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Correction

The January 5 news piece "New U.S./EU Conformity Assessment Bodies for EMC, Telecom Equipment," incorrectly states that the newest Notified Bodies under the US-EU MRA are approved for testing to the EU requirements.

Testing is not included under the list of conformity assessment tasks covered by the EU Notified Body status under the EMC and R&TTE Directives.

The conformity assessment tasks covered by the EU approval are as follows.

1. EMC Directive

Under this directive, Notified bodies are approved to review the technical documentation of the apparatus and assess whether the technical documentation properly demonstrates that the relevant aspects of the essential requirements of the EMC Directive have been met.

The EU is not approving the Notified Bodies for testing activities.

2. R&TTE Directive

Under this directive, Notified Bodies are approved for up to 3 conformity assessment tasks:

- identifying the essential radio test suites for the manufacturer (Annex III of the Directive);
- reviewing and issuing opinions on technical construction files (Annex IV of the Directive);
- assessing and performing periodic surveillance of manufacturers' full quality assurance systems (Annex V of the Directive).

Notified bodies are specifically not allowed to carry out testing or prepare test reports for the equipment for which a statement of opinion is being issued.

References:

- EMC Directive Guide - see 6.2
  http://ec.europa.eu/enterprise/sectors/electrical/files/emc_guide__updated_20100208_v3_en.pdf
- R&TTE Directive Guide - See Section 8
  http://www.ero.dk/B8FF1CC0-8C6C-4C8C-9019-7EB21FCABBD6
- The criteria that must be met in order to apply for recognition (via NIST as the Designating Authority) are identified on the resource section of the NIST MRA web site:
  http://gsi.nist.gov/global/index.cfm/L1-4/L2-16/L3-85

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CONTENTS

April 2012
Volume 4 • Number 4

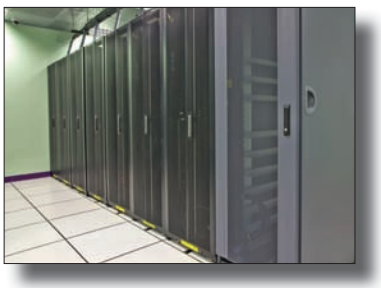
34 Low Frequency EMC and Power Quality

With smart grid technologies as well as power technologies for renewables and improved energy efficiency, there is an increased use of electronics. We see a growth in the use of power electronics as well as electronics for information technologies. The term Smart Grid enables a Smart Electrical System – the entire power system with networks as well as connected equipment converting between electrical energy and other forms of useful energy.

Dr. Magnus Olofsson

DEPARTMENTS

FEATURES



News in Compliance

FCC News

FCC Releases Fourth Quarter 2011 Consumer Complaints

The U.S. Federal Communications Commission (FCC) has released its quarterly report on inquiries and complaints made by consumers to the agency's Consumer & Government Affairs Bureau during the final quarter of 2011.

The Bureau regularly tracks inquiries and complaints from consumers on matters within the scope of the Commission's jurisdiction. In the area of wireline telecommunications matters, the Bureau is particularly interested in instances of "cramming" (the placing of unauthorized, misleading or deceptive charges on a telephone bill) and "slamming" (the practice of changing a subscriber's telecommunications service provider or calling plan without the subscriber's permission). The Commission also tracks violations of the Federal Telephone Consumer Protection Act (TCPA), which includes regulations covering both the "Do Not Call" registry and unsolicited fax advertisements.

During the period from October through December 2011, the Bureau received a total of 29,638 complaints regarding wireline telecommunication services, with 26,893 complaints (90.7% of the total) in the area of TCPA issues alone, and more than 3353 complaints in connection with unsolicited fax advertisements. This compares with 22,553 total complaints during the October-December 2010 period, with 19,478 (86.4% of the total) involving TCPA issues.

In the area of inquiries, the Bureau also received 6072 inquiries in connection with wireline telecommunications during the period from October through December 2011, including 3552 inquiries dealing with TCPA issues. This compares with 7878 total inquiries during the fourth quarter of calendar year 2010, of which 6730 were related to TCPA issues.

The complete text of the Commission's most recent quarterly report is available at www.incompliancemag.com/news/1204_01.

The U.S. Federal Communications Commission (FCC) has approved changes to its rules governing telemarketing practices that will further protect consumers from unwanted autodialed or prerecorded calls, also known as "robocalls."

FCC Maps Areas Eligible for Mobility Fund Phase 1 Auction

The U.S. Federal Communications Commission (FCC) is moving forward with its plans for an auction later this year that will expand the availability of high-speed mobile services to unserved and underserved populations in the U.S.

Scheduled to begin September 27, 2012, the Mobility Fund Phase 1 reverse auction will award $300 million to carriers who commit to provide 3G or better mobile voice and broadband services in areas where such services are currently unavailable. The Commission says that it has chosen a reverse auction mechanism to award these funds to ensure that the available funds maximize the coverage in such areas.

The Commission has now published a new interactive map at www.incompliancemag.com/news/1204_02 that identifies U.S. geographic areas that are potentially eligible for support. The identified areas correspond with U.S. Census blocks that currently lack 3G or better mobile coverage as of January 2012. The map provides block-by-block data, including population, road miles and other census information.

The Mobility Fund program is part of the Commission's overall modernization of the nation's universal service system to provide all citizens with access to fixed and mobile communication networks.

FCC Strengthens Protections Against RoboCalls

The U.S. Federal Communications Commission (FCC) has approved changes to its rules governing telemarketing practices, further protecting consumers from unwanted autodialed or prerecorded calls, also known as "robocalls."

In a Report and Order issued in February 2012, the Commission took steps to align its regulations of robocalls with those of the Federal Trade Commission's Telemarketing Sales Rule, as required under the Do-Not-Call Implementation Act. The rule changes will further protect consumers from robocalls in the following ways:

Lost Time Is Lost Money

Would You Like to Reduce Radiated Immunity Testing from Days to Hours? Now You Can With our NEW MultiStar Multi-Tone Tester!

EMC test accuracy is critical. But taking too long to test can be costly and it delays your time to market. With the speed of the revolutionary MultiStar Multi-Tone tester, you don't have to dwell on tedious EMC radiated immunity testing anymore.

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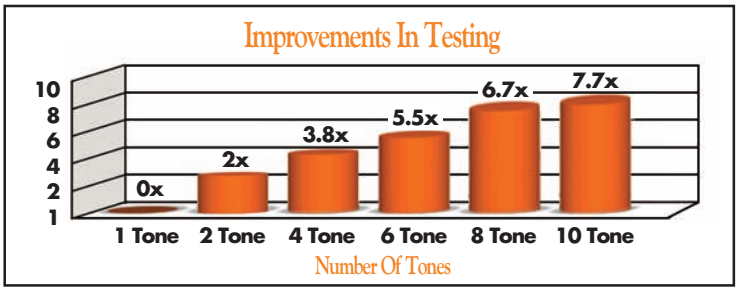
Mimic real world threats with the ability to expose EUT's to more than one frequency at a time. The MultiStar Multi-Tone Tester meets requirements of IEC 61000-4-3 and all associated standards.



IEC 61000-4-3 1% step sizes, taking into account dwell time

So, if you believe lost time is lost money, don't dwell on it. Ask about our new MultiStar Multi-Tone Tester. Also be sure to ask about our new DSP-based EMI Receiver. Amazing speed. Incredible accuracy.

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News in Compliance

FCC News

- Telemarketers will be required to obtain prior express written consent from consumers before placing robocalls to them. Written consent can be obtained by electronic means, such as a website form, for example.
- The exemption to obtain permission from those consumers with an "established business relationship" with a company has been eliminated.
- Robocalls will now be required to include an "opt-out" mechanism so that consumers can signal their desire to be dropped from authorized calling lists.
- Telemarketers will now be limited as to the number of abandoned or "dead air" calls they can make within each calling campaign.

Exemptions from the new rules will remain for informational automated calls, such as those alerting communities to school closings and local emergencies.

The complete text of the Commission's Report and Order regarding robocalls can be viewed at www.incompliancemag.com/news/1204_03.

Commission Extends Network Outage Reporting Requirements to VoIP

The U.S. Federal Communications Commission (FCC) will now require operators of Internet-based phone services to comply with service outages reporting requirements that currently apply to wireline and wireless carriers.

The Commission uses service outages reports from telecommunications carriers to track and analyze problems that could affect 9-1-1 services and other emergency communications, and as the basis for making recommendations to prevent future outages. However, according to Commission data, almost one third of the country's 87 million residential phone subscriptions are provided through Voice-over-Internet Protocol (VoIP) service providers, which have been exempt from the reporting requirements. The Commission says that the rule change will better ensure that consumers are able to make emergency calls, regardless of the telecommunications technology they use.

In a Report and Order issued in February 2012, the Commission defines outage reporting requirements for interconnected VoIP service, including reporting criteria and thresholds, and describes the reporting process and what information must be reported. The Commission also deferred taking action on setting specific thresholds for reporting outages and defining outages based on performance degradation instead of complete service outages.

The complete text of the Commission's Report and Order regarding VoIP network outage reporting requirements is available at www.incompliancemag.com/news/1204_04.

FCC Expands Broadband Speed Testing

The U.S. Federal Communications Commission (FCC) has announced plans to continue its evaluation of broadband Internet service in 2012 through testing programs involving consumer volunteers.

Part of the Commission's ongoing efforts to increase transparency regarding broadband services and enhance competition in the marketplace, the 2012 studies will expand on previous research by including more broadband technologies and extending the study into new regions of the country. The 2012 testing is expected to begin in March, and the FCC says that it will release two separate reports during the year on the data collected.

The FCC plans to continue its evaluation of broadband Internet service through testing programs involving consumer volunteers. Consumers who wish to participate in the testing can obtain more information at http://fcc.us/testisp.

Consumer participation will be an essential element in the studies, and the FCC is encouraging volunteer participation by providing a free wireless modem that will measure broadband speeds delivered to the home. Consumers who wish to participate in the FCC's 2012 broadband service testing can obtain more information at http://fcc.us/testisp.

The studies planned for 2012 follow the FCC's first broadband services study conducted in March 2011. In that study, the FCC examined service offerings from 13 of the largest broadband providers, which then accounted for about 86% of all wireline broadband

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Get more information and register for this course at www.hottconsultants.com

EMC Exhibits and reception - Wednesday, April 18, 2012

Exhibitors: for information contact Sharon Smith sharon.smith@incompliancemag.com or (978) 873-7722

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HENRY OTT

Henry W. Ott is President and Principal Consultant of Henry Ott Consultants (www.hottconsultants.com), an EMC training and consulting organization. He has literally "written the book" on the subject of EMC and is considered by many to be the nation's leading EMC educator. He is the author of the popular EMC book Noise Reduction Techniques in Electronic Systems (1976, 1988). The book has sold over 65,000 copies and has been translated into six other languages. In addition to knowing his subject, Mr. Ott has the rare ability to communicate that knowledge to others.

Mr. Ott's newly published (Aug. 2009) 872-page book, Electromagnetic Compatibility Engineering, is the most comprehensive book available on EMC. While still retaining the core information that made Noise Reduction Techniques an international success, this new book contains over 600 pages of new and revised material.

Mr. Ott is a Life Fellow of the IEEE and has served the EMC Society in various capacities including: membership on the Board of Directors, Education Committee Chairman, Symposium Committee Chairman and Vice President of Conferences. He is also a member of the ESD Association and a NARTE certified ESD engineer. He is a past Distinguished Lecturer of the EMC Society, and lectures extensively on the subject of EMC.

News in Compliance

FCC News

connections in the United States. The study was based on direct measurements of broadband performance as delivered to the residences of several thousand volunteer broadband subscribers.

Key among the findings of the FCC's 2011 study was that actual broadband service achieves speeds of 80-90% of those advertised by broadband service providers, significantly better than a 2009 study which estimated that actual broadband speeds were only about 50% of those advertised.

FCC Proposes $400k Junk Fax Fine

The U.S. Federal Communications Commission (FCC) has proposed forfeiture penalties in the amount of $432,000 against a California woman for delivering unsolicited advertisements to consumers via facsimile machine.

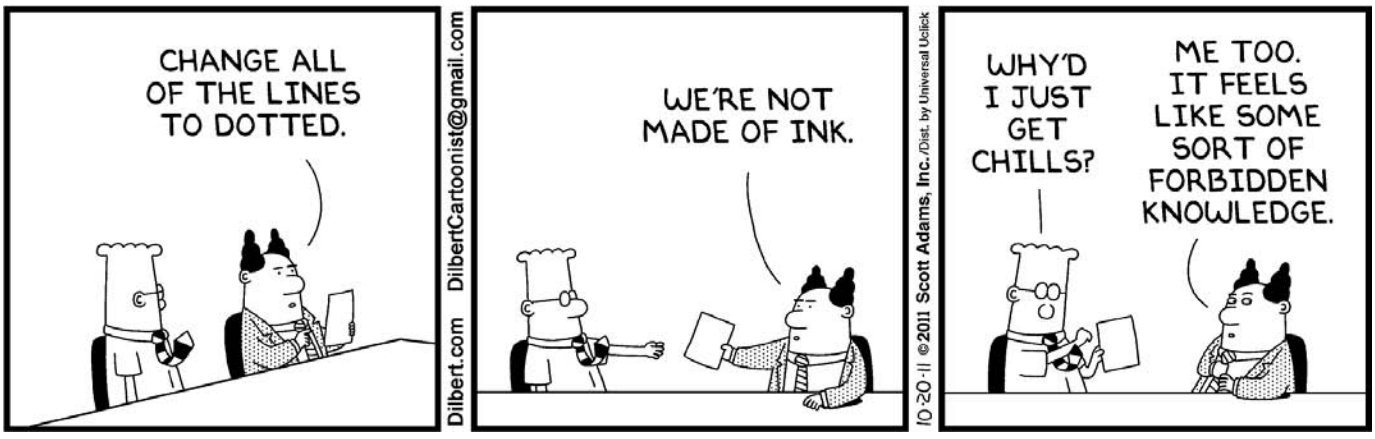
Issued in February 2012, the Notice of Apparent Liability for Forfeiture cites Teresa Goldberg (also known as Tammy Pocknett) and her companies, Software Training Company, Software Business Management and Software Managing Systems, for delivering 27 unsolicited fax advertisements. The fax advertisements reportedly offered two separate courses for "hands-on consulting and training" in the use of QuickBooks.

> The Telephone Consumer Protection Act of 1991 makes it "unlawful for any person within the United States…to use any telephone facsimile machine, computer, or other device, to send, to a telephone facsimile machine, an unsolicited advertisement."

Responding to consumer complaints, the Enforcement Bureau of the Commission originally issued a citation against Software Training Company in December 2010. In its response to the citation, the company asserted that it "was no longer active or in business" and that it had "no plan or resources to start the company again." However, less than two months later, the Commission began receiving consumer complaints regarding fax advertising from Software Business Management and Software Managing Systems that were similar to those send by Software Training Company. Further investigation by the Enforcement Bureau convinced officials that the different companies were simply various trade names through which Goldberg operated.

The Telephone Consumer Protection Act of 1991 makes it "unlawful for any person within the United States…to use any telephone facsimile machine, computer, or other device, to send, to a telephone facsimile machine, an unsolicited advertisement" without prior authorization of the recipient. In this case, the Commission cited Goldberg for willful and repeated violations of its regulations, levying $16,000 in fines for each of the 27 apparent violations, for a total of $432,000. The Commission noted that the proposed penalty was based on the number of apparent, willful, repeat violations involved, as well as Goldberg's "complete disregard for the Commission's authority and an intent to continue to violate the law."

The complete text of the Commission's Notice of Apparent Liability for Forfeiture is available at www.incompliancemag.com/news/1204_05.



European Union News

EU Commission Updates Standards List for PPE Directive

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

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

The extensive list of CEN and Cenelec standards was published in February 2012 in the Official Journal of the European Union, and replaces all previously published standards lists for the Directive.

The complete updated standards list for the EU's PPE Directive is available at www.incompliancemag.com/news/1204_06.

EU Commission Expands REACH Regulations

The Commission of the European Union (EU) has amended its regulations covering the registration, evaluation, authorization and restriction of chemicals (REACH), adding a number of substances deemed carcinogenic or toxic for reproduction.

The regulation, published in the *Official Journal of the European Union* in February 2012, adds eight new chemicals which have been classified as carcinogenic, mutagenic or toxic for reproduction (CMR). The newly added chemicals that are carcinogenic include diarsenic trioxide, diarsenic pentaoxide and 2,4-dinitrotuluene (2,4-DNT). The chemicals that are toxic for reproduction include diisobutyl phthalate (DIBP) and tris (2-chloroethyl) phosphate (TCEP). The chemicals lead chromate, lead sulfochromate yellow and lead chromate molybdate sulphate red are both carcinogenic and toxic for reproduction.

The changes, which reflect recommendations made by the European Chemicals Agency in December 2010, affect the list of chemicals identified in Annex XIV of the REACH Regulation (EC) No 1907/2006. Restrictions against the use of these newly added chemicals begin as early as August 2013.

The complete text of the amended REACH regulations is available at www.incompliancemag.com/news/1204_07.

News in Compliance

CPSC News

Container Store Recalls Power Strips

The Container Stores, Inc. of Coppell, TX has recalled about 7200 of the Lush Life brand power strips manufactured in China.

According to the company, the power strips have undersized wiring, and the wiring and plastic strips fail to meet the requirements for fire resistance, thereby posing a fire hazard to consumers. The Container Store has not received any reports of incidents related to the defective power strips, but has initiated the recall to minimize the risk of future incidents.

The recalled power strips, which include the Pop Power Strip in Scroll, Dot and Zebra designs, were sold at Container Stores nationwide and through the company's website from October 2011 through December 2011, for about $15.

More information about this recall is available at www.incompliancemag.com/news/1204_08.

Konica-Minolta Recalls Laser Color Printers

Konica Minolta Business Solutions U.S.A. Inc. of Ramsey, NJ has announced the recall of about 8400 of its Konica Minolta color laser printers manufactured in China.

Konica Minolta has reported to the U.S. Consumer Product Safety Commission (CPSC) that the printers can short-circuit and overheat during use, thereby posing a fire hazard to consumers. The company says that it has received two reports of printers overheating, but that there have been no reports of injuries in connection with the overheating.

The recalled printers were sold through direct retail sales and authorized Konica Minolta dealers, as well as various value-added resellers, from June 2010 through March 2011 for between $900 and $3500, depending on the printer model.

Additional details about this recall are available at www.incompliancemag.com/news/1204_09.

Hewlett-Packard Recalls Fax Machines

The Hewlett-Packard Company of Palo Alto, CA is recalling about 928,000 of its HP-brand fax machines manufactured in China.

According to HP, the fax machines can overheat due to an internal electrical component failure, thereby posing fire and burn hazards to consumers. The company has received seven reports of fax machines overheating and catching fire, resulting in property damage and once instance of a minor burn injury to a consumer.

This recall involves HP Fax 1040 and 1050 models, which were sold through electronics, computer and camera stores nationwide, as well as through the company website and other websites, from November 2004 through December 2011 for between $90 and $120. In addition, some of the recalled fax machines were replacements for a prior recall involving HP fax model 1010 in June 2008.

Additional information about this recall is available at www.incompliancemag.com/news/1204_10.

Single-Cup Coffee Makers Recalled

BSH Home Appliances Corporation of Irvine, CA is announcing the recall of about 835,000 of its Tassimo-brand single-cup coffee brewers manufactured in Slovenia and China.

BSH has reported that the plastic disk (or T Disc) that holds the coffee or tea can burst and spray hot liquid and coffee grounds or tea leaves onto consumers using the device as well as onto bystanders, thereby posing a burn hazard. The company has received 140 separate reports of the coffee brewers spraying hot liquid, coffee grounds or tea leaves, including 37 reports of second-degree burns and one reported hospitalization.

The recalled coffee brewers were sold at department, mass merchandise and home improvement stores, as well as through various websites, from June 2008 through February 2012 for between $100 and $250. Additional models were sold directly to hotels and food service providers.

Recalls have been issued for power strips, laser color printers, fax machines, single-cup coffee makers, fire control panels and radio modules used in home security control panels. Visit www.cpsc.gov for more information.

CPSC News

More information about this recall is available at www.incompliancemag.com/news/1204_11.

Fire Control Panels Recalled Due to Alarm Failure

Bosch Security Systems, Inc. of Fairport, NY has recalled about 330 of its fire alarm control panels manufactured in China.

According to the company, the control panel can fail to sound an alarm even when the alarm verification feature of the system is turned on. In addition, on those systems with 50 or more reporting stations, a break in the loop for the alarm system may result in a delay in sounding an alarm. Bosch says that it has not received any reports of incidents or injuries related to the control panels.

The recalled fire control panels were sold through Bosch-authorized distributors and installers nationwide from May 2009 through October 2011 for about $1200.

Additional details about this recall are available at www.incompliancemag.com/news/1204_12.

