FEBRUARY 2011

IN COMPLIANCE™ Magazine

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EMC IN MILITARY EQUIPMENT

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REALITY ENGINEERING: What's Luck Got To Do With It?

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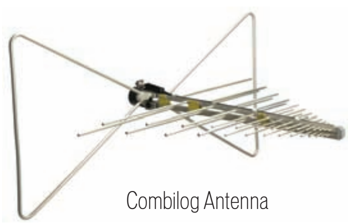
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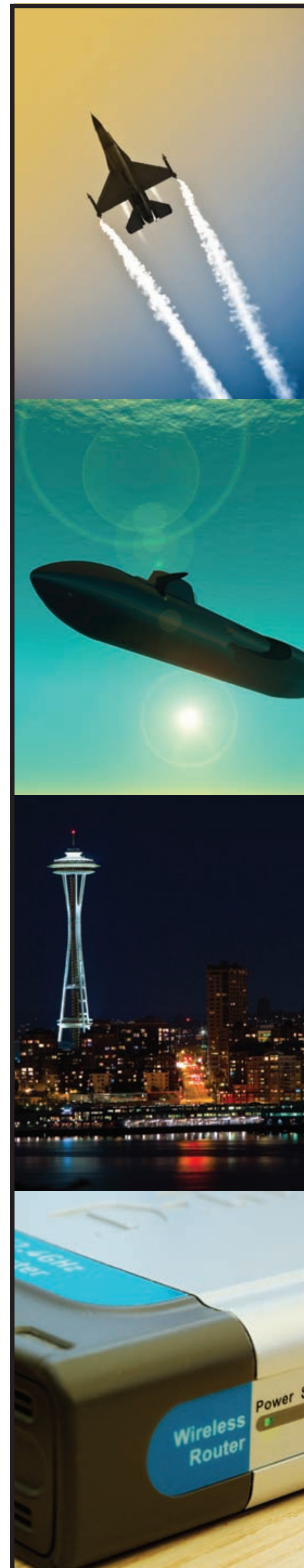
Wireless
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FCC Takes Steps to Open TV Spectrum to Wireless Broadband

As part of its ongoing effort to increase the spectrum available for wireless broadband use, the Federal Communications Commission (FCC) has taken steps that may eventually allow broadband service operators to utilize spectrum formally allocated to television broadcasts.

In a Notice of Proposed Rulemaking (NPRM) issued in November 2010, the Commission signaled its interest in voluntary broadcast spectrum auctions that would preserve spectrum for so-called over-the-air television while also providing additional spectrum for mobile broadband services. The Commission called for comments on its plans to establish new allocations for both fixed and mobile wireless services in these television broadcast bands.

In addition, the Commission's NPRM called for comments on proposed rules that would enable television broadcasters to share channels by taking advantage of new technical capabilities, and also for comments on proposals to increase the transmitting power and establish minimum performance standards for indoor antennas, in order to improve television reception of VHF channels (2-13).

The complete text of the Commission's NPRM is available at http://www.fcc.gov/Daily_Releases/Daily_Business/2010/db1130/FCC-10-196A1.pdf.

FCC Proposes Research for More Spectrum Efficiency

The Federal Communications Commission (FCC) has launched two separate proceedings intended to foster the development of innovative spectrum-efficient technologies and services in order to meet the growing demand for wireless broadband services.

In a Notice of Proposed Rulemaking (NPRM) issued in November 2010, the Commission has requested comments on a proposal to expand its rules covering Experimental Radio Services to allow for the issuance of a new type of "program license." The proposed program license would give qualified entities broader discretion to conduct research without the need to seek approval for each individual experiment.

In a separate action, the Commission has issued a Notice of Inquiry (NOI), requesting comments on ways in which advance dynamic radios and techniques, such as "white spacing" and spectrum sensing, might be used to provide more intensive and efficient use of spectrum.

According to the FCC's recent forecast of mobile broadband spectrum use (see http://www.fcc.gov/Daily_Releases/Daily_Business/2010/db1102/DOC-302324A1.pdf), the United States faces a spectrum deficit of nearly 300 megahertz within the next five years.

The complete text of the Commission's NPRM regarding the expansion of Experimental Radio Service rules is available at http://www.fcc.gov/Daily_Releases/Daily_Business/2010/db1130/FCC-10-198A1.pdf. The complete text of the NOI on advanced dynamic devices and techniques is available at http://www.fcc.gov/Daily_Releases/Daily_Business/2010/db1130/FCC-10-197A1.pdf.

FCC Reiterates Narrowbanding Migration Deadlines

The Federal Communications Commission (FCC) has issued a Public Notice, reminding manufacturers that it will no longer certify certain types of private land mobile radio equipment as January 1, 2011.

The deadline applies to equipment designed to operate in the 150-174 MHz

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or 421-512 MHz bands but capable of operating with only one voice path per 25 kHz of spectrum. After the January 1, 2011 date, the Commission will only consider for certification equipment which either operates on 12.5 kHz or narrower channels, or which employs a technology that achieves the narrowband equivalent of one channel per 12.5 kHz of bandwidth.

Equipment with a 25 kHz mode that has previously been certified can continue to be manufactured and/or imported until January 1, 2013.

The new restrictions are part of the Commission's efforts to reduce spectrum congestion, and increase overall access for spectrum users. Additional information about the Commission's narrowbanding efforts is available at http://www.fcc.gov/narrowbanding.

FCC Issues White Paper on Consumer Broadband Decisions

Despite the number of offers directed at consumers to switch their Internet broadband service providers, the majority tend to stick with their current carrier. But don't assume that the choice to stick is a measure of consumer loyalty.

That's one of the conclusions of a recent white paper issued by the Federal Communications Commission (FCC). Entitled "Broadband decisions: What drives consumers to switch-or stick with-their broadband Internet provider," the white paper identified a number of factors that prevent or inhibit consumers from switching, even when they'd like to.

Among the reasons noted in white paper for not switching Internet service providers were the following concerns:

- Paying a set-up or installation fee (50% of respondents)
- The inconvenience of arranging for new service (43%)

> ***Despite the number of offers directed at consumers to switch their Internet broadband service providers, the majority tend to stick with their current carrier. But don't assume that the choice to stick is a measure of consumer loyalty.***

- Providing a deposit for service from a new provider (40%)
- Having to give up a current e-mail address (34%)
- Having to pay a termination fee to the current provider (32%)

Of those surveyed by the Commission, just over one-third of Internet users have changed their service provider in the prior three years, with only 13% having switched providers more than once during the three years.

The complete text of the Commission's white paper on consumer broadband decisions is available at http://www.fcc.gov/Daily_Releases/Daily_Business/2010/db1206/DOC-303264A1.pdf.

FCC Issues Citation to Chinese Company for Illegal Marketing Jammers

The Federal Communications Commission (FCC) has issued a citation to a Chinese company for illegally marketing in the United States a device that jams cellphones and GPS systems.

The cited company, Everbuying.com, is based in China's Shenzhen's Province, but its website was discovered by an agent from the FCC's Enforcement Bureau here in the United States. In browsing the website, the FCC agent observed a number of devices being marketed by the company as "jammer devices." The agent then placed an on-line order for a "Mini Cigarette Lighter Anti-Tracker GPS Jammer Blocker," which subsequently arrived by mail. Testing by the FCC confirmed that the device it received from the company jammed the GPS L1 frequency.

FCC regulations prohibit both the marketing and operation of such jamming devices in the United States. Importantly, in a footnote to the Citation issued to Everbuying.com, the FCC reiterated the responsibility of the seller to comply with applicable laws, and further affirmed that the posting of a notice on the website indicating that jammer devices may not be allowed in certain countries is an insufficient defense.

The complete text of the Citation against Everybuying.com is available at http://www.fcc.gov/Daily_Releases/Daily_Business/2010/db1206/DA-10-2295A1.pdf.

FCC Releases Decade of Data on High-Speed Internet Access

The Federal Communications Commission (FCC) has released its most recent report on access in the United States to high-speed Internet connections.

According to the Commission, the total number of high-speed connections (which are defined as connections that deliver services at speeds exceeding 200 kbps in at least one direction) have

increased at an average rate of 42% per year over the past decade, from 2 million connections in 1999 to 81 million connections at the end of 2009. During the same period, household adoption of high-speed Internet connections have increased from 3 connections per 100 households to 60 connections per 100 households.

Equally important as the increased penetration of high-speed Internet connections is the average downstream and upstream speeds reported. At the end of 2009, 30% of all connections provided download speeds of 6 mbps or greater, with an additional 12% of all connections providing download speeds of between 3 and 6 mpbs. But 58% of all connections still provide download speeds of less than 3 mpbs. And nearly half (49%) of all connections provide upstream speeds of less than 768 kbps.

In its report, the FCC notes that it has now been collecting, compiling and publishing data on the adoption of high-speed Internet connections for a full decade.

The complete text of the Commission's report on high-speed Internet access is available at http://www.fcc.gov/Daily_Releases/Daily_Business/2010/db1208/DOC-303405A1.pdf.

EU Commission Issues Revised Energy Labeling Requirements for Home Appliances

The Commission of the European Union (EU) has issued new regulations regarding the requirements for the energy labeling of a number of common household appliances and electronic devices.

The new energy labeling requirements were promulgated by the Commission in an effort to increase consumer knowledge about the actual energy consumption of comparable household appliances, thereby creating incentives for manufacturers to improve the energy efficiency of their respective products.

Four separate "Delegated Regulations," covering dishwashers, refrigerators, washing machines and television sets, were published in November 2010 in the *Official Journal of the European Communities*, and replace labeling requirements previously found in earlier energy labeling directives. The new labeling requirements come into effect beginning in late 2011.

The Commission's revised labeling requirements for dishwashers are available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:314:0001:0016:EN:PDF, for refrigerators at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:314:0017:0046:EN:PDF, for washing machines at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:314:0047:0063:EN:PDF, and for televisions at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:314:0064:0080:EN:PDF.

Hammer Drills Recalled Due to Potential Shock Hazard

The Robert Bosch Tool Corporation of Mt. Prospect, IL has announced the recall of about 20,000 of its Bosch-brand hammer tools manufactured in Switzerland.

The company reports that the recalled models have a grounding system and trigger switch that could cause ground wire abrasion and/or ground connector failure, posing a shock hazard to consumers. In addition, the switch trigger could become stuck in the "on" position, posing an injury hazard.

Bosch says that it has not received any reports of incidents or injuries associated with the recalled hammer tools, but has initiated the recall to prevent any such incidents in the future.

The recalled hammer tools were sold through home improvement, hardware and major retailers, as well as various distributors nationwide, from September 2009 through August 2010, for between about $140 and $220.

Additional details about this product recall are available at http://www.cpsc.gov/cpscpub/prerel/prhtml11/11051.html.

Company Recalls Digital Clamp and MultiMeters

Extech Instruments of Waltham, MA has recalled about 5100 digital clamp meters and multimeters manufactured in China.

According to Extech, the meters can fail to give an accurate voltage reading when the battery runs low, potentially misleading the operator to believe that the electrical power is off or low, and posing a potential electrocution hazard.

The company has received one report of a meter displaying an incorrect voltage reading, but no reports of injuries.

The recalled meters were sold through industrial and electrical distributors and wholesalers nationwide and through online tool and test equipment retailers, from January 2008 through November 2010, for between $150 and $300.

Additional information about this product recall is available at http://www.cpsc.gov/cpscpub/prerel/prhtml11/11067.html.

Wal-Mart Recalls Electric Heaters

Wal-Mart Stores Inc. of Bentonville, AK is recalling about 2.2 million of its Flow Pro, Airtech, Aloha Breeze and Comfort Essentials-brand heaters manufactured in China.

Wal-Mart reports that the heaters can malfunction, resulting in overheating, smoking, burning, melting and fire. The company says that it has received 21 reports of incidents, including 11 reports of property damage, as well as four reports of injuries, three of which required medical attention for minor burns and smoke inhalation.

The recalled heaters were sold at Wal-Mart stores nationwide from December 2001 through October 2009 for about $18.

Additional information about this product recall is available at http://www.cpsc.gov/cpscpub/prerel/prhtml11/11069.html.

UL Standards Updates

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

UL 6: Electrical Rigid Metal Conduit – Steel
Revision dated November 30, 2010

UL 462: Standard for Heat Reclaimers for Gas-, Oil-, or Solid Fuel-Fired Appliances
New Edition dated December 13, 2010

UL 496: Lampholders
Revision dated December 20, 2010

UL 499: Standard for Electric Heating Appliances
Revision dated November 30, 2010

UL 561: Standard for Floor-Finishing Machines
Revision dated November 30, 2010

UL 641: Standard for Type L Low-Temperature Venting Systems
New Edition dated December 13, 2010

UL 719: Standard for Nonmetallic-Sheathed Cables
Revision dated December 13, 2010

UL 746A: Standard for Polymeric Materials - Short Term Property Evaluations
Revision dated December 10, 2010

UL 746F: Standard for Polymeric Materials - Flexible Dielectric Film Materials for Use in Printed-Wiring Boards and Flexible Materials Interconnect Constructions
Revision dated December 8, 2010

UL 959: Standard for Medium Heat Appliance Factory-Built Chimneys
New Edition dated December 17, 2010

UL 963: Standard for Sealing, Wrapping, and Marking Equipment
New Edition dated December 15, 2010

UL 1004-7: Standard for Electronically Protected Motors
Revision dated December 3, 2010

UL 1004-3: Standard for Thermally Protected Motors
Revision dated December 10, 2010

UL 1180: Standard for Fully Inflatable Recreational Personal Flotation Devices
Revision dated December 3, 2010

UL 1322: Standard for Fabricated Scaffold Planks and Stages
Revision dated December 17, 2010

UL 1426: Standard for Electrical Cables for Boats
New Edition dated December 6, 2010

UL 1978: Standard for Grease Ducts
New Edition dated December 13, 2010

UL 2167: Standard for Water Mist Nozzles for Fire Protection Service
Revision dated December 16, 2010

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Standards Update: North American Low-Voltage Surge Protective Devices

by Matthew Wakeham

Perhaps the most recognized industry standard in North America for surge protectors may be UL 1449, the Standard for Safety for Surge Protective Devices ranging in applications from surge arresters (1000v ac max) to service entrance and distribution panels to plug-in surge strips. The standard was officially adopted as an ANSI standard in May 2010 and a supplement specific to the evaluation of Photovoltaic applications is expected in 2011. However, it is important to keep in mind that UL 1449 is first and foremost a safety standard. For more in-depth information regarding characterization of the surge environment, test methods and the application of these devices, the IEEE C62 standards are the definitive source in North America.

The IEEE Surge Protective Devices Committee (SPDC) meetings were held the week of November 8 in Clearwater, FL. The SPDC working groups meet twice every year in the Spring and Fall under the Power & Energy Society of the Institute of Electrical and Electronics Engineers (IEEE). Many engineers around the world use the standards contained in the C62 collection, therefore working groups continually strive for harmonization with complementary IEC standards in their efforts to expand and/or update standards development activities.

Often referred to as "a trilogy" concerning the occurrence, characterization and testing of surges in low-voltage ac power circuits, the following C62 standards published in 2002 provide a solid base of fundamentals on the subject:

C62.41.1 – IEEE Guide on the Surge Environment in Low-Voltage (1000V and Less) AC Power Circuits.

Engineers engaged in the surge protection industry are encouraged to participate in respective working groups to contribute in their areas of expertise. The tireless dedication of working group members has resulted in a comprehensive contribution to the field.

C62.41.2 – IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000V and Less) AC Power Circuits.

C62.45 – IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000V and Less) AC Power Circuits.

The responsible working group, WG 3.6.4 is presently developing a long term plan to keep these documents up to date with the latest developments and research papers in the field. The group is also responsible for C62.48, IEEE Guide on Interactions between Power System Disturbances and Surge Protective Devices.

This past year some exciting, new working groups have formed to keep up with trends specific to the power transmission and distribution industry. These groups are:

WG 3.6.11 – Protection Guide for Wind Generation Systems will develop guidelines for surge protective devices on electrical equipment and systems with voltages of 1000 V(ac) and 1200 V(dc) or less within a wind generation system. Included within this scope are communications and data acquisition equipment and associated circuitry and interfaces.

WG 3.6.12 – Protection for Photovoltaic Facilities will development test specifications and application guidance for surge protective devices on electrical equipment and systems with voltages of 1000 V(ac) and 1200 V(dc) or less within a photovoltaic facility or installation. It will also consider communications and data acquisition equipment and associated circuitry and interfaces.

WG 3.6.13 – Smart Grid Protection Guide will develop guidance for surge protective devices connected to electrical equipment and systems with voltages of 1000 V(ac) and 1200 V(dc) or less for components of the Smart Grid. Included within this scope are communications and data acquisition equipment and associated circuitry and interfaces. Additionally, there are cases, which involve smart grid equipment attaching or coupling to higher voltage circuits such as electric utility medium voltage distribution. This scope is not limited to providing guidance for such matters.

In addition, working group WG 3.6.6 has been quite busy expanding C62.62 (2000) IEEE Standard for Test Specifications for Surge Protective Devices for Low-Voltage AC Power Circuits. Revisions include modifications to previous tests and several new tests such as short-circuit current ratings, nominal discharge current and operating duty cycle, Another important revision is the formatting which now includes rationale, purpose, test procedure and setup, and expected results. It should also be noted that the document now clearly defines its scope for installations on the load side of the service equipment; IEEE C62.34 Standard for

Performance of LV SPDs/Secondary Arresters covers line side installations. Publication of the revised C62.62 standard is expected in 2011. This group is also working on expanding the 2007 version of the IEEE Guide for the Application of Surge Protective Devices for Low-Voltage (1000V or Less) AC Power Circuits; a useful guide to assist specification engineers on installation and coordination of SPDs in a facility.

