Er of 3.2 is assigned to the trace layer in the stackup to mimic the results of actual board fabrication.

Use of incorrect dielectric constant values can also throw off timing calculations in simulation. You can notice a difference of up to about 100ps for a 10-in. trace, which can be quite detrimental to design margins.

It is also important to realize that when traces are manufactured, the etching process can leave them in more of a trapezoidal shape than a rectangle. For a ½-oz. trace, this can lead to a difference in trace width from top to bottom of about 0.5 mils. This effect should be included when modeling the traces, and is easily approximated by assigning the mean width of the actual trace to the trace width. For a ½-oz. trace, that would mean subtracting 0.25 mils from the target trace width. This is also included in Figure 2.

SUMMING UP

As you can see, most of the causes for discrepancy between simulated and actual impedance result in too low of

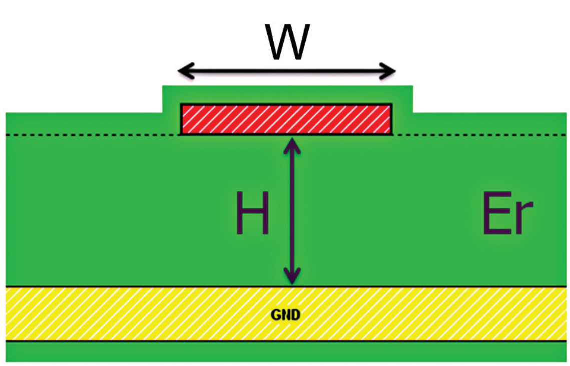
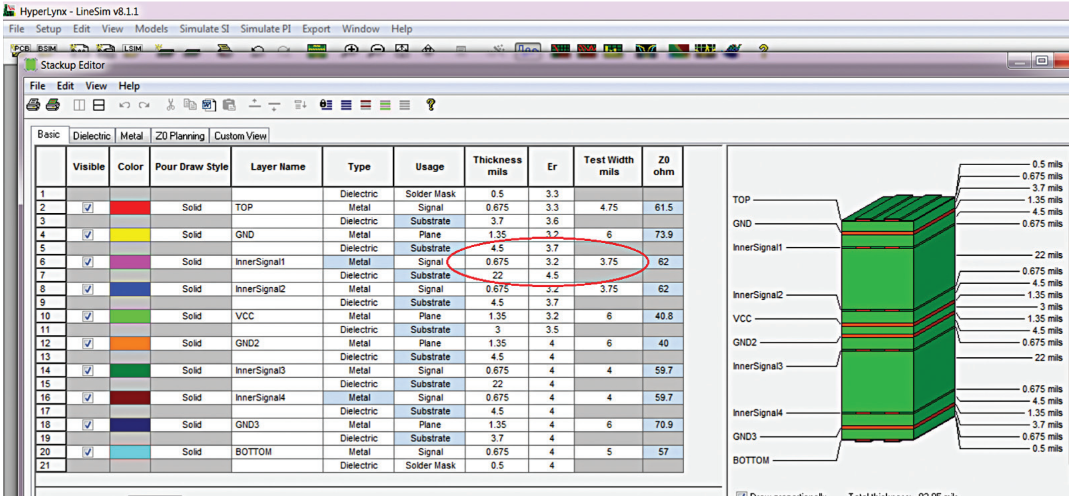


Figure 1: Factors that determine trace impedance



	Visible	Color	Pour Draw Style	Layer Name	Type	Usage	Thickness mils	Er	Test Width mils	Z0 ohm
1					Dielectric	Solder Mask	0.5	3.3		
2	✓		Solid	TOP	Metal	Signal	0.675	3.3	4.75	61.5
3					Dielectric	Substrate	3.7	3.6		
4	✓		Solid	GND	Metal	Plane	1.35	3.2	6	73.9
5					Dielectric	Substrate	4.5	3.7		
6	✓		Solid	InnerSignal1	Metal	Signal	0.675	3.2	3.75	62
7					Dielectric	Substrate	22	4.5		
8	✓		Solid	InnerSignal2	Metal	Signal	0.675	3.2	3.75	62
9					Dielectric	Substrate	4.5	3.7		
10	✓		Solid	VCC	Metal	Plane	1.35	3.2	6	40.8
11					Dielectric	Substrate	3	3.5		
12	✓		Solid	GND2	Metal	Plane	1.35	4	6	40
13					Dielectric	Substrate	4.5	4		
14	✓		Solid	InnerSignal3	Metal	Signal	0.675	4	4	59.7
15					Dielectric	Substrate	22	4		
16	✓		Solid	InnerSignal4	Metal	Signal	0.675	4	4	59.7
17					Dielectric	Substrate	4.5	4		
18	✓		Solid	GND3	Metal	Plane	1.35	4	6	70.9
19					Dielectric	Substrate	3.7	4		
20	✓		Solid	BOTTOM	Metal	Signal	0.675	4	5	57
21					Dielectric	Solder Mask	0.5	4		

Figure 2: Inclusion of realistic parameters in the modeling of a stackup design

> It is best to work with your board manufacturer to get accurate data about your board stackup, to make sure that your design specs are within reason and can be maintained

an impedance in the simulation. In fact, in Figure 2 above, you may notice that the lower half of the stackup (a mirror image of the top) is modeled without taking into account actual dielectric constant, the resin-rich area around the traces, or the proper trace width. You will notice discrepancies in impedance for equivalent layers and traces. In some stackups, this difference can be up to about 5 ohms. This becomes problematic because the fab house will have to widen the trace or increase the dielectric thickness to compensate for the miscalculation, which can lead to possible manufacturing issues.

For instance, if a trace is spaced the minimum clearance from an object like a pin or via and then becomes widened, it could become too close to that object. Similarly, enlarged dielectric layers may cause the total board thickness to fall out of spec. This is why it is best to work with your board manufacturer to get accurate data about your board stackup, to make sure that your design specs are within reason and can be maintained, and that you don't run into problems later in the design cycle. IN

(the author)

PATRICK CARRIER

has over 10 years experience in the field of signal and power integrity. He worked as a Signal Integrity Engineer at Dell for 5 years before joining Mentor in Sept. 2005, where he is a Technical Marketing Engineer for the high-speed PCB analysis tools.

