MAY 2011

IN COMPLIANCE Magazine

THE COMPLIANCE INFORMATION RESOURCE FOR ELECTRICAL ENGINEERS

NOISE MITIGATION ANALYSIS OF A π-FILTER FOR AN AUTOMOTIVE CONTROL MODULE

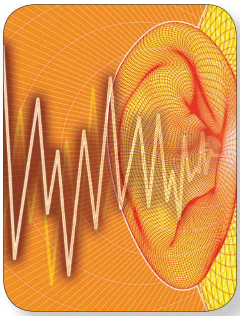
AUTOMOTIVE EMC CASE STUDY
HMI GRAPHICS INFLUENCE ON RADIATED EMISSIONS

ETSI EN 300 132-2
COMPLIANCE TESTING

A REGULATORY ROADMAP
THAT'S JUST REGULATIONS... RIGHT?

FEATURE ARTICLES

DEPARTMENTS



Genachowski Puts Economic Impact of Voluntary Spectrum Auctions at $300 Billion

Arguing that voluntary incentive auctions are a key tool in the effort to free up portions of spectrum for broadband communications, Federal Communications Commission (FCC) Chairman Julius Genachowski told participants at a recent wireless industry conference that such spectrum auctions could generate as much as $300 billion in benefits to U.S. consumers.

Speaking at the Cellular Telecommunications Industry Association's (CTIA's) annual conference and convention in Orlando, FL, Genachowski pointed to experience with past FCC auctions as the basis for his projection of a ten-fold return over the value that the sale of unused spectrum would generate at auction. Estimates by the U.S. Office of Management and Budget (OMB) and others place the direct potential value of future such spectrum auctions at approximately $30 billion.

Congress is currently considering legislation that would grant the FCC the authority to run two-sided, voluntary spectrum auctions. Under the proposed scheme, spectrum for the auction would be voluntarily contributed by current licensees, including TV broadcasters and mobile satellite operators, and then auctioned off for wireless broadband use, with a portion of the auction proceeds going back to the original licensees.

The spectrum auction proposal reportedly has the support of President Obama, as well as bipartisan support in Congress.

"A voluntary incentive auction can provide a capital infusion for those broadcasters that choose to participate," Genachowski told CTIA Wireless 2011 attendees. "And, the incentive auction proposal provides an incentive-based, market-driven path to tackle the spectrum crunch."

As further evidence of the economic catalyst provided by expanded wireless broadband capacity, Genachowski cited data from the High Spectrum Coalition that the investment required to roll-out 4G wireless technologies could create as many as 205,000 additional jobs.

The complete text of Genachowski's remarks at CTIA Wireless 2011 is available at http://www.fcc.gov/Daily_Releases/Daily_Business/2011/db0322/DOC-305309A1.pdf .

Commission Seeks Comment on Frequency Bands

The Federal Communications Commission (FCC) is seeking information and comments on spectrum frequency bands that have been identified for the possible future use by wireless broadband services.

According to a Public Notice issued in March 2011, the Commission is seeking public comments on whether and to what extent several specific bands could be made available for broadband deployment. The spectrum under consideration includes the following frequency bands:

1695-1710 MHz - Currently used for downloads from certain weather satellites administered by the National Oceanographic and Atmospheric Administration (NOAA) for weather forecasting, storm tracking and hazard warnings.

3550-3650 MHz - Currently allocated to the radiolocation and aeronautical radionavigation services on a primary basis for Federal use and to the radiolocation service on a secondary basis for non-Federal use.

1755-1850 MHz - Currently assigned to the fixed, mobile and space operation services on a primary basis and used by the Department of Defense, Federal law enforcement agencies and others for satellite, surveillance, aeronautical and fixed microwave operations.

4200-4220 and 4380-4400 MHz - Currently used worldwide for radio altimeters in aircraft.

IN COMPLIANCE Magazine

Lorie Nichols
Publisher & Editor
(978) 873-7777
lorie.nichols@incompliancemag.com

Sharon Smith
Director of Sales
(978) 873-7722
sharon.smith@incompliancemag.com

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

Erin C. Feeney
Director of Media Services
(978) 873-7756
erin.feeney@incompliancemag.com

IN Compliance Magazine
ISSN 1948-8254 (print)
ISSN 1948-8262 (online)
is published by
Same Page Publishing LLC
P.O. Box 235
Hopedale, MA 01747
tel: (508) 488-6274
fax: (508) 488-6114

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

Subscriptions outside North America are $129 for 12 issues. The Digital Edition is free.

Please contact our circulation department at circulation@incompliancemag.com

For more information, view the Commission's Public Notice at http://www.fcc.gov/Daily_Releases/Daily_Business/2011/db0308/DA-11-444A1.pdf .

Commission Releases New Data on High-Speed Internet Access

The Federal Communications Commission (FCC) has released its most recent report on access in the United States to high-speed Internet connections, continuing to document the gap between current service levels and the benchmark Internet connection speeds recommended under the Commission's National Broadband Plan.

According to the Commission's report, entitled "Internet Access Services: Status as of June 2010," 60% of fixed Internet connections to U.S. households fall below the targets set in the National Broadband Plan of 4 megabits per second (Mbps) downstream and 1 Mpbs upstream. Further, the growth of fixed broadband service slowed to 1% during the first half of 2010, to 82 million connections.

However, taking a broader look at Internet adoption trends over a 10 year period, the Commission reports that residential fixed-location Internet connections faster than 200 kbps in at least one direction have grown from 3 million in June 2000 to 82 million in June 2010, a compounded annual growth rate of 35% a year. During the same period, the penetration of Internet connections has increased from 3 connections per 100 households to 63 connections per 100 households.

As for Internet access via mobile wireless devices, the number of mobile wireless service subscribers with data plans for full Internet access increased by 27% over the first six months of 2010, to 71 million.

The complete text of the Commission's most recent report on high-speed Internet access is available at http://www.fcc.gov/Daily_Releases/Daily_Business/2011/db0321/DOC-305296A1.pdf .

EU Releases Updated Standards List for EMC Directive

The Commission of the European Union (EU) has published an updated list of standards that can be used to demonstrate conformity with the essential requirements of the EU's directive on electromagnetic compatibility (also known as the EMC Directive, 2004/108/EC).

The EMC Directive applies to "any apparatus or fixed installation" and regulates the "ability of equipment to function satisfactorily…without introducing intolerable electromagnetic disturbances to other equipment."

The provisions of the EMC Directive do not apply to telecommunications terminal equipment, which are covered under the essential requirements of Directive 1999/5/EC (also known as the R&TTE Directive).

The updated list of CEN, CENELEC and ETSI standards that can be used to demonstrate compliance with the EMC Directive was published in February 2011 in the *Official Journal of the European Union* and replaces all previously published standards list for the Directive.