GSM Modules for Home Security Control Panels Recalled

2GIG Technologies Inc. of Lehi, UT has announced the recall of about 40,000 of the GSM modules manufactured in China and used in its Go!Control-brand home security system control panels.

The company has reported to the U.S. Consumer Product Safety Commission (CPSC) that the GSM radio modules used inside the control panel can overheat and combust, potentially exposing consumers to a fire or burn hazard. 2GIG Technologies says that is has received 22 reports of the modules overheating, including three reports of minor smoke, heat or fire damage to the wall where the control panel was mounted. However, there have been no reports of injuries.

The recalled GSM radio modules were sold between December 2010 and October 2011 to home security companies and security system equipment distributors for use in Go!Control panels, who then installed the modules as a component of home security systems.

Additional information about this recall is available at www.incompliancemag.com/news/1204_13.

You Can't Make This Stuff Up

Scientists at the famed European Organization for Nuclear Research (CERN) in Geneva, Switzerland may have some explaining to do, in light of revelations that recent major research findings regarding the speed of light may have been compromised due to a poor cable connection.

In September 2011, CERN researchers claimed that neutrinos (sub-atomic particles) zapped from Geneva to a laboratory in Gran Sasso, Italy traveled the 450 mile distance about 60 nanoseconds faster than the speed of light, or about 186,000 miles per second. If validated, such a finding would have called into question the basis for many scientific theories, including Einstein's theory of relativity and the theory of gravity.

However, the BBC, the Wall Street Journal and other media outlets are reporting that researchers are planning to rerun the experiment this May to check the original work. The reason? It appears that there might have been a problem with the optical fibre connection between the GPS signal and the main clock used to time the experiment. Or, as the BBC delicately put it, "a cable not quite fully plugged in"

A separate problem related to the oscillator used in the experiment was also discovered. However, according to researchers, since it would have had the effect of decreasing the apparent speed of the traveling neutrinos, the faulty cable connection seems the likely culprit for the breakthrough findings that may prove untrue in the end.

News in Compliance

UL Standards Updates

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

STANDARDS

UL 172: Standard for Sustainability for Toys
New Edition dated February 10, 2012

UL 291: Standard for Automated Teller Systems
New Edition dated February 15, 2012

UL 558: Standard for Industrial Trucks, Internal Combustion Engine-Powered
New Edition dated January 10, 2012

UL 746F: Standard for Polymeric Materials - Flexible Dielectric Film Materials for Use in Printed-Wiring Boards and Flexible Materials Interconnect Constructions
New Edition dated January 13, 2012

UL 763: Standard for Motor-Operated Commercial Food Preparing Machines
New Edition dated January 31, 2012

UL 1026: Standard for Electric Household Cooking and Food Serving Appliances
New Edition dated January 27, 2012

UL 1026: Standard for Electric Household Cooking and Food Serving Appliances
New Edition dated January 27, 2012

UL 1097: Double Insulation Systems for Use in Electrical Equipment
New Edition dated February 1, 2012

UL 1803: Standard for Factory Follow-Up on Third Party Certified Portable Fire Extinguishers
New Edition dated February 15, 2012

UL 2368: Standard for Fire Exposure Testing of Intermediate Bulk Containers for Flammable and Combustible Liquids
New Edition dated January 31, 2012

UL 62368-1: Audio/Video, Information and Communication Technology Equipment - Part 1: Safety Requirements
New Edition dated February 17, 2012

UL 61215 (IEC 61215:2005): Crystalline Silicon Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval
New Edition dated January 25, 2012

UL 61215 (IEC 61215:2005): Crystalline Silicon Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval
New Edition dated January 25, 2012

UL 61646 (IEC 61646:2008): Thin-Film Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval
New Edition dated January 25, 2012

UL 61646 (IEC 61646:2008): Thin-Film Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval
New Edition dated January 25, 2012

UL 62108 (IEC 62108:2007): Concentrator Photovoltaic (CPV) Modules and Assemblies - Design Qualification and Type Approval
New Edition dated January 25, 2012

REVISIONS

UL 20: General-Use Snap Switches
Revision dated February 17, 2012

UL 73: Standard for Motor-Operated Appliances
Revision dated January 9, 2012

UL 94: Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
Revision dated January 31, 2012

UL 101: Leakage Current for Appliances
Revision dated January 24, 2012

UL 234: Standard for Low Voltage Lighting Fixtures for Use in Recreational Vehicles
Revision dated January 9, 2012

UL 325: Standard for Door, Drapery, Gate, Louver, and Window Operators and Systems
Revision dated January 12, 2012

UL 498A: Current Taps and Adapters
Revision dated January 11, 2012

UL 796: Standard for Printed-Wiring Boards
Revision dated January 18, 2012

UL 823: Standard for Electric Heaters For Use in Hazardous (Classified) Locations
Revision dated January 31, 2012

UL 873: Standard for Temperature-Indicating and -Regulating Equipment
Revision dated January 6, 2012

UL Standards Updates

UL 900: Standard for Air Filter Units
Revision dated February 14, 2012

UL 962A: Standard for Furniture Power Distribution Units
Revision dated February 13, 2012

UL 1012: Standard for Power Units Other Than Class 2
Revision dated January 19, 2012

UL 1046: Standard for Grease Filters for Exhaust Ducts
Revision dated January 13, 2012

UL 1090: Standard for Electric Snow Movers
Revision dated January 20, 2012

UL 1310: Standard for Class 2 Power Units
Revision dated January 26, 2012

UL 1323: Standard for Scaffold Hoists
Revision dated January 25, 2012

UL 1363: Standard for Relocatable Power Taps
Revision dated January 17, 2012

UL 1569: Standard for Metal-Clad Cables
Revision dated January 6, 2012

UL 1574: Standard for Track Lighting Systems
Revision dated January 25, 2012

UL 1795: Standard for Hydromassage Bathtubs
Revision dated January 13, 2012

UL 1917: Standard for Solid-State Fan Speed Controls
Revision dated February 23, 2012

UL 2777: Standard for Sustainability for Hard Floor Care Products
Revision dated February 6, 2012

UL 2785: Standard for Sustainability for Printing Cartridges
Revision dated January 24, 2012

UL 60065: Standard for Audio, Video and Similar Electronic Apparatus - Safety Requirements
Revision dated January 25, 2012

UL 60950-23: Information Technology Equipment - Safety - Part 23: Large Data Storage Equipment
Revision dated January 31, 2012

UL 60950-21: Information Technology Equipment - Safety - Part 21: Remote Power Feeding
Revision dated January 31, 2012

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

Send news items to the editor:

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iNARTE Informer

iNARTE's 30th Birthday

BY BRIAN LAWRENCE

This year, 2012, marks iNARTE's 30th birthday. Over 30 years, we have certified more than 18,000 engineers and technicians in 33 different countries around the world..

In 1982, our organization began in Salem, Oregon, offering certification in telecommunications engineering. In 1989, we added a second program of certification for engineers and technicians working in electromagnetic compatibility (EMC). Then, in 1991, we moved to new offices in Medway, Massachusetts.

By 2004, we had added other certification opportunities for engineers and technicians in ESD control and product safety engineering, supported by formal agreements with internationally recognized engineering societies and associations. In 2008, our offices moved again to New Bern, North Carolina, since which time we have added four more programs with two more planned for later this year.

We attribute our success to our high ethical standards and the fact that we offer recognition of professional excellence to engineers and technicians working in very specific disciplines, where there are few if any other ways to validate their credentials. The following is just such an opportunity to advance your career and enjoy a great time at a very special place...

SO WHAT ARE YOUR PLANS THIS SUMMER?

What about going to university? That's where we will be, at the University of Oxford. Oxford is acknowledged around the world as one of the finest seats of learning. It is the oldest surviving university in the English-speaking world, with evidence of its teachings going back to 1096.

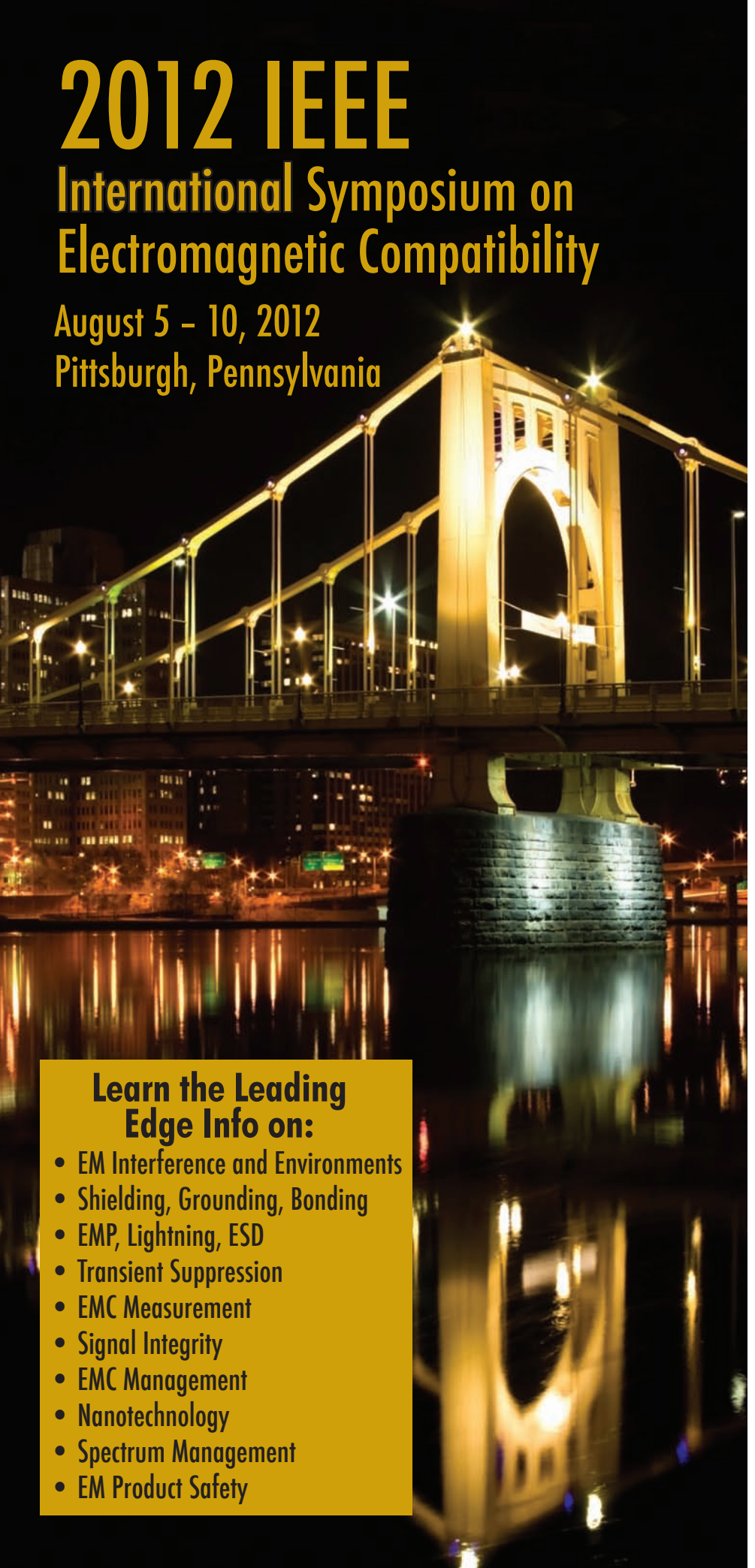
But did you know that in addition to its world-class undergraduate and postgraduate programs, Oxford also offers more than 800 Continuing Education courses each year in a wide variety of subjects, and open to anyone interested in furthering their professional development?

You can see all that Oxford offers by visiting, http://www.conted.ox.ac.uk/courses/index.php. If you then "Search", **High-speed digital engineering and EMC,** you will find the following:

- *Electronic Product Design and Retrofit for EMC (June 19-20, 2012)*
- *High Frequency Measurements (probes and equipment used in Signal Integrity and EMC work) (June 19-20, 2012)*
- *EMC and ESD Lab Techniques for Designers (troubleshooting to proactively avoid field or compliance problems) (June 21, 2012)*
- *Advanced Troubleshooting Techniques for Circuits and Systems (June 22, 2012)*
- *High-speed Digital Design (June 26-27, 2012)*
- *Printed Circuit Board Design for Real-world EMI Control (June 26-27, 2012)*

2012 IEEE
International Symposium on Electromagnetic Compatibility

August 5 – 10, 2012
Pittsburgh, Pennsylvania



Learn the Leading Edge Info on:

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- Shielding, Grounding, Bonding
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iNARTE Informer

- *High-speed Noise and Grounding (June 28-29, 2012)*
- *Advanced EMC: Fullwave Modelling for EMC and Signal Integrity (June 28-29, 2012)*
- *Power Distribution Design (July 2 - 3, 2012)*

Over the course of these two weeks, you can polish up your knowledge on the application of EMC principles in electronic systems design. And that is why iNARTE will be there on Saturday, June 30, 2012 at the Sadler Room of the Rewley House Education Center, to provide you with an independent validation of your knowledge and credentials in electronic design for EMC compliance.

As many of you know, and in response to industry demand, iNARTE introduced a new lifetime certification program in 2011 for **EMC Design Engineers** and **Senior EMC Design Engineers.** These two certificates of professional excellence are respectively intended for engineers about to begin a career in electronic design, and the more seasoned engineers with four or five years experience wishing to validate their expertise.

Our certification programs all have four main components that we consider:

- **Education** – transcripts of post-secondary education
- **Experience** – detailed work history clearly showing related experience
- **Endorsement** – letters of reference
- **Examination** – achieve a passing grade in the iNARTE examination and write new questions for us

The examination phase of the Design Engineer and Senior Design Engineer Programs consists of two papers, each of three hours duration and to be taken on the same day. The examination questions are all multiple-choice and cover the subjects:

- **EMC Countermeasures & Components**
- **EMC Design & Design Review**
- **EMC Simulation & Rule Check**
- **Signal Integrity & Power Integrity**
- **Electronics Circuits & Power Electronics**
- **Electromagnetics & Shielding**
- **Electrical Circuit Theory**
- **Measurement & Analysis**
- **Specification & Standards**
- **Mathematics**
- **EMC Basic Knowledge**
- **Terminology**

Much of the exam content is the subject matter of the Oxford courses. So join us at Oxford on June 30, 2012. You are welcome to attend our examination without attending any of the Oxford courses if you wish, and for that reason you need to register directly with iNARTE for the examination day by visiting www.narte.org/h/examregformint.asp. First enter the exam of your choice,

choice, then from the date menu select "Special Event Location", and in that box select "Oxford 2012". Add your registration to the basket and at the fees line enter $300.00, (US Dollars). This is all you will pay for your complete application, including the examination. All the information about this certification program is at www.narte.org/h/emcdesignengineer.asp.

The Rewley House at Oxford also offers convenient accommodation, and iNARTE will provide lunch between the two examination papers. To book a room at Rewley House, go to www.conted.ox.ac.uk/facilities/booking/enquiries.php.

If you need to digest the course materials before examining with iNARTE, you can book any of our examinations through York EMC Services (YES). YES does have certain regular examination dates, but may also be able to accommodate your schedule. YES is running its course Fundamentals of Design and Testing for EMC on April 16 - 20, 2012, which would be an excellent preparation for both the exam and the more in-depth courses at Oxford. The next scheduled iNARTE examination day at York will be July 17, 2012. All information about YES courses and iNARTE examinations may be found at www.yorkemc.co.uk.

SOME NEW PROGRAMS COMING IN 2012

Watch for announcements on the iNARTE website and in this publication as we develop and launch the following additional and new programs in 2012:

- **Senior EMC Design Engineer:** A credential for the more experienced engineers with at least four years of electronic systems design work experience. This is an expansion to the EMC Design Engineer program launched in 2011.
- **Wireless Regulatory Professional:** A new credential for the EMC test engineers and technicians who are knowledgeable and experienced in the qualification of wireless products. The knowledge requirements will focus on current and ever-changing FCC regulations.
- **Spectrum Management/Frequency Coordination:** A new credential for engineers and technicians working in the highly specialized technology that deals with management of the electromagnetic spectrum.

QUESTION OF THE MONTH

Last month we asked:

During a site survey, a meter reading of 97 dBµV/m is recorded. The cable loss is 2.5 dB, attenuation is 10 dB and the antenna gain is –20 dBi. What is the corrected value in V/m?

A) 0.07 V/m
B) 2.99 V/m
C) 29.9 V/m
D) 7.0 V/m

The correct answer is: B) 2.99 V/m

This month's question is:

An ideal dummy load for use in a 50 Ω system should have:

A) 50 ohm reactance, zero resistance
B) 50 ohm resistance, zero reactance
C) 50 ohm inductive reactance
D) 50 ohm capacitive reactance
E) None of the above

(the author)

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

MR. Static

Environmental ESD: Part 1

The Atmospheric Electric Circuit

BY NIELS JONASSEN, sponsored by the ESD Association

An understanding of the atmospheric electric circuit provides an insight into the processes underlying ESD events.

INTRODUCTION

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

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

~ The ESD Association

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Compliance Engineering Magazine,
Mr. Static Column

When people hear about static electricity, most of them think of unpleasant shocks experienced when touching a doorknob or of electronic components being destroyed because of electrostatic discharge (ESD) events. Fifty years ago, it was more likely that static electricity would be connected with explosions in chemical or pharmaceutical factories or laboratories. However, in most cases, ESD phenomena are thought of as the result of human activity. People often overlook atmospheric electricity, which by its nature is very similar to well-known static electric processes.

If a properly grounded fieldmeter is brought outside and directed upward, the meter would likely measure an electric field directed downward with a strength of approximately 150 $V \cdot m^{-1}$. If the measurement were made on a mountaintop, the field may be 10 or more times stronger. These measurements are indicative of fair-weather conditions.

If there is a thundercloud overhead, the field is usually reversed and runs easily into the tens of $kV \cdot m^{-1}$. If a horizontal metal plate exposed to the free atmosphere is connected to ground through a sensitive ammeter, it would measure a current of about $3 \cdot 10^{-12}$ $A \cdot m^{-2}$. A value of 3 $pA \cdot m^{-2}$ is not much, but when it is taken for the earth as a whole, the current amounts to about 1500 A.

Although there are still many atmospheric electric processes that are not understood in detail, there is a general understanding of the atmospheric electric circuit (Figure 1 provides a simplified picture of the processes). Fair-weather conditions are shown on the left side of the figure, where a downward electric field drives positive charges toward ground. Most of the field lines start at positive charges in the lower atmosphere, and some extend all the way to the atmospheric electric exchange layer (at a height of about 60 km), the lower part of the ionosphere. The necessary field distribution is maintained by

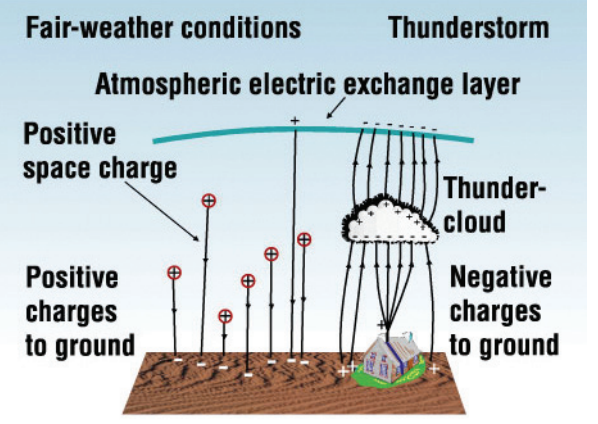

Figure 1: The atmospheric electric circuit

thunderstorms (or thunderclouds), shown on the right side of the figure. A thundercloud normally has a negative base and a positive top, which brings negative charges to ground.

Furthermore, the values of the fields below the thunderclouds may be much greater than the fair-weather values, often 5–10 kV·m^{-1} as compared with a fair-weather field of 100–200 V·m^{-1}. The greater field strength may cause corona and brush discharges from the tips of leaves and branches, not to mention lightning rods, which contribute to the total current. Regular lightning discharges also represent a certain current to the ground (primarily negative), but this contribution is rather modest. The field has the same direction above, as well as below, the thunderclouds, causing a positive current to flow to the atmospheric electric exchange layer and closing the circuit (see Figure 2 for an equivalent diagram).

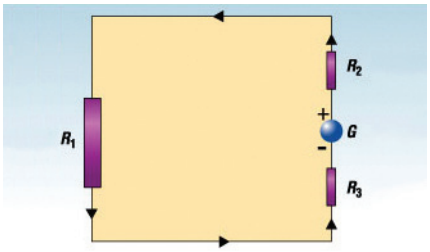

Figure 2: An equivalent diagram of the atmospheric electirc circuit

Between the exchange layer and the ground, there is a voltage difference of about 300 kV, which drives a current of about 1500 A to ground, where it is distributed over all areas with fair-weather conditions. This corresponds to a resistance R_1 of 200 W, representing the parallel resistance of all fair-weather air columns. G represents the generator effect of all simultaneously active thunder systems, and R_2 and R_3 represent the resistances of the air columns above and below these systems, respectively.