An Equivalent Three-Dipole Model for IC Radiated Emissions Based on TEM Cell Measurements

BY SIMING PAN, JINGOOK KIM, SUNGNAM KIM, JAESU PARK, HEONCHEOL OH, AND JUN FAN

An equivalent dipole model is proposed in this paper to represent the source of radiated electromagnetic emissions from an integrated circuit (IC). The height of an IC is usually much smaller than its length and width, so only three dipole moments are sufficient to characterize an IC in terms of its electromagnetic emissions. The dipole moments can be extracted from three TEM cell measurements. The radiated fields from the IC can then be calculated based on the extracted dipole sources. This IC emission model with three dipole moments is validated using the far-field measurements in a semi anechoic chamber for a test IC. For complex structures, it is desirable that the extracted dipole moments can be incorporated into a commercial full-wave tool as equivalent sources to simulate the radiations from an IC. This is demonstrated using an approach developed in this article

Integrated circuit (IC) devices are the ultimate noise sources that contribute to many component and system-level electromagnetic compatibility (EMC) issues, which become increasingly critical for high-speed digital circuit designs due to the constant increase of clock speeds, power consumption, circuit density and complexity. The international standard IEC 61967-2 [1] describes a specific procedure to evaluate the component-level EMC performance of ICs from 150 kHz to 1 GHz via TEM cell measurements. However, specific IC emission models are desirable to further simulate and predict the radiated fields from ICs in complex systems.

Generally speaking, a complete set of six dipole moments are necessary to represent the emissions of a device under test.

Previous work has established several models for determining the emissions from ICs. Models with mutual capacitance and inductance were extracted from TEM cell measurements to estimate the radiated emissions for simple structures in [2] and [3]. A set of dipole arrays was proposed from near-field scanning measurements to model IC emissions in [4] and [5]. The TEM cell and open area test site (OATS) measurements of a radiated device were correlated through a set of six electric and magnetic dipole moments in [6], where the extraction of the six dipole moments requires nine TEM cell measurements and, further, special shielding is needed for some of the measurement steps.
In this article, it is validated that only three dipole moments out of the six are dominant when there is a large ground plane under the IC being tested. Thus, the TEM cell measurement procedure proposed in [6] can be greatly simplified to three measurements instead of nine. Each of these three TEM cell measurements strictly follows the standard procedure proposed in IEC 61967-2. The IC emission model using three equivalent dipole moments is introduced in Section II with justifications. This model is validated using the far-field measurements in a semi anechoic chamber for a test IC in Section III. An approach to incorporate the extract dipole moments as equivalent sources in a full-wave tool is developed in Section IV in order to model system-level EMI in complex environments.

IC EMISSION MODEL UUSING THREE DIPOLE MOMENTS

For EMC applications, the maximum emission level is of interest, instead of the radiation nulls or side lobes. Then, it becomes a good approximation to neglect the phase differences between the various moments. Particularly, when the sizes of ICs are electrically small, only the initial dipole terms are dominant to determine the magnitude of the radiated fields [7].

Generally speaking, a complete set of six dipole moments are necessary to represent the emissions of a device under test (DUT), including three electric ones Px, P_y, P_z and three magnetic ones M_x, M_y, M_z. The subscript (x, y, or z) indicates the individual direction of each dipole moment. The electric and magnetic dipoles are defined as [8]

$$\mathbf{P} = \int_v \mathbf{J}(r')dv' \qquad \mathbf{M} = \frac{1}{2}\int_v \mathbf{r}' \times \mathbf{J}(r')dv' \qquad (1)$$

where J is the current density distributed over a volume v, and r' denotes the position vector of the source point.

For a typical IC shown in Figure 1, its dimensions in x and y directions are much larger than its z-directional height. When there is a large perfect electric conductor (PEC) ground plane under the IC, P_x, P_y, and M_z cannot be the dominant dipole moments because their fields cannot satisfy the PEC boundary condition at the ground plane if the distance between the IC and the ground plane is small enough. Further, the main current

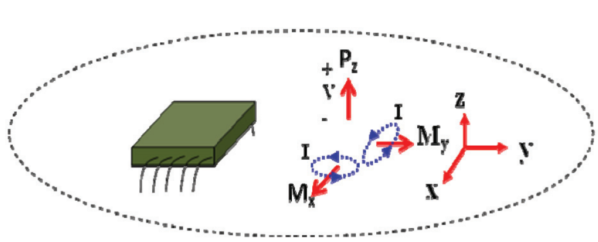


Figure 1: Typical dimensions of IC and its emission model using three equivalent dipole moments

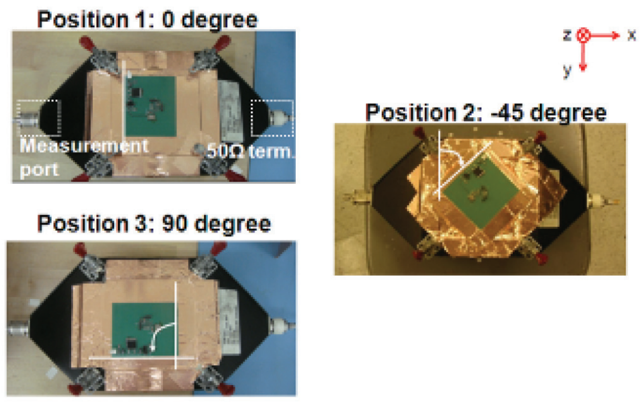


Figure 2: Three TEM cell measurements necessary to extract the proposed IC emission model using (2)

loops comprised of the IC traces and the ground reference plane can be sufficiently modeled using M_x and M_y. Similarly, most patches in the IC against the ground reference plane can be sufficiently modeled using P_z. Therefore for the typical IC structures, M_x, M_y and P_z are adequate as the equivalent sources of their electromagnetic emissions.

The three equivalent dipole moments in the proposed IC emission model can be calculated from three TEM measurements as [6]

$$\begin{aligned} b_1 &= P_z^2 + k_0^2 M_y^2 \\ b_2 &= P_z^2 + \frac{1}{2} k_0^2 M_x^2 + \frac{1}{2} k_0^2 M_y^2 - k_0^2 M_y M_x \\ b_3 &= P_z^2 + k_0^2 M_x^2 \end{aligned} \quad (2)$$

where k_0 is the wave number in the free space and, b_1, b_2, and b_3 are the normalized power measured using the TEM cell when the IC under test is orientated as in Positions 1, 2, and 3 shown in Figure 2, respectively. The three measurement positions have a rotation of 0, -45, and 90 degrees as illustrated by the white lines in Figure 2.