The complete list of standards can be viewed at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2011:059:0001:0019:EN:PDF .

Updated Standards List Published for the EU's Electrical Safety Directive

The Commission of the European Union (EU) has published an updated list of standards that can be used to demonstrate conformity with the essential requirements of its directive relating to electrical equipment designed for use within certain voltage limits (2006/95/EC).

The Directive defines 'electrical equipment' as any device designed for use with a voltage rating of between 50 and 1000 V for alternating current, and between 75 and 1500 V for direct current.

The U.S. Consumer Product Safety Commission (CPSC) has officially launched a new website that allows consumers to post reports of unsafe products and for manufacturers to respond to those reports.

The updated list of standards that can be used to demonstrate compliance with the Directive was published in March 2011 in the *Official Journal of the European Union* and replaces all previously published standards lists.

The complete list of standards can be viewed at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2011:087:0001:0091:EN:PDF (note that the list runs 91 pages!)

Commission Terminates Anti-Dumping Action Against China

The Commission of the European Union (EU) has terminated an investigation into charges that manufacturers in the People's Republic of China (PRC) were shipping government subsidized wireless wide area networking (WWAN) modems into the EU, in violation of the EU's anti-dumping laws.

The Commission's investigation, which commenced in September 2010, followed a complaint received from OPTION NV, an EU-based producer of WWAN modems. In its complaint, OPTION NV alleged that WWAN imports from China had increased overall in absolute terms and in terms of market share and that the prices being charged for the imported WWAN modems had a negative impact on overall price levels, thereby putting both the company and its employees at risk.

Based on a review of the charges, the Commission initially determined that there was sufficient evidence to launch a formal investigation into the dumping complaint. However, the Commission has now terminated the investigation at the request of OPTION NV, who notified the Commission that the company "had entered into a cooperation agreement with an exporting producer in the PRC."

The Commission's notice of termination of the anti-dumping proceedings was published in March 2011 in the *Official Journal of the European Union* and is available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:058:0036:0038:EN:PDF .

CPSC Launches New Consumer Product Safety Database

The U.S. Consumer Product Safety Commission (CPSC) has officially launched a new website that allows consumers to post reports of unsafe products and for manufacturers to respond to those reports.

The new website, which is accessible at www.SaferProducts.gov, was officially launched on March 11, 2011. The website allows consumers to file a report directly with the CPSC about an incident with an unsafe product or potentially hazardous consumer product. According to the CPSC, approximately 1500 reports of unsafe products have already been posted by consumers since the soft launch of the website in January.

Upon the posting of a report by a consumer of an unsafe product, the CPSC reviews the claim and forwards the report to the manufacturer. The manufacturer then has 10 business days to respond to the CPSC and provide any comments or claims regarding the report. At that point, the consumer's report and the manufacturer's response are posted to the SaferProducts.gov website.

Prior to the official launch of SaferProducts.gov, the Commission encouraged manufacturers to register with the CPSC so that they can receive timely, on-line access to reports submitted by consumers about their products. According to the CPSC, about 1400 manufacturers have already signed up through the website's business portal. Companies who wish to register with the CPSC can do so at https://www.saferproducts.gov/CPSRMSPublic/Industry/Home.aspx.

Company Recalls Electronics Remote Control Systems

Niles Audio Corporation of Miami, FL has announced the recall of about 4100 of its remote control systems for entertainment electronics manufactured in China.

The company reports that batteries powering these devices can fall during routine handling, potentially resulting in the rupturing of the battery and posing a fire hazard to consumers. Niles says that it has received four reports of batteries falling from the remote control system during handling, leading to three reports of smoke and one report of fire and a singed carpet.

The recalled remote control devices were sold through authorized dealers and distributors of audio/video equipment from January 2008 through September 2010 for between $1000 and $1300, depending on the model.

More information about this recall is available at http://www.cpsc.gov/cpscpub/prerel/prhtml11/11141.html .

Surge Protectors Recalled Due to Shock Hazard

Milestone AV Technologies of Savage, MN has recalled about 2500 of its low-profile power conditioners/surge protectors manufactured in China.

According to the company, improper grounding of the case and inadequate insulation for the circuit breaker pose an electrical shock hazard to consumers. There have not been any reports of incidents or injuries related to the recalled surge protectors, but the company has initiated the recall to prevent any incidents in the future.

The affected surge protectors were sold through independent home theatre dealers from June 2009 through December 2010 for about $90.

Additional details about this product recall are available at http://www.cpsc.gov/cpscpub/prerel/prhtml11/11158.html .

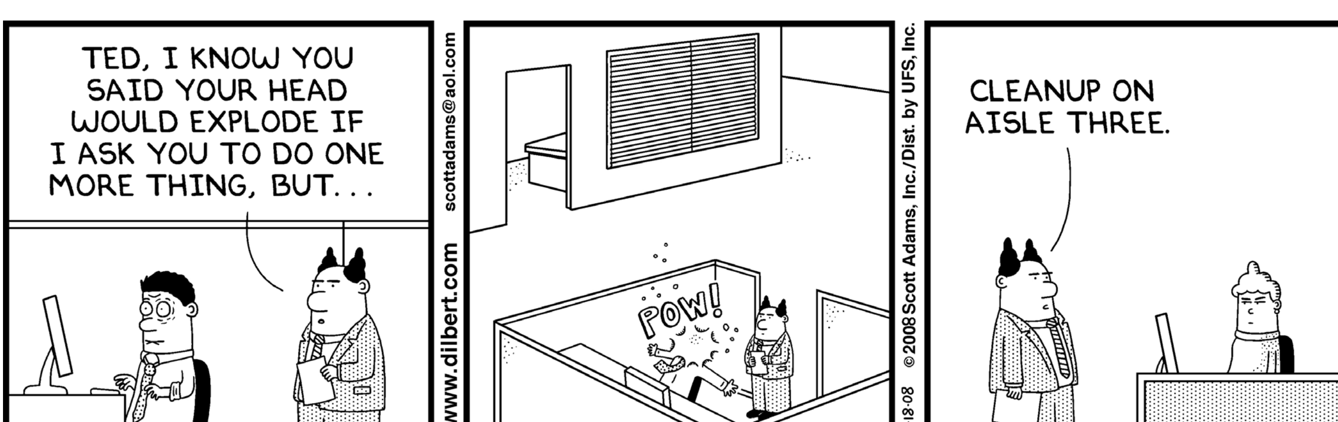
Company Recalls Workbench Components

Global Industries of Port Washington, NY is recalling about 5000 of its workbench power risers, power aprons and power shelves manufactured in China.

Global reports that misrouted wiring in the electrical outlets of these workbench components, and reverse polarity in some workbench power cords, could pose an electrical shock hazard to consumers. The company says that it has so far received eight reports of misrouted wires.