CHARGE CARRIERS

For a current to flow in a given medium, an electric field has to be established and the medium must contain mobile charge carriers. In atmospheric air, the charge carriers are air ions (or atmospheric ions), molecular clusters that carry an electric charge.

An ion is formed when a neutral oxygen or nitrogen molecule receives enough energy to lose an electron and is left as a singly positively charged elementary ion. Within less than a microsecond, the electron will combine with (usually) an oxygen molecule, forming a negatively charged elementary ion.[1] Other types of elementary ions include hydroxonium (H_3O+) and charged nitrogen oxides.

Small Ions. By polarization, both polarities of elementary ions will bind 10–20 molecules of water around themselves (a few more for positive than for negative ions) within a fraction of a second, thereby forming small molecular clusters. These molecular clusters are called air ions, and they are almost 100% responsible for charge neutralization by air ions.[2]

Large Ions. However, any atmosphere will contain aerosol particles or condensation nuclei in numbers from a few thousand to several hundred thousand per cubic centimeter. These are particles or molecular clusters with radii ranging from 10^{-10} to 10^{-7} m. If a small ion collides with a condensation nucleus, the two may attach to form a large ion.

ION SOURCES

An air molecule may receive the necessary ionization energy from a colliding atomic particle or from a quantum of electromagnetic radiation energy. In the lower atmosphere, ions are predominantly produced by radiation from radioactive materials in the soil, in building materials, and, first of all, in the air (radon and its daughter products). Although all three types (alpha, beta, and gamma) of radiation may ionize the air, alpha radiation is by far the most important.

An alpha particle (with energies in the order of 4–8 MeV [6–13 x 10^{-13} J]) emitted from a decaying radioactive atom (see Figure 3) will, along its trajectory through the surrounding air, knock off electrons from oxygen and nitrogen molecules—at the expense of about 34 eV per successful collision. Cosmic radiation contributes maybe 10% to the ionization at ground level. However, at higher altitudes, the partitioning shifts dramatically both because the radiation from the soil and airborne materials decreases and because the intensity of the cosmic radiation increases.

MOBILITY

Normally, ions are characterized by their mobilities. If an ion is exposed to an electric field E, it will move with a constant velocity v given by:

$$v = kE. \qquad (1)$$

For positive ions, v is in the direction of the field, and for negative ions, v is in the opposite direction.

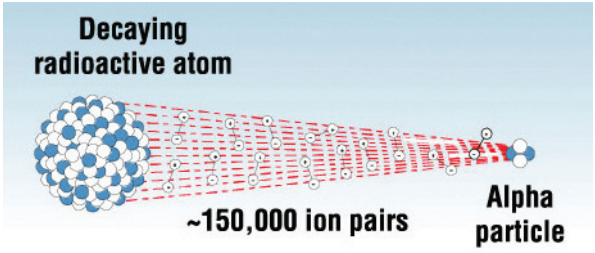

Figure 3: A decaying radioactive atom emitting an alpha particle.

MR. Static

The factor of proportionality, k, represents the mobility of the ion. The unit of k is (m/second)/(V/m) = $m^2 \cdot V^{-1} \cdot s^{-1}$. Small positive ions have mobilities of approximately 1.4×10^{-4} $m^2 \cdot V^{-1} \cdot s^{-1}$, and small negative ions have about 1.8×10^{-4} $m^2 \cdot V^{-1} \cdot s^{-1}$. The difference in mobility reflects the difference in the numbers of attached water molecules in the ions. Large ions cover a range of mobilities from about 3×10^{-7} to 8×10^{-8} $m^2 \cdot V^{-1} \cdot s^{-1}$, depending partially on the nature and size distribution of the aerosol particles in the air.

REMOVAL PROCESSES

An ion has a limited lifetime. It may deposit on a surface either by diffusion or by the aid of an electric field. An ion may combine with oppositely charged ions or particles and hence cease to exist as an ion, or with aerosol particles and then either be neutralized or become a large ion. This latter process usually determines the lifetime of an ion. In polluted city air, the average lifetime may be in the order of 10–20 seconds, whereas in polar air, poor in aerosols, the lifetime may be as long as 300–400 seconds.

CONDUCTIVITY

For a current to flow in a medium, that medium must contain mobile charge carriers. Consider an atmosphere containing one type of ions with the concentration n and the mobility k, with each ion carrying a single elementary charge e. If an electric field E is established in the medium, a current with the density j will flow in the medium in the direction of the field (for positive ions) given by $j = enkE$ or

$$j = \gamma E. \qquad (2)$$

Equation 2 is Ohm's law in differential form. The factor

$$\gamma = enk \qquad (3)$$

is called the conductivity of the air, and the unit is $W^{-1} \cdot m^{-1}$.

It appears from Equation 3 that, of two groups of ions with the same concentration, the group with the greatest mobility contributes the most to the conductivity. It is often convenient to separate the contributions to the conductivity of positive and negative ions by introducing the polar conductivities, that is, the conductivities caused by the positive and negative ions, separately. In the case of an atmosphere with the concentration n^+ and mobility k^+ for positive ions and n^- and k^- for negative ions, the polar conductivities are $g^+ = en^+k^+$ and $g^- = en^-k^-$. Both polar conductivities are positive quantities, causing positive currents to flow in the direction of the field, with positive and negative charge carriers moving in opposite directions.

Usually, the ions do not all have the same mobility but are, in general terms, distributed according to some function of frequency $f(k)$ in such a way that the concentration dn of ions with mobilities from k to $k + dk$ is given by $dn = f(k)dk$. The conductivity may then be written as

$$\gamma = e\int_0^\infty kf(k)dk. \qquad (4)$$

Normally, only small ions contribute significantly to the conductivity of the air because their mobility is much greater than that of large ions and charged particles.

At ground level, under fair-weather conditions, the average value of the conductivity is about 2×10^{-14} $W^{-1} \cdot m^{-1}$. The conductivity shows annual and diurnal variations, depending on variations in the ionization and aerosol conditions. The conductivity increases with increasing altitude both because of the decrease in aerosol concentration and because of the increase in the cosmic radiation intensity. At an altitude of 5 km, the conductivity may be about 10 times greater than at ground level.

THE VERTICAL FIELD

It has been known for more than two centuries that the normal prevailing condition in the atmosphere is best described in today's language as an electric field directed downward, bringing a positive charge to the ground. At ground level, the field strength is about 100–150 $V \cdot m^{-1}$. The field strength decreases rapidly with increasing altitude, and at 5 km, the field strength is about one-tenth of the value at ground level.

The potential of the atmosphere can be found by integrating the field strength with respect to height. At a height of approximately 60 km, the field strength is virtually zero, and, consequently, the potential does not change with further increases in height. This is the location of the atmospheric electric exchange layer shown in Figure 1. The mean value of the potential of the exchange layer is about 300 kV.

The current density (see Equation 2) is more or less constant in a given vertical column of air and can be written as

$$j = \gamma E = \frac{V}{R_c}, \qquad (5)$$

where V is the potential of the atmospheric electric exchange layer and R_c is the columnar resistance (i.e., the

resistance of an air column that extends from the ground to the exchange layer and has a unit area cross section).

Equation 5 expresses two important relations. For a given value of V, the conductivity g and the field strength E are inversely proportional, which is in good accordance with experiments. For locations where the conductivity exhibits small changes with time (e.g., over the oceans), the field strength is, at a given place, proportional to the potential of the exchange layer, and recordings of the field strength may therefore reveal patterns in the value of this potential.

The top graph of Figure 4 shows an example of an atmospheric field strength recording, normalized to the mean value, as a function of Greenwich mean time (GMT). It appears that the field strength, and therefore the exchange layer potential, has a minimum at 3 GMT and a maximum at 19 GMT.

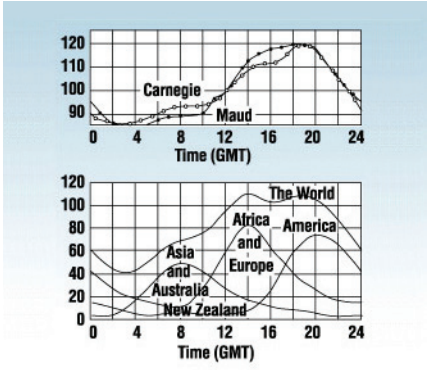

Figure 4: Example recordings of field strength as a function of Greenwich mean time.

Because the atmospheric field and potential are maintained by active thunderstorms, it is therefore to be expected that variations in the field and potential reflect corresponding variations in concurrent thunderstorm activity. Such a relationship is shown in the bottom graph of Figure 4. The graph plots areas where, at a given time, thunderstorms are active in major parts of the world. A place is regarded as having been in a thunder area at a specified time if thunder was audible in the interval from 60 minutes before to 60 minutes after that time. Although this is a rather uncertain estimate, the curve for the world as a whole does show a correspondence with the field strength curve plotted in the top graph, allowing a causal relationship to be deduced.

ATMOSPHERIC CURRENTS

The effect of the ground-level field strength of 150 $V \cdot m^{-1}$ and conductivity of 2 x 10^{-14} $W^{-1} \cdot m^{-1}$ is, according to Equation 2, a current to the ground with the density j @ 3 x 10^{-12} $A \cdot m^{-2}$. This is the fair-weather vertical current density, but this field-induced charge transport is not the only way by which charge is brought to the ground.

It has long been known that most precipitation elements, such as rain drops, snowflakes, and hailstones, are often charged. If large raindrops are falling in a strong turbulent updraft, they may split into smaller droplets. The majority of the smallest droplets are negatively charged because of the Lenard effect, that is, the breakup of the electrical double layer at a water-air interface.

A similar process may charge snow particles, but it should be mentioned that charging processes are much more complicated with solid materials. The charging involves contact and friction, and the result therefore depends on the physical state of the contacting materials (temperature, purity, origin, etc.). For example, it has been shown that when two ice pellets are rubbed against each other, the ice pellet with the higher conductivity will become negative, regardless of whether the higher conductivity is caused by higher temperature or lower purity.
The charge brought to the ground by precipitation is normally positive, averaging about 30 C/km^2 per year, or about 10^{-12} $A \cdot m^{-2}$. The charge from precipi-tation together with the fair-weather vertical current yields a positive current to the ground of about 4 x 10^{-12} $A \cdot m^{-2}$, or a total current of about 2000 A to the earth as a whole.

The second part of this article on atmospheric electricity will show that the collective effects of thunderstorms are enough to balance the current brought to the ground. In addition, the physics of lightning discharges will be discussed.

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1. Niels Jonassen, "Ions" in Mr. Static, *Compliance Engineering* 16, no. 3 (1999): 24–28.
2. Niels Jonassen, "Neutralization of Static Charges by Air Ions: Part I, Theory" in Mr. Static, *Compliance Engineering* 19, no. 2 (2002): 28–31.

(the author)

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

ON Your Mark

Who, What and Where

BY GEOFFREY PECKHAM

This column is primarily a resource for the safety symbols you place on the products you design. This time, let's step back a bit and ask the question, "What are we doing here?" To answer this, I want to show you a similarity between the overturned cruise ship, *Costa Concordia*, and the products under your design control.

Appropriately enough, I recently returned from a January ISO committee meeting in London where we put the finishing touches on a set of standards that improve the graphic design and installation guidelines for safety sign systems used onboard ships. The committee consists of safety sign experts from national maritime organizations like the U.S. Coast Guard, ship builders, marine risk management organizations, and companies that specialize in the field of symbol-based safety signs, like Clarion. The goal: to provide the International Maritime Organization (IMO) with updated standards they can use to define best practices for shipboard safety sign systems.

To set the stage for this comparison, imagine you were aboard the *Costa Concordia*, ready to enjoy your first cruise experience. As you sail from port, you are told that a safety evacuation drill will occur later that evening. Before the drill takes place, the ship's hull is torn open when it collides with underwater rocks and the next several hours are filled with chaos and loss of life.

The *Costa Concordia* (like all cruise ships, commercial vessels, tankers, and ferries) was outfitted with a system of ISO/IMO standardized safety signs meant to reinforce training that crew and passengers receive in order to be better prepared should an emergency situation occur. The signs for passengers point the way to specifically designated assembly stations where they are to be met by crew. The assembled group then follows another set of signs to specifically designated debarkation stations where they climb inside the lifeboats (now called "survival craft"). Once inside the lifeboats, another set of safety signs is used by trained crew both on the ship and in the lifeboat to

Figure 1: Your product safety label system

Figure 2: The Costa Concordia rescue effort
(Photo Credit: Associated Press/Giuseppe Modest)

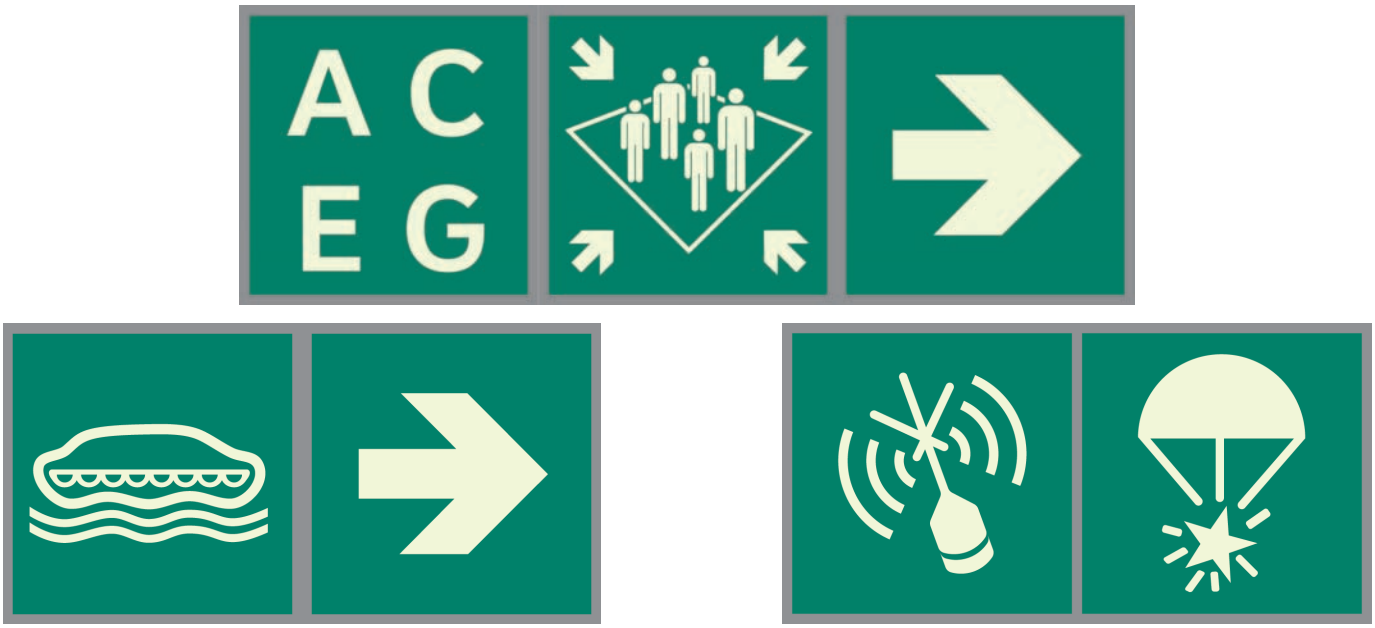

Figure 3: Three shipboard safety signs: Directional assembly station sign (top), directional lifeboat sign (bottom left), safety equipment signs for radio beacon transmitter and parachute flare (bottom right)

ON Your Mark

Correct: A safety label placed at the point of possible interaction with a mechanical hazard.

Incorrect: All safety labels placed in a single location.

Figure 4: Location of safety labels is important. The top photo shows a safety label placed at the point of possible interaction with a mechanical hazard. The bottom photo shows the incorrect placement of all safety labels in a single location.

properly lower it into the water and separate it from the ship. Inside the lifeboat is another set of signs that locate safety equipment like flares, radio beacons and first aid supplies.

While participating in this ISO meeting, it occurred to me that, when implemented properly, the safety labels you place on your products operate much like safety signs used on ships. First, they must be created and installed as a *system*. This means they must be planned and designed in ways that will best communicate critical safety information. Try to convey too much information and you risk people not bothering to read your signs; too little information runs the risk of people not being able to make informed and correct decisions. Think of your product's safety labels as if they were a shipboard sign *system*. Your job is to provide people with the information they need at the right point of anticipated interaction. Not before, and not after. For instance, onboard ships assembly station directional signs are placed in the hallways and gathering spaces, not inside cabins. And safety equipment location signs are placed inside lifeboats, not outside the lifeboats. Similarly, the safety labels that appear on your products should be placed where people could most likely interact with the hazard, not assembled all together in one spot 50 feet away on the electrical panel (though best practices for machinery safety labeling do include placing certain location-specific warnings on control stations and electrical panels).

Second, both shipboard safety signs and your product safety labels should make use of graphical symbols so their messages can be conveyed quickly and across language barriers. If possible, standardized ISO symbols should be used for international acceptance of your warnings. If customized symbols

need to be developed, standardized illustration methods should be used. The point is consistency of message, both internally on your equipment, and externally to help ensure that your products fit into the global language of safety used in the worldwide marketplace.

Third, like shipboard safety signs meant for both crew and passengers, your product's safety labels are often used to convey safety messages to people who have had various levels of training. Some of your labels are meant for your product's users, while other labels are for those who perform maintenance. Knowing who your audience is will help you craft the messages on your safety labels so they properly convey the right information.

Finally, like the evacuation drill that occurs on ships, your safety labels often serve to reinforce a broader scope of safety information provided in your product manual. In this capacity, they serve as critical reminders of training (see the February 2012 *On Your Mark* column on how to tie manuals and safety labels together).

The point is that your safety signs and markings need to be planned, they need to function as a system, and they need to serve a well-defined set of objectives that take into account ***who*** they are intended to communicate to, ***what*** they should say, and ***where*** they are to be placed. Lastly, do not reinvent the wheel –use best practice methods, formats, and symbols as much as possible so your resulting system of signs and labels has the best chance at being both effective and in compliance with the latest standards.

For more information about safety signs and symbols, visit www.clarionsafety.com.

(the author)

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MYTH vs. Reality

The First Axiom of System-Product Design

BY W. MICHAEL KING

The myth: Electromagnetic Compatibility (EMC) performance was initially intended for the realization of system-product compliance with the requirements of regulatory agencies through standards applications.

The reality: EMC performance criteria were conceived to assure system-product functionality.

In history and in reality of practice, the essential and fundamental first axiom of systems-product design criteria is literally electromagnetic compatibility (EMC); system-product circuits, signals, modules, circuit architecture and sub-systems must be functionally compatible with themselves! In recent years, understanding and application of the term "EMC" increasingly seems to have become narrowly and inappropriately limited to defining the comparative performance between regulatory agency-mandated EMI immunity and emission requirements, and the profiles exhibited by system-products. Historically, the intention of EMC as both a term and a process was to assure that the integrated system or system-product will perform as intended within defined functionality requirements with regard to: a) sources of fields and currents within the design itself (for signal integrity and signal/noise ratios at the unit level), b) sources of fields, potentials and currents produced to and from other modules/units of a system or among multiple systems in a common "platform" environment, and c) sources of fields, potentials and currents to and from the external operating environment.

Item "b" can be carried forward in military or space implementations to define the first increment of "environment" as a sphere of functionality within a common-platform, such as a warship, spacecraft or air form (war bird). The concept in these applications is sufficiently compartmentalized to conceptualize the 'envelope' of the common-platform (often a weapon, surveillance or communication package) first as an environment within itself, and secondly with that envelope as a platform to determine EMC with the intended operating environment external to the platform. These concepts are typically conveyed through environmental specifications such as MIL-E-6051. For this application, the measurement processes are intended to assure that no system component or sub-system interferes with the needed operation of any other component or sub-system, and that fields to or from the platform as a whole are compatible with a rigorous (e.g. battlefield) operating environment. In commercial parallels, the platform could be any individual package, such as a desktop computer or a medical device. Within these descriptions, it is observed that specific EMI emissions or susceptibility (immunity) specifications are only interim tools to increase confidence that the goals of the ultimate functional environmental demand will be achieved.

Given this viewpoint, signal integrity, signal timing (propagation time), signal perturbation, cross-talk and coupling, signal-to-noise ratios, common-mode containment and partitioning, common-mode architectural derivations, power delivery/quality, and electromagnetic field captures and exclusions are all mutually inclusive to the term "EMC". In impact, great performance profiles with regard to all of these sub-set characteristics of EMC will combine to produce a thoroughly integrated and compatible system-product with reference to factors

While the limited definition of EMC described by system-product compliance with the requirements of regulatory agencies is a fact of contemporary electrical engineering, it does not adequately relate the whole significance of what the term "EMC" represents, in intention or reality.

of compatibility within itself, other systems, and the external environment.