An alternative approach is to use a hybrid to separate the contributions of P_z, M_x, and M_y. A test setup using a hybrid in the TEM cell measurement is shown in Figure 3. The hybrid can generate signals that are the sum and the difference of the two TEM cell outputs. The sum of the two output voltages is proportional to the electric field coupling, since the electric field coupling, if the DUT is located in the center of the TEM cell, generates two responses that are in phase and the magnetic field coupling generates two out-of-phase ones. Similarly, the difference of the voltages is proportional to the magnetic field coupling. As a result, the equivalent electric dipole moment P_z can be obtained from the sum of the voltages as

$$P_z = \sqrt{\frac{(A+B)}{2}} \quad (3)$$

and the difference of the voltages gives the magnetic dipole moment as

$$M = \sqrt{\frac{(A-B)}{2k_0^2}} \quad (4)$$

Measurements with two DUT positions (0 and 90 degrees) are sufficient to calculate the P_z, M_x, and M_y using (3) and (4). Notice that the P_z value shall be approximately the same at any measurement position.

VALIDATION OF THE PROPOSED IC EMISSION MODEL

A phase locked loop (PLL) chip was used as a test IC to illustrate the experimental procedure to obtain the IC emission model proposed in this article. Then, far-field emission measurements were performed to validate the model.

The test print circuit board (PCB) designed according to the requirements of the IEC Standard 61967-1 is shown in Figure 4. The input signal of the PLL has a fundamental frequency of

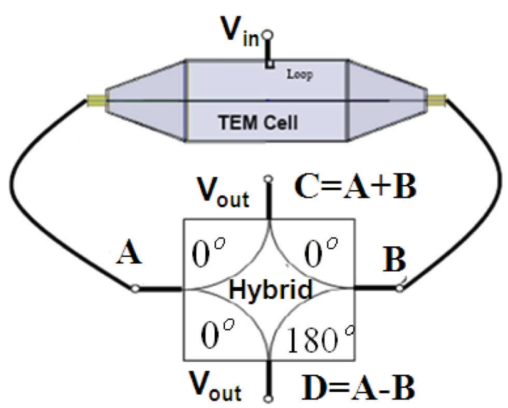


Figure 3: TEM cell measurement with a hybrid

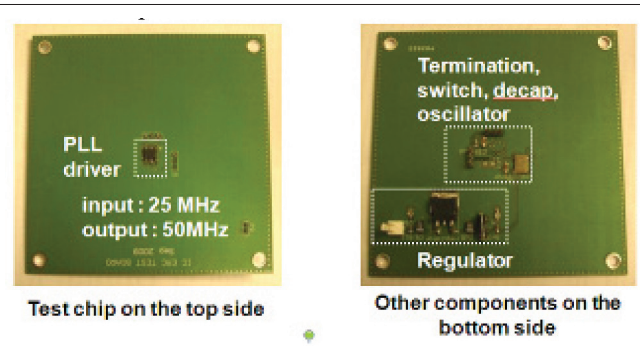


Figure 4: Test PCB geometry with a PLL chip

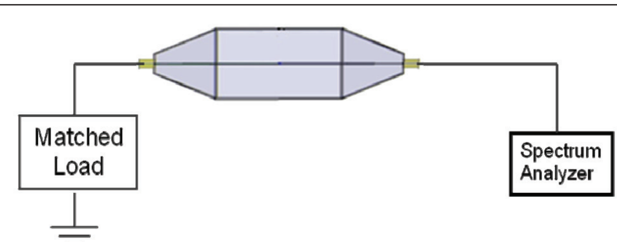


Figure 5: TEM cell terminations

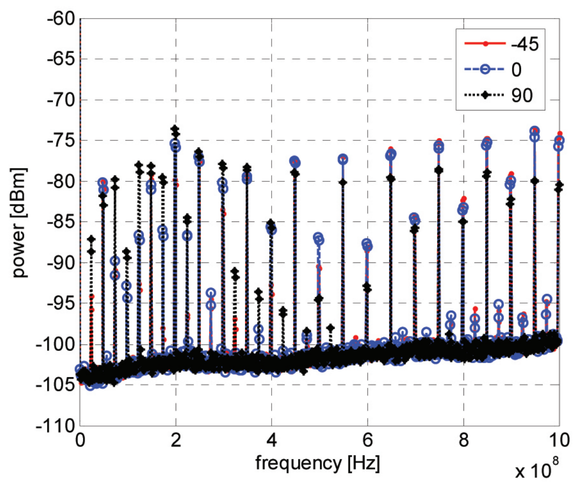


Figure 6: Output power measured using a spectrum analyzer for the test board placed in three different positions

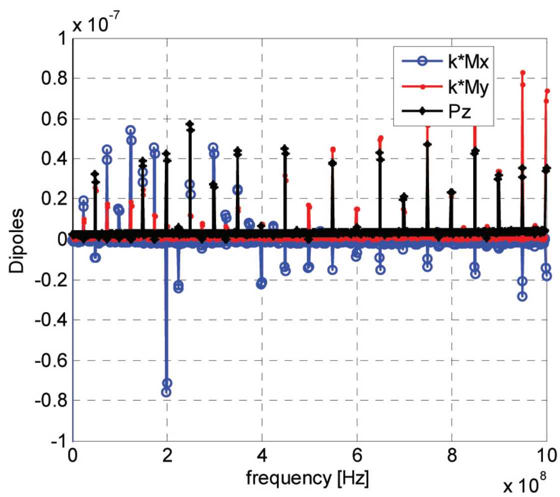


Figure 7: Equivalent dipole moments extracted from the TEM cell measurements for the PLL chip under test

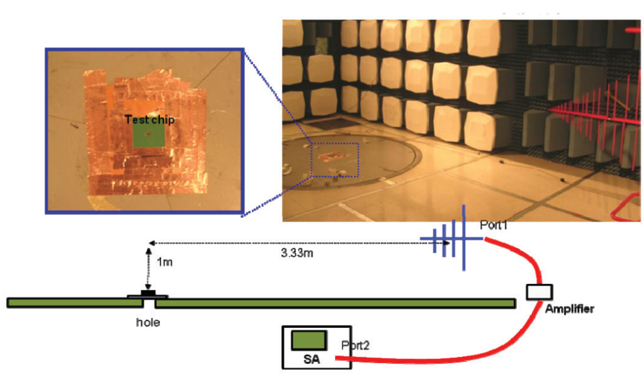


Figure 8: Far-field measurement in a semi anechoic chamber

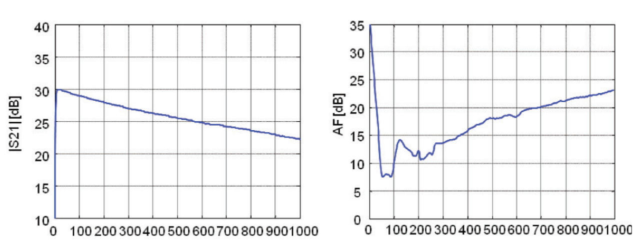


Figure 9: Gain of the measurement setup and antenna factor

25 MHz while the output signal doubles the input frequency. The PLL chip is the only component on the top side of the board while other components such as power regulator, terminations, and decoupling capacitors are on the bottom side of the board. The board size, stackup, as well as via type followed the specifications in IEC 61967-1.