The recalled workbench components were sold through the Global catalog and the company's website from January 2009 through December 2010 for between $85 and $516, depending on the workbench configuration selected.

More details about this recall are available at http://www.cpsc.gov/cpscpub/prerel/prhtml11/11724.html .



DILBERT: © Scott Adams/Dist. by United Feature Syndicate, Inc. Reprinted with permission.

ELECTRIC VEHICLE BATTLE MOVES BEYOND CARS

Dr. Peter Harrop, Chairman, IDTechEx

By a big margin, Toyota is number one in hybrid car sales and indeed in sales of electric vehicles overall thanks to such things as sales of its electric forklifts, where it is in the top three in most countries. For example, it is number two in material handling vehicles in the United Kingdom. Indeed, Toyota's position in electric material handling vehicles may have been strengthened even further by the fact that world number one, Linde sold its materials handling business, rebranded as KION Group to financiers KKR and Goldman Sachs for €4bn, not to an engineering company optimizing long term success with synergies.

LEVERAGING ELECTRIC CARS, FORKLIFTS AND BUSES

Companies such as Hyundai, Nissan and Toyota cross fertilise EV component purchasing power and experience between their material handling, car and other electric vehicle making activities such as buses. Some of the first moves to ac motors were in forklifts and lithium-ion batteries have appeared in some Nissan forklifts since 2008. Hyundai has a large hybrid outdoor forklift, and Jungheinrich field tested an innovative electric counterbalanced forklift in 2010 for launch in 2011. This type EFG 216k truck is equipped with a lithium-ion traction battery. Toyota is also introducing lithium-ion here, not just working to replace NiMH in hybrid cars and for use lithium-ion traction batteries in pure electric cars. The material handling aspect is no sideshow. Mitsubishi Heavy Industries Ltd., Japan's largest diversified machinery manufacturer, completed construction of a traction battery plant inside its Nagasaki Shipyard and Machinery Works in November 2010. Capacity at the plant, which will produce lithium-ion batteries for forklifts, is 400,000 units yearly.

CHASING TOYOTA

The Toyota Prius still drives almost all of its hybrid car sales, being made in three continents. Its Auris now has a hybrid option, global production being in the UK, and electric versions of all its car models are being rapidly introduced. Toyota is not very keen on pure electric cars at present levels of battery performance, so hybrid versions of most Toyota car models will be made available.

To chase Toyota from a position a long way behind, many car companies have formed alliances. Now the BMW cooperation with PSA Peugeot Citroen is being solidified into a 50:50 joint venture, functioning in the second quarter, to share the formidable cost of developing hybrid powertrains and seek early volume.

Before that, Daimler AG, playing catch up in EVs by buying 10% of Tesla, and developing electric Smart and Mercedes models, struck a partnership with Renault Nissan to develop small cars, notably pure electric ones. Renault Nissan also partners with Mitsubishi on this. Mitsubishi promises electric versions of all new car models. Like Nissan and Fiat, it seems to prefer the pure electric small car route.

FOR STATE OF THE ART COMPONENTS LOOK BEYOND CARS

Third generation traction batteries such as lithium sulphur are being successfully used today but it is in Unmanned Aerial Vehicles UAVs long before they will be considered for cars. Manned aircraft already incorporate the benefits of very thin, wide area traction batteries. Others will follow.

Indeed, look for the new, very flexible copper indium gallium diselenide CIGS solar cells all over solar boats for up to 150 people such as those made by Kopf Solarschiff GmbH near Stuttgart. More area can be covered and electric land and air vehicles will follow later in adopting this, starting with the massive new orders for solar dirigibles. Come back Zeppelin: all is forgiven. The new flexible photovoltaics is typically printed reel to reel. By contrast, traction batteries pushing the limits of energy storage up to 400 kWh or more are first seen in electric tugboats and electric Autonomous Underwater Vehicles AUVs.

SINGLE ORGANIZATION: WIDE VIEW

In an excellent example of the new cross fertilization of ideas between many very different types of electric vehicle, the huge German research organization DLR is developing electric nose wheels for taxiing using its own Airbus A320 airliner and its state of the art permanent magnet synchronous brushless "dc electronically commutated" motor for better performance than that obtained with ac motors. But it is also developing fuel cell powered material handling vehicles and cars and a simplified flat internal combustion engine for next generation hybrids in its Institute of Vehicle Concepts division near Stuttgart. Winners see the big picture.

TRACK THE BIG PICTURE

Whether you are a vehicle, components of materials developer or producer, it is now vital to track this big picture and optimize your sales, rather than follow the herd into cars alone. Help is at hand. Go to the IDTechEx event "Electric Vehicles Land Sea Air" in Stuttgart June 28-29. Everything from electric planes and solar boats to material handling vehicles and, yes, cars and delivery vans will be involved. As happened at the first such event in San Jose USA in December, delegates will meet people for the first time that have similar problems and solutions in other industries. AFS Trinity, with breakthrough technology that gets supercapacitors to do more of the work in large hybrid vehicles, said, "I think you did a great job of bringing together people that do not normally cross paths at other conferences."

DISRUPTIVE SUBSYSTEMS, MATERIALS AND COMPONENTS

Completely new subsystems, materials and components will be covered. Examples are Bladon Jets mini turbines as range extenders in the new Jaguar supercar. Internal combustion engines, even ones optimized for use in hybrids, are cheekily referred to as "reciprocaurs" by those creating next generation hybrid electric vehicles that do not need them. For example, DesignLine of New Zealand is successfully selling large electric buses in Australia, Europe and the USA with mini turbine range extenders. At this unique event, you will understand the design of improved in-wheel motors, supercabatteries and third generation lithium traction batteries and more. There will be visits to see the most exciting EV work in the Stuttgart region, home to Bosch, Mercedes and Porsche electric vehicle activity. See www.IDTechEx.com/evEurope for full details. ■

to

The iNARTE Informer

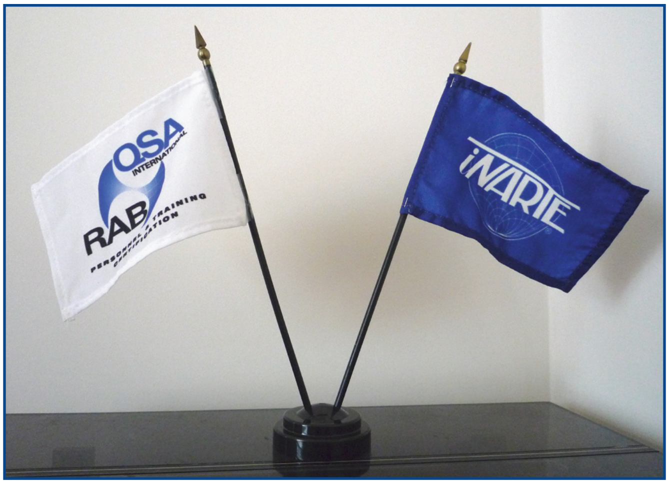
Provided by the International Association for Radio, Telecommunications and Electromagnetics

HEADQUARTERS NEWS

This month we have some great news to share with our members. On March 21, 2011, the iNARTE Board of Directors voted unanimously in favor of an Affiliation Agreement with RABQSA International. A similar motion to affiliate had been adopted a few days earlier by the Board of RABQSA.