While the limited definition of EMC described by system-product compliance with the requirements of regulatory agencies is a fact of contemporary electrical engineering, it does not adequately relate the whole significance of what the term "EMC" represents, in intention or reality.

(the author)

W. MICHAEL KING

is a systems design advisor who has been active in the development of over 1,000 system-product designs in a 50 year career. He serves an international client base as an independent design advisor. Many terms used for PC Board Layout, such as the "3-W Rule", the "V-plane Undercut Rule", and "ground stitching nulls", were all originated by himself. His full biography may be seen through his web site: www.SystemsEMC.com.

Significantly, he is the author of EMCT: High Speed Design Tutorial (ISBN 0-7381-3340-X) which is the source of some of the graphics used in this presentation. EMCT is available through Elliott Laboratories/NTS, co-branded with the IEEE Standards Information Network.

TECHNICAL Tidbits

Measuring Capacitor Self-inductance and ESR

BY DOUGLAS C. SMITH

Technical Background

The parasitic parameters of a capacitor, that is its equivalent series resistance (ESR) and its inductance, affect the way the capacitor performs in circuits. Some applications are very sensitive to these parameters. For instance, a bypass capacitor used between power and ground in a digital circuit must be able to supply current quickly to nearby active devices. If it has too much inductance it will not be able to do this. Similarly, the transient response of a capacitor used to divert a current pulse due to electrostatic discharge is very important to the ability of the capacitor to do its job.

So how can the parasitic parameters of a capacitor be measured? One could certainly connect the capacitor to a network analyzer and get a very good characterization. Such an instrument can be quite expensive though. Even the less expensive capacitance measuring instruments may not be available when needed. Both instruments may not provide the information in an easily usable form. If you have a pulse generator (preferably with a 50 ohm output impedance) and an oscilloscope, you can easily measure the transient response of a capacitor. From this data, the capacitor's ESR and inductance can be determined.

First, construct the simple network shown in Figure 1 at the end of a 50 ohm coaxial cable fed from a 50 ohm pulse generator. A 50 ohm resistor is used in Figure 1 to terminate the coax during the rising edge and provide a total of 100 ohms of source impedance. The resistor shown is a 51 ohm 1/2 watt carbon composition resistor with one lead trimmed so that the resistor just seats with the trimmed lead fully inserted into the BNC connector. It may be necessary to put a little solder bump on the resistor lead so that it stays firmly in the BNC connector. The capacitor to be tested is connected between the end of the resistor and the shell of the BNC connector. An oscilloscope is connected directly across the capacitor, using the shortest leads possible to connect the probe. Probes with a resistive input impedance of 500 to 1000 ohms are recommended. Standard 10X HiZ probes often have rising edge effects that will distort the part of the waveform used for the calculations.

Figure 1: Test circuit for measurement of capacitor self-inductance and ESR

For a pulse length that is long with respect to the RC time constant, one will see an exponential rise to the open circuit voltage of the pulse source. For the purposes of this discussion, we will be looking at the first couple of hundred millivolts of a 5 volt exponential rise. An example of this appears in Figure 2.

Figure 2 shows the beginning of the exponential voltage rise across the capacitor when the generator pulse starts. The vertical scale is about

As is the case for most generators I have used, the current rise from the generator used for the data in this article was not a ramp with very sharp corners and constant slope.

200 mV. The horizontal time is a small fraction of the RC time constant of 100 ohms and the capacitor being measured. Since the capacitor voltage is still very small compared to the 5 V open circuit output of the generator, the current through the capacitor may be presumed to be constant and equal to the generator open circuit voltage divided by 100 ohms, 50 mA in this case.

The risetime of the current will be the same as the generator voltage. If the rise is a ramp with a constant slope and the capacitor had no inductance, the initial rise shown in Figure 2 would follow the dotted line and then the slope would change to the initial slope of the exponential rise determined by:

$$dv/dt = i/C = 50\ mA/C \quad (1)$$

where C is the value of the capacitor at this low voltage and the risetime of the current << RC.

The offset between the baseline and the beginning of the exponential rise is just the voltage that the current, 50 mA for this case, develops across the ESR of the capacitor. The ESR can be easily estimated in this case by dividing the voltage offset (labeled ESR in Figure 2) by 50 mA.

Parasitic inductance in the capacitor will cause the spike in the waveform shown in Figure 2, exceeding the value of the dotted line along its length. If the current rise were in fact a ramp with constant slope and very sharp corners (high di^2/dt) then the spike would be a square pulse of value:

$$E = L^*di/dt \quad (2)$$

where L is the parasitic inductance of the capacitor.

As is the case for most generators I have used, the current rise from the generator used for the data in this article was not a ramp with very sharp corners and constant slope. That characteristic of the generator combined with probe effects led to a peaked shape, shown as the Ldi/dt spike in Figure 2. The inductance of the capacitor can be calculated using Equation 2. Often, one does not need to calculate the inductance or ESR but just choose a capacitor with the lowest inductance and/or ESR from several that are available.

Soldering the components onto a BNC connector, as in Figure 1, works up to 300 MHz. I estimate the inductive reactance of the loop formed by the capacitor and resistor to be about 20 ohms at 300 MHz (estimating the inductance at 10 nH). This is small enough relative to the 100 ohms of resistance in the circuit to not significantly affect the initial current very much. For this frequency range, a generator with a risetime of one to two nanoseconds will do.

If you need to check the capacitor using faster risetimes, it would be best to build the test setup on a small circuit board with a ground plane and controlled impedances. At this point, the parasitic capacitance of the 50 ohm resistor would also be an issue to be taken into account. Fortunately, such accuracy is often not needed. Especially, if one is just comparing the relative performance of several capacitors.

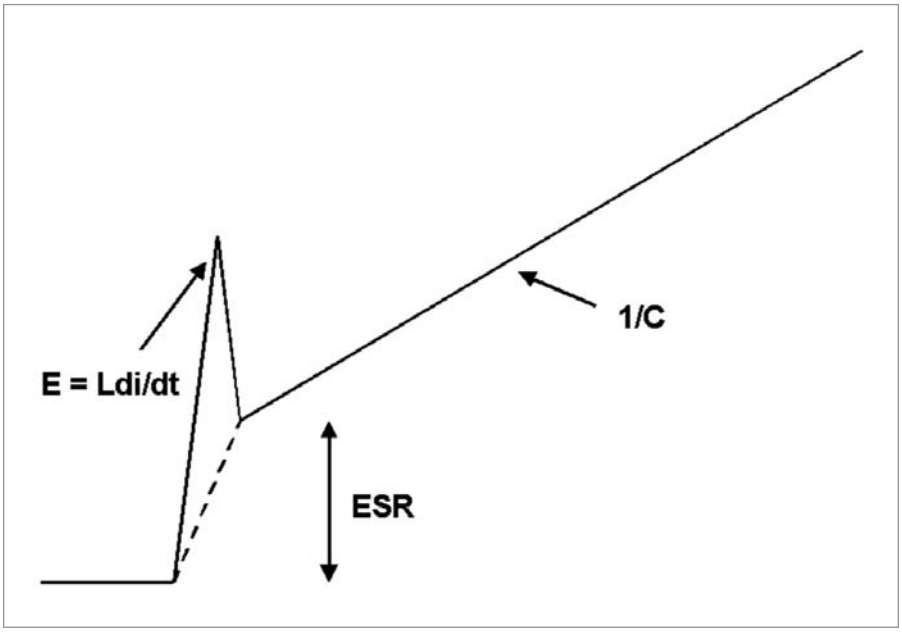

Figure 2: Initial rise

TECHNICAL Tidbits

DATA

Figure 3 shows the initial rise from the generator. The black square indicates the vertical voltage and horizontal time scales. The open circuit voltage was a little over 4 Volts with about a 5 nanosecond risetime. The data in Figures 3 through 6 were taken with an analog scope some years ago. Figures 4 through 6 show data obtained from several leaded capacitors (as opposed to surface mount). Two traces were taken for each capacitor. The lower trace was measured at the capacitor body where the leads entered and the upper trace included the minimum amount of lead to practically connect the capacitor to a printed wiring board. The upper trace would not be needed for modern surface mount capacitors unless one wanted to model the connection inductance from the capacitor to the point of interest on a printed wiring board.

Figure 4 shows data from a 4 uF electrolytic capacitor. The ESR offset is about 50 mV yielding an estimate of the ESR of just over 1 ohm. Notice that there appear to be some oscillations on the 1/C part of the slope. This could be scope probe resonance or a resonance in the capacitor. The data was taken with a standard 10X HiZ probe, so the probe is suspect. I have seen capacitors with pronounced oscillation from internal resonance. If you are planning to put a large capacitor in parallel with a smaller one, especially if they are constructed from different technologies, it would a good idea to check out the impulse response of the combination using this method. It is possible for the smaller capacitor to resonate with the inductance of the larger one, causing an unexpected result.

Figure 5 shows the result for a 1 uF capacitor of the same construction as the 4 uF capacitor tested in Figure 4. Note that the inductance is similar to the 4 uF capacitor, but the ESR is slightly lower. Since an analog scope was used, the waveform was repetitive and the slight slope on the left half of the waveform was the end of the exponential fall from 5 V. If a single pulse on a digital scope was used, the slope to the left of the Ldi/dt spike would be zero.

Figure 6 shows the result for a 1 uF radial ceramic capacitor (square case). Note the low inductance and undetectable ESR. Note also that the slope of the 1/C exponential rise is flatter, indicating more capacitance than the 1 uF capacitor of Figure 5. This may be due to the fact that the electrolytic capacitor used for Figure 5 may have lower capacitance near zero voltage than at its operating voltage, whereas the ceramic capacitor has a more constant capacitance with voltage. The inductance corresponding to the lower trace is estimated to be 4.4 nH.

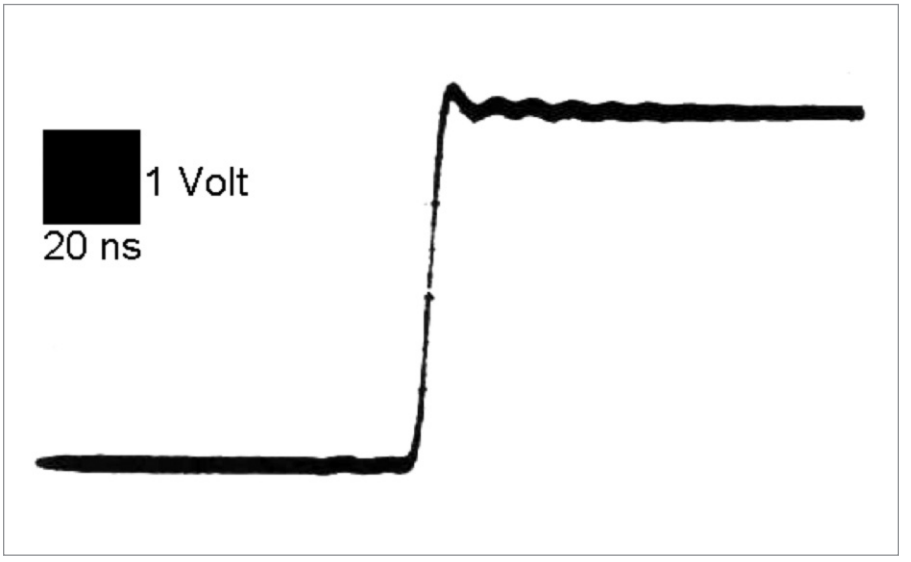

Figure 3: Input from pulse generator

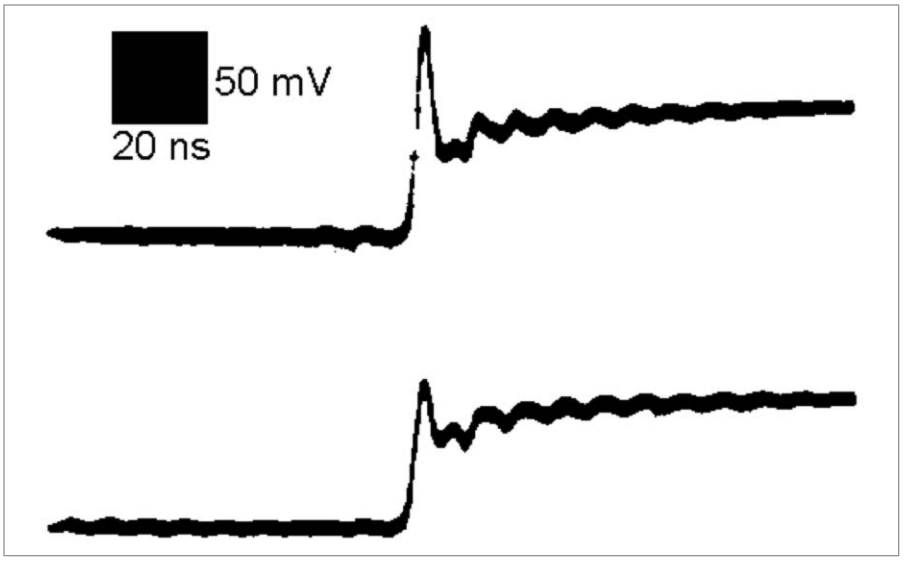

Figure 4: 4uF capacitor

It is interesting to note that a 0.1 uF ceramic capacitor in the same size package as the 1 uF of Figure 6 showed a slightly *higher* inductance in this test setup. I believe this was due to the fact that the smaller capacitor did not fill the package and internal lead inductance caused the effect. In this case, a 1 uF capacitor was a better choice than a 0.1 uF!

One of the advantages of this test is that the output waveform is the transient response of the capacitor. The voltages developed across the capacitor in this test are directly related to what will happen in a real circuit if the current risetime from the generator is similar to what the capacitor will see in its intended application.

For more Technical Tidbits*, please visit Doug's site,* http://emesd.com.

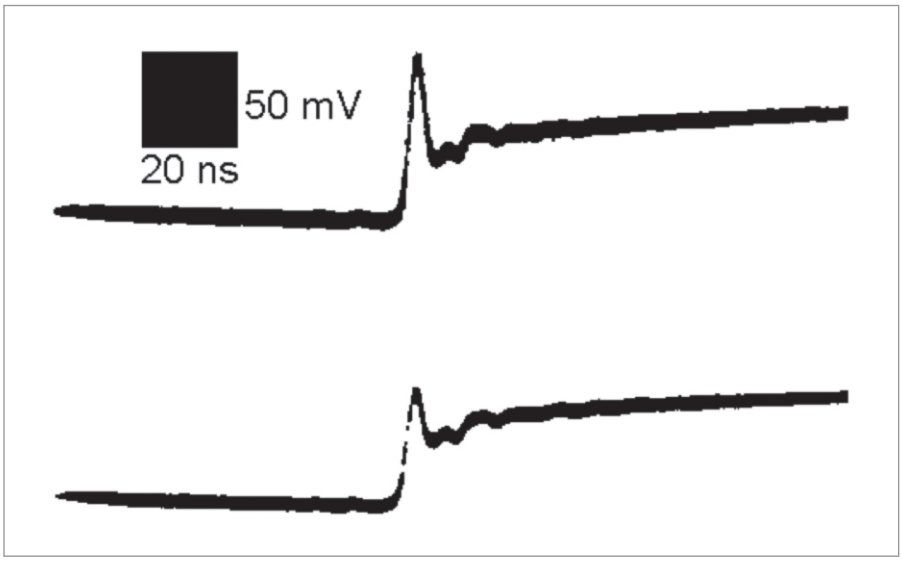

Figure 5: 1uF capacitor

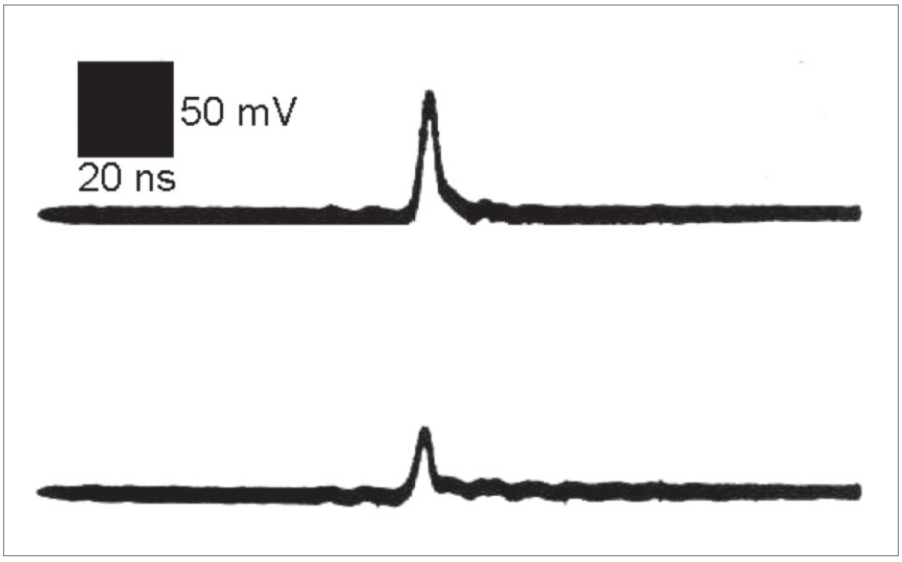

Figure 6: 1uF ceramic capacitor

(the author)

DOUGLAS C. SMITH

Mr. Smith held an FCC First Class Radiotelephone license by age 16 and a General Class amateur radio license at age 12.
He received a B.E.E.E. degree from Vanderbilt University in 1969 and an M.S.E.E. degree from the California Institute of Technology in 1970. In 1970, he joined AT&T Bell Laboratories as a Member of Technical Staff. He retired in 1996 as a Distinguished Member of Technical Staff. From February 1996 to April 2000 he was Manager of EMC Development and Test at Auspex Systems in Santa Clara, CA. Mr. Smith currently is an independent consultant specializing in high frequency measurements, circuit/system design and verification, switching power supply noise and specifications, EMC, and immunity to transient noise. He is a Senior Member of the IEEE and a former member of the IEEE EMC Society Board of Directors.

His technical interests include high frequency effects in electronic circuits, including topics such as Electromagnetic Compatibility (EMC), Electrostatic Discharge (ESD), Electrical Fast Transients (EFT), and other forms of pulsed electromagnetic interference. He also has been involved with FCC Part 68 testing and design, telephone system analog and digital design, IC design, and computer simulation of circuits. He has been granted over 15 patents, several on measurement apparatus.

Mr. Smith has lectured at Oxford University, The University of California Santa Barbara, The University of California Berkeley, Vanderbilt University, AT&T Bell Labs, and internationally at many public and private seminars on high frequency measurements, circuit design, ESD, and EMC. He is author of the book High Frequency Measurements and Noise in Electronic Circuits. His very popular website, http://emcesd.com (www.dsmith.org), draws many thousands of visitors each month to see over 150 technical articles as well as other features.

He also provides consulting services in general design, EMC, and transient immunity (such as ESD and EFT), and switching power supply noise. His specialty is solving difficult problems quickly, usually within a couple of days. His work has included digital and analog circuits in everything from large diesel powered machinery to IC chip level circuits. His large client base includes many well known large electronic and industrial companies as well as medium sized companies and start-up companies.

Low Frequency EMC and Power Quality

Development of standards towards convergence

BY DR. MAGNUS OLOFSSON

FIGHTING CLIMATE CHANGE MEANS MORE ELECTRONICS

Electrification clearly facilitates our progress toward a resource-efficient and climate-friendly energy system. The share of electricity in total energy demand is projected to increase drastically in all the decarbonasation scenarios of the recent European Union (EU) Energy Road Map 2050[1] (Figure 1).

Wind and solar power are examples of expanding technologies for renewable power. Germany now has 25 gigawatts of installed solar power[2]. Electric vehicles, light emitting diode lamps and heat pumps are energy efficient electrical technologies of importance when fighting climate change. In virtually all such technologies, electrical energy is passing power electronics.

In addition to power electronics, there is also an increased use of electronics for supervision and control.

Smart Grid is More than Networks

The smart grid is a very topical issue. The term is widely used by many, especially politicians. Now the International Electrotechnical Commission (IEC) has defined the concept of smart grid[3]. The definition states that the smart grid is an electrical energy system that uses information technology. The smart grid is thus not only related to electrical networks, but to entire the power system. With smart grid technologies as well as power technologies for renewables and improved energy efficiency, there is an increased use of electronics. We see growth in the use of power electronics, as well as electronics for information technologies.

Electromagnetic disturbances may be radiated or conducted and electrical/electronic equipment is potentially sensitive to any or to both of these types of disturbances. Disturbances are in turn subdivided into a number of low and high frequency phenomena.

One example of smart grid application is the possibility of charging electric car batteries during hours with a surplus of low cost renewable energy. When electricity price is high, electric cars may feed energy back to the electrical network. This can be achieved using a continuous transfer of electricity price information with automatic control of the power flow to and from the electric cars. The term smart grid is thus enabling a ”smart” electrical system where the entire power system, with networks as well as connected equipment, is converting between electrical energy and other forms of useful energy.