Other activities of interest include WG 3.6.10 with development on draft C62.50, Standard for Performance Criteria and Test Methods for Plug-in, Multiport SPDs which include communication ports and associated ground equalization reference considerations. WG 3.6.7 is responsible for standards development in the communications field including C62.43, Application Guide for SPDs used in Data, Communications and Signaling Circuits.

On the discrete component side, WG 3.6.3 responsible for C62.42, the Guide for the Application of Component SPDs for use in Low-Voltage Circuits serves as a very useful resource to design engineers who employ gas discharge tubes, air gaps, metal-oxide varistors and avalanche diodes in end use products. These are components which correlate to a Type 5 SPD in UL 1449.

This summary offers just a very brief overview of the breadth of IEEE C62 SPD Standards. Engineers engaged in the surge protection industry are encouraged to participate in respective working groups to contribute in their areas of expertise. The tireless dedication of working group members has resulted in a comprehensive contribution to the field and it is encouraging to see the SPDC continue to update and expand existing standards; as well as create new standards projects to keep pace with emerging trends and technologies. For more information, please visit the SPDC website at http://grouper.ieee.org/groups/spd.

Matthew Wakeham is an independent consultant focused in the fields of power quality, energy management and electrical safety. He has held positions managing new product development groups, as well as a senior project engineer at Underwriters Laboratories. Matt is a member of the IEEE Power & Energy Society and participates on several SPDC working groups including Vice Chair for WG 3.6.13 Smart Grid Protection. He is also a voting member of the UL 1449 Standards Technical Panel for Surge Protective Devices. He has a B.S.E.E. and holds several U.S. patents. Matt can be reached at mwakeham@powernota.com or 212-877-9515.

The iNARTE Informer

Provided by the International Association for Radio, Telecommunications and Electromagnetics

GOODBYE TO AN OLD FRIEND

In December 2010, our long time colleague and administrator of the iNARTE EMC program in Japan, Teru Kawahara, retired from KEC. We were pleased to be able to visit him and present him with a certificate of Honorary Lifetime Membership.

Brian Lawrence and Teru Kawahara

WHAT'S NEW FOR 2011

One new thing that happened was that New Bern, NC did get a white Christmas this year, although somewhat late in the day. Not really "white" by the standards that many readers will have seen, but pretty good for us down here.

Looking forward to 2011, there are a number of really interesting things we are working on, some of which are too early in development to discuss, so be sure that you visit our web site regularly and also keep up to date here in *IN Compliance*.

- The 2011 schedule of ACLASS internal auditor training and iNCLA examinations will be published next month. Last year we visited the Atlanta and Chicago areas, so look for a different set of venues this year.
- The ESD Association will be offering a number of their **Essentials for ESD Programs** tutorials this year. This is a two day program that is a concentration of the most valuable information extracted from their traditional ten session tutorials. Each **Essential**s tutorial is accompanied by an iNARTE ESD Certification examination on the third day. The first of these events was held in Shenzhen, China in January, the next will be in Anaheim from February 8th to 10th. Follow the links at http://www.esda.org/index.htm#education to register.
- This year the Asia Pacific EMC Week, APEMC 2011, is on Jeju Island, off the south coast of South Korea, from May 16th to 19th. iNARTE will be there for the event and will offer a workshop, a trial examination and a full examination day at the end of the week. Attendees can register for any of the iNARTE examinations. Candidate training prior to the event will be offered by RAPA (EMC training) and CORE INSIGHT Inc. (ESD training).
- Closer to home we have the IEEE EMCS 2011 symposium in Long Beach, CA, the ESDA symposium in Anaheim and

the IEEE PSES symposium in San Diego. So, in the second half of the year you can spend time in the sunshine state, catch some rays and get iNARTE certified all in the same week.

- By the time of the IEEE EMCS 2011, from August 14th to 19th, iNARTE will be offering not only our traditional **EMC Engineer and Technician Certifications**, but also we should have the new **EMC Design Engineer Certification** program rolled out. After August, all candidates can register for this new credential and be examined at any of the above mentioned symposium events, or at any of the regular iNARTE Authorized Test Centers.

iNARTE CERTIFIED EMC DESIGN ENGINEER LEVELS

Last month, we introduced the concept of a new EMC Certification offering intended specifically for engineers working in electronics design fields as opposed to EMC testing areas. There has been a very enthusiastic response to the new program, and we are working hard to flesh it out and get it ready to offer in 2011. Here are the concepts and logistics of the program so far:

- There will be Certified EMC Design Engineers only, no Technician options will be offered.
- There will be three levels of Certification: Engineer, Senior Engineer, and Master Engineer
- Engineer level applicants should have a bachelors degree in an appropriate engineering or science discipline, but do not need work experience.
- Senior Engineer applicants should have the above credential and at least one year of working experience. Applicants holding a masters degree may be exempted from the work experience time.
- Master Engineer applicants should have Engineer credentials and three years of design working experience or a masters degree and two years experience.
- Certified Engineers can apply to upgrade as they gain experience.

As with all new iNARTE programs, there will be a twelve month "Grandfather" period, during which time experienced practitioners may apply for certification without examination. Such applications will need to be supported by verifiable references from three referees who have knowledge of the applicant's work.

THE DESIGN ENGINEER EXAMINATION

The EMC Design Engineer examination is proposed to consist of two Parts, each Part is required to be completed in three (3) hours. Part 1 will be compiled from questions considered to be basic technology. There will be 30 multiple choice questions in Part 1 and all 30 should be attempted. Part 2 will consist of 40 questions, some basic technology and some more specialized. Thirty of the forty questions in Part 2 should be attempted.

Passing levels will be an average of 70% between the two Parts.

Applicants will be required to compile two (2) new questions that iNARTE can use in future examinations. New questions will be reviewed for suitable depiction of current technology and practices before being accepted. Questions should be developed in one or more of the following categories:

- EMC/EMI Theory
- Mathematics of EMC
- Electronic Circuitry
- EMC and Printed Circuit Boards
- Methods of Communication
- Safety standards
- Laboratory Management
- EMI standards
- EMS Standards
- Measurement Techniques
- Countermeasures Techniques

Questions should be appropriate for examination at the level for which the applicant seeks certification and are preferred to be drawn from personal experiences rather than plagiarized from text books.

Next month we will start our 2011 series of "Questions of the Month" and we will feature questions that are suitable for inclusion in the new EMC Design Engineer program. ■

A Tall Tale: What's Luck Got to Do With It?

by Mike Violette

Rising above the tidal marshes of Southern New Jersey stands a red and white antenna tower shadowing a World War II era radio shack. The marsh was a simple mosquito nursery in the 40s when the first modest building—a cinder block foundation and stick-framed walls— was erected as part of a string of radio stations that formed a wartime network on the East Coast. German subs prowled the waters just off the shore of Cape May which hosted just a few houses and one general store with peeling gray paint and sway-back roofline.

The Army Signal Corps operated the station and for years the tower radiated Morse and Voice. During some of the worst of the Nor'easters that raked the coast, the link was an important shore-to-ship link—an invisible lighthouse warning ships away from the hungry shoals.

During the Cold War, the station was used for protection against another set of submarine threats: Russian nukes.

"High Frequency" or HF communications evolved to VHF and to UHF and over time, and with Walls crumbling and balances shifting, the location was no longer of strategic significance to the Army—not to mention the shift of terrestrial communications to geosynchronous networks 22,000 miles aloft the Jersey Shore in airless orbits.

Thus, the installation passed from public service to private industry. WEMC opened and UHF-TV radiators were strung to the top of the mast and the radio shack, modest in its wartime construction, was expanded to include a news and weather studio. Up-to-the-minute local scandals and meteorology were dispensed to the Atlantic City market 40 miles to the Northeast.

Things were fine, for a while.

The beach is a confluence of water, land and sky. In the dead of winter, the crucible of the elements is even more pronounced. The grey gloom at twilight is foreboding; sounds are muffled by the strong wind, stiff, lofting sand that cuts like icy glass against exposed skin. It is a stretch to imagine this being the same planet: comparing the frosty winter to the Sun-soaked summers (and why don't we get these jobs in June?). But in EMC, you often have to go where the work is. It is not always unpleasant—in the right company—and it's rarely boring, especially if you have a little luck.

That January we were called to investigate an interference problem. The "classic rock" programming from the station sharing the tower with the UHF-TV operator was spilling over into the audio and video of the local TV broadcast.

The signal modulated and wiggled the raster scan on the outbound video and in some conditions The Rolling Stones could be heard as a ghostly accompaniment to the nightly newscasts.

The TV station owned the tower and was getting ready to throw out the FM operator unless the problem was fixed. With real estate on transmit towers difficult to get (and some of the most expensive around), the radio station was desperate to fix the problem and keep on rocking the high rollers in nearby Sin City.

We arrived late in the day, cruising over from Lewes to Cape May, across the Delaware Bay. The wind cut the tops of the waves to a brisk chop during the ninety minute ride ferry ride. Arriving at the station, we were met at the door by the staff technician.

"I'm Lou." Not holding out his hand. He eyed us warily and a bit wearily. Lou was sixty, sixty-five, with a dark furrowed brow and a fierce look. About five-foot eight, compact, ex-Navy, with huge forearms covered with smeary black tattoos.

We offered our business cards; he took and pocketed them without a glance.

"You guys called by the radio station, eh?" Lou asked, motioning us to follow him inside. "Hmph, you're the fourth or fifth buncha guys to come and take a look. No one knows what to do about this and my bosses are ready to kick the rock and rollers off the tower."

"Follow me. I'll show you what the problem is," voiced with no enthusiasm.

We were lead into a room with a wall of monitors, just outside the control room—maybe six or eight TVs mounted on the wall. The five o'clock news was just airing and through the glass of the control room, we could see the news desk and the plastic-haired announcers, well into the breaking top stories.

"Take a look." The screen had a sheen of dark bars that pulsed—wide then thin—traveling slowly and rolling up and off the top of the screen.

"See that crap? And it's worse at high tide." He paused, reached up and rotated the knob on a monitor on the wall. He turned it up. Loud.

"Guess who is playing?" he shouted over the mash of announcer and R&R, singing along with the throbbing audio "You make a grown man cry…"

We looked at each other and shrugged. Lou turned the music down and we continued the tour, heading outside to look at the tower.

"This is all new." Lou said, exiting a back door and pointing skyward. The westering sun cut a long shadow of the mast across the marsh. We walked around the base of the tower. Several fat waveguides sprouted from the side of the building, snaking upwards. Arrays were hung at various heights along the 300' tall structure: microwave dishes, paging antennas, monopole emergency services. Near the top, the FM and TV antennas were aimed north and east, towards Gomorrah on the sea.

"This tower was recently installed, along with the FM antenna. Since then the TV signal has been trashed. And my bosses are PO'd."

"The FM array's at the very top. The TV just below it. We tried all kinds of stuff—even went so far as to separate them as much as possible. Nothing's helped." The wind rose and we gripped our coats tightly. "The FM station's been running at half-power. It helps a little, still the rock and roll doesn't go over too well with the advertisers."

Lou took us to the edge of the parking lot where the macadam dissolved into soft grasses and an inlet of water. "The old tower is over there." He motioned to the marshy scrub. "It blew over last year during Hurricane Floyd." We looked into the watery flats and here and there ribs and struts undulated above and into the flora, a long snaky skeleton.

What happened?

"Heh," Lou snorted. "When they installed the tower, oh about seven or eight years ago, they didn't seal the guy wires at their bases." He swept our attention towards the edge of the marsh where the long wires disappeared into the scrub. "Over time, the tides spilled enough water into the anchors, eventually corroding 'em. Floyd came in at 50 mph and phewww, pushed it right over." He shook his head. "Tore the waveguides right out of the building. We had to re-build almost the whole wall." He motioned back towards the station. "What a mess."

He looked over the marsh. "We spent four days trying to find the antennas, using thirty foot poles. They must'uve hit hard, 'cause they're in the muck for good." He paused "And, as they say, the old tower is now a man-made reef." He laughed. "Let's go inside, it's cold out here." We wondered if Lou was warming up to us.

"What do you guys want to see next?" We walked through the break room. Lou picked up a dark stained carafe of well-baked coffee and poured a cup. "Care for some? Sugar and white stuff on the counter."

We asked to see the control room. "Can't. Not 'til after the news. And tonight's a 'special segment'. We won't get in."

How are the cables routed? "Cables?! You want cables?!" Lou walked us into the back and motioned up. "Cables we got." We looked up. The ceiling looked like Medusa's hairbrush after a grooming. "Parts of this station are over fifty years old. Nothing's been taken out of here. When something breaks, we just run a new cable."

We looked at each other and suggested that we take some field measurements, at least to look useful until we could see some of the station's electronics.

"Do whatever you need to do. I'm on break 'til after the news." Lou left the room and headed back to the coffee pot.

We broke out the spectrum analyzer and bicon and made some measurements of the fields around the base of the tower. We verified that we could see the signal from the TV and, just for kicks, we identified the UHF signal. The levels were nominal, as I recall. We were certainly off-axis of the main beam, standing at the base of the tower. We figured that there was zero likelihood of anything happening between the antennas and any harmonics of 100 MHz would be greatly attenuated; besides, the frequencies didn't line up with the WEMC's UHF signal. The 100.7 MHz FM signal must be coupling into something in the station. We took the analyzer and a current probe inside and fiddled around with some Medusa's strands. Sure enough, there was plenty of common mode current—on everything.

It was, aside from Lou's curmudgeon-y character, a typical EMC job: Fix it, but don't do anything. We decided to break off and head into town for dinner and return the next day, hopefully with some ideas, or some magic, or some luck.

Wildwood in January is anything but wild and the shuttered shops and stores and deserted streets a bit disquieting, like after the Rapture or walking around Prypiat near Chernobyl, but with carvings of mermaids and fish in contrasting whimsy to the empty cold.

After dinner at the only open place (Suzanne's Family Restaurant, no ABC but setups are $5) and a very brief walk on the beach, we checked into the hotel and turned on the TV, tuning to WEMC. Sure enough, the screen wavered and throbbed and with the sound at high volume: clearly Tom Petty.

High tide? Why was it worse at high tide, we wondered.

The next day we figured out some semblance of strategy. The only way we could wrangle some time poking around the console, where the stuff was getting in, was when the station was off-the-air. We negotiated with the station to be down after midnight.

As evening fell, we went back to the station. Lou greeted us again, this time a little friendlier. "We got things set. At midnight, we'll shut things down and you guys can do what you want. The FM signal's still up. The TV's down."

My dad used to joke "It's doesn't matter if you're skilful or lucky, as long as you're effective." It turned out it was one of those lucky times. After pondering all the potential modes of coupling in the snakepit of conductors, we were shooting a little in the dark.

The glow of the klystron ebbed and the TV signal faded and we started poking around the patch panels, looking for a clue. Flashlight in-hand, we lay on our backs looking up into the naked side of one of the mixing boards. Lou, what's this wire?

"That's a feed into the panel." It was a simple twisted wire-pair, an aluminized-mylar type with a pigtail shield.

We clamped the current probe on the wire and measured the current, about 30 milliamps at 100.7 MHz.

The pigtail connection was about three inches long—a nice service loop—and was connected to a ground screw for the terminal board that, in turn had another few inches of 18 gauge (or so) wire running to a chassis screw. Norm used to say, too, that 'nothing is completely useless: it can always be used as a bad example.' Well, here was (another) one.

The impedance of any wire is equal to the Resistive plus Inductance terms according to the familiar $|Z| = |R + j\omega L|\ \Omega$ or $|R + j2\pi fL|\ \Omega$.

The inductance, from the *CRC Handbook*, is:

$$L = 2l[2.303\log(4l/d) - 1 + \mu/4 + (d/2l)]\ \text{nH}$$

Where l is the length of the wire and d is the diameter and μ is the permeability of free space (4π X 10E-7nH/m).

The 26 gauge "pigtail" has a diameter of 0.4mm and, doing the math, the inductance works out to about 88 nH.

At 100 MHz, the impedance, then (neglecting resistance) is $Z = 2*3.1415*88 \simeq 28\ \Omega$.

Assuming the current that we measured flows through the shielded "ground," the voltage is around V = IZ = 0.83 Volts! Pretty hefty and at 100 MHz freely coupling to the wires the shield was supposed to protect.

We grabbed the copper tape and shorted the shield to the chassis of the panel with a nice wide strap. The self-inductance of the strap much less than the skinny wire.

We told Lou to give it a try. He shrugged and he walked back to the transmitter room and lit the klystron (which wasn't off, just idling).

"Let's see what we get here." He flipped on the test pattern and looked at the monitors and was, for the first time all day, quiet.

He went over and flipped on the monitor for the FM station. "Whaaat's love got to do, got to do with it?…".

"It's gone. You fixed it."

Lou was all smiles. ■

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EMC in Military Equipment

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Military EMC design can be particularly vexing. Multiple environments combined with multiple threats lead to multiple requirements. The threat levels, and the resulting requirements, are usually more stringent than found in the commercial world.

As a result, commercial design techniques are often woefully inadequate for military applications. This can lead to frustration for those moving into military EMC from other areas. It can also lead to frustration to those wishing to use COTS (commercial off the shelf) equipment in military environments.

In this article, we'll explore some of the unique EMC challenges presented by military electronics, and how they differ from those of the commercial world.

MULTIPLE ENVIRONMENTS WITH MULTIPLE THREATS

Unlike commercial equipment, military systems may need to work in a wide range of environments. These can range from the arctic to the desert, and from the bottom of the ocean to outer space. Fortunately, most systems only need to operate in selected environments, rather than in every potential situation. This leads to subsets of requirements, and even tailoring in select cases.