As shown in Figure 2, the test board was then measured in three different positions by rotating the test board at certain degrees with regard to the TEM cell orientation. The TEM cell terminations are illustrated in Figure 5, with one port terminated with a 50-Ohm matched load and the other port connected with a spectrum analyzer. The output power at the measurement port was measured from 10 MHz to 1 GHz.

The measured results of the output power for all three measurements using the spectrum analyzer are shown in Figure 6. The peaks correspond to the fundamental and harmonic frequencies of the clock. Then the equivalent electric and magnetic dipole moments were calculated based on the measured results using (2) and are shown in Figure 7. Naturally, these dipole moments have peak values at the fundamental and harmonic frequencies.

To validate the extracted IC emission model, radiated fields can be calculated from the extracted dipole moments as sources and compared with measurements. Closed-form expressions for the radiated fields generated by the known dipole sources can be derived for simple cases where Green's functions are available. One such case is to assume that the IC is placed on top of an infinitely large ground plane. The analytical expressions for the radiated fields from the dipole moments in this kind of half space can be easily obtained as in [9].

For validations, far-field measurements in a semi anechoic chamber were conducted to obtain the emissions from the IC chip in the half space. The experimental setup is shown in Figure 8, where the setup of the DUT is different to the usual EMI testing. In this measurement, it is important to ensure that the IC is the only source of the radiated emission. Otherwise there's no apple-to-apple comparison with the analytical solution of the radiated fields from the extracted dipole moments. To remove the radiation from the test PCB as well as other components, the PCB was placed on the ground plane of the chamber with the side containing the PLL chip facing up. Then the board was completely covered using copper tape with only the test chip exposed, as shown in the Figure 8. The copper tape was connected to the ground plane of the chamber. Therefore, the test chip was equivalently placed on a very large ground plane. The radiated electric field was measured at 3.33 m away from the test board using a broadband antenna. To improve the signal to noise ratio, two amplifiers were used.

The gain of the measurement setup including the gain of the amplifiers and the loss of the cables and the antenna factor are shown in Figure 9, where the antenna factor was provided by the antenna manufacturer. Then, the radiated electric field can be calculated from the measured power at the spectrum analyzer as

$$E[dBuV/m] = (\text{Power}[dBm] + 107) - S_{21} + AF \quad (5)$$

where S_{21} is the gain of the measurement setup, and AF is the antenna factor.

The measured electric fields in both the y and z directions are compared with those calculated from the extracted dipole moments in Figure 10. The peak values of the radiated fields at the harmonic clock frequencies match well for the electric field in the z direction. However, the values of the electric filed in the y direction from the TEM cell measurements are smaller than the noise floor in the far-field measurements. When the radiated levels are low, there is not enough signal to noise ratio in the far-field measurements to achieve meaningful comparisons. Nevertheless, when the radiated levels exceed the noise floor of the far-field measurement, the obvious agreements at the peaks validate the proposed IC emission model.

INCORPORATING IC EMISSION MODEL INTO A FULL-WAVE EM TOOL

In complex geometries, analytical expressions of the radiated fields from the equivalent dipole moments may not be available. It is necessary to develop an approach to incorporate the extracted dipole moments as sources in common commercial full-wave

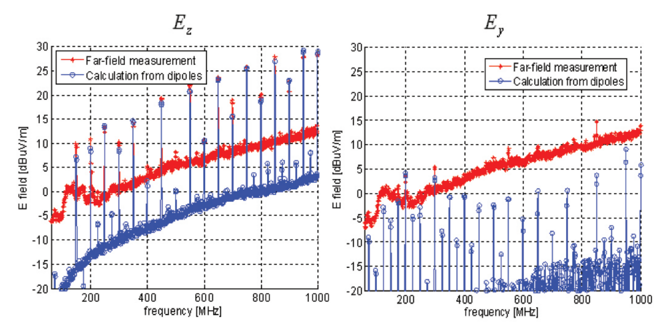


Figure 10: Comparisons of the radiated fields from measurements with those calculated from the extract IC emission model

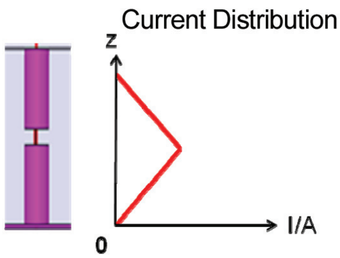


Figure 11: Electric dipole approximated with a short wire antenna

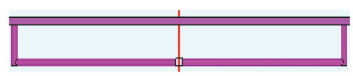


Figure 12: Magnetic dipole approximated with a small loop antenna

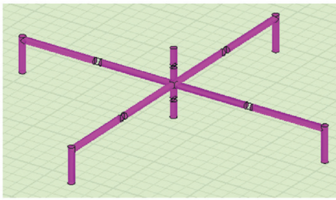


Figure 13: A combined source with one wire antenna and two loop antennas

electromagnetic tools so that system-level EMI problems can be investigated.

The ideal infinitesimal electric dipole can be approximated using a short wire antenna as shown in Figure 11. The current excitation is at the middle of the wire. Since the current vanishes at the two ends of the wire, the electric dipole moment of this short wire antenna can be approximated as

$$P_z = \frac{1}{2} l * I_P, \qquad (6)$$

where l is the length of the wire, and IP is the magnitude of the current excitation at the middle of the wire antenna.

For ideal infinitesimal magnetic dipoles, they can be approximated as loop antennas as shown in Figure 12. The direction of the current in the loop and the direction of the magnetic dipole moment follow the right-hand rule. The magnetic dipole moment of the small loop antenna can be approximated as

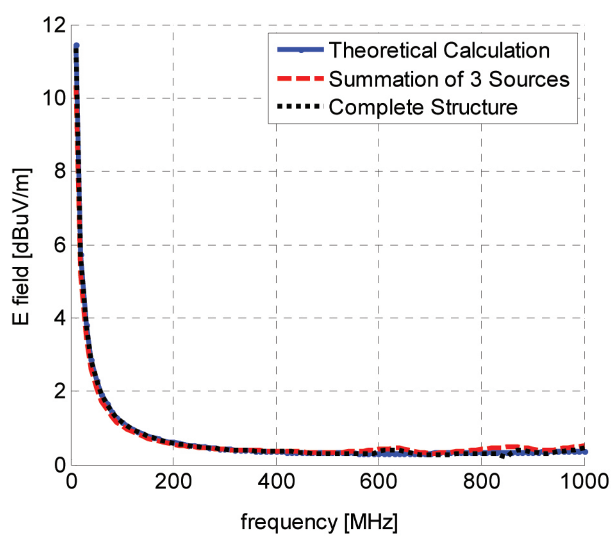
$$M_x = A * I_M, \qquad (7)$$

where A is the area of the loop, and I_M is the magnitude of the current excitation in the loop.