Smart Grid and the Concept of EMC

The physical characteristic of smart grid technologies, with an increased incorporation of potentially sensitive electronics, naturally has implications with respect to electromagnetic compatibility (EMC). The satisfactory function of electrical and electronic equipment with respect to electromagnetic disturbances is the aim of EMC. The IEC defines[4] electromagnetic compatibility as ”the ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment”. In the European Union EMC Directive the ”equipment or system” of IEC corresponds to the EU term “equipment”, where equipment in turn is subdivided into apparatus and fixed installation.

Electromagnetic disturbances may be radiated or conducted and electrical/electronic equipment is potentially sensitive to any or to both of these types of disturbances. Disturbances are in turn subdivided into a number of low and high frequency phenomena, where IEC defines low frequency up to and including 9 kilohertz.

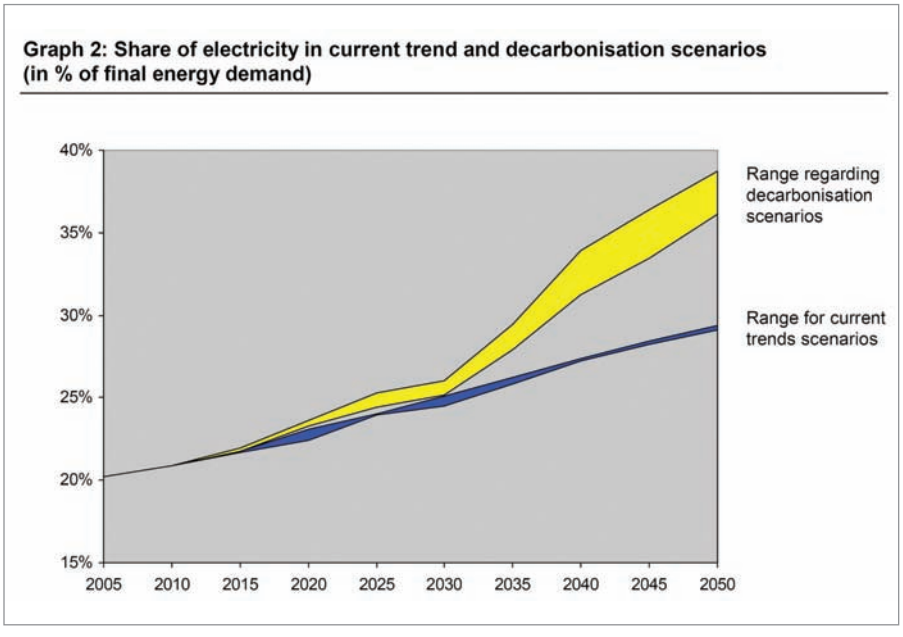

Figure 1: Share of electricity in final energy demand, according to the EU Energy Road Map 2050

Field Experiences with Smart Grid Technology

Examples of lack of EMC in relation to evolving smart grid technologies have been reported in Sweden. Kilowatt-hour meters in households sending data signals through power lines have caused interference with, for example, dimmer controlled lamps and electrical appliances. There are also cases reported where electrical apparatuses in households have interfered with electronic kilowatt-hour meters with adverse errors in registration of energy. Power electronics in wind power plants have emitted disturbances interfering with transfer of kilowatt-hour meter readings as signals on power lines.

Power electronic-based photovoltaic solar and wind energy equipment may emit disturbances causing variations such as voltage fluctuations and unbalance[5]. However, with a proper design such equipment may well improve voltage quality, for instance by reducing depth of voltage dips[6].

VOLTAGE QUALITY AND EMC

Both IEC and EU define EMC to cover electromagnetic phenomena from zero hertz. Furthermore, the IEC defines the following principal electromagnetic conducted phenomena[7]:

Conducted low-frequency phenomena:

- harmonics, interharmonics
- signals superimposed on power lines

Voltage quality can be seen as an umbrella name for deviations from ideal voltage conditions at a site in a network. This is equivalent to electromagnetic disturbances of the voltage at the site.

- voltage fluctuations
- voltage dips and interruptions
- voltage unbalance
- power frequency variations
- induced low-frequency voltages
- DC component in AC networks

Conducted high-frequency phenomena:

- induced voltages or currents
- unidirectional transients
- oscillatory transients

Voltage quality can be seen as an umbrella name for deviations from ideal voltage conditions at a site in a network[8]. This is equivalent to electromagnetic disturbances of the voltage at the site. With no disturbances the voltage quality is perfect, otherwise it is not. electromagnetic disturbances are defined as electromagnetic phenomena that may degrade the performance of equipment[9]. Adequate voltage quality contributes to the satisfactory function of electrical and electronic equipment in terms of electromagnetic compatibility. Electromagnetic disturbances as imperfect voltage quality at a site in a network can be regarded as electromagnetic emission from the network[10]. According to the EMC Directive, a network is equipment. This is in line with the original name of the IEC Technical Committee (TC) 77, which was *EMC Between Electrical Equipment Including Networks* and is now simply EMC[11].

The technical function of an electrical network is electromagnetic energy transfer with adequate voltage quality at its sites(connection points). Similarly, immunity of an electrical network

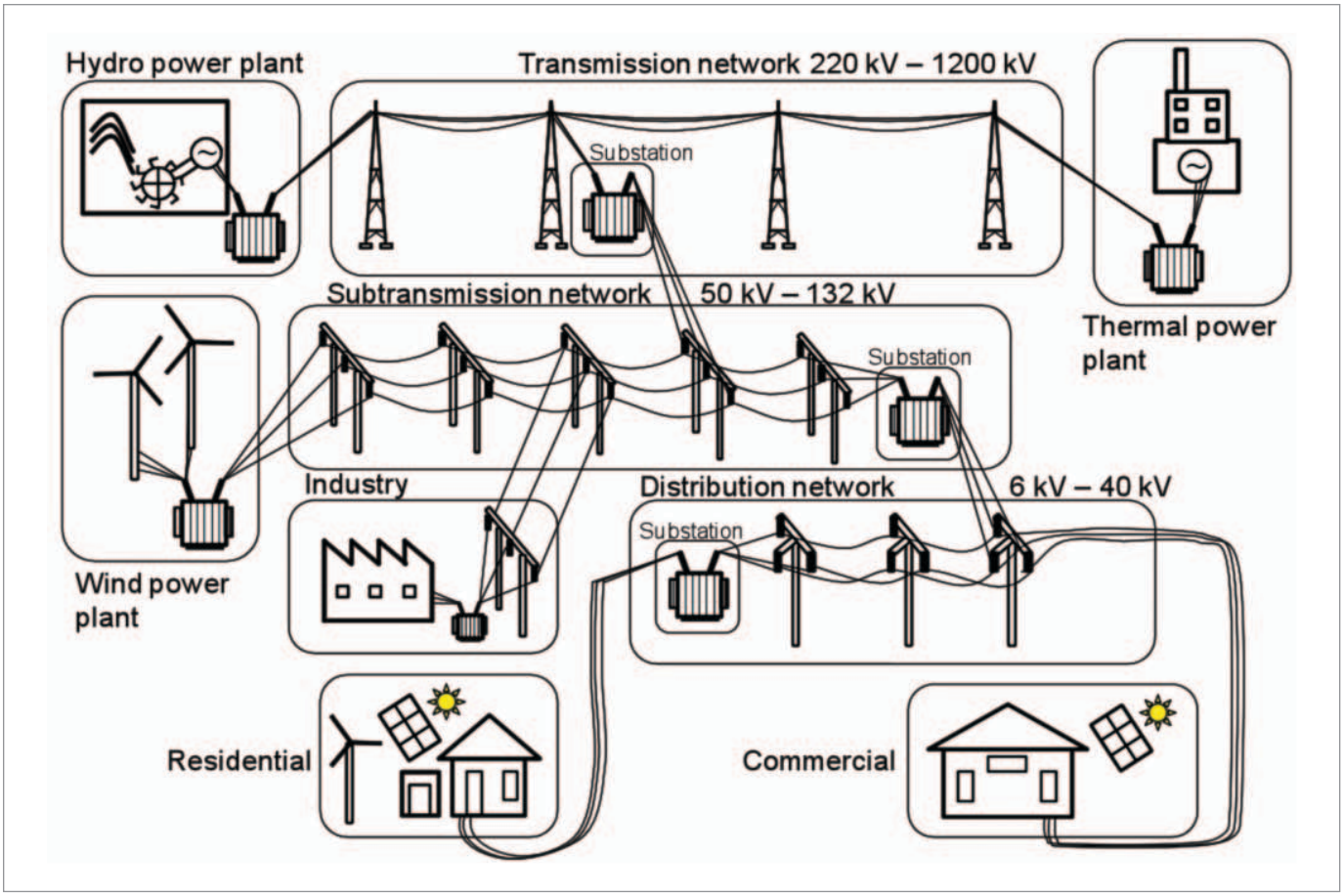

Figure 2: Power system made-up of equipment

Beyond safety, the usefulness of electricity in power systems relies on the function of such equipment. Electromagnetic compatibility is about the satisfactory function of equipment with respect to electromagnetic disturbances.

can be seen as the ability to absorb disturbing emissions (such as distorted current) with adequate voltage quality while transferring energy or, in other words, with satisfactory function. For example, for low order harmonics and voltage fluctuations, network strength is relevant for network immunity[12, 13].

Geomagnetically-induced current caused by space weather is another example of the relevance of electromagnetic immunity for keeping an electric grid[14] functioning satisfactorily.

The importance of voltage quality to achieve EMC is clearly stated in a report from the Council of European Energy Regulators (CEER)[15]: "Due to the nature of electricity, voltage quality is affected by all the parties connected to the power system. When voltage quality is too poor, a key question is whether the disturbance (e.g. a harmonic disturbance) from a customer's installation into the power system is too big or whether the power system (the short circuit power) at the point of connection is too weak. The aim should be to have an electromagnetic environment where electrical equipment and systems function satisfactorily without introducing intolerable electromagnetic disturbances to other equipment. This situation is referred to as electromagnetic compatibility (EMC)."

EQUIPMENT-BASED POWER SYSTEM MODEL

Power systems consist of electrical equipment. Beyond safety, the usefulness of electricity in power systems relies on the function of such equipment. Electromagnetic compatibility is about the satisfactory function of equipment with respect to electromagnetic disturbances.

According to the EMC Directive, equipment are either apparatus or a fixed installation. Apparatuses are part of the EU system for CE marking, while fixed installations are not. However, protection requirements on emission and immunity are enforced on all equipment.

Examples of fixed installations are[16]: power plants, power supply networks, wind turbine stations, industrial plants and railway infrastructures. According to the EMC Guide, the classification of fixed installations is wide and the "definition covers all installations from the smallest residential electrical installation through to national electrical and telephone networks, including all commercial and industrial installations".

Applying the concept of fixed installations to power systems may suggest a schematic illustration like Figure 2. As indicated in the picture, various types of equipment are connected to other types of equipment. Equipment for energy conversion is normally connected to only one other type of equipment, creating a network. Equipment for conveying energy, such as networks, are normally connected to several other types of equipment including networks.

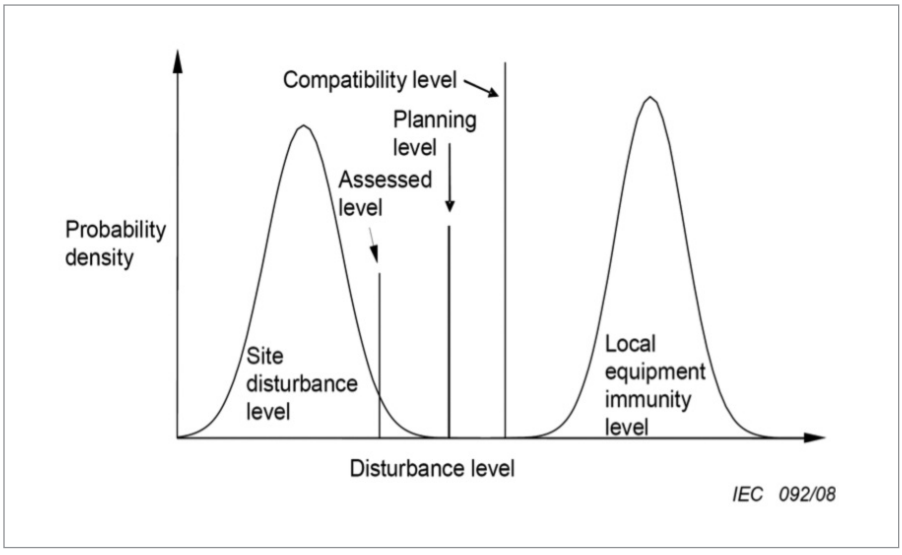

Figure 3: Voltage Quality concepts with time statistics for a site within a network[17]

COMPATIBILITY MARGINS AND PROTECTION REQUIREMENTS

The objective of protection requirements for equipment, including fixed installations such as electrical networks and connected equipment, is the achievement of EMC.

When aiming for EMC in electrical power systems, it is reasonable to apply the same reference for voltage quality (emission) in electrical networks as

When harmonic current of low order is injected into a network, the voltage is distorted which reduces voltage quality. The level of voltage distortion is dependent on the network strength.

for limits on immunity of connected equipment. This is schematically indicated in Figure 3, where a common compatibility level is applied for voltage quality as well as for immunity of connected equipment. Electromagnetic compatibility levels are defined in the IEC 61000-2 series (IEC 61000-2/4/12 for use as references for emission and immunity of equipment). For very slow voltage variations, limits are given in the standard IEC 60038. Network emission levels, which are essentially voltage quality planning levels, are defined with a margin in relation to compatibility levels, as indicated in Figure 3.

PROTECTION REQUIREMENTS FOR EQUIPMENT IN POWER SYSTEMS

In the following example, application of protection requirements on emission and immunity are illustrated for selected principal electromagnetic phenomena.

HARMONICS AND INTERHARMONICS

Origins of low order harmonics are, for example, classical line commutated diode and/or thyristors based rectifiers. Examples of equipment emitting high order harmonics are voltage source converters, such as transistors which are switched at high frequency.

Emission of low order harmonics can often be modeled as current sources, while high order harmonics normally appear as voltage sources. In between these two simplified models there is naturally a more complex reality. Resonances may increase the complexity further.

When harmonic current of low order is injected into a network, the voltage is distorted which reduces voltage quality. The level of voltage distortion is dependent on the network strength. Similarly, high frequency current harmonics may cause voltage harmonics in the network. Network strength in terms of short-circuit power or fundamental frequency short-circuit impedance is less essential for voltage quality at higher frequencies. The geographical spread of higher frequency distortion is normally relatively small.

Current harmonics may cause overheating of e.g. neutral conductors and capacitors in three-phase systems. Voltage harmonics may upset electronics, e.g. due to multiple zero crossings. Loading capability of induction machines may be reduced.

Some sources of interharmonics are frequency converters and transformers saturated during energizing.

Suggested responsibilities for equipment's accountable parties are given in Table 1. Compatibility margins are found in IEC 61000-2/4/12. A basis for apportionment of harmonic disturbances in networks is available in IEC 61000-3-6.

Voltage Fluctuations

Voltage fluctuations may range from very slow voltage variations to rapid voltage fluctuations. Very slow voltage variations are equivalent to variations within voltage ranges, i.e. voltage deviations from nominal values. If the nominal voltage is 230 volt and the actual voltage is 240 volt, there is a voltage variation of 10 volts, which is an electromagnetic disturbance. However, a very slow variation causing an offset of only 10 volts is, in practice, not expected to cause any interference. Limits for very slow voltage variations

Responsible	Emission	Immunity
Network operator	Voltage quality planning levels	Apportioning of distortion limits (except at public low voltage), network strength at lower frequencies
Equipment connected to network (may be another network)	Fulfillment of emission standards (e.g. within CE marking system), as well as as well as fulfillment of network operator apportioning levels	Fulfilling of immunity standards (e.g. within CE marking system), as well as consideration for EMC in own equipment

Table 1: Responsibility for protection requirements – harmonics and interharmonics

Due to connection of wind and solar power at the end of weak feeders, the occurrence of temporary overvoltages is a disturbance of increased concern.

are given in IEC 60038 at supply terminals, i.e. the connection point between the network and connected equipment.

Suggested responsibilities for controlling voltage fluctuations within the network system are given in Table 2. Slow voltage variations in a network are depending on a number of technical issues ranging from design, maintenance and operation.

Rapid voltage fluctuations may cause flickering of lights. Source of disturbance may be electric arc furnaces that cause rapid current fluctuations.

Suggested responsibilities for equipment's accountable parties are given in Table 2. A framework for apportioning of distortion limits is given in IEC 61000-3-7.

CONVERGENCE OF STANDARDS

A smart grid enables more renewables and more efficient use of electricity. The smart grid also is expected to boost use of electronically based equipment in the electrical power system.

To realize the smart grid, the following issues are important to consider:

1. EMC is essential for a robust smart grid, both with respect to radiated and to conducted disturbances.
2. Power quality is a means to achieve EMC between the smart grid and connected equipment.
3. Electrical networks, including smart grids, are equipment.
4. Protection requirements, such as those for emission and immunity, also are valid for electrical networks.
5. Protection requirements for networks and connected equipment should be economically and fairly balanced.
6. A complete set of standards for EMC in power systems, including power quality, is needed from the standardization community.
7. Seeing EMC as a technical issue, where cost optimization is to a large extent governed by the standardisation community, regulatory frameworks should be designed without links to market mechanisms, i.e. similar to the handling of electrical safety.

CHANGING FOCUS IN LOW FREQUENCY EMC OVER TIME

Over the years, focus has shifted between various electromagnetic phenomena. During 1980s, low-order harmonics were high on the agenda due to the introduction of thyristor and diode based current stiff line commutated power electronics. Similarly, voltage fluctuations causing flickering lights were of great concern where arc furnaces were the main source of disturbances. In the 1990s, the use of variable speed drives for induction motors was introduced on a large scale. Voltage dips were causing interruptions in industrial processes due to inadequate immunity for those drive systems.

Presently, there is an increased awareness of electromagnetic disturbances in the frequency range 2 to 150 kilohertz. This is due to switched converter technologies used over time in an increasing number of apparatuses, from energy efficient luminaries to charging units for electrical vehicles. Due to connection of wind and solar power at the end of weak feeders, the occurrence of

Responsible	Emission	Immunity
Network operator	Voltage quality planning levels	Network strength, apportioning of distortion limits (except at public low voltage)
Equipment connected to network (may be another network)	Fast changes in active and reactive power demand, generation kept within limits stated by network operator	Fulfilling of immunity standards (e.g. within CE-marking system), as well as consideration for EMC in own equipment

Table 2: Responsible for Protection Requirements – Rapid Voltage Fluctuations

Regardless of the phenomena, it is clear that a appropriate division of responsibilities for networks and connected equipment is paramount.

temporary overvoltages is a disturbance of increased concern. Regardless of the phenomena, it is clear that a appropriate division of responsibilities for networks and connected equipment is paramount.

NOTES

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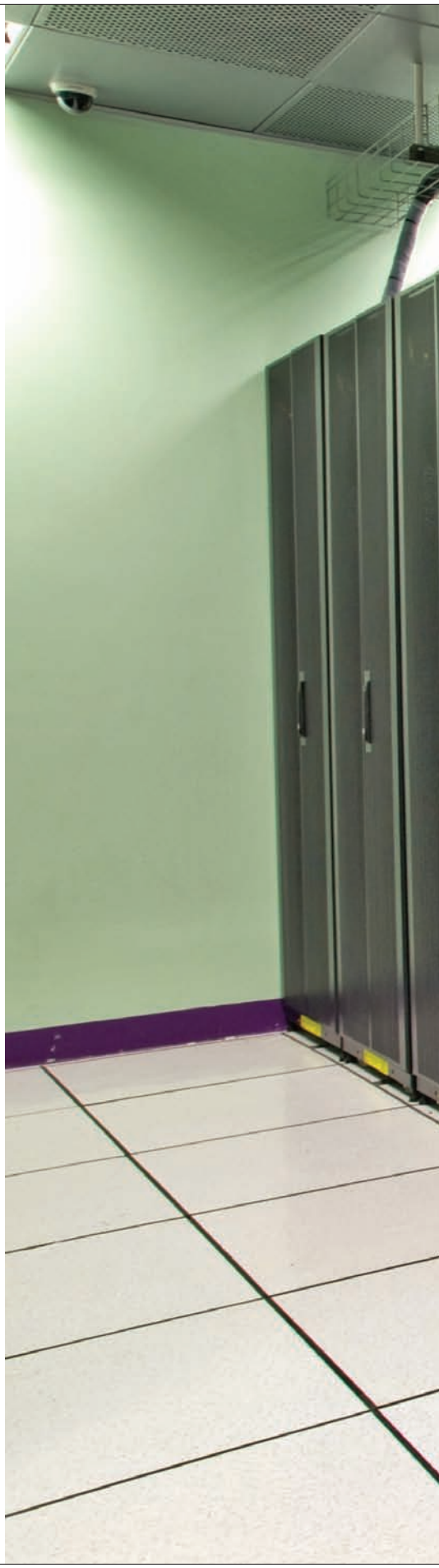
Data Centers are Going Green

Will electrostatic discharges get worse?