Furthermore, military systems are often subjected to multiple threats. These threats are typically more severe than in commercial environments. Here are some examples of five general environments and their associated threats, and how they contrast with nonmilitary environments.

Fixed Land Based - This environment includes residential and office buildings. For commercial electronics, these are considered relatively benign in terms of EMC. As an aside, this is the primary EMC environment for most commercial electronics.

The emissions concerns are moderate, and are aimed at protecting nearby television receivers. The susceptibility concerns are a bit more challenging, and include threats such as RF (radio frequency) energy from nearby hand held radio transmitters, human ESD (electrostatic discharge), and power disturbances such as lightning or EFT (electrical fast transients.)

These same buildings on a military base, however, may pose much more severe conditions, particularly for radiated emissions and susceptibility. Both field levels and frequency ranges can be much higher than commercial environments. Due to radar systems, those frequencies can extend to 40 GHz or more, well above the typical 1 - 5 GHz upper limits for commercial equipment. Also, many military systems are designed to include protection against EMP (electromagnetic pulse) effects from nuclear weapons, which adds another level of complexity.

As such, commercial emissions requirements may not be adequate to protect nearby military communications receivers, which can be much more sensitive that a television receiver. Commercial susceptibility requirements may also be inadequate, due to radio and radar transmitters with higher radiated field levels, and EMP. The little bit of good news is that commercial levels for ESD and power disturbances are often still adequate.

Mobile Land Based - These environments include cars, trucks, buses, etc. Even for commercial vehicular electronics, these can be quite harsh. The emissions concerns are severe, and usually aimed at protecting entertainment radios (AM/FM), with secondary concerns for protecting land mobile

VHF/UHF radios. The susceptibility concerns are also severe, and include RF, ESD, and a range of power transients and other power disturbances unique to vehicles.

Military vehicles share these same concerns, but as with fixed systems, the frequencies and amplitudes may be well above commercial levels. Nevertheless, commercial vehicular electronics can be expected to do fairly well in military environments, but may need some additional protection for radar and EMP.

Due to their experience working with harsh environments, we've found that commercial vehicular EMC engineers often have a relatively easy time making the transition to military electronics.

Military EMC is different from commercial EMC. There are multiple environments to consider, with multiple threats. Those are usually much more severe than commercial threats.

Marine Based - These environments include large surface ships, submarines, and even smaller water craft. Ships with metal hulls have vastly different EMC concerns depending on whether the equipment is located above deck (outside) or below deck (inside.)

For both the military and commercial environment, emissions concerns are severe and are aimed at protecting communications and navigation receivers, including radar. Susceptibility concerns are also severe, and include RF and power disturbances. Since most military ships have multiple communications and radar transmitters, the levels and frequencies can be much higher than for commercial ships.

A classic tale of military EMC at sea was the sinking of the HMS Sheffield in the Falkland Islands War in 1982. It turns out there was a compatibility problem between the satellite communications and a defensive radar system. The "solution" was to disable the radar when communicating via satellite. Unfortunately, the launch of an enemy missile went undetected during one of these radar blackouts, and the ship was lost due to an EMC problem.

One bit of good news is that ESD is usually not a big concern for marine applications, due to high humidity conditions. A notable exception is helicopter ESD, which has resulted in special requirements for both helicopters and electronics equipment (and ordnance) that might be located near a helicopter landing pad. Lightning and EMP, of course, are major concerns for all military naval vessels.

Air based - These environments include all aircraft, and include small aircraft, helicopters, fighters, bombers, and more. Like ships, EMC concerns vary depending on whether the electronics are located inside or outside the aircraft. An emerging concern is the use of composite material rather than aluminum, which can affect overall shielding performance.

The commercial and military EMC environments are actually quite similar. In fact, the predominant commercial avionics requirements (RTCA DO-160) are derived from the military requirements (MIL-STD-461). The commercial requirements are even a bit more comprehensive, and include very specific lightning and power quality requirements.

Additional military concerns include HIRF (high intensity RF) and EMP. The former can come from radar exposure which may be quite high in a tactical situation, or as a weapons effect. ESD is also a big concern, particularly for helicopters transporting materials or munitions.

Magnetic field emissions are a unique concern for antisubmarine warfare (ASW) aircraft. One way of locating submarines is to look for low level magnetic field perturbations. The sub hunters need to maintain clean electronic environments so they can detect the perturbations.

Space - This is probably the most unique and varied of military environments. There has been very little commercial space electronics, although this may be starting to change. Nevertheless, we expect to see the commercial space designers closely follow military design practices.

Due to the expense of launching hardware into space, the EMC requirements are often highly tailored. Extensive engineering efforts are made to optimize (and not over design) for EMC. Extensive testing is performed to assure EMC is achieved. After all, if something doesn't work, it is almost impossible to fix (the Hubble telescope being one very expensive exception.)

Space electronics are subjected to several environments that must be considered. For example, during *pre-launch*, precautions must be taken to prevent damage due to human ESD. During *launch*, precautions must be taken to prevent damage due to triboelectric charging and also due to high RF

levels from tracking radar, etc. In a tactical situation, the RF may also include antimissile efforts. Once *on-orbit*, space electronics are subjected to "space charging," and also cumulative degradation from ionizing radiation present in space.

Another unique space requirement is "magnetic cleanliness." This is often a requirement for satellites that employ magnetometers for navigation. Even small magnetic fields, from either permanent magnetization or from power electronics, can interfere with the on orbit navigation. Of course, nuclear weapons effects (such as EMP and ionizing radiation) are a also a major concern for military space electronics.

MILITARY EMC REQUIREMENTS

These various environments and threats have resulted in specific EMC requirements. Although these have evolved over the years, we now have two major military EMC requirements, MIL-STD-461 and MIL-STD-464.

MIL-STD-461 is applied at the module (box) level. The current revision level is MIL-STD-461F, and should be applied to new procurements. Existing equipment may use earlier versions, so it is important to be sure you are using the correct version when dealing with updates or legacy systems.

MIL-STD-461F provides both recommended test levels and the test procedures for a number of different tests. These are divided into four broad categories:

CE - Conducted Emissions
CS - Conducted Susceptibility
RE - Radiated Emissions
RS - Radiated Susceptibility

These are further subdivided into specific tests, with a three number designator, such as RE101. As an aside, older versions of MIL-STD-461 (A,B, and C) used the same nomenclature but with two number designators, such as CS06. This distinction is important, as legacy systems may still be using the older versions of MIL-STD-461 for qualification purposes. For more details, see MIL-STD-461F, Table IV.

Note that not all tests are required for all equipment. Rather, different tests and different levels are recommended for various situations. These recommendations are based on anticipated environments and threats. For more details, see MIL-STD-461F, Table V.

Note that requirements may vary among the different services for similar equipment. For example, the electric field radiated emissions (RE102) differ for Army, Air Force, and some Navy aircraft. Since Air Force and most Navy aircraft rarely use radios below the 2 MHz, they have no recommended requirements at the lower frequencies, while the Army goes down to 10 kHz.

Special cases may deserve special attention. For example, Navy aircraft used for antisubmarine warfare extend their electric field emissions (RE102) down to 10 kHz. They also include magnetic field emission requirements (RE101) that are not recommended for other Navy aircraft. The reason is that hunting for submarines often means detecting low level magnetic fields at

TABLE IV. Emission and susceptibility requirements.

Requirement	Description
CE101	Conducted Emissions, Power Leads, 30 Hz to 10 kHz
CE102	Conducted Emissions, Power Leads, 10 kHz to 10 MHz
CE106	Conducted Emissions, Antenna Terminal, 10 kHz to 40 GHz
CS101	Conducted Susceptibility, Power Leads, 30 Hz to 150 kHz
CS103	Conducted Susceptibility, Antenna Port, Intermodulation, 15 kHz to 10 GHz
CS104	Conducted Susceptibility, Antenna Port, Rejection of Undesired Signals, 30 Hz to 20 GHz
CS105	Conducted Susceptibility, Antenna Port, Cross-Modulation, 30 Hz to 20 GHz
CS106	Conducted Susceptibility, Transients, Power Leads
CS109	Conducted Susceptibility, Structure Current, 60 Hz to 100 kHz
CS114	Conducted Susceptibility, Bulk Cable Injection, 10 kHz to 200 MHz
CS115	Conducted Susceptibility, Bulk Cable Injection, Impulse Excitation
CS116	Conducted Susceptibility, Damped Sinusoidal Transients, Cables and Power Leads, 10 kHz to 100 MHz
RE101	Radiated Emissions, Magnetic Field, 30 Hz to 100 kHz
RE102	Radiated Emissions, Electric Field, 10 kHz to 18 GHz
RE103	Radiated Emissions, Antenna Spurious and Harmonic Outputs, 10 kHz to 40 GHz
RS101	Radiated Susceptibility, Magnetic Field, 30 Hz to 100 kHz
RS103	Radiated Susceptibility, Electric Field, 2 MHz to 40 GHz
RS105	Radiated Susceptibility, Transient Electromagnetic Field

Source: MIL-STD-461F

low frequencies. In order to detect these fields, the local environment must be clean at those low frequencies.

There are two important philosophical differences between MIL-STD-461 and commercial requirements. First, MIL-STD-461 can be tailored as needed. Second, test failures can be waived. Of course, both require the customer to agree. We feel both of these options should be considered as needed, as they often yield good EMC systems engineering solutions.

One caveat on MIL-STD-461. It is not a guarantee of ultimate EMC, but rather it increases the overall probability of success. You still need to plug everything together and see if it works.

MIL-STD-464, the second common EMC requirement, is applied at the systems or platform level. This document supersedes a number of older documents, and addresses grounding, bonding, lightning, EMP, HIRF, and more. Since this requirement applies to the platform level, it is often of secondary concern to the box/module designer.

Unlike MIL-STD-461, the actual test methods are not well defined in MIL-STD-464. This makes sense, as these are platform requirements, and platforms can vary widely. But as a result, these requirements can be difficult if not impossible to validate at the box level.

In spite of the system emphasis, we have seen increasing attempts by the platform designers to "flow down" their system requirements to the box designer. Since systems level testing is not appropriate at the box level, the result is often a request for engineering analysis. This is certainly prudent early in the design, but should not be a substitute for testing later at the full system/platform level.

DESIGN SOLUTIONS – SYSTEMS ENGINEERING OVER CIRCUIT BOARDS

This is an area where commercial and military systems differ in their EMC approaches. Most commercial designs focus on circuit board design, and then apply shielding as needed. Military systems, however, take the opposite approach, emphasizing shielding (and other systems design issues) over the circuit boards.

We've seen this subtle difference cause frustration for designers moving from commercial to military electronics. We recall one young EMC engineer who was questioning why his new company even hired him. As he said, "All they worry about here is grounding, shielding, and cables. They aren't even using my circuit board experience." He felt much better after we assured him that his EMC experience was indeed very valuable – only the focus was different.

Most military systems are already in metal enclosures. Thus, shielding becomes a key EMC design approach. Furthermore, many military systems use embedded controllers, and don't need the latest and greatest speeds and raw performance. As a result, there is more emphasis on systems design, and less on circuit board design. (We still recommend good EMC circuit board design practices for military electronics.)

The systems design solutions often revolve around interfaces. These include the following:

Power - This is an *energy interface*. Design protection of this interface typically combines passive circuits (filters and transient protection) with active power supply circuits. The goal is to provide clean regulated output power under varying input conditions. Since the bandwidth for power is low, the input power wiring is often unshielded.

Signal - This is an *information interface*. Design protection of this interface typically includes a combination of passive circuits (filters and transient protection) with active I/O circuit design. Due to bandwidth requirements, filtering is often traded off with external cable shielding or even fiber optics. Thus, cables and connectors also become an important part of this interface, along with the specific I/O circuits.

Grounding - This is primarily a *safety interface*, but it also affects the power and signal interfaces. The primary strategy here is topology control. Single point grounds are preferred for low frequency circuits, such as analog sensors and input power. Multi-point grounds are preferred for high frequency circuits, such as digital and RF circuits. Hybrid grounding approaches (using capacitors and inductors to make grounding paths and connections frequency dependent) are often used when both types of circuits or threats are present.

Shielding - This is an *electromagnetic field interface*. This is usually bi-directional, and designed to contain internal electromagnetic fields (emissions) while providing protection against external electromagnetic fields (susceptibility.) Design strategies include metallic enclosures, and then sealing any penetrations or discontinuities with gasket, screening, and filters.

In addition to interfaces, risk management is an important aspect for EMC systems design. This is accomplished several ways:

Design reviews - Most military programs follow a detailed design procedure that includes formal design reviews at critical junctures. Additional design checkpoints may also be employed. We often recommend dedicated EMC reviews. These can be brief, yet can be helpful in uncovering potential EMC problems early in the design process.

Engineering tests and analysis - Many military programs depend on test and analysis throughout the design process to validate design approaches. We certainly encourage this.

Documentation - Most military programs have mandatory documentation requirements. These typically include an EMC Control Plan, and EMC Test Plan, and an EMC Test Report. All three are used to document the process, and as

TABLE V. Requirement matrix.

Equipment and Subsystems Installed In, On, or Launched From the Following Platforms or Installations	Requirement Applicability																	
	CE101	CE102	CE106	CS101	CS103	CS104	CS105	CS106	CS109	CS114	CS115	CS116	RE101	RE102	RE103	RS101	RS103	RS105
Surface Ships	A	A	L	A	S	S	S	A	L	A	S	A	A	A	L	A	A	L
Submarines	A	A	L	A	S	S	S	A	L	A	S	L	A	A	L	L	A	L
Aircraft, Army, Including Flight Line	A	A	L	A	S	S	S			A	A	A	A	A	L	A	A	L
Aircraft, Navy	L	A	L	A	S	S	S			A	A	A	L	A	L	L	A	L
Aircraft, Air Force		A	L	A	S	S	S			A	A	A		A	L		A	
Space Systems, Including Launch Vehicles		A	L	A	S	S	S			A	A	A		A	L		A	
Ground, Army		A	L	A	S	S	S			A	A	A		A	L	L	A	
Ground, Navy		A	L	A	S	S	S			A	A	A		A	L	A	A	L
Ground, Air Force		A	L	A	S	S	S			A	A	A		A	L		A	

Source: MIL-STD-461F

Legend:

A: Applicable
L: Limited as specified in the individual sections of this standard
S: Procuring activity must specify in procurement documentation

communications tools between the contractor and customers. Yes, we know that most engineers don't like documentation, but this is a very important part of the EMC systems design process.

MISSION SUCCESS TRUMPS COST

All this design effort, analysis, test, and documentation costs money, which can lead to complaints about $100 hammers or $400 toilet seats. In spite of carping by politicians, the extra costs are usually justified. Furthermore, since most military systems have relatively low volumes, there are fewer units over which to amortize the extra engineering and test costs.

Military equipment must operate as designed and when needed. Reliability is crucial. For example, you can't power down or push the reset button on a missile or torpedo after it has been launched. Furthermore, you don't want them turning around and coming back home.

The true bottom line is not cost, but mission success. Remember, lives are often at stake. Our servicemen and women who go in harm's way deserve the absolute best engineering we can deliver – EMC and otherwise!

CONCLUSIONS

1. Military EMC is different from commercial EMC. There are multiple environments to consider, with multiple threats. Those are usually much more severe than commercial threats.
2. Complex military systems require systems engineering approach. The focus is often on interfaces, rather than on circuit boards. Design reviews and documentation are critical to keep everyone in the loop and on schedule.
3. Mission success trumps costs, and reliability is key. ■

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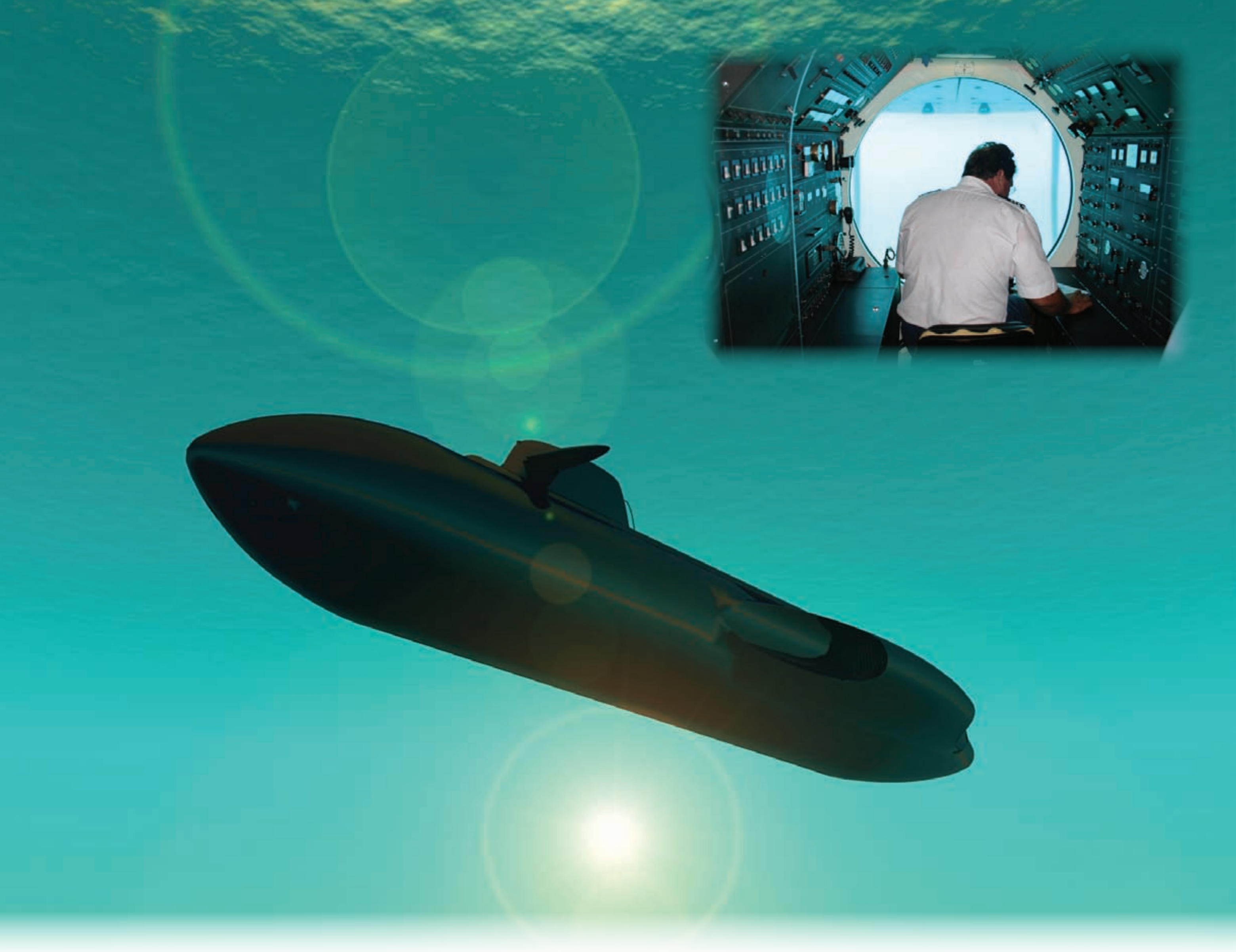


MIL-STD-464C

A Review of the Latest Revisions to the Standard

Part 3

by Ken Javor, EMC Compliance

AUTHOR'S NOTE

Due to problems in the digital publishing process, MIL-STD-464B 01 October 2010 is scrapped and MIL-STD-464C, release date 01 December 2010, will take its place. There are no technical changes from what are described in this three part article, but the replacement for MIL-STD-464A will be MIL-STD-464C. MIL-STD-464B dated 01 October 2010 will cease to exist.