The extracted dipole moments from the TEM cell measurements can then be incorporated in full-wave tools as the wire and loop antennas. One intuitive solution is to incorporate each dipole moment individually as an antenna source. Then the totally radiated fields generated from the IC can be calculated by adding the three sets of the simulated fields from the individual dipole moments, according to superposition. Using this approach, obviously three full-wave simulations are needed to get the total radiated fields, which is undesirable since typical system-level simulations could be complex and time-consuming.

An improved method is to combine the three antennas in one full-wave simulation as shown in Figure 13. The trick is to assign two current sources to each antenna, forcing the exact current distributions so that the dipole moments can still be estimated using (6) and (7). Notice that there exist multiple scatterings among the antenna structures in this case, which could be a potential source of error.

Figure 14: Comparison of the radiated electric field results between analytical calculations and HFSS simulations



To illustrate and validate the proposed method of using the combined antennas in full-wave electromagnetic tools, HFSS (High Frequency Structure Simulator) from Ansoft was used to show an example. Suppose the extracted dipole moments are M_x = 2.5e-6 Am^2, M_y = 2.5e-6 Am^2, and P_z = 2.5e-4 Am, and they are located on top of an infinitely-large ground plane. In the HFSS model, the areas of the loop antennas were chosen as 2.5e-6 m^2 and the length of the wire antenna as 1e-3 m. The current excitations were then 1 A in the loop antennas and 0.5 A in the wire antenna. The distance between the source and observation points was set to be 145 mm. The simulated electric field results in the x direction using the superposition approach, the combined antenna approach, and the analytic expressions are compared in Figure 14. They agree very well in the frequency range of interest from 10 MHz to 1 GHz.

CONCLUSION

In this article, an IC emission model has been proposed using three dipole moments (Pz, Mx, and My) extracted from TEM cell measurements. This model has been validated using the comparisons between the radiated fields calculated using the extracted dipole moments as equivalent sources and those obtained from the far-field measurements for a PLL test chip. An approach with combined loop and wire antennas to incorporate the dipole moments as sources in commercial full-wave EM tools has also been developed. The study reported in this article has demonstrated that the radiated emissions from ICs can be well characterized using three dipole moments extracted from simple TEM cell measurements. The proposed model can accurately predict the emission level from a single isolated IC. For system-level EMI simulations, complex emission model, such as dipole arrays, need to be further studied by considering the near-field coupling in the system. IN

REFERENCES

1. IEC 61967-2:2005, "Integrated Circuits – Measurement of Electromagnetic Emissions, 150 kHz to 1 GHz – Part 2: Measurement of Radiated Emissions, TEM Cell and Wideband TEM-cell Method," 1st Edition IEC Basic Safety Ppublication (September 2005).

2. V. Kasturi, S. Deng, T. Hubing and D. Beetner, "Quantifying Electric and Magnetic Field Coupling from Integrated Circuits with TEM Cell Measurements," *2006 IEEE Symposium on Electromagnet Compatibility, Portland, OR* (August 14-18, 2006).

3. Goulette, R.R., "The Measurement of Radiated Emissions from Integrated Circuits," *IEEE Symposium on Electromagnet. Compatibility* (August 17-21, 1992).

4. Weiping He and Dr. Richard E DuBroff, "Modeling Radiated Emissions of Electronic Circuits with a Set of Electric Dipoles", *MST EMC Laboratory Technical Brief, Third Quarter* (2008).

5. R. M. Gulrajani, "The Forward and Inverse Problems of Electrocardiography," *IEEE Engineering in Medicine and Biology Magazine,* Volume 17 (September 1998): 84-101.

6. Wilson, P., "On Correlating TEM Cell and OATS Emission Measurements," *IEEE Transactions on Electromagnetic Compatibility, Volume 37, Issue 1* (February 1995): 1–16.

7. A. Tsaliovich, "Modelling Electronic System Radiated Field Patterns," 8th Internation Zurich Symposium and Technology. Exhibition on Electromagnetic. Capability, Zurich, Switzerland (March 1989): 323-328.

8. R. E. Collin, *Field Theory of Guided Waves. New York, NY: McGraw-Hill* (1960).

9. R. Johnson and H. Jasik, eds., *Anrennu Engineering Handbook, 2nd* Edition. New York, NY: McGraw-Hill (1984): Chapter 2.

With this paper, we conclude the publication of Best Papers awarded at the 2010 IEEE International Symposium on Electromagnetic Compatibility. We hope that you have enjoyed the works of our community of EMC Engineers. We thank the authors and the IEEE for their permission to republish their work in *IN Compliance Magazine.*

BUSINESS News

Technology Improves Test Times of Bluetooth® and Wi-Fi Devices

Aeroflex Limited has announced that SAE Magnetics (H.K.) Ltd. has commissioned a production line based on the PXI 3000 Series multi-technology test platform. This has enabled the Hong Kong-based company to achieve a dramatic improvement in test throughput—and hence in overall productivity—for the RF devices it manufactures.

SAE Magnetics is part of TDK Corporation, and is a leading supplier of both Bluetooth® and Wi-Fi system-in-package (SiP) devices to international Tier 1 mobile phone manufacturers.

"We chose the Aeroflex PXI 3000 Series because it provides all the measurement capability we need in a single multi-technology box, and it is both faster and more highly integrated than other test solutions we evaluated," commented Michael Yang, director of engineering for SAE Magnetics. "Not only are we seeing immediate results in terms of greater throughput and higher customer yields, but the modular nature of the PXI system also means that it can be readily upgraded to meet our future production test needs."

The speed improvements that SAE has achieved result from the modular control of Aeroflex's hardware and software, and from the collaboration among SAE, a commissioned company, and Aeroflex to optimize the test process. A further advantage of having multiple cellular and non-cellular technologies integrated into the same test instrument is that the box has a much smaller footprint than discrete test solutions. The equipment is always fully utilized rather than having instruments standing idle while other technologies are being measured. It also requires less time for calibration and verification than when separate instruments are used.

For further information visit the company's website at www.aeroflex.com

ISO 17025 Expansion of Scope of Accreditation

Educated Design & Development, Inc. (ED&D) has been accredited by ACLASS, an ILAC Member, as being an ISO 17025 compliant calibration lab, and has recently expanded their Scope of Accreditation. ED&D is the world's first manufacturer of a full line of Product Safety test equipment to receive the coveted ISO/IEC 17025 accreditation.