BY JOHN MAAS



Going "green" by reducing electricity consumption in data centers certainly has the attention of manufacturers of information technology equipment (ITE) and of data center operators. Cost and availability of electricity are just two of the factors driving interest. A globally increased emphasis on reducing greenhouse gases is another key factor. Energy efficiency initiatives will continue to be implemented, and few would argue against their benefits. Could some of these initiatives contribute to a possible increase in the number of electrostatic discharge (ESD) events or in their severity?

GOING GREEN IN DATA CENTERS

The past few years has seen an increased interest in improving the efficiency of how computer data centers operate. The basic economics of reducing operating costs is one clear factor driving this interest. Another compelling reason is a desire to operate data centers in a more environmentally sustainable manner. It has been estimated that improving energy efficiency on all data centers worldwide by 20% could be equivalent to eliminating the need for some 150 250-MW coal-fired electric power plants. [1]

IT equipment manufacturers and data center operators are taking notice and implementing innovations to reduce electricity consumption and related greenhouse gas emissions.

To be sure, IT equipment manufacturers and data center operators are taking notice and implementing innovations to reduce electricity consumption and related greenhouse gas emissions.

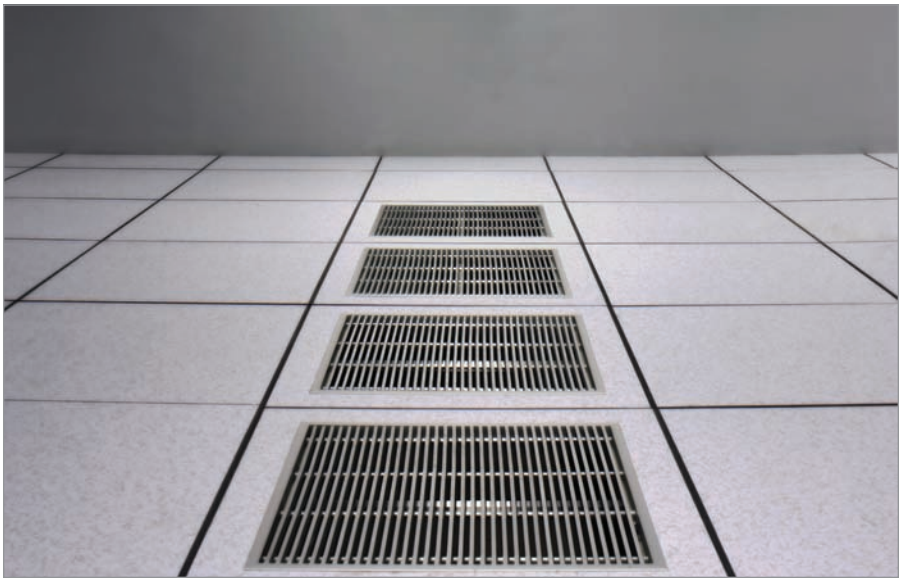
While no one would deny the importance of this activity, some beneficial actions could have unintended consequences for electromagnetic compatibility (EMC) practitioners, including the potential to increase the number of equipment malfunctions[1] caused by ESD.

What possible connection exists between improving energy efficiency and ESD? Let's take a look at how data centers are kept cool and some of the ways we can make that process more efficient.

DATA CENTER COOLING TECHNIQUES

In a traditional data center, the heating, ventilating and air-conditioning (HVAC) infrastructure used to keep the room cool uses nearly as much electricity as the computing equipment itself. Various analyses indicate approximately 45% of electricity used is to power the ITE and 55% for HVAC and related infrastructure. Whatever the specific numbers, the message is clear: the cost to keep the IT equipment in its operating temperature and humidity range is very similar to the cost of operating that same IT equipment. Implementing techniques that reduce the cost of cooling these facilities can have a very large impact on overall cost of operation and the electricity used.

ITE manufacturers generally specify the temperature and humidity ranges in which their equipment is to be operated. More often than not, these environmental conditions are established to provide a reasonable assurance of quality, reliability and longevity of the equipment. If the operating temperature is too high, the electronics under the covers could overheat, causing a variety of undesired conditions such as operational errors, component damage and, in extreme situations, smoke or fire. If the humidity level becomes too high, several undesirable conditions can happen, including condensation which can create electrical shorts or arcing, and growth of mold or mildew.



A limit on minimum humidity is often established to reduce the occurrence and severity of ESD events to the ITE in the data center. Typical lower limits for relative humidity (RH) have traditionally been in the neighborhood of 30%. For example, the 2004 guidelines from the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) [2] include an allowable operating class with RH maintained no lower than 20% and a recommended operating class with RH maintained no lower than 40%. The lower limits on RH for controlling ESD are often based on experience and may be on the conservative side, particularly for 24/7 operations with business-critical applications.

The design characteristics of electronic equipment need to be aligned with the conditions of the environment in which it will be installed and operated. Focusing solely on ESD, if the equipment is designed to meet the ESD test limits of the international standard CISPR 24 [3], then the operating environmental conditions should be within a range that can be expected to prevent discharges that are more intense than those represented by the 4 kV contact discharge and 8 kV air discharge limits of that test standard. Conditions likely to create discharges more severe than these test limits

A very simplified description of an air-side economizer is a system that directly utilizes outside air to provide cooling instead of traditional air conditioning.

should only be allowed for equipment that is designed to withstand more severe discharges.

Traditional approaches to control temperature and humidity use computer room air conditioning units (CRACs) distributed around the perimeter of the room. CRACS are quite good at lowering the temperature and humidity of a room, although locating them near the perimeter can create temperature differences throughout the space. Maintaining humidity above some lower limit, however, generally requires some type of humidification technique used in conjunction with the dehumidification provided by the cooling coils of the CRAC. The complex system of dehumidification for cooling and humidification for meeting a lower limit on humidity impacts the infrastructure and operating costs of the overall HVAC system for a data center. Given the realities of electricity consumption, alternate strategies to reduce demand and cost are being considered.

Alternative cooling strategies include:

- liquid cooling of equipment
- alternate air flow paths through equipment
- localized cooling of equipment in the data center
- wider operating ranges for temperature and humidity
- air-side economizers
- water-side economizers.

All five of these strategies provide real benefits in terms of reducing how much electricity is needed to operate the environmental infrastructure of a data center. No single one of these strategies is ideally suited to all situations, and each comes with its own particular benefits and challenges.

Let's focus on the last three.

The first of these three, wider operating ranges for temperature and humidity, is a rather straight forward technique. The more tightly controlled the environmental conditions are in any facility, including data centers, the more complex the infrastructure is. If I want the temperature in my house to stay below 25 C in the summer, I simply set the thermostat for my air conditioner to that temperature. If the temperature drops down to 22 C, my operating condition is still met. No further control or action is needed. However, if I want to keep the temperature at 25 ±2 C, then my home infrastructure will need to operate the air conditioning when the indoor temperature is above 27C and the heat source if the temperature drops below 23 C, as may happen at night. This latter arrangement, with its smaller operating range, would require a more complex control system and cost more to operate. The same concept applies to data centers but on a large scale where, in addition to temperature, humidity levels are also controlled. The wider the operating ranges, the less complex the HVAC system and the less costly it is to operate (in theory at least).

The last two strategies, air- and water-side economizers, are sometimes called free cooling. These techniques take advantage of the ambient conditions outside the data center to supplement or replace traditional techniques for temperature and humidity control.

A very simplified description of an air-side economizer is a system that directly utilizes outside air to provide cooling instead of traditional air conditioning. When ambient conditions are favorable, cool outside air is brought into the data center and warmer air from the data center is exhausted to the outside. A similarly simplified description of a water-side economizer is a system that uses a body of water to provide pre-cooling of the chilled water used to lower the temperature inside the data center. More complete descriptions of these forms of free cooling can be found in multiple sources, including [4] and [5].

To maximize the effectiveness of these cooling methods, wide enough ranges for operating temperature and humidity need to be allowed. Recent activity with ASHRAE has aimed to do just that: allow and encourage operators of data centers to increase their operating ranges for temperature and humidity. One key result of this work is a revision to ASHRAE's guidelines for temperature and humidity in data centers, [6] which have been incorporated into the 2011 edition of the European Union's code of conduct for data centers. [7] The revised guidelines from ASHRAE includes an environmental class that allows moisture levels down to 0.5°C dew point without special precautions, and relative humidity as low as 8% if appropriate static control measures are implemented. These changes represent a significant reduction in the humidity level in data centers. The additional static control measures are intended to alleviate concerns over potential increase in ESD events as a result of reduced humidity.

Some types of circuits are sensitive to high-frequency disturbances and will be more affected by ESD currents with faster rise times.

RELATIONSHIP BETWEEN HUMIDITY AND ESD

Conventional wisdom and years of experience indicate that allowing the humidity level to become too low is likely to increase the number and severity of machine malfunctions from ESD. Manufacturers of ITE and operators of data centers are aware of numerous situations where equipment malfunctions caused by ESD happened at an increased rate during times when humidity levels were low. For decades, ITE manufacturers have been resolving problems caused by ESD to their products by raising the humidity in the operating environment. Those of us who live in cold-weather climates know all too well that ESD events above the threshold of human sensation tend to happen more often when humidity is low.

The observation that noticeable ESD events happen more often when humidity is low does not tell us what specific mechanism is impacted by humidity. What is quite apparent is that if humidity is too low, equipment malfunctions can happen. Keeping in mind the need for compatible equipment design characteristics and environmental conditions, quantifying how low humidity can become before ESD-induced malfunctions increase in frequency would be beneficial. Now, let's examine the relationships between humidity and an ESD event, including the mechanism by which ESD causes electronic equipment to malfunction.

A static electricity discharge is a complex event. The critical elements of the event include:

- charge of one object or surface with respect to another
- pre-discharge voltage differential
- arc through which transient discharge current is delivered
- discharge current, including its rise time, amplitude and derivative with respect to time.

Does variation in humidity affect any of these elements? If it does, are they elements that will make discharges occur more often or be more severe when they do happen? What is it that makes a discharge more severe: a higher pre-discharge voltage, the amplitude of the discharge current, the rise time of the discharge current, or perhaps a secondary discharge?

The answers to these questions are not simple. We know that all of the indicated elements of a discharge have the ability to make a discharge more severe. Which ones are important is determined by the characteristics of the electronics being impacted. Some types of circuits are sensitive to high-frequency disturbances and will be more affected by ESD currents with faster rise times. Other circuits are not so sensitive to high-frequency energy but are affected by the amplitude of the disturbing current. For these circuits, the peak amplitude of the current is the more important element of a discharge. Other interactions and sensitivities also exist for different circuit types.

Research by Pommerenke [8] has demonstrated a clear correlation between the arc length of the discharge current and both the current's rise time and peak amplitude. An arc is a non-linear circuit element that is affected by humidity. When arc length increases, the rise time of the discharge current increases and the peak current amplitude decreases. Over the range of 700 to 1200 μm for arc length, rise time varies from approximately 0.5 to 2 ns. Over the same range of arc lengths, peak current for a 5 kV discharge varies from 25 A down to 10 A. The demonstrated variations in these two critical elements of an ESD event with change in arc length are a good indication that the impact of humidity on arc length cannot be ignored.

A recent Green Grid paper by Swenson and Kinnear [9] provides an interesting, indepth discussion about charge generation and discharges. It includes a description of some research into the relationships between humidity and charge generation. One conclusion of that work is that humidity can indeed affect the static voltage that is generated on a surface. This work also indicates the possible affect of humidity on ESD should be considered when altering specifications on humidity in data centers.

SUMMARY

Humidity does directly or indirectly affect all of the critical elements of an ESD event listed above. It has a direct impact on the static charging of surfaces and on the length of the arc through which the discharge current is delivered. Static charging of surfaces is a critical factor that determines pre-discharge voltage differential at the point of the ESD event. Arc length affects the rise time and peak amplitude of the discharge current. Caution should be exercised when allowing reduced humidity in data centers based on these findings, since they are preliminary and reliable quantitative data are not yet available.

This finding does not mean that going "green" in data centers will necessarily create additional equipment malfunctions because of ESD.

This finding does not mean that going "green" in data centers will necessarily create additional equipment malfunctions because of ESD. It definitely does not imply that the industry should stop pursuing relaxed temperature and humidity operating ranges as part of plans to reduce energy consumption and cost in data centers. It does tell us that EMC professionals can expect additional challenges as data centers reduce energy use. It also points to the importance of close interaction between EMC and HVAC professionals, as well as the many other engineering disciplines involved in designing and operating ITE and data centers.

Additional work is needed to quantify the challenges and risks associated with allowing lower humidity levels in data centers. The industry will be well served by knowing how low is too low. Until that level of detail is discovered, the approach included in ASHRAE's revised guidelines [6] is probably a prudent one: accept a wider range of humidity levels to allow the introduction of effective energy efficiency initiatives and require additional static control measures if humidity levels are allowed to drop below a point that is considered "too low" to coexist with the design point of mainstream ITE.

ASHRAE is planning a research project to help quantify the relationship between humidity and the severity of the reactions of electronic equipment to ESD events. Members of the EMC community are participating in this research effort. We can expect to hear more about this activity in the future.

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NOTE

1. The phrase "equipment malfunction" is used herein to describe unexpected, and unwanted, departure from normal performance of electrical and electronic equipment when it is in operation. This includes temporary degradation of performance or loss of function that is automatically corrected by the equipment or that requires action by the operator to correct, and physical damage to the equipment or its circuitry.

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Power Quality and EMC

The impact of power electronics on power systems in renewables and electrical vehicles

BY D W P THOMAS

Power quality and EMC is an increasingly important area of research. In Europe it is estimated that poor power quality results in annual costs of €150 billion. [1] Increasing demands are also being imposed on power distribution systems, not only to provide better efficiency and functionality but also to accommodate new uses and generation techniques such as renewable energy and hybrid cars. New paradigms for power systems are appearing, such as smart grids, micro grids, the more electric ship, more electric aircraft and hybrid cars. These new paradigms are being created to improve the performance of power distribution systems and to meet the demands imposed by these modern users. Power electronics is a vital enabler for these new systems and has led to the widespread use of power electronic converters for energy efficient loads, flexible transmission systems and advanced power generation. This article discusses the opportunities and challenges created for power quality and EMC by the wider deployment of electronic power converters and the development of new power electronic devices.

Electronic power converters are widely used in electrical generators and in many loads. They are being deployed in distribution systems because they provide substantial benefits to power quality. The power electronic devices can be used to convert from one AC frequency to another AC frequency or just to decouple two AC systems. Electronic power converters can also be used to convert from AC to DC (rectifiers) or from DC to AC (inverters). Power converters have many design types and topologies but tend to have two main applications; as a series buffer device controlling current or power between two systems, or as a shunt device providing reactive power or harmonic currents to improve voltage quality (as shown schematically in Figure 1). Through these power electronic controlling devices, improved power quality can be achieved in such ways as:

- more flexible control of power flow around a distribution system
- improved control of voltage levels and increased voltage stability
- increased loading capability of equipment to its maximum thermal capabilities
- increase of the transient stability margin
- damping of power oscillations and limitation of short circuit currents
- reduction of reactive power flows and reduced current loop flow.

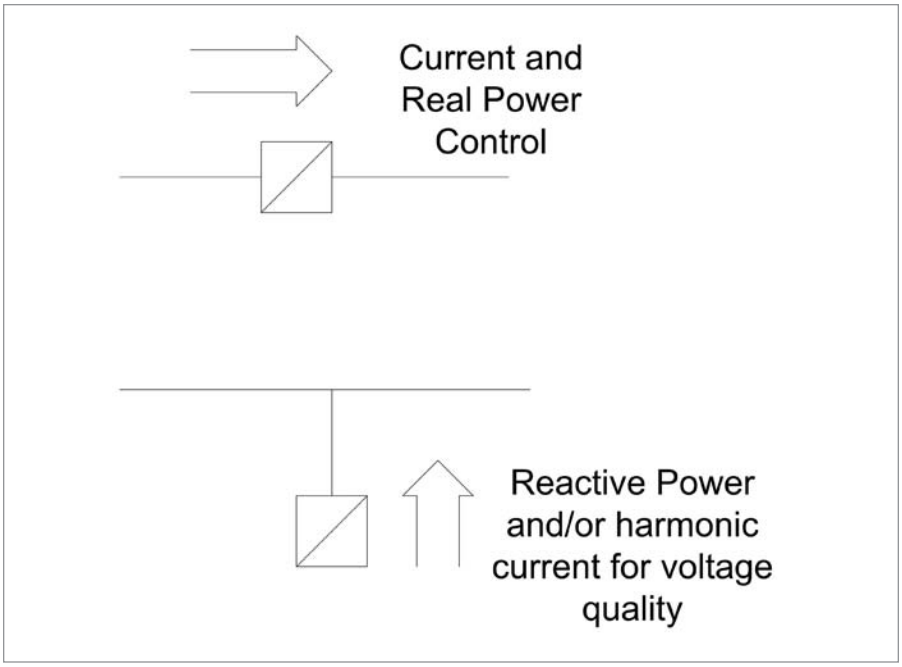

Figure 1: Typical converter arrangements for improved power quality

Power electronics controllers are thus the essential enabler that underpins the latest generation of power systems based on the concepts of smart grid and more electric vehicles. A power electronic supply or power converter is also an essential part of modern energy efficient loads and power sources. For instance, a typical energy efficient lighting ballast comprises an AC to AC converter changing the mains frequency to a high frequency to supply a fluorescent lamp, whereas a battery storage device has a DC to AC inverter converting a DC battery supply to the mains frequency. It can also be argued that, since most modern loads incorporate an electronic power converter buffering the connection to the supply system, the quality of modern supplies can be reduced without a significant detrimental effect