This is the last in a three part review of the newly released MIL-STD-464C, "Electromagnetic Environmental Effects Requirements for Systems." The following is a summary of Parts 1 and 2 of the review, then on to new material.

MIL-STD-464 is the DoD top-level E3 requirement set for procurement of complete or modified systems. "Systems" meaning an integrated platform of one type or another, such as a ground or air vehicle, a ship or submarine, a spacecraft or launch vehicle. Note that some systems can be parts of other systems, such as an F-18 fighter aircraft that operates from an aircraft carrier.

MIL-STD-464C is the latest in a long line of standards that goes back to at least MIL-I-6051, Interference Limits and Methods of Measurement; Aircraft Radio and Electronic Installations, released in 1950. The -6051 series culminated in MIL-E-6051D, Electromagnetic Compatibility Requirements, Systems, released in 1967 and used until MIL-STD-464 replaced it in 1997.

The A & C revisions of MIL-STD-464 amend the original release, but are evolutionary, not revolutionary, changes. MIL-STD-464C has many changes, so many that the new Section 6.8, "Changes from Previous Issue" states, "Marginal notations are not used in the revision to identify changes with respect to the previous issue due to the extensiveness of the changes." However, there are no major departures from MIL-STD-464A. There are some additional requirements, and changes to environment definitions, but the overall standard has the same look and feel and if readers have worked with MIL-STD-464A, they will be right at home with the "C" revision. In fact, the changes are subtle and buried enough that the point of this review is to flag things that might not leap out at the reader at first glance. This review functions as the non-existent "marginal notations."

Aside from the contractual aspect of being the E3 discipline procurement standard, the appendix of MIL-STD-464C continues to be where the really good lessons-learned type information may be found. The appendix has been significantly revised. For each main body change identified in the article, the reader is well-advised to seek out the corresponding Appendix section(s).

Part 1 of the review gave a broad-brush treatment to what was new in the standard, the high power microwave requirement and the co-located systems compatibility requirement and then went through Section 3 definitions and listed all the changes.

Part 2 continued with Section 4, General Requirements, and Section 5, Detailed Requirements, through Section 5.3, Electromagnetic Environment Tables. This last part of the review begins with Section 5.4, the new High Power Microwave Requirement.

And now, a section-by-section summary of changes. Only changed sections are listed. In the list that follows, the bold section number is for MIL-STD-464C. If the section number is the same as it was for MIL-STD-464A, then it only appears once. If the number is different, then the -464A number appears after it in parentheses.

Section 5.4 is the High Power Microwave sources section. The requirement is only applicable if specifically invoked by the procuring activity. The requirement is very high level and very succinct. Much supporting information is to be found in the appendix.

Section 5.5 (5.4) Lightning Table VII (-464A Table 2A) adds a new component called A_h, Transition zone first return stroke. The new component is described: "NOTE: Current Component A_h is applicable in the Transition Zone 1C and represents the estimated shape of the first return stroke (Component A) at higher altitudes." The old Table 2B is now Table VII, with no other changes to it. Figure 1 has separate expanded scale lightning component waveforms.

Section 5.6 (5.5) EMP requirement is unchanged, but there is a change in the appendix. The following -464A A5.5 paragraph has been deleted from -464C: "EMP protection should be implemented for selected military systems. Many systems do not have a specific need expressed in their operational requirements for the EMP environment. In these instances, EMP requirements should not be imposed, since protection and verification can merely add unnecessary acquisition costs."

The effect of removing this paragraph is to make expensive and potentially heavy/massive EMP protection more routine than previously. The intent of the deleted paragraph was to impose EMP protection only on systems where careful evaluation of strategic concerns demonstrated the necessity.

Section 5.7 (5.6) Subsystems and equipment electromagnetic interference (EMI) requirement is unchanged, but the following new statement appears in the appendix: "For aircraft applications where equipment verification has not been completed prior to first-flight use on the aircraft, the following MIL-STD-461 (or equivalent) testing should be completed

-464C **TABLE IX Maximum external EME levels for ordnance** vs. -464A **TABLE 3A. External EME for HERO**

Frequency Range		Field Intensity (V/m – rms)			
		Unrestricted		Restricted **	
(MHz)	(MHz)	Peak	Avg	Peak	Avg
0.01	2	200/70	200/70	80/70	80/70
2	30	200	200	100	100
30	150	200/90	200/61	80/50	80/50
150	225	200/90	200/61	70/90	70/61
225	400	200/70	200/70	100/70	100/70
400	700	2200/1940	410/260	450/1500	100
700	790	700/290	410/95	270/290	270/95
790	1000	2600/2160	490/410	1400/1500	270/100
1000	2000	6100/3300	600/460	2500	160/200
2000	2700	6000/4500	500/490	490/2500	160/200
2700	3600	27460*	2620*	2500	220
3600	4000	8600/9710	280/310	1900/2500	200
4000	5400	9200/7200	660/300	650/2500	200
5400	5900	9200/15970	660/300	6200/2500	240/200
5900	6000	9200/320	270/320	550/320	240/200
6000	7900	4100/1100	400/390	4100/1100	240/200
7900	8000	550/860	400/860	550/860	200
8000	8400	7500/860	400/860	1100/860	200
8400	8500	7500/390	400/390	1100/390	200
8500	11000	7500/13380	910/1760	2000/2500	300/200
11000	14000	7500/2800	680/390	3500/2500	220/200
14000	18000	8700/2800	680/350	8700/1500	250/200
18000	40000	2900/7060	580/420	2800/1500	200
40000	45000	2900/570	580/570	2800/200	200
45000	50000	2900/*	580/*	2800/*	200/*

NOTES:

* The EME levels in the table apply to ship launched ordnance that will traverse the main beam of systems in the 2700 to 3600 MHz frequency range on surface combatants. For all other ordnance, the unrestricted peak EME level is 12667 V/m and the unrestricted average level is 1533 V/m.

** In some of the frequency ranges for the "Restricted Average" column, limiting the exposure of personnel through time averaging will be required to meet the requirements of 5.9.1 for personnel safety.

-464C values first, -464A values second, where different.
*Color coding: Red fill means level has increased. Yellow fill means change is less than 1 dB, either higher or lower, and blue fill means -464C level is lower than for -464A. * means no emitters in that frequency range.*

prior to flight to ensure flight safety: RE102, RS103, CS114, CS115, and CS116 for safety-critical equipment and RE102 for all other equipment."

Section 5.7.2 (5.6.2) The requirement rationale appendix is augmented from that in -464A.

Section 5.8 (5.7) ESD adds wording relating to duding, which did not exist in -464A. This is also reflected in the appendix.

Section 5.8.1 (5.7.1) adds applicability to "any man portable items that are carried internal to the aircraft." It also adds extra information defining the ESD "gun" used to verify performance.

Section 5.8.2 (5.7.2) Precipitation Static adds the following quantitative requirement: "The system shall protect against puncture of structural materials and finishes and shock hazards from charge density of 30 uA/ft^2 (326 uA/m^2)." Given that number, and the area over which that current density is deposited, a design solution in terms of bonding resistance for static wicks can now be determined.

Section 5.8.3 (5.7.3) Ordnance subsystems. Compliance verification, in addition to MIL-STD-331 which is referenced in both standards, now also refers to AECTP 500, Category 508 Leaflet 2 for ordnance. Description of the actual "ESD gun" is amended to add an NTE inductance of 5 uH. Gun capacitance and discharge resistance remain unchanged.

The -464C rationale appendix verification guidance section 5.8.3 is slightly rewritten from the corresponding -464A A5.7.3 verification guidance section.

Section 5.8.4 Electrical and electronic subsystems (new in -464C). "Systems shall assure that all electrical and electronic devices that do not interface or control ordnance items shall not be damaged by electrostatic discharges during normal installation, handling and operation. The ESD environment is defined as an 8kV (contact discharge) or 15 kV (air discharge) electrostatic discharge. Discharging from a 150 picofarad capacitor through a 330 ohm resistor with a circuit inductance not to exceed 5 µH to the electrical/electronic subsystem (such as connector shell (not pin), case, and handling points). Compliance shall be verified by test (such as AECTP 500, Category 508 Leaflet 2)."

There is supporting new rationale appendix material in Section A5.8.4.

Section 5.9.3 (5.8.3) Hazards of electromagnetic radiation to ordnance (HERO). The section has been augmented. "Electrically initiated devices (EIDs) in ordnance shall not be inadvertently actuated during or experience degraded performance characteristics after exposure to the external EME levels of Table 3A for both direct RF induced actuation of the EID and inadvertent activation of an electrically powered firing circuit. Relevant ordnance phases involving unrestricted and restricted levels in Table IX (old Table 3A) are listed in Table X (old Table 3B). In order to get a HERO classification of "HERO SAFE ORDNANCE" at the all-up round or appropriate assembly level, the ordnance or system under test (SUT) must be evaluated against, and be in compliance with, Table IX. Compliance shall be verified by test and analysis using the methodology in MIL-HDBK-240."

Table IX (3A) is modified (see page 28).

The rationale appendix section is extensively revised.

Section 5.14 (5.13, expanded) System Radiated Emissions. Includes old 5.13 EMCON section (unchanged), but adds a new 5.14.2 Inter-system EMC as described at the beginning of this review. "Unintentional radiated emissions from overall Army tactical ground vehicles shall be controlled such that antenna-connected receivers located in nearby Tactical Operation Centers (TOCs), vehicle convoys and other systems meet their operational performance requirements. Compliance shall be verified by test and analysis."

The supporting rationale appendix section is completely revised with a great deal of explanatory material for 5.14.2.

Section 5.15 (5.14) EM spectrum supportability renamed from the previous 5.14 Spectrum Compatibility. Slight rewording. The supporting rationale appendix material is extensively revised. ■

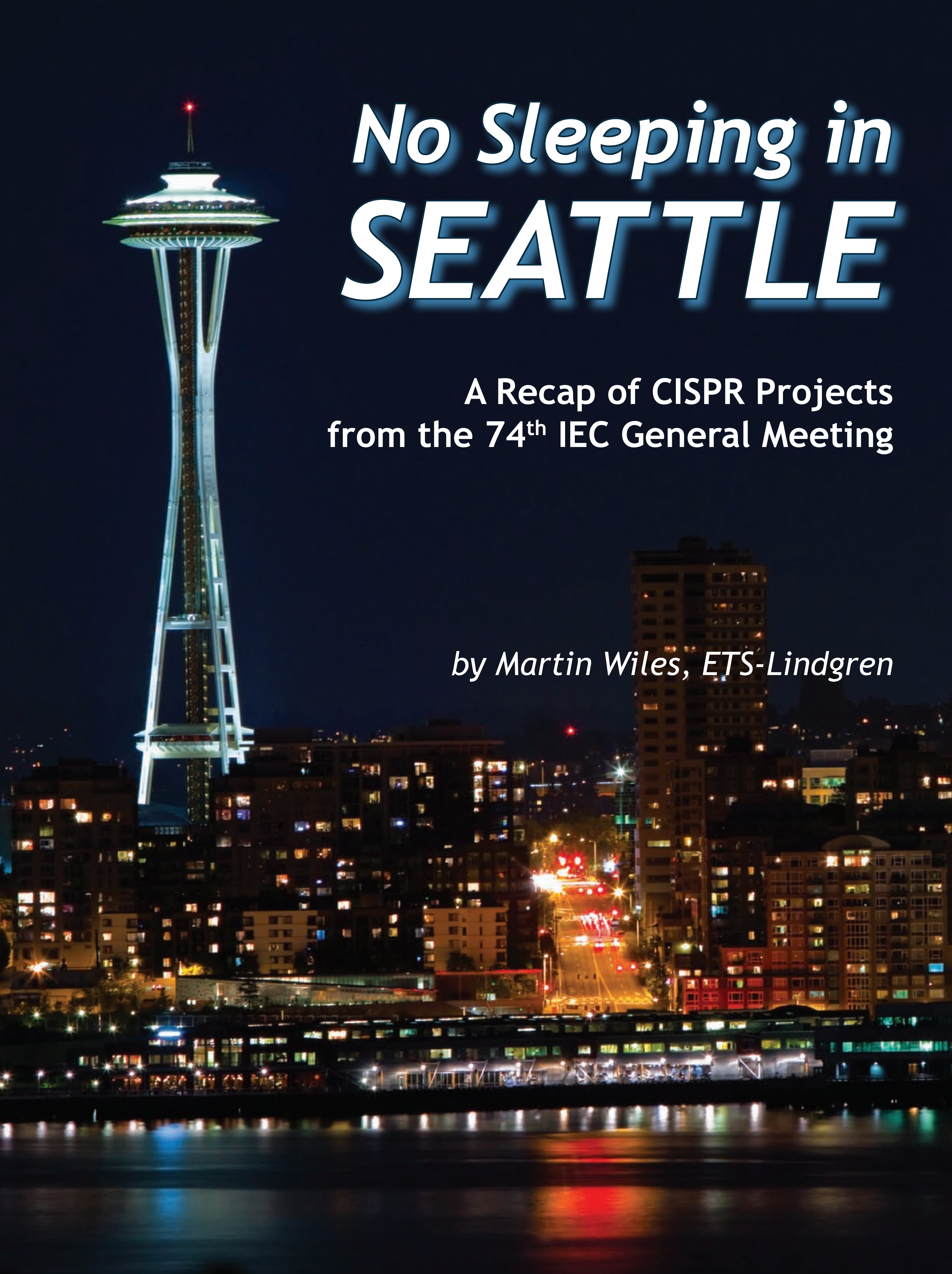
ABOUT THE AUTHOR

Ken Javor *has worked in the EMC industry for thirty years. He is a consultant to government and industry, runs a pre-compliance EMI test facility, and curates the Museum of EMC Antiquities, a collection of radios and instruments that were important in the development of the discipline, as well as a library of important documentation. Mr. Javor is an industry representative to the Tri-Service Working Groups that write MIL-STD-464 and MIL-STD-461. He has published numerous papers and is the author of a handbook on EMI requirements and test methods. Mr. Javor can be contacted at ken.javor@emccompliance.com.*

No Sleeping in SEATTLE

A Recap of CISPR Projects from the 74th IEC General Meeting

by Martin Wiles, ETS-Lindgren



October 2010 saw the 74th IEC General meeting in Seattle, Washington, USA. Within the IEC, its special committee CISPR (Comite International Special des Perturbations Radioelectriques –International Special Committee on Radio Interference) came together and this article reviews some of the key projects discussed at that meeting. The activities of IEC TC 77, a parallel committee to CISPR developing the IEC 61000 series and of equal importance, did not meet in Seattle and hence will not be discussed here except for the JTFs (Joint Task Forces) that exist in common with CISPR Subcommittee A, responsible for the basic standard CISPR 16, which will be the main focus of this first part of a two part article. In the second part of the article (to be published in a subsequent edition of this magazine), we will continue with the CISPR product standards and the Joint Task Forces (JTFs) existing between the different subcommittees as well as between CISPR subcommittees and IEC SC 77 B.

CISPR ORGANIZATION

Before we take a detailed look at the current projects of CISPR, we need to briefly explain the system and the process for those not fully acquainted with it. Standardization can at first appear complicated and it is not unusual to take several years before becoming completely familiar with it. It is a common belief that since the IEC is based in Geneva, Switzerland, CISPR standards are European. However, CISPR standards are in fact applied globally, and are developed by experts from around the world. Participants in standards development need to be technical experts and require being nominated by their respective National Committees (NCs) to particular CISPR subcommittees and working groups based on their expertise or interest. Some experts come from manufacturing companies focusing on the impact of CISPR standards on their products, some from test laboratories monitoring measurement standards, some from regulatory authorities implementing CISPR standards by law, and some from national metrology (testing and calibration) laboratories.