The expanded scope of the accreditation now includes Accessibility Probes, Creepage & Clearance Gauges, Angle Meters, Impact Balls, Impact Hammers, Pressure Gauges, Force Gauges, Dust Chambers, Jet Nozzles, Drip Boxes, Glow Wire, Flame test equipment, Tracking Testers, Hipot, Leakage Current and numerous other specific products and general categories utilized in Product Safety compliance testing applications.

ED&D's Calibration Lab is the world's first and only to attain scope for these and other unique categories. Copies of the accreditation certificate are available on the company's web site at www.ProductSafeT.com. For more information, please visit their web site.

Popular EMC Antennas Now Available for Immediate Shipment

ETS-Lindgren has announced the immediate availability of its most popular electromagnetic compatibility (EMC) antennas. Double- and quad-ridged horn antennas as well as conical log, shielded loop, biconical, log periodic, and active monopole antennas are now in inventory awaiting shipment.

Recognizing the importance of "time to market" and the expense incurred when product testing is delayed, ETS-Lindgren created a short list of its most popular antennas purchased over the past several years. These address common EMC test and measurement requirements per CISPR 16-1, FCC Parts 15 and 18, IEC/EN 55022, SAE J551 and J113, ANSI C63.4 as well as the MIL-STD-461F and -285 standards, among others. The table below shows the antenna models now available for immediate shipment:

Antenna Model	Description
3115	Double-Ridged Guide Antenna
3117	Double-Ridged Guide Antenna
3301C	Active Monopole Antenna
3142D	BiConiLog™
3148B	Log Periodic Dipole Array
3116B	Double-Ridged Waveguide Horn Antenna
3106B	Double-Ridged Waveguide Horn Antenna
6511	Shielded Loop Antenna
3102	Conical Log Spiral Antenna
3164-06	Open Boundary Quad-Ridged Horn

"This 'top ten' program was created in response to customer requests for faster lead times of the quality antennas they've come to expect from ETS-Lindgren. They didn't want to settle for an inferior antenna simply because ours had a longer lead time," said Bill Giacone, ETS-Lindgren's Senior Vice-President, Americas. "We realize our customers schedule a test with the best intentions and think they have every item covered. Unfortunately, the reality can be a critical antenna is suddenly needed to finish a test – or address a newly added test requirement – to meet production deadlines. With this new program we can minimize delays in our customers' test schedules by shipping the needed antenna immediately," he added.

For additional information please call +1.512.531.6400 or email sales@ets-lindgren.com.

Ferrite Testing Reveals Significant Performance Variations

Leader Tech has reported that a recent empirical testing of FerriShield Ferrites shows that there is a notable increase in Ohms of impedance when compared to the exact same competitive alternative. Due to an industry-wide shift in raw material formulation and manufacturing processes, many RFI/EMI ferrites on the market are delivering lower performance across a wide-band frequency range. This variation is an important design consideration for most commercial, military and consumer electronics manufacturers because in order to attain the desired level of EMI/RFI suppression, a larger and therefore heavier ferrite must be specified. These physical characteristics typically conflict with target engineering and market demands for smaller, lighter-weight electronic devices.

For the purposes of testing, Leader Tech engineers selected one of the Company's most popular FerriShield 28 Material Ferrites with a true 850 permeability. All ferrites in the sample group were analyzed on the same test wire using an Agilent 4396B RF Network/Spectrum/Impedance Analyzer and an Agilent 16192A test meter. Broadband frequencies ranging from 1 MHz to 400 MHz were generated across the test wire and ferrite impedance in Ohms was recorded. Performance variations among manufacturers that offer 850 permeability wideband ferrites are noteworthy.

For more information about the results of this performance test, please contact Blake Roberts directly at 813-440-9243 or BRoberts@leadertechinc.com

Intertek Launches Consumer Carbon Index (CCI) Label

Intertek has launched its Consumer Carbon Index label, a consumer-facing indication of the amount of Greenhouse Gases (GHG) being emitted by a product while in use. The CCI Label is a tool for manufacturers to display the GHG value on advertising, product packaging or other marketing materials and differentiate it from competing products. It can also be a valuable tool for retailers who look to build their "green products" reputation among environmentally-savvy consumers.

Intertek issues its CCI label only to those products that have completed a full energy efficiency testing and the data is available. The CCI value is derived by multiplying a product's annual or hourly energy consumption by the GHG factor of a particular country or region. Individual countries publish their own factor based on how much GHG is produced from electricity generation in that country. Intertek's CCI label will indicate both the CCI value as well as the country or region for which the value is applicable.

For more information please visit: www.intertek.com/consumer-carbon-index.

Extruded Ceramic Tubular Capacitors

Spectrum Advanced Specialty Products has added an extrusion process to their current manufacturing methods of ceramic tubular capacitors. The addition of this process enhances Spectrum's design flexibility with an increased custom product offering. Spectrum is now capable of producing sizes of up to 1" in length as well as diameters of ½" and larger. Spectrum's extruded ceramic tubular capacitors are ideal for applications such as EMI filtering for multi-pin connectors, RFI suppression and circuit protection.

All Spectrum ceramics are produced 100% in-house in their established MIL-STD-790 ceramic facility located in State College, PA. With complete vertical integration, Spectrum provides customers with application-specific, high performance solutions, all in the industry's shortest lead times. For more information visit: www.specemc.com

Thermistors Sample Kits Available

TDK-EPC is presenting three new sample kits of ceramic PTC thermistors from EPCOS:

1. Sample kit "*SMD PTC Thermistors for Limit Temperature Sensing/ Superior Series"* features components designed for use as temperature sensors, such as in LED lamps, power supplies and notebooks. The kit contains samples for sizes 0402, 0603 and 0805 across the temperature range between 75 and 145 °C in steps of 10 K. All thermistors are certified to AEC-Q200 and are suitable for reflow and wave soldering.
2. Sample kit "*SMD PTC Thermistors for Overcurrent Protection"* contains components for surge current protection applications. They are used as self-resetting fuses and as such limit currents to uncritical values in the event of overload or short circuit. These thermistors are available in sizes 0603, 1210, 3225 and 4032.
3. Sample kit "*PTC Thermistors for Inrush Current Limiters"* are suitable as inrush current limiters in AC-DC inverters, frequency converters, air-conditioning systems, pumps and all other equipment that exposes the power line to high inrush currents.

To order any or all of these sample kits, go to www.epcos.com/samplekit.