It is possible that few of you will be familiar with the RABQSA organization, but it is one of the largest, internationally recognized, independent credentialing agencies in the world. RABQSA was created in 2004 by the merging of the personnel certification activities of the USA based Registrar Accreditation Board (RAB) and the Australian based Quality Society of Australasia (QSA). At the time of this merger, RAB activities were controlled by the American Society for Quality (ASQ). In 2005, RAB's accreditation programs for management systems certification bodies became the responsibility of the ANSI-ASQ National Accreditation Board (ANAB), while the auditor certification and auditor training provider programs of RAB became the responsibility of RABQSA International.

ASQ is still the controlling and sole voting member of RABQSA, and in the same way, RABQSA will become the sole voting member of iNARTE as a result of this new affiliation. These terms are commonly used when non-profit organizations merge or affiliate, but what it means is that iNARTE will in the future be a part of a much larger and more influential organization, with ASQ at the head.



ASQ was established in 1946. Headquartered in Milwaukee, WI, ASQ is a global community of experts and the leading authority on quality in all fields, organizations, and industries with over 85,000 members worldwide. ASQ supports membership services and business operations through ASQ Global, ASQ China, and ASQ Mexico; with ASQ WorldPartners® around the globe; and through its work with ANAB and RABQSA.

The RABQSA organization has principal offices in Sydney, Australia, in Milwaukee, WI, and in Seoul, Korea. They design, develop, and deliver personnel and training certification services for various industries, and work through more than a dozen regional offices in Asia, Europe and South America.

The activities of iNARTE and RABQSA do not compete but are entirely complimentary, in that iNARTE has programs for certification of the hands on engineering communities, whereas RABQSA schemes are directed at assessors, auditors and inspectors. iNARTE programs are almost entirely "Qualification Based," RABQSA schemes are, for the most part, "Competency Based."

This affiliation raises the profile of iNARTE in the global community. Becoming part of the ASQ, ANSI, ANAB, RABQSA family, exposes iNARTE to the upper echelon of international regulatory organizations and industry associations and will provide new opportunities for significant growth. Affiliation will be a seamless process for iNARTE members. Existing iNARTE certification programs will continue to be administered as before and the status of iNARTE members will not change.

GET READY FOR EMC DESIGN ENGINEER CERTIFICATION IN 2011

Negotiations with industry leaders are progressing as planned and the definitions and skill sets for this new certification are taking shape. Final decisions from the Certification Review Committees in the USA and in Japan are expected by mid June. This should permit our first certification examinations to be ready for the EMCS 2011 in August.

The latest proposals being discussed will reduce the examination question categories to just the following twelve:

Program Categories	Categories include
EMC Countermeasure & Countermeasure Components	Contains RF Shielding Techniques & Components
EMC Design & Design Review	
EMC Simulation & EMC Rule Check	
Signal Integrity & Power Integrity	
Electronics Circuit & Power Electronics	
Electromagnetics & Shielding	
Electrical Circuit Theory	Contains Transmission, Reflection, Resonance, Distributed Constant Circuits, S-Parameter
Measurement & Analysis	
Specifications & Standards	
Mathematics	
Fundamental Knowledge	Antennas, ESD, Lightning, Electrical PS, Safety
Terminology	

Within the above categories there will be both basic knowledge questions and advanced level questions. The examination will consist of two parts, each to be completed within three hours. Part 1 will contain 30 basic knowledge level questions and all should be attempted. Part 2 will be a selection of 40 more advanced and selective questions, from which the candidate should choose to answer no more than 30. The passing grade will be an average of 70% correct.

Unlike the traditional EMC certification exam, this new exam will not be open book. Candidates may bring only a scientific calculator and a self made note book of approximately 1cm thickness. This exam is not a test of your problem solving skill using your normal day to day tools, but is instead a test of your knowledge related to EMC design principles.

Eventually there will be two certification grades offered; Certified Engineer and Certified Senior Engineer. However the 2011 examinations will be for the Engineer level only.

Those of you with a wealth of EMC Design experience should get prepared with your education and experience credentials to apply for Certification during the initial grandfather period. In June we will publicize the full list of requirements for acceptance under the grandfather program.

Unlike the traditional iNARTE EMC certification program that requires members to renew each year, the new Design Engineer certification will be for life. However, Engineers will be offered an opportunity to upgrade to Senior Engineer once they have held their certificate for three years or more.

Look for more details to be confirmed in June.

REGISTER FOR CERTIFICATION EXAMS

Don't forget the following events that offer candidates a chance to take the iNARTE certification examinations without added proctoring fees.

- **APEMC 2011** – Jeju, South Korea. iNARTE workshop on May 16, examinations on May 19
- **IEEE EMCS 2011** – Long Beach, CA. iNARTE workshop on August 15, examinations on August 19
- **EOS/ESD 2011** - Anaheim, CA. iNARTE examinations on September 16
- **IEEE PSES 2011** – San Diego, CA. iNARTE examinations on October 13

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

QUESTION OF THE MONTH

Last month we asked you the following ESD question:

A large piece of paper is left on top of an ESD control work surface. Someone sets a 15 cm x 15 cm tote directly on top of the paper. Given the following data, what is the capacitance between the tote and the work surface?

Data: ε of paper = 1.5, paper thickness = 0.05 cm.

A) 29.8 pF

B) 298 pF

C) 59.7 pF

D) 597 pF

The correct answer is **D) 597 pF**.

This month the question is:

If 10 V is applied across the ends of a 1mm diameter copper wire 100 m long, find the current and electrical field over the length of the wire.

The conductivity of the copper = 5.7×10^7 Siemens/m

A) 4.5 A, 0.1 V/m

B) 4.5 mA, 100 V/m

C) 9 A, 0.1 V/m

D) 9 mA, 100 V/m

Days in Türkiye: Part 2

Frosty Goes To Istanbul

by Mike Violette

Our last days in Diyarbakir were relaxed and uneventful; we wrapped up the final data collection and loaded up the equipment to ship back to the US. We packed the battered antennas, cables, equipment and bits (road gear takes a beating) into the shipping cases and stepped outside to snap a quick picture in front of a radome (Mustafa and Ibrahim here).