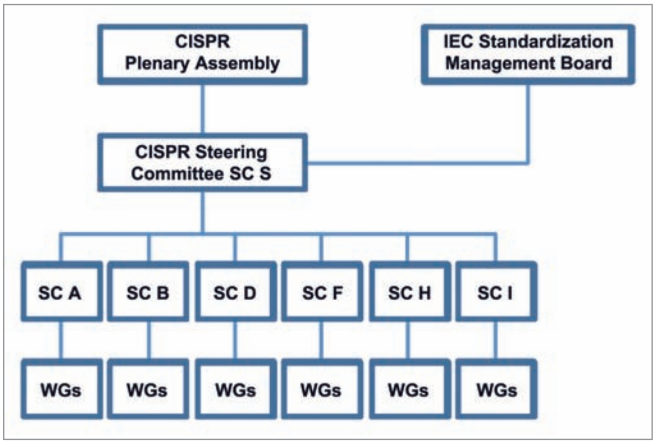


Image courtesy of ETS-Lindgren

Figure 1: CISPR Organization

The committee consists of sub-committees that fulfil both product (vertical) and basic (horizontal) standardization roles:

- **CISPR A** - Radio-interference measurements and statistical methods
- **CISPR B** - Interference relating to industrial, scientific and medical radio-frequency apparatus, to other (heavy) industrial equipment, to overhead power lines, to high-voltage equipment and to electrical traction
- **CISPR D** - Electromagnetic disturbances related to electric/ electronic equipment on vehicles and internal combustion engine powered devices
- **CISPR F** - Interference relating to household appliances, tools, lighting equipment and similar apparatus
- **CISPR H** –Limits for the protection of radio services
- **CISPR I** - Electromagnetic compatibility of information technology equipment, multimedia equipment and receivers
- **CISPR S** - Steering Committee of CISPR that manages its operation

All projects fall into one of two categories: new projects or maintenance of existing standards.

A new standardization project will follow this route:

- NP (New Project)
  - New Projects are generally started after an NP document has been circulated to the National Committees (NCs) and agreed by the simple majority of the permanent members of the Subcommittee (SC). At that time, at least five NCs must each identify one expert to serve on the project for the vote to be successful. A successful NP is then assigned a project number by the IEC Central Office and the subcommittee allocates it to one of its working groups (WGs) with a project leader for action. The project will be given a maximum of five years to publish an international standard. If this is not possible, it can be reset to stage zero (not active).
- 1st CD (Committee Draft)
  - A CD is produced by a working group within the subcommittee and once ready it is sent out to National Committees for comment. This is a three month process.
- CC Comments
  - The comments of the National Committees are collected and the Working Group is tasked with resolving the comments and then updating the CD accordingly if the comments require changes.
- 2nd CD
  - A second (third or fourth are possible) CD may be produced and commented again or if the working group feels that it is mature enough to go to voting then they

can submit a request to the subcommittee to authorize it to go out for vote as a CDV.

- CDV (Committee Draft for Vote)
  - A CDV will be sent out to National Committees for comment and vote.
  - A positive vote can lead to a final draft international standard (FDIS); a negative vote usually sends it back to the WG to produce another CDV taking into account the comments that caused the vote to fail.
- RVC (Result of Voting with Comments)
  - National Committee voting is summarized in this document and the decision on the next stage given. Comments can be attached to the votes by National Committees in which case the document is an RVC.
  - The draft will go directly to publication if the vote on the CDV is 100% approved.

CISPR 16-1-1	Measuring apparatus
CISPR 16-1-2	Ancillary Equipment - Conducted disturbances
CISPR 16-1-3	Ancillary Equipment - Disturbance Power
CISPR 16-1-4	Ancillary Equipment - Radiated Disturbances and immunity measuring apparatus - Antennas and test sites for radiated disturbance measurements
CISPR 16-1-5	Antenna calibration test sites
CISPR 16-1-6	EMC antenna calibration **Note:** This document is being prepared and is not yet published.
CISPR 16-2-1	Conducted disturbance power
CISPR 16-2-2	Measurement of disturbance power
CISPR 16-2-3	Radiated disturbance measurements
CISPR 16-2-4	Immunity measurements
CISPR 16-2-5	In situ measurements for disturbing emissions produced by physically large equipment
CISPR 16-3	CISPR technical reports
CISPR 16-4-1	Uncertainties in standardized EMC tests
CISPR 16-4-2	Measurement instrumentation uncertainty
CISPR 16-4-3	Statistical considerations in the determination of EMC compliance of mass
CISPR 16-4-4	Statistics of complaints and a model for the calculation of limits
CISPR 16-4-5	Uncertainties, statistics and limit modeling - Conditions for the use of alternative test methods

Table 1: CISPR 16 Publication Structure

- RVD (Result of Voting)
  - The standard will be published if not more than one quarter of the votes cast are negative.
- FDIS (Final Draft International Standard)
  - The FDIS will be circulated for comment if the CDV had less than 100% approval; this is a two month process.

Once a standard is published, it is said to be in its stability period and amendments can be published after this period expires. Maintenance will take place on the standard automatically after three years, although it can be started earlier or later but not more than five years. After two amendments, if a third amendment is produced, then all amendments will be combined together and a new edition of the standard will be published.

BASIC STANDARDS

CISPR SC/A provides basic standards to CISPR product committees as well as to other IEC technical committees for use in determining conformity to limits.

Standard: CISPR 16

Specification for radio disturbance and immunity measuring apparatus and methods.

Working Groups

- WG 1 - EMC instrumentation specifications
- WG 2 - EMC measurement techniques, statistical methods and uncertainty

Joint Task Forces with other CISPR SCs developing standards

- SC A/D/ -SITE-VAL - Chamber validation methods
- SC A/F - CDN measurement method of radio frequency disturbances for lighting equipment in the frequency range 30 MHz to 300 MHz
- SC A/H - Maintenance of CISPR 16-4-5 on conditions for the use of alternative test methods
- SC A/I – Placing testing and instrumentation from CISPR 13 and 22 into Pub 16 and referencing Pub 16 without repeating it in SC I documents

Joint Task Forces with TC 77 SC77B

- TC 77/SC 77B/JTF REV on Reverberation Chambers
- TC 77/SC 77B/JTF TEM on TEM Waveguides
- TC 77/SC 77B/JTF FAR on Fully Absorber-lined Rooms (FARs)

Table 1 shows how the CISPR 16 standard is structured.

CISPR 16-1

CISPR 16-1-1 Ed 3.0 Measuring Apparatus

Use of Spectrum Analyzers

CISPR 16-1-1 has been revised and has added the use of spectrum analyzers without pre-selection for compliance measurements. The RMS/Average detector has been introduced and is of interest particularly for the protection of digital radio services.
Status: Published January 2010

Inclusion of FFT-based Test Instrumentation

The addition of Fast Fourier Transform (FFT)-based measuring instrumentation brings the possibility of reducing test time for emission measurements. This is done by taking the time domain emission response, use of the FFT and then comparing the amplitudes to the limits which are in the frequency domain. In particular, there will be significant advantages for pre-scan due to better coverage of maximization procedures, turntable and antenna height scan, better probability of intercept, and where non Quasi-Peak measurements are allowed. Final measurements, however, will probably better be left to conventional methods where true Quasi-Peak compliance can be obtained.
Status: Published January 2010

CISPR 16-1-2 Ed 3.0 Ancillary Equipment – Conducted Disturbances

JTF CIS/A -I; Transfer of AAN (Asymmetric Artificial Network) characteristics from CISPR 22

The JTF CIS/A-/F was established in 2008, tasked with transferring the CDN (Coupling Decoupling Network) method of emission measurement in the frequency range 30 MHz to 300 MHz, currently limited to lighting equipment in CISPR 15, to CISPR 16 with the goal of applying the methods to other types of equipment.

The JTF has developed specifications and measurement methods for a CDNE ("E" stands for a CDN for Emission testing), the CDN for Emission measurement. A draft will introduce and define the CDNE in CISPR 16-1-2. Subsequent drafts will follow for the measurement method in CISPR 16-2-1 and measurement uncertainty in CISPR 16-4-2.
Status: Being discussed within WG1

CISPR 16-1-4

Specification for radio disturbance and immunity measuring apparatus and methods – part 1-4: radio disturbance and immunity measuring apparatus – Antennas and test sites for radiated disturbance measurement. Ed. 3 – 2010.

Evaluation of Setup Table

The impact of the setup table on EUT emissions can be measured and included in the uncertainty budget, also now above 1 GHz in CISPR 16-1-4 Ed 3.0. The move above 1 GHz now requires more focus on the materials used for these tables and as a result, the use of lower permittivity materials is needed if the test shows a significant effect of the table top material. (See Figure 2.)
Status: Published April 2010

CISPR 16-1-4 Reference Site Method

CISPR 16-1-4 (and also 16-1-5) will be amended for the introduction of the Reference Site Method which offers an improvement on the method of validation of compliance test sites through the use of the A_{APR} Antenna Pair Reference. A few definitions before we explain Antenna Pair Reference.

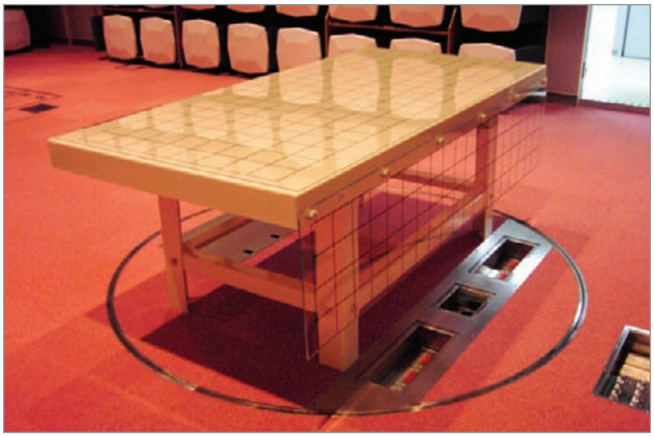


Image courtesy of ETS-Lindgren

Figure 2: CISPR 16-1-4 set up table

Three methods of site validation and the antennas used to show validation are described in CISPR 16-1-4:

- Tuned dipoles - Normalized Site Attenuation Method (NSA) up to 1 GHz
- Broadband antennas - Normalized Site Attenuation Method (NSA) up to 1 GHz
- Broadband antennas - Reference Site Method (RSM) up to 1 GHz

Table 2 identifies the site validation methods that are applicable for specific test sites.

There is currently a joint amendment of CISPR 16-1-5 with the RSM project defining the following sites:

- An **OATS** is an open area test site with a metallic ground plane. (See Figure 3.)
- A **CALTS** is an antenna calibration test site using an open area test site (OATS) with a metallic ground plane and a tightly specified SA (Site Attenuation) performance in horizontal electric field polarisation only. A CALTS can be used to determine the FSAF (Free Space Antenna Factor) of an antenna.
- A **REFTS** - Reference Test Site - is defined by CISPR 16-1-5 as an OATS with a metallic ground plane and a tightly specified SA performance in horizontal and vertical electric field polarizations.
- A **COMTS** is defined as a compliance test site which is used for the demonstration of compliance to radiated emission limits.

The antenna pair reference site attenuation A_{APR} is a set of site attenuation measurement results for both vertical and horizontal polarizations that uses a pair of antennas separated by a defined distance on a REFTS, with one antenna at a specified fixed height above the ground plane and the other antenna scanned over a specified height range, over which the minimum insertion loss (maximum received signal from the transmitting antenna) is recorded.

	Site Validation Method		
Test Site Type	Tuned Dipoles NSA 30 MHz to 1 GHz	Broadband Antennas NSA 30 MHz to 1 GHz	Broadband Antennas RSM Above 30 MHz
OATS (open area test site)	X	X	X
OATS with weather protection		X	X
SAC (semi anechoic chamber)		X	X
FAR (fully absorber lined room)		X	X

Table 2: Site validation methods applicable to various types of test sites

The advantage of the A_{APR} is that it includes the antenna factors as well as the coupling of each antenna to the ground plane and the coupling between the antennas. In addition, the radiation patterns of the antennas are included as compared to the NSA method where the radiation patterns are approximated Hertzian dipoles.

Assuming the reader is familiar with the NSA approach, there are two different ways of obtaining the antenna pair reference site attenuation as shown below:

1. **REFTS**
   Use a REFTS according to CISPR 16-1-5 (see next section). Identical positions on the REFTS should be used for A_{APR} determination as were used for the REFTS validation according to CISPR 16-1-5.

2. **Averaging Technique**
   On a large OATS, deviations of the site attenuation from the ideal behavior are caused by the limited area and flatness of the ground plane and reflections from objects in the near vicinity such as buildings and trees. The OATS must meet 16-1-5 construction conditions, in which the recommended ground plane is of minimum size 20 m by 15 m and flatness less than +/-10 mm.

   A sinusoidal ripple is created in the measured site attenuation, mainly in vertical polarization due to reflections from the edges of the ground plane. The magnitude and the location of the ripple will also change if the location of the antennas on the ground plane is changed.

   The site attenuation is measured at several locations to minimize these effects and an average value is calculated. This average value will converge to the site attenuation of an ideal site.

   Measurements are carried out at multiple locations, in a form of a mapping, around the prospective reference site at 3 and/or 10m and the standard deviation between the measurements sets is compared. (See Figure 4.) If the standard deviation of the results in both horizontal and vertical polarizations is below the stated limit, then the site can be used as a reference site.

   Round robin tests have already given valuable input and several papers presented in the last CISPR A meeting show good correlation between the RSM and NSA methods.

The method has been published in both standards as an amendment at the end of 2010.

Status: CISPR 16-1-4 amd1 Ed. 3.0 Publication December 2010
Status: CISPR 16-1-5 amd1 Ed. 1.0 Publication December 2010

CISPR 16-1-4 Radiated Emission Methods above 1 GHz

Very recently, some concerns have been raised about the problems of performing chamber validations according to CISPR 16-1-4 and radiated emission product tests according to CISPR 16-2-3 for large equipment above 1 GHz. Issues highlighted include the significant quantities of floor absorber required at distances greater than 3 m (Figure 5), the enormous logistics of such a configuration that can mean raising large and heavy equipment off of the floor and the fact that no product standard currently has emission limits other than at 3 m above 1 GHz. The current generic standards IEC 61000-6-3 and IEC 61000-6-4 include emission limits from 1 to 6 GHz at 3 m, but state that emissions may be measured at greater distances with the limits decreased by 20dB/decade (relative to distance) with SAC and OATS facilities requiring absorber to achieve free space conditions as defined in CISPR 16-1-4. The basic standard CISPR 16-1-4 does not specify a test distance for the chamber validation

Image courtesy of ETS-Lindgren

Figure 3: Example of an outdoor test environment, an open area test site (OATS) for antenna calibration testing per CISPR 16-1-4 and CISPR 16-1-5 using a metallic ground plane. This ground plane is constructed of all welded steel with dimensions 80 m x 50 m.

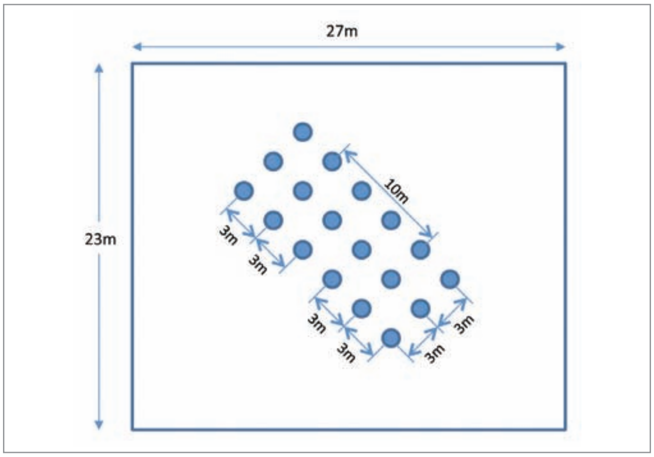


Image courtesy of ETS-Lindgren

Figure 4: Example of test point selection for a test distance of 10 m

test, nor emission limits, naturally leaving this to the product standards. The basic standard CISPR 16-2-3, clause 7.6, states a preferred distance of 3 m and allows for other distances between 1 and 10 m with the requirement that the antenna beam-width encompasses the EUT. Significant detail is given on the definition of the RX characteristics [1] which may or may not now be included in CISPR 16-1-4. While there is adequate detail on the setting up of EUTs below 1 GHz, there is less detail and guidance concerning EUT setup above 1 GHz. Some of the product standards, such as CISPR 22, specify measurements above 1 GHz with limits between 1 and 6 GHz for 3 m only, but since they now refer back to CISPR 16-1-4 and CISPR 16-2-3 the same problems apply as just mentioned.

Status: A pre-project to discuss the above issues was initiated at the Seattle meeting.

Image courtesy of ETS-Lindgren

Figure 5: Example of an indoor test environment, a high performance 10 meter semi-anechoic chamber used for testing according to CISPR 16-1-4 from 30 MHz to 18 GHz.

Chamber Validation above 1 GHz: TDR

In a separate discussion on the chamber validation methods above 1 GHz, there has been some effort in the USA to challenge the sVSWR chamber validation method described in 16-1-4 by proposing an alternative Time Domain Reflectometry (TDR) method [2]. The proposal first challenges the sVSWR method's sampling of a standing wave at six positions and recommends measuring along the same distance continuously - the error between the two measurements being not insignificant. The TDR method proposed avoids the under-sampling and reduces the number of test positions and therefore claims to be more accurate and faster. It is not currently clear how this idea will progress or not, but it will most likely be taken up within the US National Committee and the ANSI C63 committee before any attempt at introducing any changes to CISPR 16-1-4 take place.