PSES
Product Safety Engineering Society

2011 IEEE Symposium PRODUCT COMPLIANCE ENGINEERING

October 10-12, 2011 - San Diego, California

EXHIBITING AT THE SHOW

The Symposium provides the perfect venue to reach qualified buyers for product safety related products and services! People attending our Symposium are:

- Certifiers and Regulators
- Product Safety Managers and Engineers
- Regulatory Managers and Engineers
- Test Laboratory Managers and Engineers

For more information related to exhibitions and/or patronage opportunities at our show, contact Sue Kingston, s.kingston@ieee.org +1 (310) 699-2609

VENUE

Hilton San Diego Mission Valley
901 Camino del Rio South
San Diego, CA 92108
(619) 543-9000
sandiegomissionvalley.hilton.com
$129 single/double

Paper Submission
The 2011 Symposium seeks original, unpublished papers and tutorials on all aspects of product safety and compliance engineering. Please see the Call for Papers.

Abstract submission: May 15, 2011
Draft formal e-paper: June 30, 2011
Notification of Acceptance: July 15, 2011
Formal Paper (Final): August 15, 2011
All Final Papers and Presentations: September 1, 2011

Venue
The symposium is being held at the beautiful Hilton San Diego Mission Valley in San Diego, CA. We have negotiated a room rate of $129.
Reservations should be made online through the Symposium website.

http://www.psessymposium.org

IEEE

EVENTS in Compliance

August 2011

15

REACH Essentials Training

UL University, Pittsburgh, PA
www.incompliancemag.com/events/110815_2

15-19

Electronics Laboratory Technician Training

UL University, Research Triangle Park, NC
www.incompliancemag.com/events/110815_1

16-17

REACH Practical Implementation

UL University, Pittsburgh, PA
www.incompliancemag.com/events/110816_1

16-18

Designing for Compliance to IEC 60601-1 3rd Edition

UL University, Research Triangle Park, NC
www.incompliancemag.com/events/110816_2

18-19

REACH Moving Forward with Registration

UL University, Pittsburgh, PA
www.incompliancemag.com/events/110818

22

REACH IUCLID5 Training

UL University, Pittsburgh, PA
www.incompliancemag.com/events/110822

23-25

Designing for Compliance to IEC 60601-1, 2nd Edition and Transition to the 3rd Edition (Bundled)

UL University, San Jose, CA
www.incompliancemag.com/events/110823

25

Intrinsic Safety Design Fundamentals for Hazardous Locations

UL University, Northbrook, IL
www.incompliancemag.com/events/110825

September 2011

1

A/V, Information and Communications Technology Equipment Safety Requirements: Intro to IEC 62368-1

UL University, Hartford, CT
www.incompliancemag.com/events/110901

11-16

33rd Annual International EOS/ESD Symposium

Disneyland Hotel , Anaheim, CA
www.incompliancemag.com/events/110911

12-15

NFPA 79: Standard for Industrial Machinery UL 508A and Short-Circuit Current Ratings

UL University, Quincy, MA
www.incompliancemag.com/events/110912_1

12-16

Photovoltaic (PV) System Installation Training

UL University, Research Triangle Park, NC
www.incompliancemag.com/events/110912_2

13

Understanding Ground Resistance Testing A One Day Training Seminar

AEMC Instruments, Denver, CO
www.incompliancemag.com/events/110913_9

13-14

Designing for Compliance to UL 60730: Automatic Electrical Controls for Household and Similar Use

UL University, San Jose, CA
www.incompliancemag.com/events/110913_1

Electrical Insulation Systems: UL 1446

UL University, Brea, CA
www.incompliancemag.com/events/110913_2

Industrial Control Panels UL 508A and Short-Circuit Current Ratings

UL University, Toronto, ON Canada
www.incompliancemag.com/events/110913_3

13-14 (continued)

Industrial Control Panels UL 508A and Short-Circuit Current Ratings

UL University, Anchorage, AK
www.incompliancemag.com/events/110913_4

Lightning Protection Installation Standard Review

UL University, Northbrook, IL
www.incompliancemag.com/events/110913_5

Test, Measurement and Laboratory Use Equipment: Designing for Compliance to UL 61010-1, 2nd Edition

UL University, Dallas, TX
www.incompliancemag.com/events/110913_6

13-15

Photovoltaics: Overview of UL 1703 and IEC 61730 (Bundle)

UL University, Northbrook, IL
www.incompliancemag.com/events/110913_7

13-16

MIL-STD-461F

WL Academy, Gaithersburg, MD
www.incompliancemag.com/events/110913_8

14

Electric Signs: Designing for Compliance to UL 48

UL University, St. Louis, MO
www.incompliancemag.com/events/110914

15

Documenting Required ISO 14971 Risk Management File Elements in the IEC 60601-1 TRF

UL University, Boston, MA
www.incompliancemag.com/events/110915_1

System Level Approach to EMC Shielding on Hybrid and Electric Vehicles

University of Michigan College of Engineering , Ann Arbor, MI
www.incompliancemag.com/events/110915_2

Submit event items to:
events@incompliancemag.com

CONSULTING Marketplace

EMC/EMI CONSULTING

DLS
EMC & Product Safety Testing & Consulting
847-537-6400
www.dlsemc.com

CE Notified Body - R&TTE and EMC
Certifications - Telecom, FCC, Canada, BSMI, China, ACMA, VCCI
Testing - Electrical Safety, EMC/EMI, Product Safety, CE Marking, Radio, Wireless, Product Pre-Compliance, Mil 461 & RTCA DO 160
Consultants - EMC/EMI, EU, Medical Devices, Product Safety, Telecom
Design Services/EMC Design Seminar

DNB ENGINEERING, INC.
"One World, One EMC Solution"

DNB Engineering, Inc. provides a full range of customized Engineering and Consulting services in the following areas: EMC/EMI, HIRF, Lightning Protection, Environmental, FCC Compliance, Product Safety and more!
(800) 282-1462
www.dnbenginc.com

Don HEIRMAN Consultants, L.L.C.
Donald N. Heirman, NCE
President
143 Jumping Brook Road
Lincroft, NJ 07738-1442 USA
+1 732-741-7723 (Voice)
+1 732-530-5695 (FAX)
d.heirman@ieee.org
http://www.DonHEIRMAN.com

We can certify it if it's perfect, and help fix it if it's not.

LS Research is the industry's premier full-turnkey wireless product development firm. In addition to providing on-site FCC / IC / CE test facilities and approvals, we offer:

- Antenna Design & Testing
- CAD Design
- RF / EMC Troubleshooting
- HW, SW and Embedded Firmware Design
- Prototype and Volume Production
- Linux, WinCE, and PC Development

www.lsr.com 262.375.4400 sales@lsr.com
LS RESEARCH WIRELESS PRODUCT DEVELOPMENT

EMC/EMI CONSULTING

Montrose Compliance Services, Inc.