In a few years hence, Pirinclik would be dismantled, a casualty of the end of the Cold War, if you could call it a casualty.

We had a few hours to kill so we took the tourist walk around the ancient city.

Frosty was a novelty in cowboy boots, jeans and a white T-shirt emblazoned with a picture of Carlos Santana. We were followed for 20 minutes by a gaggle of kids squealing "Hello Yankee! Hello! Hello!"

These guys were the most effervescent, doing splits and cartwheels in the square. We offered them some small change, but they wouldn't take it.

Another stop was at one of the few Catholic churches in the city, left over from the Crusades, I suppose, but still as well preserved as any of the old buildings in the area. We walked in just as a few of the faithful were gathering for an afternoon service.

After our lightning tour of the old town (I guess everywhere is old town there), we headed over to Ibrahim and Mustafa's apartment for a beer. The four-story apartment building in the middle of town didn't have an elevator, as many buildings in Diyarbakir. We trudged up the sixty steps to the top level.

"It's good to be on the top floor." Mustafa said. "Less noise from the street up here."

We reached the top of the stairs and turned down a hall lit dimly by a small window at the far end. We stopped at the first door. Ibrahim took a ring of keys out of his pocket and opened a heavy padlock that was bolted between the door and the frame. He then clicked open another pair of deadbolts, the sound of the lock clanking and echoing down the empty hall.

"Can't be too safe." He smiled, swinging the door open. "Come on in."

The apartment was not unlike a typical male college dorm room, except maybe a little more forlorn. Bare walls, beaten carpets. A threadbare couch was arranged in front of a small TV set that sprouted a bent coat hanger from a stub of an antenna. An unmatched set of four kitchen chairs were arrayed around a small table, a book balancing up one of the wobbly table legs.

Frosty looked around and asked: "Nice. Who's your decorator?"

"Very funny. Three more days here, then we go back to Ankara—for good." Mustafa said turning into the dingy kitchen. A half-size refrigerator, round and ancient and humming loudly was the only appliance. The door was held shut with tape. Mustafa gingerly pulled the tape back and opened the refrigerator. A sweet musty smell hit our faces.

"Beer?"

What the heck. We each took a bottle of Efes Pilsen; Mustafa handed us a pair of side cutters and we popped the tops off the slightly-cool brews. Frosty's beer ran over the top of the bottle and he slurped it quickly to calm the foam…and not waste any.

We sat for an hour watching Turkish television which featured an excessively dramatic soap opera of some kind. The only other channels were a continuous chanting of a mullah and a talk show of some kind; the set looked like it was in the bedroom of a house, complete with colorful curtains. An old grey typewriter was a table prop. I guess they were trying to look journalistic.

Ibrahim, this looks like secular TV. Not religious stuff.

“Sure. We have all kinds of western TV here. Do you want to watch Gunsmoke? It is very popular in Turkey. It comes on at—“ He broke off. “Hey Mustafa, what time is Tüfek-Duman?”

“Seven.” Mustafa said, lighting up a cigarette.

It was getting just past six p.m.; it had been an exhausting trip already so we demurred.

We’ve got an early flight tomorrow; thanks anyway.

We said goodbye to Mustafa, nursing his third beer on the couch, watching the TV and piling up butts in a hubcap that served as an ashtray. Ibrahim took us back to the hotel and dropped us off without getting out of the car. He was tired, too.

“See you tomorrow.”

See you.

We woke the last morning in Diyarbakir and met for breakfast; we had to leave in an hour to go back to the airport. In the dining area of the hotel, breakfast was laid out, buffet-style: a variety of cheeses, cucumbers, cantaloupe, plain yogurt and thick hard bread. Coffee cooked on an electric burner. Green flies buzzed in abundance around the room and landed on the uncovered plates. A pair of squeaking ceiling fans turned lazily overhead, futilely shooing the flies away.

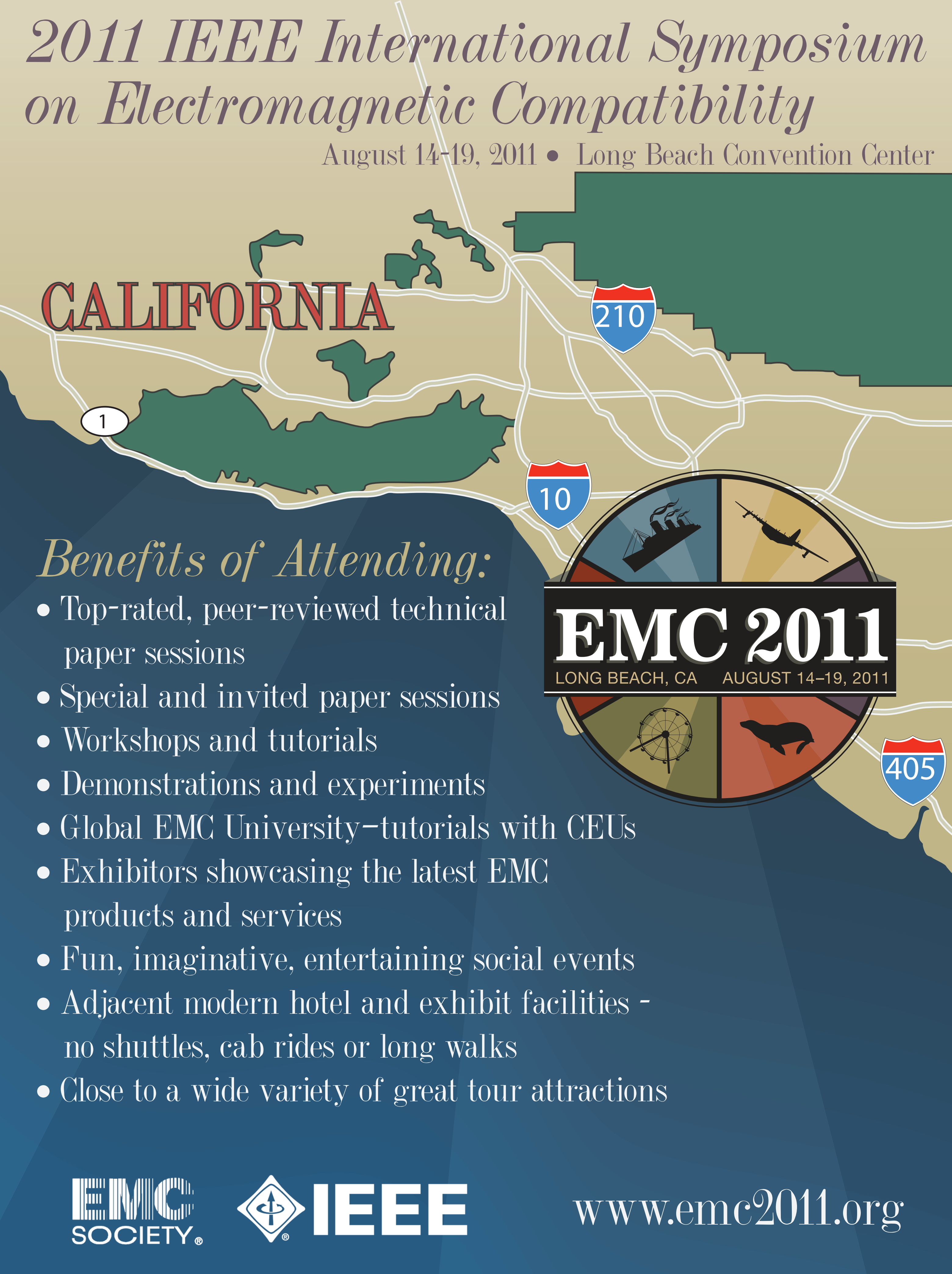
We shrugged and picked up a plate and grabbed some cheese and bread. Best to stay away from the fresh vegetables, although it was about that time that the malady we nicknamed “Atatürk’s Revenge” started playing in our guts. It was gonna be a long flight home, but first we had a few nights in Istanbul.