Status: No action currently

CISPR 16-1-5

Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-5: Radio disturbance and immunity measuring apparatus – Antenna calibration test sites from 30 MHz to 1000 MHz

As a result of the New Work Item of CIS/A/822/NP and CIS/A/847 RVN of March 2009, it was decided to split

16-1-5 new clause numbers	16-1-6	Site validation method
Introduction	-	Types of validation methods
4 8.2	SSM	SSM, use existing CALTS 30 MHz to 1 GHz, updated to include vertical polarization
4.7	9.3	Vertically polarized biconical antennas, utilizing a ground plane, use existing CALTS with VP
5	8.4	Horn and LPDA antennas in a FAR, 1 GHz to 18 GHz
6.1	8.3	LPDA/hybrids at ≥4 m height outdoors 200 MHz to 18 GHz
6.2	8.3.4	LPDA/hybrids over absorber outdoors, 200 MHz to 18 GHz
6.3	8.3.4	LPDA/hybrids over absorber outdoors, 200 MHz to 18 GHz
7.1	9.3	Vertically polarized biconical antennas, utilizing a ground plane, 20 MHz to 300 MHz
7.2	9.4	Biconical antennas in a FAR, 30 MHz to 300 MHz, use volumetric NSA CISPR 16-1-4
8.1	Annexe B.6	Measurement of *F*afs of biconical antennas utilizing ground reflections
8.2	Annexe B.6	Measurement of *F*afs of tuned dipoles utilizing ground reflections
8.3	Annexe B.8	Measurement of *Fa*(*h*) of tuned dipoles and biconical antennas utilizing ground reflections
9		Site validation by comparison of antenna factors

Table 3: CISPR 16-1-5 summary

CISPR 16-1-5 and CISPR 16-1-6 into two parts with the site validation methods now to be described in CISPR 16-1-5 corresponding to the antenna factor measurement methods being developed in CISPR 16-1-6.

Originally, it was planned that antenna calibration methods would be included in CISPR 16-1-5, but as that standard expanded on the subject of site validation, it soon became obvious that a separate document was needed in order to focus on current methods of antenna calibration and to also provide a collecting document for Antenna Factors for measurements at 1 m distance as in CISPR 25. CISPR 16-1-6 will be a horizontal and basic EMC standard that will specify the antenna calibration methods for the accurate free-space antenna factor required for radiated disturbance measurements.

The main purpose of this maintenance action is to add site validation methods for the other calibration sites in CISPR 16-1-6. Some methods do not require a ground plane reflection and in that case, the aim is to remove the influence of the ground.

The proposed antenna calibration methods in draft CISPR 16-1-6 Ed. 1.0 (CISPR/A/905/CD) are listed in Table 3.

For each method there is a corresponding method of site validation added to CISPR 16-1-5. The current CD includes methods of site validation that do not involve comparison with a theoretical value, such as used in the NSA of CISPR 16-1-4 or the CALTS of CISPR 16-1-5. They are more like the SVSWR method of CISPR 16-1-4 in which the acceptance criterion is based on a maximum allowed variation of E-field magnitude. In addition, a site is considered validated for a given pair of antennas if it gives the same value for antenna factor as obtained on a site that has been validated by a separate validation process.

At the recent meeting of CISPR, the National Physics Lab (NPL), in the UK presented the case for not validating sites using two horn antennas because of the large standing wave that exists between the horn antenna pair, and that the site should be calibrated using double-ridged horn and log periodic antennas. Examples are shown in Figures 6 - 8.

Status: Currently CC on 2nd CD (CIS A 907 CD) available

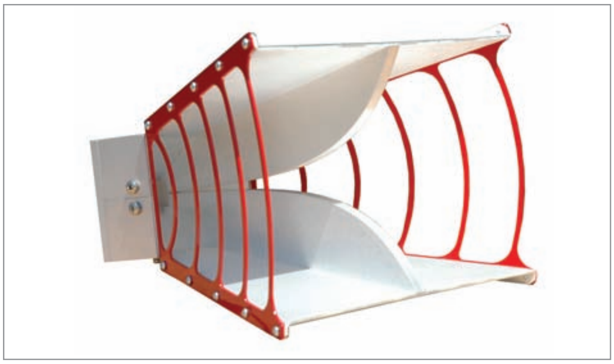


Image courtesy of ETS-Lindgren

Figure 6: The latest generation of the popular double-ridged waveguide antenna has excellent gain and VSWR characteristics as well as improved high frequency performance of 750 MHz to 18 GHz. The antenna is small and portable with a length of 24.4 cm (9.6 in), making CISPR 16-1-4 and CISPR 16-2-3 testing faster and easier.

Image courtesy of ETS-Lindgren

Figure 7: An example of a double-ridged waveguide antenna - one of the most commonly used antennas for microwave and EMC measurement, including CISPR 16-1-4 and CISPR 16-2-3 testing.

Image courtesy of ETS-Lindgren

Figure 8: An example of a hybrid log periodic and bowtie (BiConiLog™) antenna used for CISPR 16-1-4 and CISPR 16-2-3 testing from 26 MHz to 6 GHz. Antennas with a broader frequency range are optimally used to negate the need for multiple antennas and time-consuming equipment setup.

CISPR 16-1-6

Specification for radio disturbance and immunity measuring apparatus and methods

Part 1-6: Radio disturbance and immunity measuring apparatus – EMC-antenna calibration

The proposed new standard, CISPR 16-1-6 is currently at 2nd CD stage and provides procedures and information on the calibration of antennas for determining antenna factors. It is intended to be used by those antenna calibration laboratories and not for end-user test laboratories performing radiated emission measurements. Multiple calibration methods are specified that can be applied to antennas intended for use in radiated emission measurements according to CISPR 16-2-3 and CISPR-based product standards, in the frequency range of 30 MHz to 18 GHz. Guidance on uncertainties inherent in the calibration measurements and the associated instrumentation will be included. CISPR 16-1-6 will later include loop antenna calibration as required by CISPR 11 and 1 m AF as required by CISPR 25 in the future.

The proposed calibration methods are listed in Table 4.

Status CC on 2nd CD available, target date 2012-02

CISPR 16-2 Methods of Measurement of Disturbances and Immunity

- **CISPR 16-2-1 Amd. 2 to Ed. 2.0: *Conducted disturbance measurements***

  Inclusion of key test methods from CISPR 13 and CISPR 22
  (JTF CIS/A-/I - Joint Task Force between CISPR/A and CISPR/I)
  Note that CISPR requires technical committees to provide justification for product standards that set different requirements than the generic standards and that use different test methods than those given in CISPR 16. The aim is to determine both differences and places where information contained within the basic standards is repeated in the product standard with the intention of providing an opportunity to justify or re-align and simplify these documents. First up was CISPR 22 largely because some of the work had already been completed in the JTF CIS/A-I.
  Status: CDV 2011-03

- **CISPR 16-2-2 Ed. 2.0**

  Inclusion of FFT-based test instrumentation
  Status: Published

- **CISPR 16-2-3 *Radiated disturbance measurements***

  Inclusion of key test method from CISPR 13 and CISPR 22
  Status: 1st CD 2010-11

  Addition of the measurand for the radiated emission measurement method less than 1 GHz
  Status: Published

Application of CMADs
Much debated within CISPR A in the last five years, CMADs (Common Mode Absorbing Device) are ferrite clamps used during testing as cable termination on all cables leaving a test setup. In 2009, a Round Robin Test organized by CISPR/A/WG2 demonstrated that the CMAD could reduce uncertainty in radiated measurements. This first CD proposes its introduction into CISPR 16-2-3.
Status: 1st CD 2010-12

CISPR 16-4 Uncertainty in EMC Measurements

- **CISPR 16-4-2 Ed. 2.0:** ***Uncertainty in EMC measurements***

  Status: CDV approved – FDIS 2011-03

CISPR – CISPR JTF WORK

CISPR has set up a number of internal joint task forces (JTFs) or cross sub-committee groups in order to facilitate better application of test methods (using the output of SC A) and better use of the interference model (provided by SC H).

JTF CISPR SC/A & SC/D on FFT-based test instrumentation

- Inclusion of FFT (Fast Fourier Transform) based instrumentation in CISPR 16 to make use of new time domain based technology
- **Status: All CDVs 100% approved; standards published and JTF disbanded**

JTF CISPR SC/A & SC/F on CDN test method

- CDNE measurement. The task is to transfer the methods for measuring conducted emissions from luminaries from CISPR 15 into CISPR 16.
- **Status: CD in preparation**

JTF CISPR SC/A & SC/I on updating CISPR 16-1-2, 16-2-1, 16-2-3 and 16-3

- Common measurement methods so that the SC I standards using SC A basic measurement techniques simply reference them in the product standard; also to suggest that techniques used in SC I and not in CISPR 16 be added to CISPR 16 so that they can be removed from SC I publications and simply refer to the CISPR 16 documents
- **Status: CD in preparation**

IN CLOSING

This concludes part one of this update of CISPR activity from the October 2010 IEC General Meeting in Seattle.
In the second part of this article - to be published in the following issue of this magazine - we will continue with the CISPR product standards and the Joint Task Forces (JTFs) existing between the different subcommittees as well as between CISPR subcommittees and IEC SC 77 B.
For more information, please consult the IEC website, http://www.iec.ch, or contact your National Committee. ■

ACKNOWLEDGEMENTS

The author wishes to acknowledge and thank Don Heirman, CISPR Chairman, and Manfred Stecher, Chairman of CISPR SC/A, for their invaluable review of and contributions to this article. They can be contacted at d.heirman@ieee.org and manfred.stecher@rohde-schwarz.com, respectively.

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Clause	Calibration method
8.2	Standard site method, utilizing a ground plane, 30 MHz to 1 GHz
8.3	LPDA and hybrid antennas at 4 m height or over absorber by the three antenna method, 200 MHz to 3 GHz
8.4	Horn and LPDA antennas in a FAR by the three antenna method, 1 GHz to 18 GHz
9.3	biconical antennas, vertically polarized utilizing a ground plane, by the standard antenna method, 30 MHz to 300 MHz
9.4	Biconical and dipole antennas in a FAR by the standard antenna method, 30 MHz to 300 MHz
Annex B	Measurement of *Fa*(*h*) of tuned dipoles and biconical antennas
Annex B	Measurement of *Fa* fs of tuned dipole and alternative method to measure *Fa* fs of biconical antennas at great height above a ground plane.

Table 4: Proposed calibration methods in Draft CISPR 16-1-6

Effects of High-Power and Transient Disturbances on Wireless Communication Systems Operating Inside the 2.4 GHz ISM Band

Christian Klünder and Jan Luiken ter Haseborg
Institute of Measurement Technology and
Electromagnetic Compatibility
Hamburg University of Technology

Wireless digital communication systems using the 2.4 GHz ISM (Industrial, Scientific and Medical) band are earning more and more popularity from day to day. Short range communication systems like Wireless LAN, Bluetooth and ZigBee are the most widely known and used standards nowadays. These communication systems are especially used for cable reduction and replacement in home, office and industry. As these systems are - under special restrictions - nearly worldwide license free, they are very easy and cheap to integrate into electronic systems. With the use of wireless communication systems costs can be reduced and electronic communication systems can be easily extended. In either case, the Electromagnetic Compatibility (EMC) of the wireless communication systems has to be ensured so that the functionality and reliability of the system itself and other electronic systems in their vicinity is not reduced.

The effects of man-made electromagnetic interferences on electronic systems is an ongoing and widely researched topic. The effects of high-power and transient sources is a matter of particular interest and is summarized in the technical term High-Power Electromagnetics (HPEM [1]). The interferences caused by HPEM sources are refered in the topics of Intentional Electromagnetic Interferences (IEMI).

The effects of some HPEM sources on electronic equipment have been investigated in [2] and [3]. The classification of these effects on system level is given in [4]. Building on the previous investigations, this article deals with the effects and estimations of susceptibility on wireless communication systems inside the 2.4 GHz ISM band by using UWB and radar pulses. In this article the main focus of the coupling path is laid on the antenna and the effects on the receiver system of a wireless communication system by changing the power, the pulse length and the pulse repetition frequency.

SOURCES OF HIGH-POWER AND TRANSIENT DISTURBANCES

The research and description of the effects of high-power transient disturbances is centralized in the technical term HPEM. Natural sources (e.g. lightning (LEMP) or electrostatic discharge (ESD)) and military sources (e.g. Nuclear Electromagnetic Pulse (NEMP), Ultra Wideband Pulse (UWB) or High-Power Microwave (HPM)) are the area of research in HPEM. In addition the technical term of High Intensity Radiated Fields (HIRF) is especially used in aviation [5] for the exposition of electronic devices and life-forms in vicinity of high electric field strengths caused by, for example, the radar. The general parameters of the following pulses are the pulse duration and the pulse repetition frequency.

Radar-Radio Detection and Ranging

The range of application of radar is subdivided into military and civilian purposes. Especially for civilian usage, the radar is being used for surveillance and navigation of ship traffic inshore and in port entrances, navigation aid and Search-and-Rescue (SAR). In civilian shipping, navigation is being performed by using s-band (3 GHz) and x-band (9.4 GHz) pulse radars. Table 1 from [6] outlines the typical parameters of a civilian s-band radar as it is used on every modern vessel. From the general radar equation the received radar signal power P_r of a radar target is calculated by

$$P_r = \frac{P_t \cdot G_t \cdot \sigma}{(4\pi)^2 \cdot R^4} \,, \qquad (1)$$

with the transmitted power P_t, the gain of the transmitting antenna G_t, the target range R and the Radar Cross Section (RCS) σ. From Equation 1 it is obvious that the detection of targets at far distances needs a very high transmitting power as the received power decreases with the fourth order of the distance R. Therefore, very high field strengths can be observed in the vicinity of radar stations and previous measurements [7] have shown that a peak electrical field strength of some 100 V/m can easily be reached.

HPEM Sources

Typical HPEM sources are the LEMP, NEMP, UWB or the HPM. These HPEM sources have very high amplitudes and power. Due to this these sources can be seen as a serious thread for every system in their vicinity. The electromagnetic pulses of HPEM sources are characterized by the rise time t_r and the pulse duration t_d, which is expressed as full width half maximum (FWHM). Different rise times and pulse durations are summarized in Table 2.

frequency f	3050 MHz
wave length λ	10 cm
peak power	30 kW
typ. antenna gain G_t	27 dB
max. pulse length t_{Pmax}	1 μs
max. pulse repetition frequency f_{PRF}	2 kHz

Table 1: Typical parameters of a civilian s-band radar for navigation

Pulse form	Rise time t_r	Pulse duration t_d
LEMP	1 – 10 μs	700 μs
NEMP	< 5 ns	300 ns
UWB	< 200 ps	< 5 ns

Table 2: Time parameters for different electromagnetic pulse forms

The UWB pulse is characterized by the fastest rise time of less than 200 ps and the shortest duration of less than 5 ns. compared to the other electromagnetic pulses. Therefore the frequency spectrum of the UWB pulse covers frequencies up several gigahertz. The threat of UWB pulses compared to the other pulses is therefore much higher and is being used inside for the following measurements.

The unipolar ultra wideband pulse $u_{\mathrm{UWB}}(t)$ can be approximated in time domain with the use of a double exponential function [8]

$$u_{\mathbf{UWB}}(t) = V_p \cdot k \cdot \left(\exp(-\frac{t}{\beta}) - \exp(-\frac{t}{\alpha})\right) , \qquad (2)$$

where V_p denotes the maximum voltage of the pulse, α and β are time constants and k is a normalization factor, which is calculated by

$$k = \frac{1}{\exp\left(\frac{\alpha \cdot \ln(\frac{\alpha}{\beta})}{\beta-\alpha}\right) - \exp\left(\frac{\beta \cdot \ln(\frac{\alpha}{\beta})}{\beta-\alpha}\right)} . \qquad (3)$$

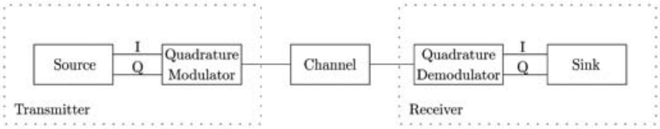
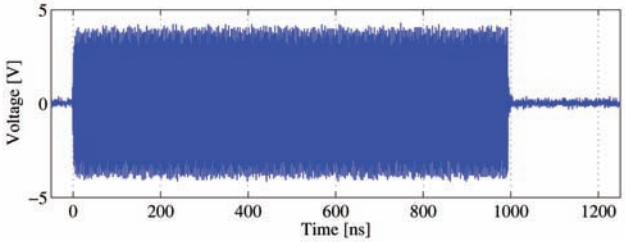
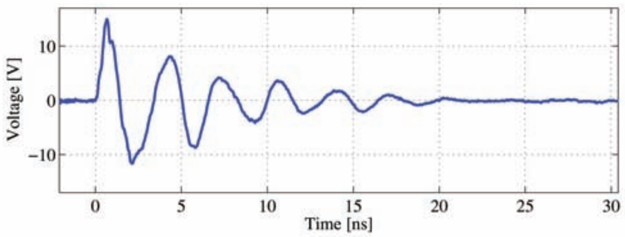


Figure 1: Block diagram of a digital wireless communication system



(a) Time response of a coupled radar pulse (pulse length 1 μs)



(b) Time response of a coupled UWB pulse

Figure 2: Time domain response of the coupled voltage into a typical 2.4 GHz ISM bar antenna. The plots are normalized to an electrical peak field strength of 1 kV/m.

MEASUREMENT OF THE INFLUENCE ON A GENERAL RECEIVER OF A WIRELESS COMMUNICATION SYSTEM

Communication theory subdivides a digital wireless communication system into three main sections: transmitter, channel and receiver. Figure 1 depicts the general structure of a digital wireless communication system. The transmitter itself consists of a source and the related quadrature modulator which mixes the digital modulated signals (inphase and quadrature component) into the passband. After the channel the passband signal is being mixed in the receiver with the help of the quadrature demodulator into the baseband and is being transferred to the sink.