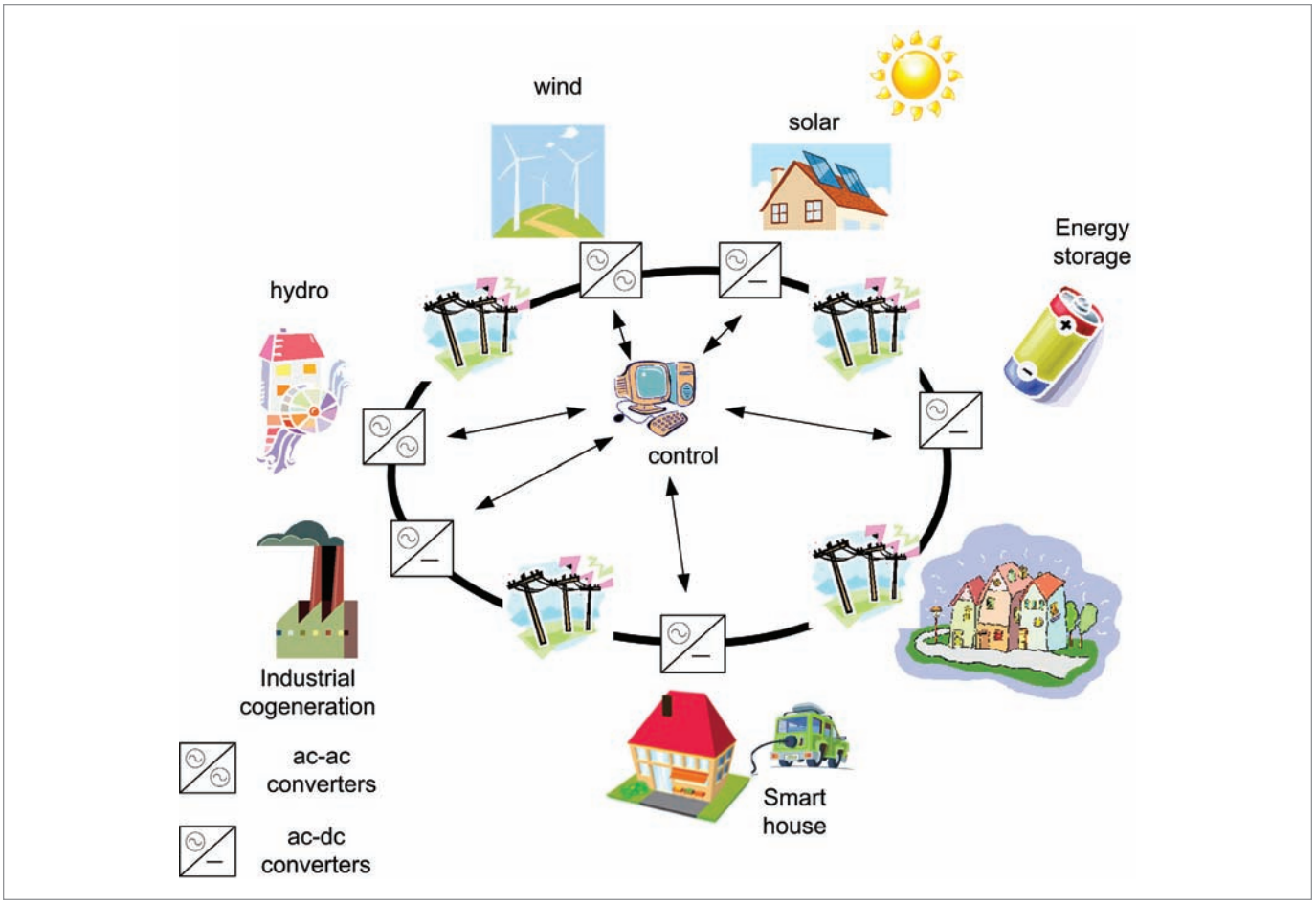

Figure 2: Diagram of a typical terrestrial microgrid

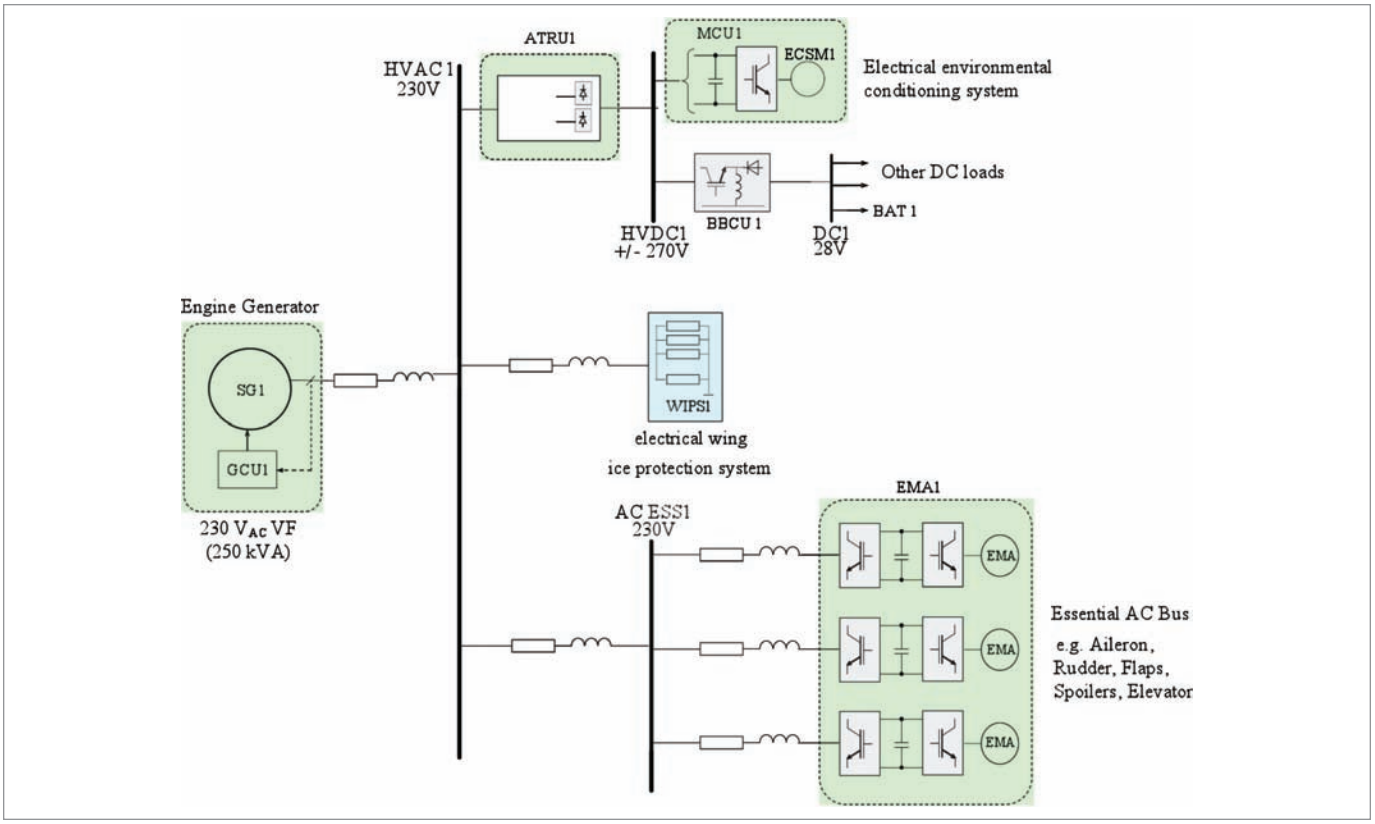

Figure 3: A generalized aircraft power system based on More Open Electrical Technologies (MOET) system for a one engine generator

on the users. For instance in aircraft frequency, wild (variable supply frequency) power systems are being considered. Figure 2 shows a typical smart grid with a range of renewable generation and energy efficient loads, all of which are connected to the power system via power converters. These power converters can be closely controlled to match load to total generation and also buffer the components from system power quality problems such as voltage dips or harmonics. Figure 3 shows a proposed, more open electric power system for commercial aircraft which also makes full use of electronic power converter technology to control and improve power quality in a more energy efficient system. The actuators can present a constant power load to the system or can even regenerate power back into the system. Figure 4 shows part of the power electronic substation being developed by the UNIFLEX research program. [2] Such a system offers far

Figure 4: 300 kVA prototype universal and flexible power management substation [2]

Although, power electronic converters are a very necessary component of the more advanced power systems with a potential to greatly improve overall power quality, they also represent challenges for power quality and EMC compliance.

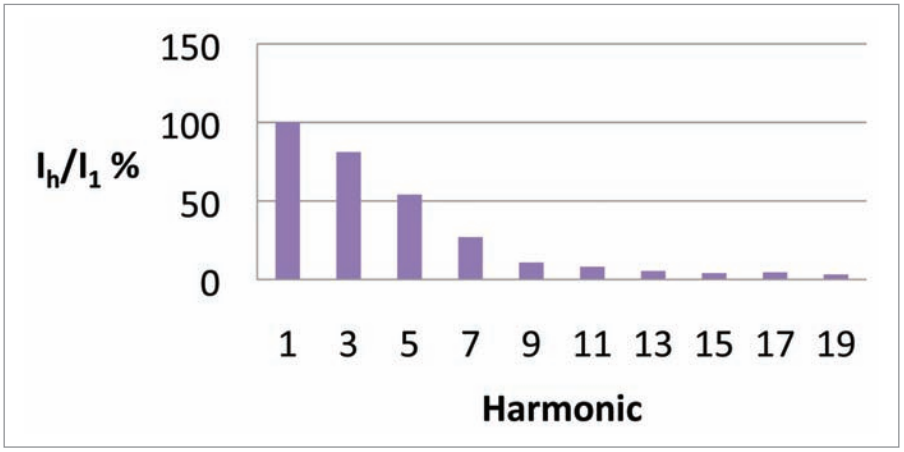

Figure 5: Typical harmonic currents (as a percentage of the fundamental rms) for a capacitively smoothed rectifier load

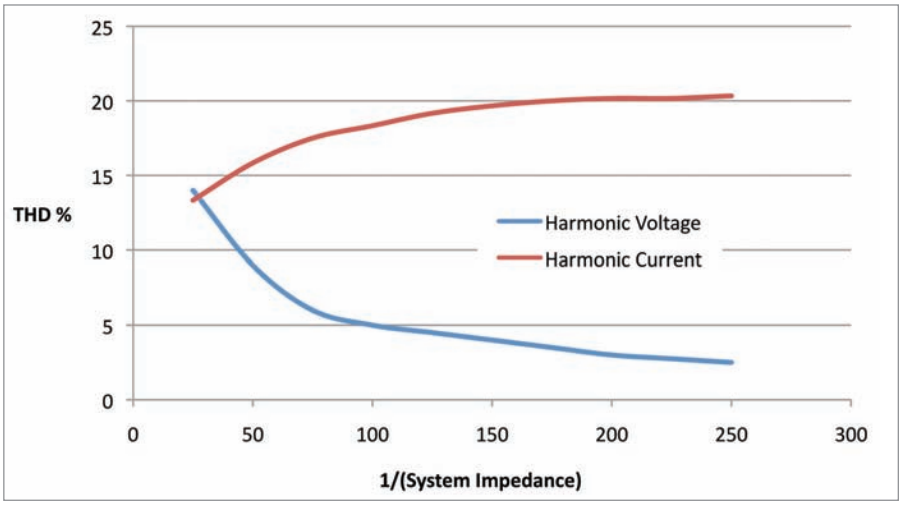

Figure 6: A typical variation in total harmonic voltage cand current distortion with the inverse of the system impedance for rectifier loads

more flexibility control than the usual transformer-based substation, with complete independent bi-directional power flow operation and control of each connected network, and reactive power support (voltage control) with active harmonic filtering to comply with grid standards.

Although, power electronic converters are a very necessary component of the more advanced power systems with a potential to greatly improve overall power quality, they also represent challenges for power quality and EMC compliance. The main problems are that:

- converters are inevitably less reliable than directly connecting the loads and generators to the power system
- converters contain switching devices, which lead to increased harmonics or conducted emissions
- constant power control or bidirectional power flow from converters can effect power system stability.

Reliability can be improved through redundancy and by making full use of a modular approach for ease of maintenance. [2] Harmonics in power systems have been known about and studied for nearly a century, however, standards were set when a significant amount of linear or resistive loads dampened the harmonics. Modern power converters using high frequency, fully controlled switching devices can virtually eliminate generation of harmonics but at the expense of higher frequency conducted emissions and greater expense. Modern power converters can also very precisely control the load power so that the loads behave as constant power loads, but this leads to stability problems for the power distribution system. In order to address these opportunities and concerns, an holistic approach to power quality and EMC is required; one that will identify the most efficient

or convenient way to provide complete compliance to standards and improved performance for the end users.

The simplest form of power converter is an uncontrolled rectifier made up of diode bridges to transform the AC power supply into DC. This is a common input stage for power converters. It has the disadvantage that it generates harmonics on the AC side. Figure 5 shows the typical harmonic currents generated by a capacitively smoothed rectifier. The triplin harmonics (3rd, 6th, 9th etc) are mostly zero sequence harmonics (identical on all phase) and therefore their return current is in the grounding system. The presence of large tripling current harmonics therefore requires a more substantial ground return conductor. Often present practice is for the ground conductor to have a reduced cross-section compared with the phase conductors, but this practice will need to be reviewed. The relationship of the voltage and current harmonics with supply admittance is typically as shown in Figure 6 for most rectifier circuits. The exact behavior of the harmonics from a rectifier circuit depends on whether a capacitor or inductor is used to smooth the DC side. From Figure 6 it can be seen that as the supply admittance increases, the current harmonics increases but voltage harmonics decreases. This represents the fundamental problem when trying to control power system harmonics. By simply adjusting the equipment rating (hence adjusting the system impedance) it is difficult to reduce or control simultaneously both the voltage and current harmonics. Usually some compromise is needed or additional filtering is required. The harmonic voltages are of concern to the users or loads as they could affect their operation. The harmonic currents are of concern to the utility or power supply as they can lead to excess losses in equipment and overheating. In the past, harmonics were dampened by the presence of linear loads (i.e. resistive loads) since the harmonic level is proportional to the ratio of non-linear loads to linear loads. But the proportion of non linear loads is rapidly increasing. It is estimated that by 2012, 60% of the loads on the power systems in the USA will be nonlinear loads. [3] If loads such as direct online motors are susceptible to this increase in voltage harmonics, then the power systems will need to be upgraded to a higher power rating (reduced system impedance) and the earth wires strengthened to accommodate the increase in current harmonics.

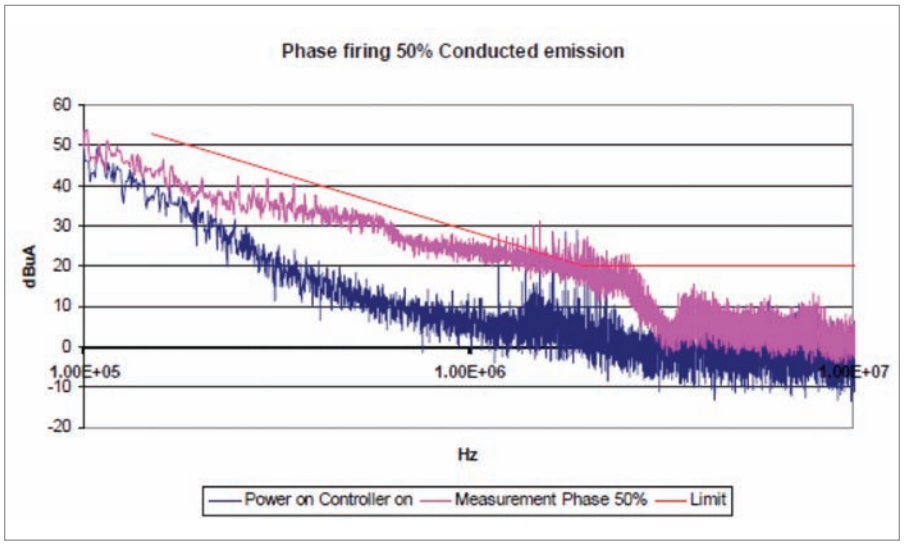

Figure 7: Typical conducted emissions measured from a six-pulse thyrister-controlled rectifier unit

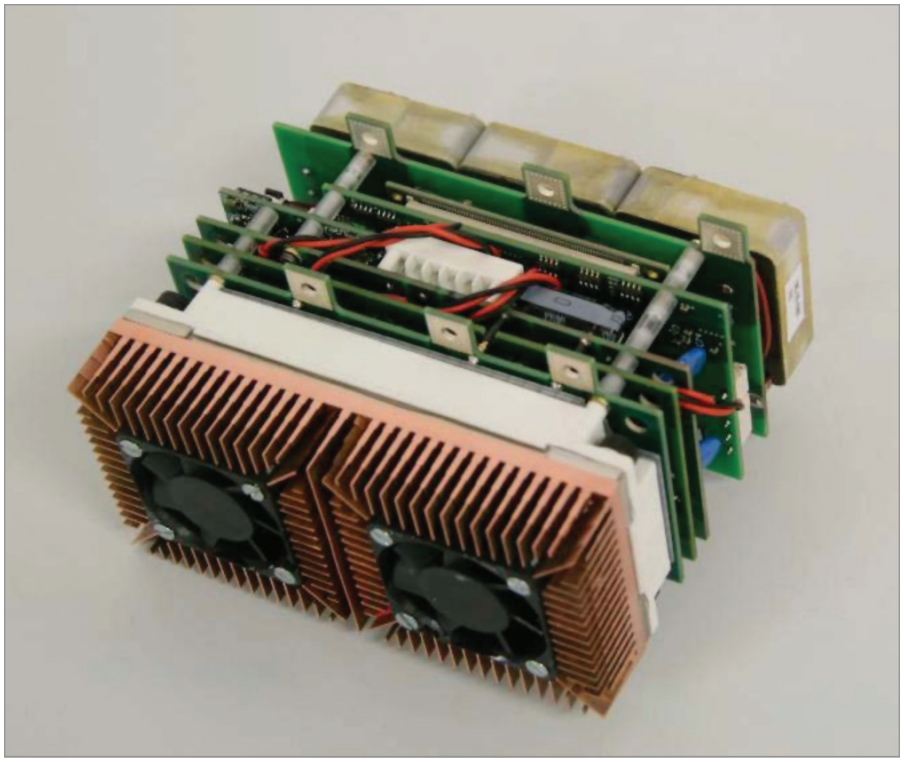

Figure 8: Photograph of a silicon carbide JFET-based matrix converter developed to reach a target of power density 20kW/dm3 with forced air cooling [5]

More sophisticated converters have a much more reduced harmonic current output. On three phase systems, it is possible to use 12 or 18 pulse rectifier units. [3] Figure 7 illustrates the conducted emissions from a six-pulse, thyrister-controlled rectifier unit, showing that for some switching conditions high frequency conducted emissions can exceed standards. Converters using fully controlled switching devices such as GTOs or IGBTs can produce almost pure sinusoidal interfaces. These are far more expensive devices and, although the harmonics are reduced, the high frequency switching leads to higher frequency conducted emissions. Although, these higher frequency conducted emissions do not propagate as far as the lower harmonics, special electromagnetic interference filters have to be fitted to prevent interference with other users at the point of common connection and even for radiated emissions. The latest matrix converters making use of Silicon Carbide(SiC)-based diods can achieve 20 kVA/litre energy densities and over 50 kHz switching frequencies with 10 ns current risetimes. An example matrix converter designed for the aircraft industry is shown in Figure 8. Such devices present extreme EMC challenges, with not only conducted emissions but potential radiated emissions in the GHz frequency range. New EMI filter designs are needed, as well as enclosures with good shielding effectiveness.

The complete ballast circuit topology for compact fluorescent lights with full filtering and power factor correction is shown in Figure 9. With such systems it is possible to provide a very compliant load that behaves as a good neighbor to all other users, but this is an expensive solution. Due to cost and size limitations, not all lighting ballasts are as complete as the one shown in Figure 9. At present there are no harmonic limits for LED light bulbs or compact fluorescent lights of less than 25 W. This has been shown to give problems if whole buildings are fitted with energy efficient lighting comprising bulbs of less than 25 W. [5] In this case, the local distribution system has to incorporate suitable filtering or be upgraded to accommodate the increased harmonics.

Not only can modern power electronic systems degrade the voltage and current waveforms, but they can also degrade the stability of distribution systems. Fully controlled converters can provide complete power control to the loads. Thus the load current will increase if there is a supply voltage dip or will decrease during a voltage swell. Such loads essentially exhibit a negative impedance to voltage fluctuations which then can significantly degrade the stability margin for small power systems. Care has to be taken in choosing the control bandwidth for the converters to avoid loss of stability or passive damping has to be incorporated, but this increases power losses and negates the use of the high performance power converter. [6]

In conclusion, the technology for generation and distribution of electrical energy is going through a stage of rapid development as electrical energy is increasingly used to improve efficiency in the transport industry, renewable generation is being developed and society as a whole is becoming more dependent on electronic technology. Power electronics devices are an essential part of these developments, as they provide new opportunities for improved power quality and EMC. However, power electronic devices are controlled nonlinear devices that also in themselves lead to power quality and EMC challenges which must be addressed. This article has outlined some of the opportunities and challenges that are currently being researched.

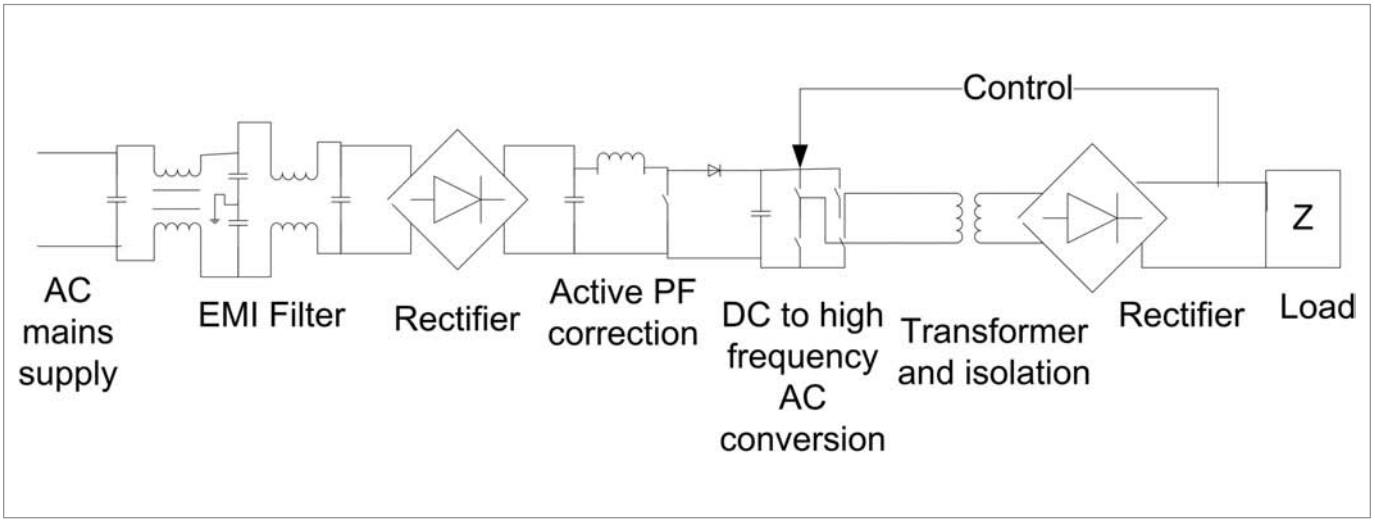

Figure 9: A schematic diagram of the principle components of ballast for compact fluorescent lights

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(the author)

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He received the B.Sc. degree in Physics from Imperial College of Science and Technology, the M.Phil. degree in Space Physics from Sheffield University, and the Ph.D. degree in Electrical Engineering from Nottingham University, in 1981, 1987 and 1990, respectively. In 1990 he joined the Department of Electrical and Electronic Engineering at the University of Nottingham as a Lecturer where he is now an Associate Professor and Reader. His research interests are in electromagnetic compatibility, electromagnetic simulation, power system transients and power system protection,. He is a member of CIGRE and convenor for Joint Working Group 4.207 "EMC of communication circuits, low voltage systems and metallic structures in the vicinity of power systems". He is also Secretary to the IEEE EMC Technical committee T7 on Low Frequency EMC.