Mustafa arrived, we loaded our suitcases into the car and headed to the airport, past the chickens and goats and mud and thatch shacks, boarded a shiny new airplane and flew away from Diyarbakir. Things here would change in a few years, but many things about life would remain the same for a long time.

Arriving in Istanbul—crucible of east meets west—one is struck by the jumble and mix of buildings, architecture, traffic and street sounds competing for the senses. Gyro stands line street-corners with inverted conical stacks of beef and lamb, rotating and roasting and testing one’s will to resist. Fresh pita with onion, tzatziki and tomatoes, wrapped in square of wax paper, all for a dollar and served up in an Istanbul minute.

Minarets pierce the skyline of the city that rings the Bosphorus, the watery connection between Europe and Asia.

Churches are spread about the city. When Constantinople became Istanbul, the Christian buildings weren’t reduced to rubble, but the minarets were built just a little higher, closer to God and further away from the noise and rumble of the street.


2011 IEEE International Symposium on Electromagnetic Compatibility
August 14-19, 2011 • Long Beach Convention Center
CALIFORNIA
210
1
10
405
EMC 2011
LONG BEACH, CA
AUGUST 14–19, 2011
Benefits of Attending:
• Top-rated, peer-reviewed technical paper sessions
• Special and invited paper sessions
• Workshops and tutorials
• Demonstrations and experiments
• Global EMC University–tutorials with CEUs
• Exhibitors showcasing the latest EMC products and services
• Fun, imaginative, entertaining social events
• Adjacent modern hotel and exhibit facilities - no shuttles, cab rides or long walks
• Close to a wide variety of great tour attractions
EMC SOCIETY
IEEE
www.emc2011.org

A nice hotel is our good refuge from the unfamiliar, and ours featured a good bar with a twinkling view of the lay of the city.

Turn in?

"What?" Frosty asked. "We're in Istanbul, man. We gotta go *out*!"

How about tomorrow?

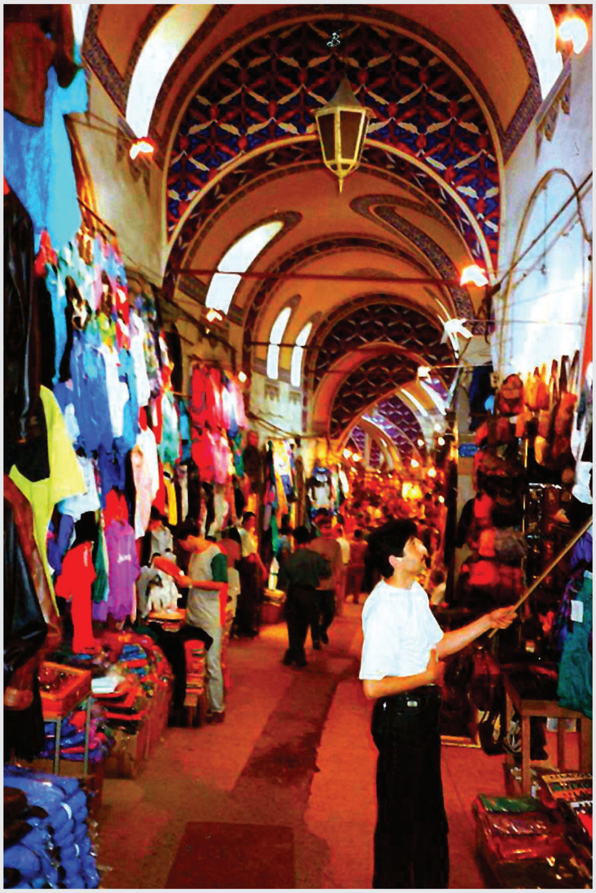
"Wuss."

Sorry, man, it's been a lot of moving around; my guts are in a Mixmaster.

I left him at the bar, more lonely than miserable, I suppose. We'll try tomorrow…which dawned early, the faithful called to prayer by loudspeaker atop the many mosques, each competing, it would seem, for the biggest draw. At six in the morning, it is a mournful cry, supplicants gathering to pray. I stuffed my face in the pillow for a few more moments, and then arose. One day in Istanbul; I should make a full day of it.

"I want to buy a fez and an outfit for my lady," Frosty announced. "It'll be fun to play 'Harem'." He winked.

OK, Sheik Frosty.



We finished breakfast and headed for the Grand Bazaar of Istanbul, a timeless place, rivaling any market on the planet with over 50 covered streets and four thousand shops.

We plunged in. The merchants were out, vigorously pushing merchandise like their lives depended on it, which they probably did.

"Carpets! Jewelry! Tea! Please sir, welcome you."

Diving into the bazaar at Istanbul is like entering the shopping netherworld. The city has literally grown up and around the ancient market (the original street-level markets plunge a story or more beneath the city), but the sounds, smells and seductions are the same as in millennia past.

"Tea?" One is beckoned from shop after shop. "Carpets? The best. Come see."

"No! I want a belly dancing outfit." Frosty kept repeating to quizzical faces. "And, you know, one of those funny hats." He pointed to another customer who was inspecting some of the jewelry across the aisle.

"What do you want? A what?"

"You know, scarves and a…" He made a motion with his hips I can't replicate, nor repeat, but it certainly spoke "Harem lingerie."

Finally a young man said. "Ah, yes. I know. Come, here. Take this card. It is my cousin. The best stuff. You will like it. I *guarantee*."

He produced a yellowed business card. It said, simply:

"**HASSIM—BEST TRADE**" and an address in the bazaar. A phone number was written in pencil on the back of the card.

"Take me there!" Frosty said excitedly.

"OK. It is not far."