Coupling into the Receiving Antenna

The interference of digital wireless communication systems against external electromagnetic disturbances is separated by frontdoor and backdoor coupling [9]. While frontdoor coupling describes the coupling of electromagnetic energy via the antenna in the receiver of a wireless communication system, backdoor coupling describes the coupling of electromagnetic energy via the geometry of the system (e.g. pcb structures) and the connected cables respectively.

In Figure 2 the coupling of a typical s-band radar (measurement is performed at a radar station) and a UWB pulse (measurement is performed by using a UWB pulse generator PBG3 from Kentech Inc.[1]) into a standard bar antenna for the ISM band is exemplified. Both plots have been normalized to a peak electrical field strength of 1 kV/m of the incident pulses at the point of installation. The used radar pulses can be varied in time (1 μs, 0.3 μs and 0.08 μs). Figure 2(a) shows the coupling of an s-band radar pulse with a pulse length of 1 μs and Figure 2(b) the coupling of a radiated UWB pulse in an antenna placed the a Gigahertz Transversal Electromagnetic (GTEM) cell.

While the maximum amplitude of the coupled s-band radar pulse reaches approximately 4 V, the maximum amplitude of the coupled UWB pulse reaches approximately 15 V. The time response of the coupled UWB pulse lasts approximately 20 ns.

Effect on the Baseband Signal

The electromagnetic coupling via the receiving antenna of a digital wireless receiver can result in corruption or disturbance of the receiving data. As the packaging of a wireless communication system receiver is very small and compact, the effect of the different coupled pulses is measured with the help on a typical quadrature demodulator.

[1] Parameter Kentech PBG3: peak voltage at 50 Ω: 12.5 kV rise time: below 100 ps, pulse length (FWHM): 3 ns

A quadrature modulator from Analog Devices (AD8347, [10]) build on an evaluation board has been used (Figure 3). The external local oscillator can be varied from 0.7 GHz to 2.7 GHz and is being selected during the measurements to a carrier frequency inside the 2.4 GHz ISM band.

The effects of the different coupled pulses with varying field strengths are presented in Figure 4. Only the inphase component of the baseband is being presented as the effect at the quadrature component shows the same behavior. Figure 4(a) and 4(b) show the effect of a radar system with electrical field strengths varying from 0.8 kV/m to 1.8 kV/m (Figure 4(b) to 2.6 kV/m). With increasing field strength the voltage deviation is rising up to 3 V. The influence length of the pulses matches at lower electric field strengths nearly the radar pulse length, but is extended at electric field strengths over 1.8 kV/m about approximately 300 ns.

The effect of a coupled UWB pulse for electric field strengths from 70 V/m to 2.2 kV/m is plotted in Figure 4(c). With increasing electric field strength the voltage deviation is increasing too. Peak voltages of up to 2.5 V are reached. The influence length at the highest field strength of 2.2 kV/m is nearly 200 ns and approximately ten times higher than the measured length of the coupled UWB pulse of Figure 2(b).

Effect of Pulse Repetition Frequency and Pulse Duration on a "Real" Wireless Communication System

The previous measurements have shown that the influence of the used pulses causes disturbances in the baseband of a typical receiving unit. A worst-case scenario for the effects of disturbances caused by pulses is the assumption that a communication link is disrupted for the time of the disturbance influence. This worst-case scenario can be measured with the use of a high-frequency switching unit (HF switch) which is integrated between channel and receiving unit of the wireless communication system. To simulate a possible disturbance the switch blocks the communication between transmitter and receiver for a specific time. The HF

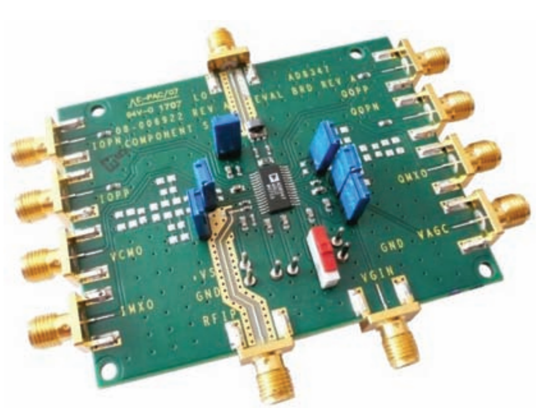
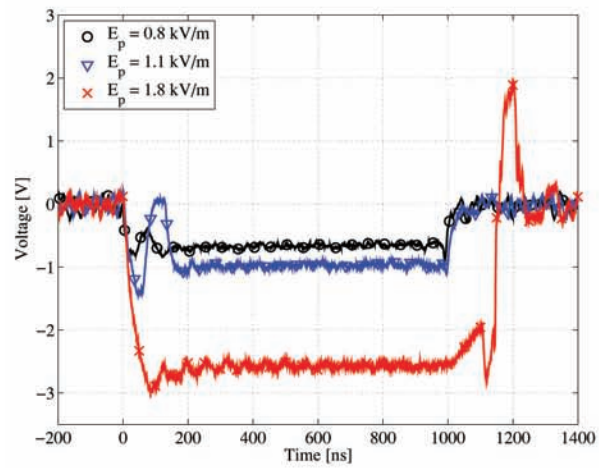
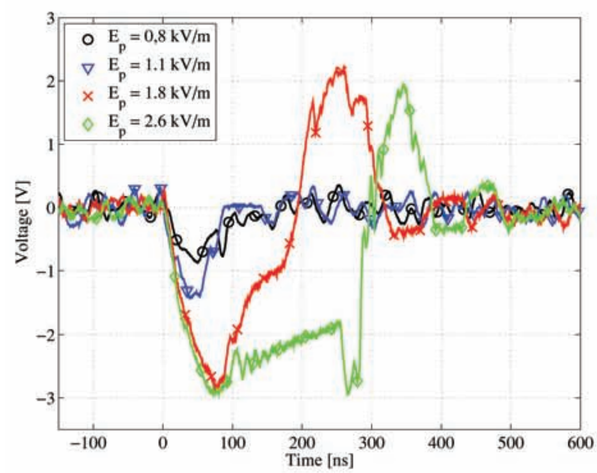


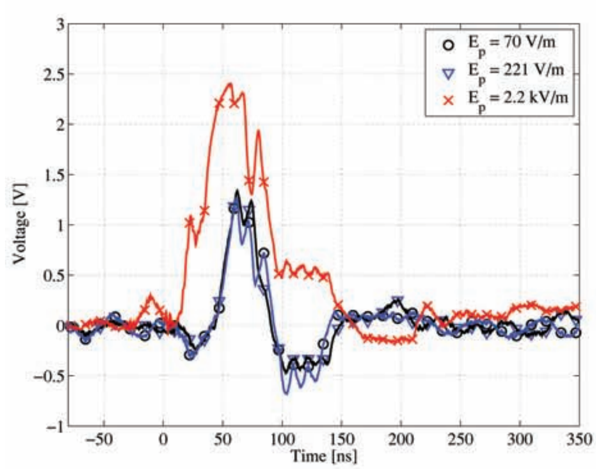
Figure 3: Evaluation board AD8347 from Analog Devices



(a) Baseband time response of a radar pulse (pulse length 1 μs)



(b) Baseband time response of a radar pulse (pulse length 0.08 μs)



(c) Baseband time response of a d UWB pulse

Figure 4: Effect of different applied pulses on the baseband signal level in time domain

switch is controlled by using a standard waveform generator to vary the disturbing length (pulse duration) and the disturbance repetition frequency (pulse repetition frequency).

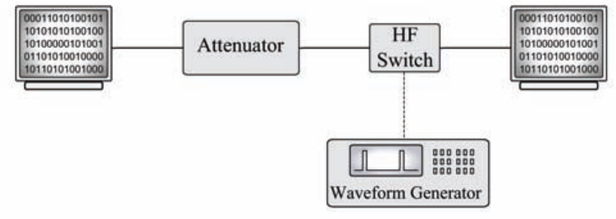
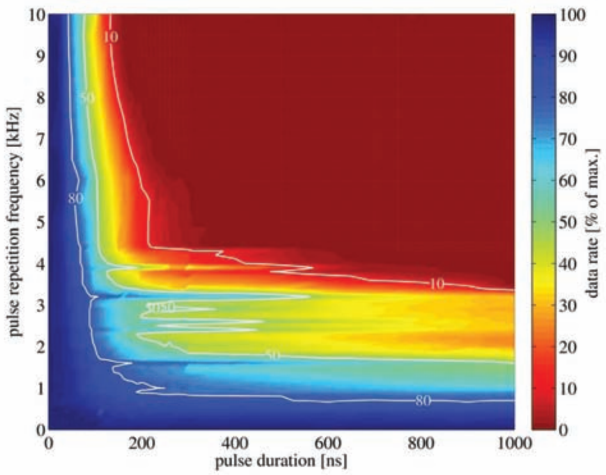
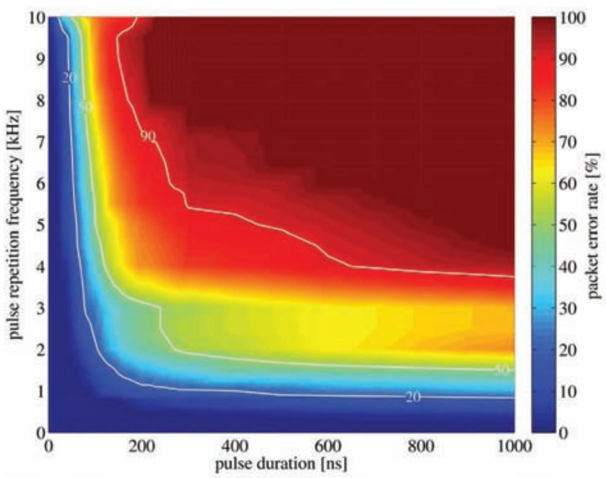


Figure 5: Measurement Setup



(a) 802.11g TCP mode (white lines mark the border of 80%, 50% and 10% maximum achieved data rate)



(b) 802.11d UDP mode (white lines mark the border of 20%, 50% and 90% packet errror rate)

Figure 6: Effects of disturbances by varying pulse length and pulse repetition frequency with a HF switch on a 802.11g communication network.

The general measurement setup is depicted in Figure 5. The transmitter and receiver are connected by using 50 Ω SMA cables so that the communication is not performed over air. The channel is represented by an attenuator. The effect of different pulse lengths and pulse repetition frequencies on a ”real” wireless communication network can be investigated with this measurement setup. The following paragraphs will show the effects on a Wireless LAN and a Bluetooth network. The results will show the performance of the different wireless networks by measuring the maximum throughput (TCP mode) and the packet error rate (UDP mode) of the wireless communication link.

Results for Wireless LAN

This paragraph illustrates the result for a Wireless LAN 802.11g adhoc network at a transmission rate of 54 MBit/s. Two typical WLAN PCI cards in two PCs have been connected with an attenuator of 40 dB as depicted in Figure 5. The maximum reached data rate without any disturbances has been measured to approximately 28.8 MBit/s. The measurement has been performed by varying the pulse length from 0 ns (connection always on) to 1000 ns and the pulse repetition frequency from 0 kHz (connection always on) to 10 kHz. The results of this measurement for TCP and UDP transfer mode are summarized in Figure 6. In Figure 6(a) the data rate in per cent of the maximum achieved data rate is being plotted, Figure 6(b) plots the packet error rate in per cent respectively.

Comparing the two plots the transfer modes correlates in their behavior at different pulse lengths and pulse repetition frequencies. If pulse disturbances are not longer than 100 ns and the disturbance repetition frequencies are less than 1 kHz, reductions of at most 20% of the maximum data rate are observed, the packet error rate reaches a maximum of 20% respectively. A complete break down of the WLAN communication link is observed at disturbance lengths longer than approximately 300 ns and at disturbance repetition frequencies more than 3.5 kHz.

Results for Bluetooth

This paragraph summarizes the results for a Bluetooth network by using two USB Bluetooth 2.0 EDR (Enhanced Data Rate) devices connected to two PCs. The attenuator of this setup has been chosen to 30 dB. Again the pulse length and the pulse repetition frequency have been changed as described in the previous paragraph. The results of this measurement are depicted in Figure 7 for the TCP transfer mode whereas the maximum data rate without any disturbances has been measured to 1.6 MBit/s.

Looking again at the border of a reduction of the maximum data rate to 80%, the disturbance durations are approximately 350 ns and the disturbance repetition frequencies are less than 0.5 kHz. A complete break down of the Bluetooth communication link is observed at disturbance durations of more than 600 ns and disturbance repetition frequencies of nearly above 2 kHz.

Comparing the Bluetooth results to the Wireless LAN 802.11g results from the previous paragraph, the influence of the disturbance duration on the Blutooth communication is less than the disturbance duration on the WLAN communication link. But comparing the influence of higher disturbance repetition rates at longer disturbance duration the communication link is more influenced at higher disturbance repetition rates.

CONCLUSION

The measurements have shown how high-power and transient pulses couple into a receiving antenna of a wireless communication system. A standard antenna for the use inside the 2.4 GHz ISM band has been exposed by an UWB and radar pulses with different pulse durations. At a peak electric field strength of 1 kV/m the maximum coupled voltage reaches up to 15 V for the UWB pulse and 4 V for the radar pulses.

Based on these coupling measurements the effect of these pulses on the baseband of a generic quadrature modulator has been investigated. The results show that the disturbance duration is increasing with increasing peak field strength of the incident electromagnetic pulse. The caused effects in the baseband are achieving voltages up to 3 V and disturb the baseband signal.

In the end the influence of different pulse lengths and pulse repetition frequencies on a ”real” wireless communication link has been investigated. A worst-case analysis by switching the communication link on and off with a fast HF switch showed that a Bluetooth communication system is less interfered at short pulse durations (up to 300 ns) than a WLAN 802.11g communication link. Otherwise the WLAN communication was able to transmit data up to pulse repetition frequencies up to 3.5 kHz while the Bluetooth communication was only able to transmit data up to 2 kHz pulse repetition frequency. However both communication links have break down at higher pulse repetition rates and pulse lengths.

A complete destruction of the system has not been observed and after switching the disturbance off, the communication systems have worked without any disturbances as before. ■

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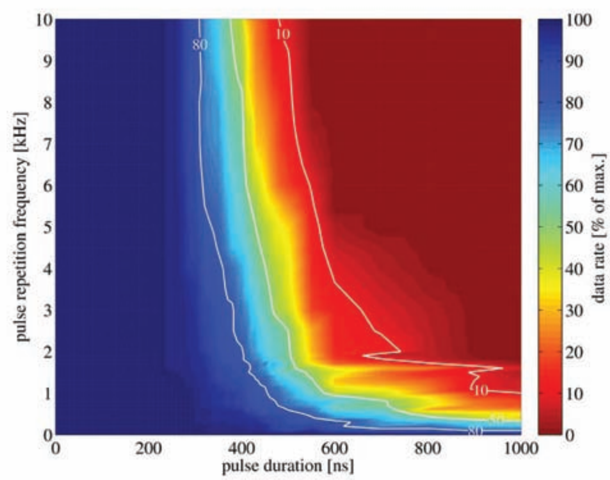


Figure 7: Effects of disturbances by varying pulse length and pulse repetition frequency with a HF switch on a Bluetooth communication network (white lines mark the border of 80%, 50% and 10% maximum achieved data rate).

BUSINESS NEWS

American Certification Body Earns EPA ENERGY STAR® Recognition

American Certification Body has recently been recognized by the US Environmental Protection Agency (EPA) under the newly-revamped ENERGY STAR® program that requires that all new product submissions from manufacturers participating in the ENERGY STAR® program be reviewed by an EPA-recognized Certification Body (CB).

To ensure that ENERGY STAR® remains a trusted symbol for environmental protection and superior energy efficiency, all ENERGY STAR® product partners will be required to follow a new set of Third-Party Certification procedures effective January 1, 2011.

The broad enhancements EPA has put in place will ensure that consumers get the energy savings they have come to expect from the ENERGY STAR label. ACB is honored to partner with EPA in this important effort.

American Certification Body is recognized by the EPA to Certify the following product categories: Audio/Video, Battery Charging Systems (BCSs), Computer Servers, Computers, Displays, Imaging Equipment, Set-top Boxes & Cable Boxes, Telephony, and Televisions.

For more information on our services, please contact ENERGYSTAR@acbcert.com.

Giant Microwave Antenna Offers Extreme Performance

ETS-Lindgren has announced the latest addition to its family of open boundary quad-ridged horn antennas for microwave measurements. The new Model 3164-01 allows antenna engineers to perform measurements from 100 MHz to 1 GHz with a single antenna. With its ability to measure two orthogonal polarized fields simultaneously, it can be used to measure radiation patterns regardless of the orientation of the antenna under test. In addition, Model 3164-01 boasts excellent gain characteristics. It demonstrates a very flat gain performance, typically less than 2 dB variation, for the upper 2/3 of its frequency range. As with other antennas in the 3164 series, this latest antenna exhibits impressive cross-port isolation with levels better than 25 dB. Model 3164-01 is also ideal for radar pulse testing as its VSWR is lower than 2:1 from 110 MHz to 1.5 GHz.

"This antenna is unique for our horn antennas due to its size, performance capabilities, and design. At some 68 inches (174 cm) in length and 152 pounds (69 kg) in weight, it is a robust antenna that is very efficient in offering measurement capabilities over a very wide frequency range. This means one antenna can do it all for most microwave applications," said Dr. Vince Rodriguez, ETS-Lindgren's Senior Principal Antenna Design Engineer. "It's interesting to note the design is not simply a scaled model of our other 3164 series horn antennas. Model 3164-01 does not have an enclosed feed cavity – this design feature not only reduced the weight, but improved the low end performance as well," added Dr. Rodriguez.