ITE Requirements Around the Globe

BY JOHN MAAS

Sellers and importers of Information Technology Equipment (ITE) must comply with a vast array of hardware regulations when marketing their products in today's world.

The scope of hardware regulations includes the following basic disciplines:

- Product Safety
- Electromagnetic Compatibility (EMC)
- Homologation of wired and wireless telecommunication devices
- Environmental
- Chemical

Such regulations are established at many levels, including national, regional, state, province and even individual cities or towns. In many case, hardware regulations carry the force of law. Hence, a complete and in-depth understanding of the regulations applicable to any particular product is needed to avoid running afoul of the law. Being aware of all the regulations that apply to a product can be challenging enough, even before understanding all the details.

REGULATORY FUNDAMENTALS

Regardless the discipline, all hardware regulations encompass a common set of basic elements.

- Technical evaluation (may include testing or engineering analysis)
- Documentation of results (test report)
- Conformity assessment procedures, including Declaration of Conformity (DOC), verification and certification
- Product and packaging marking
- Information to the user
- Market surveillance and on-going compliance

Once the technical evaluation is completed, the results must be documented. The old adage of the work not being done until the paperwork is completed definitely applies in hardware compliance.

It should be noted that some regulations may not require explicit action on some of these elements. For example, certain regulations do not require a statement of compliance to be included in the documentation provided to the end user of the product.

The technical evaluation typically includes either testing a sample of the product against some defined standard or set of standards or an engineering analysis or assessment. Restrictions or rules on who can perform the testing or evaluation vary. In some cases, the test or assessment may be performed by the product's manufacturer, while other regulations for the same basic discipline may require the use of an independent third party. If testing to standards is required, the lab performing the testing may need to be accredited by the regulatory agency or through a designated lab accrediting agency. With the wide possibility of requirements on who can perform the evaluation and what specifically is required or allowed, it is easy to see why an in-depth knowledge of the applicable regulations is essential for successful compliance.

Once the technical evaluation is completed, the results must be documented. The old adage of the work not being done until the paperwork is completed definitely applies in hardware compliance. Without adequate documentation of the evaluation, one cannot truly demonstrate compliance with the requirements. What product was evaluated? How was the evaluation performed? Who did the work, and were they properly qualified to do it? The list of content that must be included in a test report can be quite extensive. Consider the following example.

1. Test Report Cover Page stating the regulation the report encompasses
2. Test standard and test method that were applied and any deviations from the specified procedures
3. Classification of the product with respect to the regulation (for example, Class A or Class B for EMC emissions test results)
4. Description of the device being tested for approval, including marketing designation or model number
5. Product specification sheet describing its functions and capabilities
6. Functional block diagram
7. Specific identification of the device that was tested, including serial number and detailed list of all hardware content
8. Description of software used to exercise the unit being tested
9. Measuring equipment used in performing the test, including make, model, serial number and calibration details
10. Test results
11. Description of any changes made to the device during testing to meet the test limits
12. Photographs of the test setup
13. Photographs of the device being tested
14. Diagram of the physical arrangement and configuration of the unit tested
15. Drawing or photograph of the product label showing required marking(s) and location of label on the device

The conformity assessment procedures define the specific process steps that must be followed to satisfy the regulation and include things such as filing a report with an agency versus keeping it on file to be made available if requested.

These procedures can be placed into three basic categories:

- Certification
- Suppliers Declaration of Conformity
- Verification

Certification generally requires filing specific documentation (such as the test report) with the agency and receiving a certificate in return.

In a Suppliers Declaration of Conformity procedure, the supplier (typically the product's manufacturer)

completes a form attesting, or declaring, that the device complies with the required regulation. The method used for demonstrating compliance is often listed on the declaration. In same cases, the declaration is distributed with the product to the end user, while in other cases, it is kept on file to be made available upon request.

Verification is the simplest form of conformity assessment in which the supplier creates documentation to verify that the product meets the requirements. Typically, this documentation would be a test report that is kept on file and made available upon request.

Product marking involves placing a mark or statement on the product. Most often the marking is added to the product's information label. Some regulations allow alternatives of placing the product marking on the packaging (such as the cardboard box) or in the user manual, but most require the marking on the product.

Information to the user is generally a statement that the product complies with the regulation. It may also include caution or warning statements describing types of locations where the device is, or is not, allowed to be used.

Market surveillance includes any activates undertaken by the authorities to verify that products being sold do, in fact, comply with all applicable regulations. These activities include checking products at retail outlets to ensure proper labeling as well as testing samples acquired from manufacturers, importers or retail outlets. Compliance verification by Customs officials at the time of importation is another form of market surveillance and typically involves document inspection to see if all the paperwork accompanying a shipment is in order.

EMC

Let us now explore EMC regulations around the globe.

A device's ability to exist in its intended operating environment without causing electromagnetic interference with other electronic equipment (emissions) or without suffering undue interference from other equipment (immunity) is regulated in some 50 countries.

Fortunately for manufacturers, importers and other responsible parties, these regulations reference a much smaller set of common standards, as shown in Table 1.

This referencing of common standards substantially reduces the testing burden, although changes and revisions to the reference standards are not always adopted on uniform schedules by the various regulations. A recent example of the variations that can happen in adoption is the roll out of the CISPR 22 limits on radiated emissions between 1 and 6 GHz. Compliance with these limits became mandatory in October 2010 for the Republic of China (Taiwan), in March 2011 for the Peoples Republic of China, and October 2011 in Australia, the European Union and Japan. Now that the new CISPR 32 standard for emissions from multimedia equipment has been published, it will be interesting to see how the various jurisdictions incorporate the standard into their requirements.

With the use of these common standards to establish the test conditions and limits that must be met, the primary differences between various global EMC regulations are in the conformity assessment details. A sampling of these details is summarized in Table 2. Note that some regulations include multiple conformity assessment procedures, usually based on the type of product or product classification.

CONCLUSION

Many countries around the world have a variety of hardware regulations that

This referencing of common standards substantially reduces the testing burden, although changes and revisions to the reference standards are not always adopted on uniform schedules by the various regulations.

Type of Test	Base Standard
Conducted and Radiated Emissions	CISPR 22
	FCC Part 15 Rules
Power Line Harmonic Emissions	IEC 61000-3-2
	IEC 61000-3-12
Voltage Fluctuations and Flicker	IE C 61000-3-3
	IEC 61000-3-11
Immunity	CISPR 24

Table 1: Common standards serve as the basis for global EMC regulations

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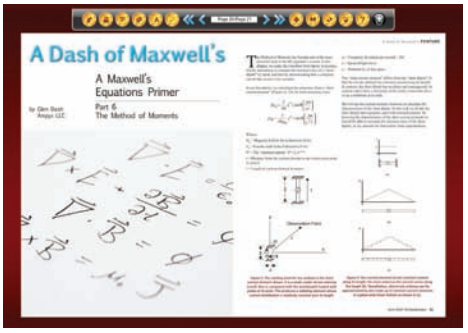

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must be met before ITE is marketed, sold or imported into those countries. These regulations exist for valid reasons and generally are intended to protect something: people, other equipment or the environment. For the most part, the technical details of hardware regulations can be met without placing excessive burden on the manufacturer, provided the requirements are understood at the start of a product's design cycle. The most challenging aspect of complying with the regulations is often the conformity assessment process – the administrative details that need to be completed after the technical analysis or testing is finished.

(the author)

JOHN MAAS

is Corporate Program Manager for EMC for IBM Corporation and has responsibility for IBM's worldwide EMC regulatory compliance program. He has over 25 Years of EMC experience including hardware design and test. He has been involved in international standardization for much of his career and currently is active in IEC SC77B/WG10 and the US advisory groups for IEC TC77, SC77A and SC77B and CISPR/I. Mr. Maas can be reached at johnmaas@us.ibm.com.

Geography	Test Type	Conformity Assessment Procedure	Submit Test Report	Product Label	User Manual Statement	Lab Accreditation or Approval
Australia	Emission	DoC	No	Yes	No	Recommended
Canada	Emission	Verification	No	Yes	Yes	No
China	Emission	Certification	Yes	Yes	Yes	Yes
European Union	Emission Immunity Harmonics Flicker	DoC	No	Yes	Yes	No
Japan	Emission	DoC	No	Yes	Yes	Yes
South Korea	Emission Immunity	Certification	Yes	Yes	Yes	Yes
New Zealand	Emission	DoC	No	Yes	No	Recommended
Russia	Emission Harmonics Flicker	Certification	Yes	Yes	Yes	Yes
Taiwan	Emission	Certification DoC	Yes	Yes	Yes	Yes
Turkey	Emission Immunity Harmonics Flicker	DoC	No	Yes	Yes	No
USA	Emission	Verification Certification DoC	No Yes No	Yes	Yes	No No Yes
Vietnam	Emission	DoC	Yes	Yes	No	Yes

Table 2: Sampling of compliance details for EMC regulations

EVENTS in Compliance

April

17-19
EMC by Your Design
D.L.S. Electronic Systems, Inc.
Northbrook, IL
www.incompliancemag.com/events/120417_1

17-19
Electromagnetic Compatibility Engineering
Henry Ott Consultants/In Compliance
Peachtree City, GA
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18
Earth and Enclosure Leakage Testing
Associated Research
Webinar
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26
NEBS Testing Seminar
MET Laboratories
Santa Clara, CA
www.incompliancemag.com/events/120426

4.30-5.9
EMC-Safety Compliance & Design Courses
EMC Technologies presented by
Keith Armstrong
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May

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Grounding and Shielding for EMC
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1
Understanding Ground Resistance Testing
AEMC Instruments
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4
iNARTE Examinations at Washington Labs Academy
iNARTE/Washington Laboratories Academy
Gaithersburg, MD
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7
EMC Tests According to ED-14F/DO-160F, MIL-STD-461F & Previous Issues
EMCC Dr Rasek
Unterleinleiter, Germany
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8-9
Essentials for ESD Programs Factory: Technologies, Controls, Procedures
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10
ESD Training for Internal Quality Auditors and Supplier Quality Engineers
Electrostatic Discharge Association (ESDA)
North Reading, MA
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10-11
Lightning Electromagnetic Pulse Effects on Aircraft
EMCC Dr Rasek
Unterleinleiter, Germany
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10-18
EMC-Safety Compliance & Design Courses
EMC Technologies presented by
Keith Armstrong
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11
ESD Device Design Seminar: On-Chip ESD Protection Design Overview and Practical Examples
Electrostatic Discharge Association (ESDA)
Heverlee, Belgium
www.incompliancemag.com/events/120511

14-17
6th Annual International Electrostatic Discharge Workshop (IEW)
Electrostatic Discharge Association (ESDA)
Oud-Turnhout, Belgium
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15-17
Laboratory, Measurement, & Control Equipment UL/CSA/EN/IEC61010-1
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BUSINESS News

3M Announces Comprehensive End-to-End Static Management Program

3M has launched its comprehensive 3M Static Management Program, designed to improve product quality and production yields for customers requiring high reliability in the electronics manufacturing industry. This unique program offers a full complement of product, software and service solutions, powered by the technical expertise of 3M staff and the company's proprietary technologies.

The 3M Static Management Program gives customers the tools and training necessary to support an effective EOS/ESD control program and to help them achieve ANSI/ESD S20.20 ESD Control Program certification.

To learn more about the complete offerings from 3M and its new 3M Static Management System, visit www.3Mstatic.com.

CSA Group Unveils New Brand Identity Reflecting Global Scope and Environmental Commitment

CSA Group has officially unveiled its new global logo and tagline to consolidate all of its divisions under a unified brand identity.

The multi-dimensional logo reflects CSA Group's global focus. The blue bands pay homage to the association's past logos and the trusted CSA certification mark while the addition of green embodies the organization's environmental commitment. The fluid spherical design reflects the unification of the operational structure and global outreach, with all divisions now recognized simply as "CSA Group."

Along with the new logo, CSA Group also unveiled a new tagline: "Advancing Today, Anticipating Tomorrow" – underscoring the organization's core principles of safety, collaboration, sustainability and innovation.

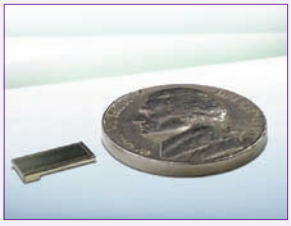
For more information about CSA Group visit www.csagroup.org.

Rodney Boyd Joins LCR Electronics

LCR Electronics has announced the placement of Rodney Boyd as their new Southeastern Regional Sales Manager for EMI Filters and Electronic Products. Rodney is based in Northwest Georgia and responsible for LCR's sales in NC, SC, TN, GA, AL, FL, MS, AR, LA, OK and TX.

Most recently, Rodney spent nine years covering the Eastern US and Canada with LA-based WEMS, a manufacturer of custom military EMI filters. Additionally, he has worked in technical sales with both Laird and Interstate Industrial Electronics. Rodney has a Bachelors degree in Business Marketing from Georgia Southern/Dalton State College and an MBA from the University of Phoenix. For more information, visit www.lcr-inc.com.

Low Profile Circuit Board Shield



Recent application demands from military and medical device manufacturers to significantly reduce footprint and enclosure space allocations have prompted Leader Tech to develop a very low profile circuit board shield.

The newest single-piece CBS shield from Leader Tech offers shielding effectiveness and has a height of only .039" (.991). The unique physical characteristic of this very low profile board-level shield make it ideal for smaller handheld and portable electronic devices. All Leader Tech CBS products are manufactured from RoHS compliant materials and exhibit exceptional solder characteristics and corrosion resistance.

For additional information contact Leader Tech at 866-832-4364 or sales@leadertechinc.com.

First Product Completes Medical Device RFID Susceptibility Testing

MET Labs has completed testing on the first product to be submitted to the Medical Device RFID Susceptibility Program. The Program – co-developed by MET Labs and the U.S. Food and Drug Administration (FDA) under the auspices of AIM Healthcare Initiative (HCI) – is designed to determine potential adverse events of radio frequency identification (RFID) emissions on electronic medical devices.

The patient-worn battery-operated vital sign monitoring device was tested at MET's Santa Clara, California laboratory. It passed six of seven tests, demonstrating a hard fault when subjected to 860-960 MHz frequency RFID at 54 V/m, as specified in ISO/IEC 18000-6 Type C. Testing was performed with the RF parameters that emit the minimum and maximum occupied bandwidth. The testing ranged from 134.2 kHz at 160 A/m to 2.45 GHz at 54 V/m.

Interested medical device manufacturers that have not expressed interest in the past are still eligible for participation in the program. For more information about MET Laboratories, please visit www.METLabs.com.

SAR Lab at Northwest EMC Celebrates First Anniversary

Northwest EMC, Inc. has marked the first anniversary of its SAR Evaluation lab at its Hillsboro test facility. SAR, or Specific Absorption Rate, is a measure of radio frequency (RF) energy absorbed by the head or body and is used to test devices used closer than 20 cm to the head or body, including wireless communication devices like cell phones. As adoption of these devices soars, so has demand for reliable SAR Testing. The addition of the new SAR Lab at Northwest EMC, opened in January of 2011, has proven a natural

fit with the test provider's other wireless testing services.

The company is currently expanding its EMC test facility in Irvine, California, to include a new 3-meter chamber that will be used to increase NW EMC automotive testing services. The new expansion is expected to conclude in late spring of 2012.

For additional information visit their website at www.nwemc.com.

R&S RTM Universal Oscilloscope Analyzes CAN/LIN signals at the Protocol Layer

Users have always been able to verify the quality of CAN/LIN signals with the R&S RTM by measuring characteristics such as amplitude and rise time. Thanks to the new R&S RTM-K3 triggering and decoding option, users can now view signals at the protocol layer and quickly and easily analyze the content of transmitted messages.

Controller area network (CAN) and local interconnect network (LIN) are serial communications buses. They are mainly used in the automotive industry to interconnect control devices or sensors. When electrical components with a CAN/LIN interface are put into operation, any faults and their origins need to be quickly and reliably found. The R&S RTM-K3 triggers on CAN/LIN-specific protocol data and decodes the recorded waveforms into easy-to-read protocol content.

For further information please visit www.rohde-schwarz.com.

New UMF 250 Quick-Acting SMD Fuse

Schurter has expanded its line of surface-mount fuses with the introduction of the Universal Modular Fuse, UMF 250. Its quick-acting characteristic according to IEC 60127-4 complements the successful UMT series, in providing overcurrent and short circuit protection for electronic systems in primary and secondary circuits. Current ratings up to 10 A at 250 VAC/125 VDC, the UMF 250 has a breaking capacity of up to 200 A at rated voltage. The UMF 250 provides maximum circuit protection while its compact size saves PCB space over larger cartridge style fuses and facilitates assembly with pick and place mounting.

See detailed specifications at www.schurterinc.com/new_fuses. For sales and product information, contact Cora Umlauf at 800 848-2600 or info@schurterinc.com.

New TDK Application Guide Features EPCOS Electronic Components for Automotive Powertrain Applications

TDK-EPC has published the EPCOS Application Guide 2012 – Electronic Components for Automotive Powertrain Applications.

This publication is part of a library of automotive application guides that cover convenience, safety, powertrain and e-mobility applications. PDF files of this and the other application guides may be downloaded free at www.epcos.com/publications.

New Immunity Test System Offers Fully Automated Switching

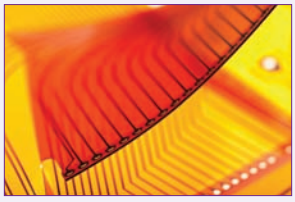
Teseq Inc., has announced the expansion of its ITS 6006 immunity test system to include the new SW 6012 RF switch option. This low-cost, high performance switching unit doubles the number of available switches within the system, enabling the ITS 6006 to fully automate the operation of three or four interconnected RF amplifiers during radiated EMC emissions testing.

The SW 6012, fully powered and controlled by the ITS 6006, features two SPDT (single pole, double throw) switches adding to the system's built-in switching network. The total of four SPDT switches can be configured to allow selection of up to four RF amplifiers with power ratings up to 1500 W. In a three-amplifier configuration, the switches can be used to reduce the number of power meters required from three to one.

Contact Teseq USA directly for pricing or to find out about renting Teseq products. You may also visit www.teseq.com.

Universal Electronics Sees Significant Growth in Flex Circuit Demand

Flexible circuit board use is on the rise, driven by the demand for increased design flexibility, smaller packaging and products that are lighter and thinner. Flexible circuitry use also eliminates connection points, which simplifies assembly and reduces the chance for human error or interconnect defects.



Universal Electronics has significant experience working with flex circuits, putting these advantages to work for customers. The company has seen demand grow at a rate of close to 20% quarterly over the last year. "We see flex circuits as a significant area for growth within the printed circuit boards industry," said Stuart Scholz, engineering manager at Universal Electronics in Whitewater, Wisconsin.

Learn more and watch a brief company overview video at www.ueinc.com, or contact info@ueinc.com.

(Authors)

NIELS JONASSEN, MSC, DSC, worked for 40 years at the Technical University of Denmark, where he conducted classes in electromagnetism, static and atmospheric electricity, airborne radioactivity, and indoor climate. Mr. Jonassen passed away in 2006. For Mr. Jonassen's full bio, please see page 23.

W. MICHAEL KING
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BRIAN LAWRENCE
began his career in electromagnetics at Plessey Research Labs, designing "Stealth" materials for the British armed services. In 1973 he moved to the USA and established a new manufacturing plant for Plessey to provide these materials to the US Navy. For Brian's full bio, please see page 19.

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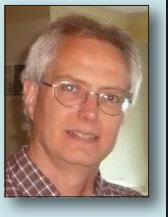

DR. MAGNUS OLOFSSON
is an IEEE Senior Member and chairman of the Technical Committee TC 7 (Low Frequency EMC) of the IEEE EMC Society. He is president of Elforsk, which is the Swedish Electrical Utilities' R & D Company.

GEOFFREY PECKHAM
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DOUGLAS C. SMITH
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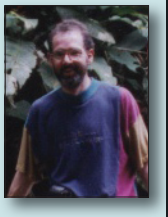
DAVID W. P. THOMAS, MIET SMIEEE CEng received the B.Sc. degree in Physics from Imperial College of Science and Technology, the M.Phil. degree in Space Physics from Sheffield University, and the Ph.D. degree in Electrical Engineering from Nottingham University, in 1981, 1987 and 1990, respectively. For Dave's full bio, please see page 55.



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E. D. & D., Inc.	25	Panashield Inc.	29
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