We walked through the bazaar. Frosty found **HASSIM—BEST TRADE**, selected a diaphanous outfit for his lady, and baggy pants and a fez for himself.

Happy?

"Yeah," he said, admiring his fez. "What do you think? Will she dig it?"

Sure. Please spare me the details.

After **HASSIM—BEST TRADE** we schlepped our stuff around for a while (Yes, I did buy a carpet, just a small one. How can you refuse?) and finished out our experience at a T-Shirt stall, picking up some souvenirs for some and ourselves.

We arrived at the hotel, pulling our bags from the cab. Something was missing.

“My fez! My girl’s costume!” Frosty was in a panic. He had left a bag with his prizes at the bazaar.

“Man, oh man. I’m freaking.” He was practically frothing. “Let’s go back!”

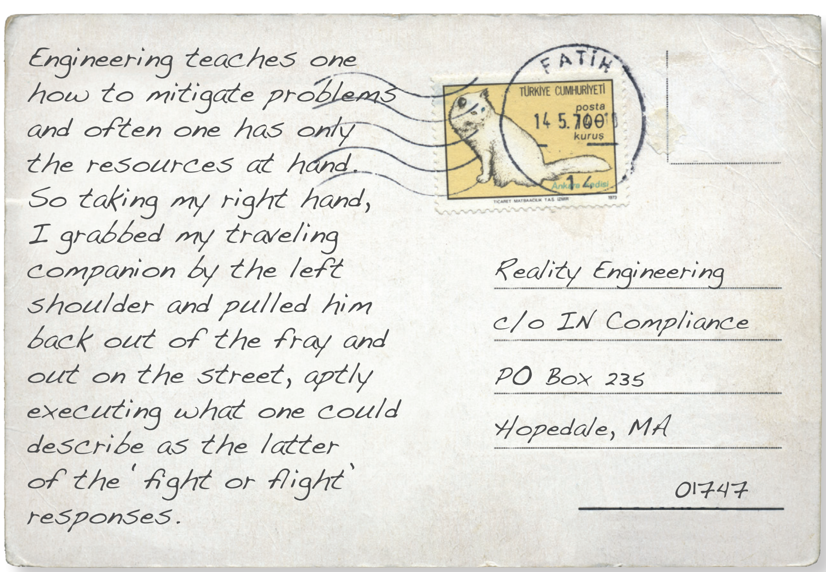
Dude, the place closes at eight. It was then eight-thirty. The bazaar is closed. Frosty was distraught. What better way to say ‘I Love You’ than a sheer nightie and a fez?

“Don’t wait for me, man. I’m going back tomorrow morning. I’ve got to get my stuff.”

Sure. Get your fez. I’m getting on the flight home. (Ataturk kept reminding me that it was time to leave.)

Later, we settled in at the bar to commiserate Frosty’s loss.

“Let’s go out. I hate this bar.”



Alright Frosty: you’ve had a bad day, let’s head out.

We took a cab to a nearby disco, humming with loud music, young Turks and their girls. The place smelled of blunted danger. We ordered drinks and settled in for a look at the local fauna. Before long, Frosty got re-animated and headed over to a couple of young chippies. Uh-oh. He chatted some up in the universal language.

Before long—maybe about two minutes—the local guys swarmed in around Frosty and started a row.

“Hey man, be cool. I’m just talking to them.”

It didn’t matter, at that point, what language was being spoken, Frosty had intruded. Intruders need to be repelled. Engineering teaches one how to mitigate problems and often one has only the resources at hand. So taking my right hand, I grabbed my traveling companion by the left shoulder and pulled him back out of the fray and out on the street, aptly executing what one could describe as the latter of the ‘fight or flight’ responses.

We hopped a cab and returned back to the hotel. The next day, we boarded our return flight to the US. The fez and belly-dancing costume were absorbed back into the bazaar, forever lost. Frosty was gloomy as we flew through de Gaulle and back to Dulles (Frosty tried for an hour to call the number on the back of **HASSIM—BEST TRADE** while in the Paris airport. No luck).

Back home, safe and sound and fortified with Imodium, I called and chatted with Frosty’s manager.

Steve laughed when I told him the story about the near-miss at the bar.

“Sounds familiar,” he chuckled. “You know, he has another nick-name.”

What’s that?

“Well, one time, he had to climb down the outside of a three story balcony because he had been, er, surprised at someone’s girlfriend’s house. He scrambled down with nearly no clothes on.” We laughed.

“That’s when he picked up the name *Spiderman*.”

***Mike Violette** is President of Washington Labs and Director of American Certification Body. He hasn’t been back to Türkiye, but would do so in a heartbeat, this time sans Spiderman.*

Noise Mitigation Analysis of a π-filter for an Automotive Control Module

Cyrous Rostamzadeh, Flavio Canavero and Feraydune Kashefi

Electromagnetic interference (EMI) filters are often used on automotive 13.8 VDC power networks to reduce high-frequency noise from being conducted off the printed circuit boards (PCB) and resulting into EMI problems. The filter performance is difficult to predict and often compromised at high frequencies due to parasitics associated with the filter itself, or the PCB layout. The power line filters with Surface Mount Technology ferrite and Multi Layer Ceramic Capacitors are attractive solutions for mitigation of RF noise in high-density automotive PCBs. A lumped-element SPICE model is introduced for optimized π-filter design, including frequency-dependent ferrite component model. The PCB implementation of EMI filter is outlined for optimum filter performance.

Switched mode power supplies (SMPS) are extensively used in automotive electronic modules due to their excellent efficiency. SMPS have virtually eliminated the use of linear-regulator supplies. However, they are inherently noisy and generate ripples that require filters to meet stringent EMC specifications. Automotive EMC requirements [1, 2, 3, 4] are more stringent than FCC-15/J Class B limits by at least 54 dB [5]. The use of EMI filters as a noise mitigation technique must be considered carefully as cost and space in highly congested PCBs are two major determining factors. Discrete π-filters in small foot-print packages are a common design practice by the automotive design community. However, design and PCB implementation of an EMI filter is not an easy task. Thus it is a major issue when a non-conformance is achieved with an EMI filter which fails to deliver the required noise mitigation [9, 10].

In an ideal world, a π-filter provides a perfect solution to EMI generated noise; more specifically, for noise reduction due to conducted RF emissions resulting from switched mode power supplies.

A π-filter that theoretically functions quite well using traditional circuit theory, or simulation tools, may fail to meet the rigor of its practical requirements (CE mitigation). It is often considered an art of black magic when a well-designed EMI filter fails to function and deliver any noise reduction, as expected [11, 12].