- Training and Consulting all aspects of EMC
- System Design Analysis
- EMC Certification, Testing and Troubleshooting

tel: 408-247-5715
mark@montrosecompliance.com
www.montrosecompliance.com

EMC: Equip-Systems-Facilities

William Bush
wbush@ieee.org
812-376-9671

Powering, Grounding & Bonding, Electrical-Lightning-Surge Protection Shielding, Interference Control

---

Wyatt Technical Services, LLC
EMC Seminars & Design

EMC Design, Troubleshooting & Seminars
Call (877) 443-9275 toll free or (719) 310-5418
ken@emc-seminars.com / www.emc-seminars.com

EMP SIMULATION CONSULTING

EM Software & Systems (USA), Inc.

tel: 866-419-FEKO
feko@emssusa.com
www.feko.info

- 3D Electromagnetic Software for real life problems
- 45 day Free Evaluation

FEKO Comprehensive Electromagnetic Solutions

Marketplace

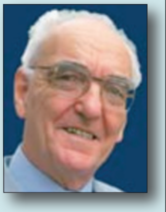
(Authors)

KEITH ARMSTRONG
After working as an electronic designer, then project manager and design department manager, Keith started Cherry Clough Consultants in 1990 to help companies reduce financial risks and project timescales through the use of proven good EMC engineering practices. For Keith's full bio, please see page 79.

PATRICK CARRIER
has over 10 years experience in the field of signal and power integrity. He worked as a Signal Integrity Engineer at Dell for 5 years before joining Mentor in Sept. 2005, where he is a Technical Marketing Engineer for the high-speed PCB analysis tools.

DANIEL D. HOOLIHAN
is the Founder and Principal of Hoolihan EMC Consulting. He is a Past-President of the EMC Society of the IEEE and is presently serving on the Board of Directors. For Daniel's full bio, please see page 28.

NIELS JONASSEN, MSC, DSC,
worked for 40 years at the Technical University of Denmark, where he conducted classes in electromagnetism, static and atmospheric electricity, airborne radioactivity, and indoor climate. Mr. Jonassen passed away in 2006. For his full bio, please see page 24.



BRIAN LAWRENCE
began his career in electromagnetics at Plessey Research Labs, designing "Stealth" materials for the British armed services. In 1973 he moved to the USA and established a new manufacturing plant for Plessey to provide these materials to the US Navy. For Brian's full bio, please see page 17.

MARK I. MONTROSE
is an EMC consultant with Montrose Compliance Services, Inc. having 30 years of applied EMC experience. He currently sits on the Board of Directors of the IEEE (Division VI Director) and is a long term past member of the IEEE EMC Society Board of Directors. For Mark's full bio, please see page 19.

JOE TANNEHILL
has been working in the EMC field for over 27 years, starting with Intergraph Corp. in Huntsville, Alabama testing and designing graphics workstations and associated computing components. From there he worked at Gateway 2000 and at Dell designing laptop, desktop and enterprise systems. For Jeff's full bio, please see page 30.

JEFFREY VIEL
is the EMI/EMC engineering manager for National Technical Systems Boxborough, Massachusetts operations. He is an electrical engineer with over 15 years experience working in the EMI engineering industry. For Jeffrey's full bio, please see page 67.

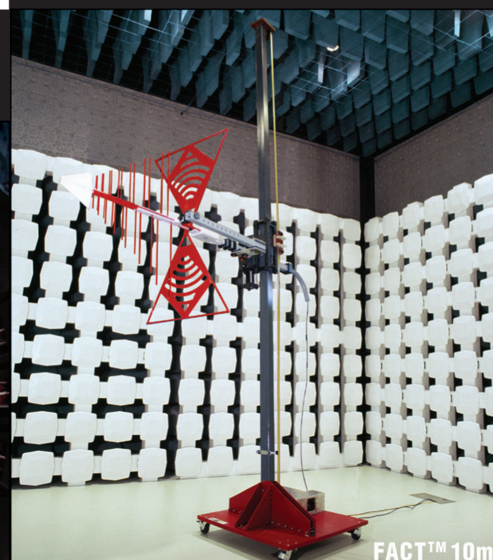
KIMBALL WILLIAMS
is a Technical Fellow for Denso Americas based in Southfield, Michigan, acting as the engineering lead for the EMC laboratory. He received his BSEE degree from Lawrence Technological University in Southfield, Michigan. For Kimball's full bio, please see page 30.

We wish to thank our community of knowledgeable authors, indeed, experts in their field - who come together to bring you each issue of *In Compliance*. Their contributions of informative articles continue to move technology forward.

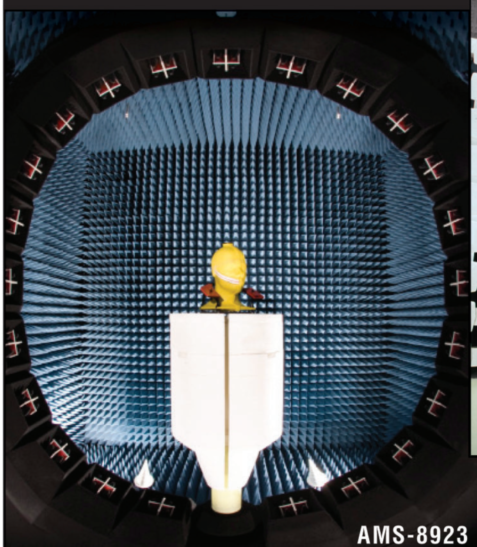
(Advertisers)

Booth 311, EMC Symposium, Long Beach, CA
August 16 - 18, 2011

EMC



Wireless



Defense

Need a Solution?
Choose One of Ours!

As your business grows, choose someone who can grow with you, like ETS-Lindgren. Whatever your requirements – EMC, wireless, or defense – we have the right solutions and the right people to make your project a success.

With more than 800 employees and over 100 reps and distributors worldwide, we have the resources to follow through on our commitments. Visit us at Booth 311 if you're at the show, or send us an e-mail at sales@ets-lindgren.com. We're friendly, knowledgeable and ready to help, whether you are in Long Beach, London, or Kuala Lumpur.

Willkommen to our newest office in Munich, Germany!

Visit us at Booth 311
IEEE EMC 2011 Long Beach, CA

Enabling Your Success™

ETS·LINDGREN™
An ESCO Technologies Company

www.ets-lindgren.com

Offices in the US, Finland, UK, France, Germany, Singapore, India, Japan, China, Taiwan