Although the feed cavity is not present, Model 3164-01 may be mounted inside chambers and nested in RF anechoic absorber or against a ground plane. A custom antenna mount is also available.

All antenna production units are individually calibrated at ETS-Lindgren's A2LA accredited lab and are shipped with a manual, actual antenna factors and a signed Certificate of Calibration Conformance.

For complete information, visit www.ets-lindgren.com/pdf/3164-01.pdf.

Gore Exapnds Line of GORE® SKYFLEX® Aerospace Materials

W. L. Gore & Associates, Inc. has expanded its family of GORE® SKYFLEX® Aerospace Materials to include preformed gaskets for multi-face aircraft applications such as hole liners, flange joints, fastener seals, and galley or restroom hard-mounts. These lightweight, non-hazardous gaskets ensure continuous protection between flat interfaces, around chamfers, and inside a component's mounting hole. By isolating dissimilar materials completely, these new gaskets significantly reduce the likelihood of galvanic corrosion, thereby increasing the life of the component.

Unlike other aircraft sealants, GORE® SKYFLEX® Aerospace Materials do not require any curing time, which reduces downtime and facilitates replacement during component maintenance. Available in diameters from 3 to 150 millimeters, these new gaskets are formed to each customer's dimensions, and they are easy to install without any special equipment or facilities needed.

The unique properties of expanded polytetrafluoroethylene (ePTFE) — the key component in the gasket's construction — enable them to last longer without hardening or becoming brittle. As a chemically inert, thermally stable material, ePTFE withstands the harsh conditions encountered in the aerospace environment. And like all GORE® SKYFLEX® Aerospace Materials, these new gaskets provide excellent protection against corrosion, water, and other environmental contaminants, including fuels and oils.

For more information about these products for aircraft applications, visit www.gore.com/aerospace.

COTS Filters Perform in Extended Temperature Range for Increased Reliability

LCR Electronics now offers a line of single phase 300 VAC 50/60Hz COTS filters ideal for high reliability applications as found in the lighting, military and medical industries.

Operating over an ambient temperature range of -40°C to +85°C (-40°F to +185°F), the new RoHS-compliant Single Stage 0913 Filters and Double Stage 0923 Filters are used where higher voltages and operating temperature ranges than standard off the shelf filters are required.

The new 300 VAC 50/60 Hz EMI filters are available with rated current from 1 A to 40 A for the 0913 filters and 1 A to 30 A for the 0923 filters in both general purpose and low leakage current versions. High potential voltage for both series is 1,450 VDC line-to-line and 2,250 VDC line-to-ground. For more information, visit www.lcr-inc.com.

Nemko Canada Recognized as Certification Body for ENERGY STAR®

Nemko Canada has received EPA recognition as a certification body (CB) for the ENERGY STAR program. ENERGY STAR is a joint program of the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy aimed at protecting the environment through energy efficient products and practices.

Nemko Canada's official scope of recognition is listed on the ENERGY STAR website, www.energystar.gov/index.cfm?c=partners.epa_recognized_certification_bodies.

Effective January 1, 2011, ENERGY STAR partners will use Third-Party Certification procedures in order to claim ENERGY STAR qualified product status. Under the Third-Party Certification procedures, partners are required to have their products tested by an EPA-Recognized test Laboratory and then certified by an EPA-recognized certification body. Upon certification of a product, the CB will notify the partner that the product meets the ENERGY STAR requirements and will submit the certification information to EPA for listing of the product as ENERGY STAR qualified on the ENERGY STAR website.

Enhanced ITS 6006 Radiated Test System Provides More Flexibility

Teseq Inc. has improved its ITS 6006 (Immunity Test System) for radiated EMC immunity testing by enhancing the RF power meters used in conjunction with the unit.

The ITS 6006, ideal for use in a variety of EMC applications including information technology, medical, RF, traffic telematics and mobile communications, features two updated, rugged RF power meter models, the PMR 6006 and PMU 6006, with an expanded frequency range from 1 MHz to 6 GHz and linear measurement range of -45 dBm to +20 dBm. Both models feature a large dynamic range, fast measurement, a sturdy design and a frequency range that matches the application being performed to meet the rigorous demands of EMC immunity testing.

The PMR 6006 and PMU 6006 are used in conjunction with Teseq's compact ITS 6006, comprised of an RF signal generator with AM and PM modulators, RF switches, inputs for up to three external power meters, EUT (equipment under test) monitoring and control ports, amplifier control outputs and software for comprehensive EMC testing.

The RF signal generator output can be switched to one of four outputs where up to four power amplifiers can be connected. Additional RF switches are available to combine two amplifier output paths into a single antenna connection. Two of these relays are included for the four amplifier paths.

The new system, controlled remotely by RS-232, LAN or USB, features software that executes both basic and configuration function tests like scalar quadripole measurements for measuring RF cable insertion loss. Teseq's WIN 6000 or Compliance 5 comprehensive test system software can be used in conjunction with the ITS 6006 system. For more information, please visit www.teseq.com.

Laboratory Authorized to Test and Certify to New Wi-Fi CERTIFIED Wi-Fi Direct™ Specifications

TÜV Rheinland®, one of only two Wi-Fi Alliance-authorized testing laboratories in the U.S., has announced they have been qualified by the Wi-Fi Alliance to perform testing to the new Wi-Fi CERTIFIED Wi-Fi Direct specification. Wi-Fi CERTIFIED Wi-Fi Direct is a certification mark for Wi-Fi devices that connect to one another without access points or Internet connections. Working with TÜV Rheinland on Wi-Fi CERTIFIED Wi-Fi Direct approvals offers member companies convenient testing services with the addition of new testing facilities.

Wi-Fi Direct devices – such as mobile phones, cameras, printers, PCs, and gaming devices – can transfer content and share applications quickly and easily, often requiring the simple push of a button. Devices can make a one-to-one connection, or a group of several devices can connect simultaneously. Additionally, Wi-Fi CERTIFIED Wi-Fi Direct devices can make device group connections using existing IEEE 802.11 a/g/n Wi-Fi CERTIFIED™ gear.

"The industry considers Wi-Fi Direct a significant leap in innovation that will change the way Wi-Fi users connect, share and communicate," said Rolf Bienert, Technical Development Manager for TÜV Rheinland. "As one of the first labs qualified by the Wi-Fi Alliance to perform this testing, we can help manufacturers certify their products to this standard right now, no matter where they are in the world."

For more information about TÜV Rheinland's Wireless Testing Services, visit www.tuv.com.

Seminars, Training, Symposiums & Webinars

March & April 2011

UL University offers a host of training opportunities throughout the year. UL University will offer over 150 courses in 2011, on 50+ subjects throughout the U.S. and Canada. The offerings included in this month's list are new for 2011. Visit their website to view additional topics, dates and locations www.uluniversity.com.

March 1
ESD Basics for the Program Manager
ESD Association
Austin, TX
www.incompliancemag.com/events/110301

March 2
How To's of In-Plant ESD Survey and Evaluation Measurements
ESD Association
Austin, TX
www.incompliancemag.com/events/110302_1

March 2
ESD On-Chip Protection in Advanced Technologies
ESD Association
Austin, TX
www.incompliancemag.com/events/110302_2

March 2
Electrical Safety Testing Your Product: A Complete Overview
Associated Research, Inc.
Webinar
www.incompliancemag.com/events/110302_3

March 2 - March 3
Data Acceptance Program: Requirements for Participation
UL University
Dallas, TX
www.incompliancemag.com/events/110302_4

March 7 - March 8
Process Validation Principles and Protocols
UL University
Orlando, FL
www.incompliancemag.com/events/110307_1

March 7 - March 10
MIL-STD-461F
WL Academy
Gaithersburg, MD
www.incompliancemag.com/events/110307_2

March 8
Understanding Ground Resistance Testing
AEMC Instruments
New Orleans, LA
www.incompliancemag.com/events/110308_1

March 8 - March 10
Designing for Compliance to IEC 60601-1 3rd Edition
UL University
Northbrook, IL
www.incompliancemag.com/events/110308_2

March 9 - March 10
Risk Management and Analysis for Medical Devices
UL University
Orlando, FL
www.incompliancemag.com/events/110309

March 14 - March 15
Process Validation Principles and Protocols
UL University
San Francisco, CA
www.incompliancemag.com/events/110314_1

March 14 - March 18
Electronics Laboratory Technician Training
UL University
Research Triangle Park, NC
www.incompliancemag.com/events/110314_2

March 15
Grounding in an Electrostatic Protected Area
ESD Association
Webinar
www.incompliancemag.com/events/110315

March 21
Printed Circuit Board Design and Layout for EMC
WL Academy
Gaithersburg, MD
www.incompliancemag.com/events/110321_1

March 21 - March 22
Process Validation Principles and Protocols
UL University
Minneapolis, MN
www.incompliancemag.com/events/110321_2

March 22
Printed Circuit Board Layout for EMC Suppression
IEEE EMC Milwaukee Chapter
Milwaukee, WI
www.incompliancemag.com/events/110322_1

March 22 March 23
EMC/SI Seminar
Kimmel Gerke Associates & Tektronix Inc.
Plano, TX
www.incompliancemag.com/events/110322_2

March 22 - March 24
Level 1: Plant Auditor
Stephen Halperin & Associates, Ltd.
Bensenville, IL
www.incompliancemag.com/events/110322_3

March 22 - March 24
Designing for Compliance to IEC 60601-1, 2nd Edition and Transition to the 3rd Edition
UL University
Orlando, FL
www.incompliancemag.com/events/110322_4

March 23
Electrostatic Calculations for the Program Manager and the ESD Engineer
ESD Association
Sunnyvale, CA
www.incompliancemag.com/events/110323_1

March 23
ESD Standards Overview for the Program Manager
ESD Association
Sunnyvale, CA
www.incompliancemag.com/events/110323_2

March 23
A Crash Course in Safety and Circuit Theory
Associated Research, Inc.
Webinar
www.incompliancemag.com/events/110323_3

March 24
Ionization Issues and Answers for the Program Manager
ESD Association
Sunnyvale, CA
www.incompliancemag.com/events/110324_1

March 24
System Level ESD/EMI: Testing to IEC and Other Standards
ESD Association
Sunnyvale, CA
www.incompliancemag.com/events/110324_2

March 24 - March 25
Risk Management and Analysis for Medical Devices
UL University
Minneapolis, MN
www.incompliancemag.com/events/110324_3

March 27 - March 31
ACES 2011: 27th International Review of Progress in Applied Computational Electromagnetics
The Applied Computational Electromagnetics Society
Williamsburg, VA
www.incompliancemag.com/events/110327

April 5 - April 6
EMC/SI Seminar
Kimmel Gerke Associates & Tektronix Inc.
Marlborough, MA
www.incompliancemag.com/events/110405_1

April 5 - April 7
Designing for Compliance to IEC 60601-1, 2nd Edition and Transition to the 3rd Edition
UL University
Toronto, ON Canada
www.incompliancemag.com/events/110405_2

April 7
System Level Approach to EMC Shielding on Hybrid and Electric Vehicles
University of Michigan College of Engineering
Ann Arbor, MI
www.incompliancemag.com/events/110407

EVENTS

April 11 - April 12
EMC/SI Seminar
Kimmel Gerke Associates & Tektronix Inc.
Aberdeen, MD
www.incompliancemag.com/events/110411_1

April 11 - April 13
High-Speed Digital Design and PCB Layout
UCLA Extension
Los Angeles, CA
www.incompliancemag.com/events/110411_2

April 11 - April 15
Electronics Laboratory Technician Training
UL University
Research Triangle Park, NC
www.incompliancemag.com/events/110411_3

April 12
Understanding Ground Resistance Testing
AEMC Instruments
Norfolk, VA
www.incompliancemag.com/events/110412_1

April 12 - April 14
EMC By Your Design:
An EMC Practical Applications Seminar and Workshop
D.L.S. Electronics Systems, Inc.
Northbrook, IL
www.incompliancemag.com/events/110412_2

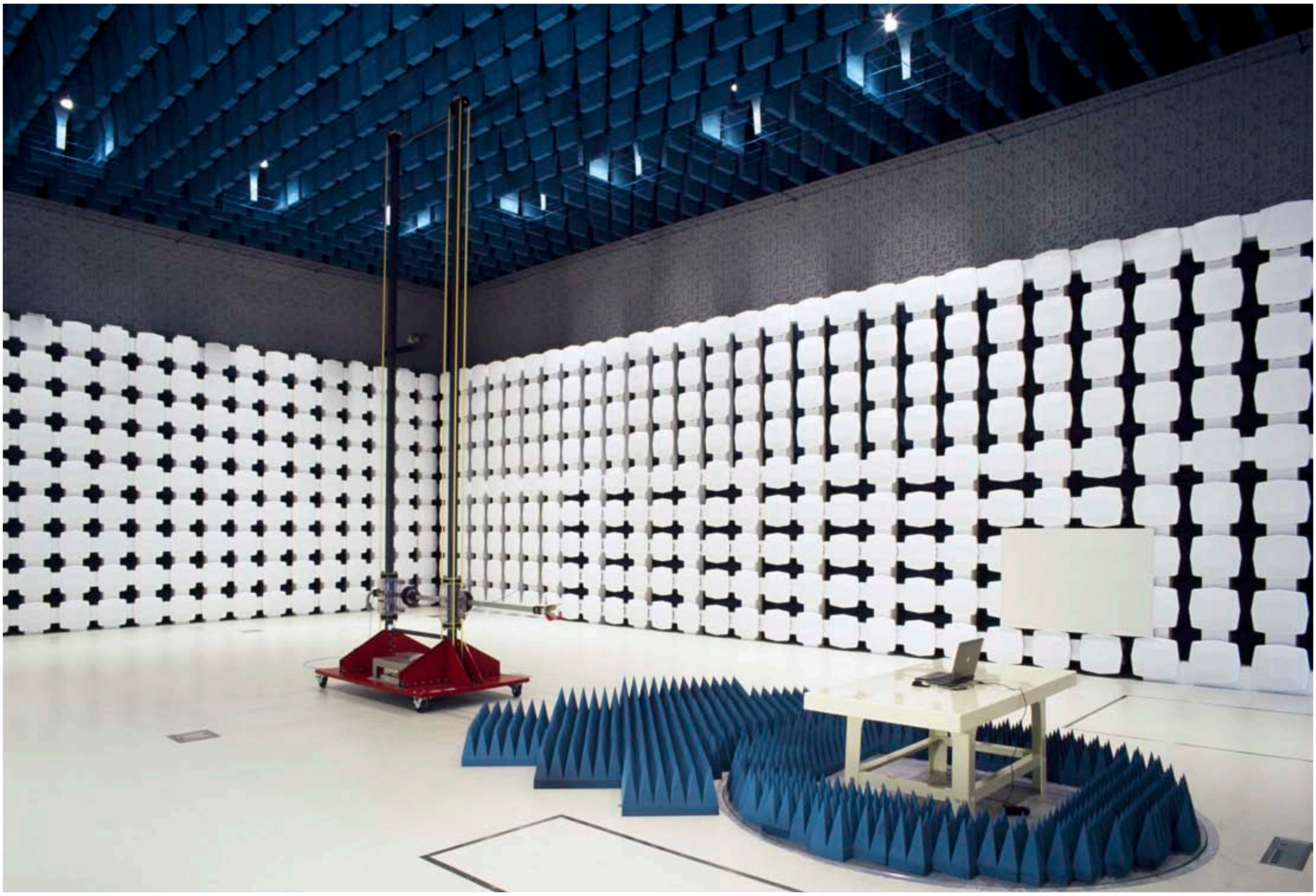
April 14
Air Ionization: Theory and Practice
ESD Association
Webinar
www.incompliancemag.com/events/110414_1

April 14 - April 15
EMI/EMC for the Design Engineer
UCLA Extension
Los Angeles, CA
www.incompliancemag.com/events/110414_2

April 20
Medical Device Testing
Associated Research, Inc.
Webinar
www.incompliancemag.com/events/110420_1

April 20 - April 21
Data Acceptance Program: Requirements for Participation
UL University
Research Triangle Park, NC
www.incompliancemag.com/events/110420_2

ADVERTISERS



EMC Chambers

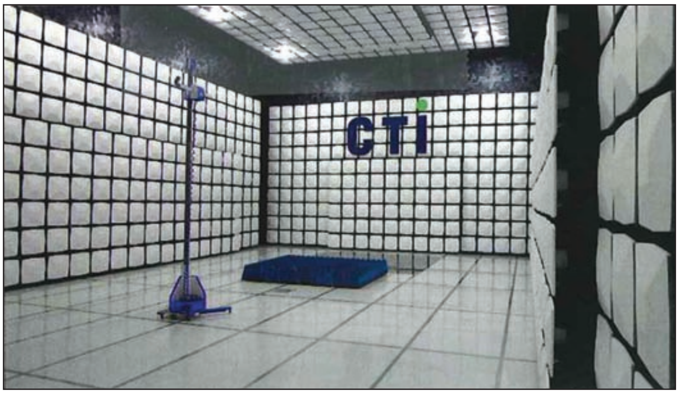
Built to Perform!

Built to be the Best!

At Braden Shielding Systems, we understand that old habits are hard to break. When it comes to EMC Chambers, Braden actually manufactures our equipment in our 50,000 square foot facility. In fact, Braden Shielding Systems has manufactured and installed over 5,000 chambers worldwide.

You can be assured that Braden Shielding Systems can install a chamber in your facility. We maintain an extensive list of contractors licenses and state registrations necessary to conduct business. We also keep up to date on laws and regulations in all states.

So the next time you're ready to eat a hamburger or purchase an EMC chamber, remember: ***You don't have to settle for second best just because they sell the most***.



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