Therefore, it is necessary to consider and undertake an experimental approach to identify the *'technical errors'* which may cause the filter malfunction. Electrical behavior of an EMI filter mounted on a real product under the influence of complex input/output impedance variation may differ substantially from its basic electrical schematic. In order to gain an insight into the realistic behavior of the EMI filter, one may consider the use of non-ideal electrical models for the filter components. However, this can also be limited to provide a solution. Furthermore, considering the PCB parasitics due to the individual copper traces, or component interaction, can be difficult under a realistic product development budget, if not impossible. In every product development timeline, engineers seek to find realistic, quick and meaningful solutions. There are a large number of EMI filter design guidelines and best-practices available to the engineering community. A product design team must deliver an EMI robust module, which must meet stringent EMI requirements that can be cost-effective, with little opportunity for any design iterations. In the cost-effective, high-volume automotive world, it is absolutely essential to avoid EMI failures and reduce design iterations. It is an extremely important aspect of the automotive world for an engineer to get it right in his first attempt. Nevertheless, an EMI filter design is considered here with components that do deviate from ideal behavior both in linear and non-linear fashion. The non-linear behavior is less understood or appreciated, more specifically, when ferrites are utilized on power distribution networks [13, 14]. Suppliers of SMT ferrites provide impedance characteristics *vs* frequency, and in addition, several lumped circuit models are offered to help the design engineers for the purpose of SPICE simulation [6, 15].

In an ideal world, a π-filter provides a perfect solution to EMI generated noise; more specifically, for noise reduction due to conducted RF emissions resulting from switched mode power supplies. The major concern is the MW-AM band radio (0.52 MHz – 1.73 MHz). Currently SMPS operate anywhere from 100's of kHz to 2 MHz of switching frequencies. The main concern is the first few harmonics of the SMPS switching frequencies in which they may cause EMI non-conformance.

PRODUCT EMI COMPLIANCE MEASUREMENTS

This section presents an examination of the fundamental problems encountered during the EMI compliance assessment of an automotive safety restraint control, that failed to meet the conducted emission requirements.

A typical airbag restraint module was designed on a printed circuit board consisting of four layers of copper, fabricated on FR4 substrate, to accommodate for the component population in excess of 500. One layer of PCB is dedicated to a return (ground) plane. A host of low speed signal traces, power distribution nets, high-speed communication nets, PWM-based sensor communication and HS-CAN Bus communication were connected in the remaining inner and outer layers. Unused gaps were filled with copper traces or copper islands. The "ground-filled" gaps were "stitched" to the return plane using a large number of vias distributed frequently at less than 1 cm apart.

Figure 1 illustrates the noise spectral content where a deviation was recorded at the harmonics of 390 kHz (SMPS switching frequency).

A diagnostic effort to identify, determine and isolate the noise source, and its conducted path, was easily reduced to the input port of a boost converter operating at 390 kHz. It was recognized that a simple third order EMI filter with 60 dB of insertion loss (MW-AM band) may be required for the unit under test to meet the CE requirements. In its simplest form, an EMI filter is an impedance discontinuity network inserted at the input port of 13.8 V DC battery or ignition line. The EMI filter provides required attenuation to noise signals that may cause non-conformance during a Conducted Emission test.

A π-filter topology is a common design practice in most automotive noise mitigation design techniques. The π-filter network was designed using a 0603 SMT ferrite bead and two identical 4.7/μF, 1210 multi layer ceramic capacitors (MLCC) to provide the insertion loss required in the frequency band of interest. However, it appears that the EMI filter behaves rather unpredictably, and this is not an acceptable situation. Design engineers with little EMC training may resort to statements that are difficult to grasp, and, for most engineers, it is discouraging to engage in a ghost-finding scenario.

In order to eliminate or reduce the inconvenience of EMI qualification of a poor filter design for noise mitigation, a systematic approach was outlined to assess the success of a design. As a number of iterations attempted by replacing the filter components can be problematic and costly, it is insightful to seek technical guidance to achieve a high-rate of success. The questions that need to be answered are:

1. Why lumped model simulation fails to address the test outcome?
2. Why incorporation of non-ideal behavior of filter components cannot solve/answer the filter misbehavior?
3. Is there a conflict in PCB design guidelines that results in poor filter performance?

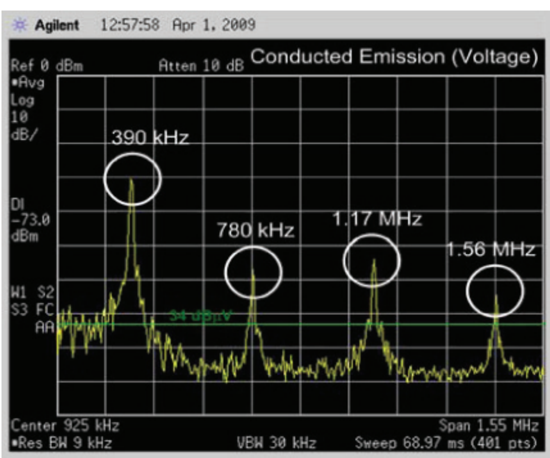


Figure 1: Conducted Emission (Voltage) Pre-Compliance Average Detector, Limit @ 34 dB/V

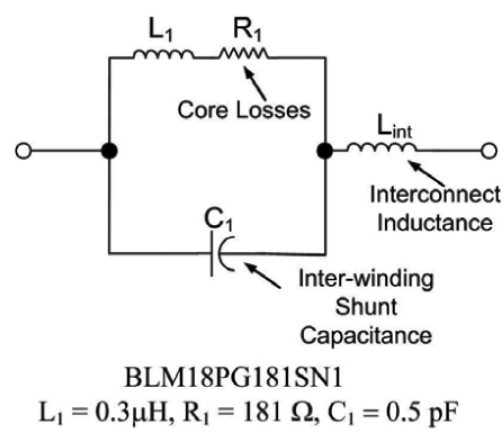


Figure 3: BLM18PG181SN1 Electrical Lumped Circuit Model

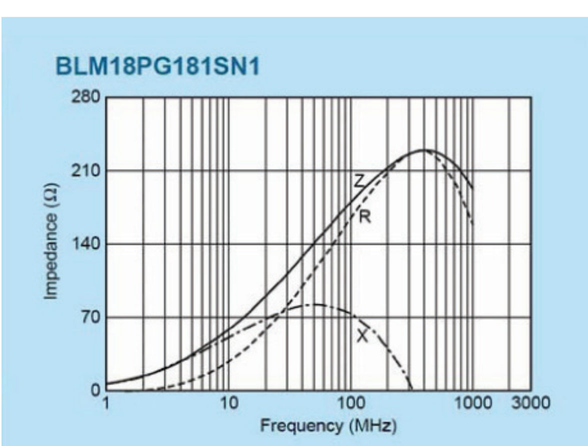


Figure 2: SMT 0603 Chip Ferrite Bead Impedance - Frequency Characteristics

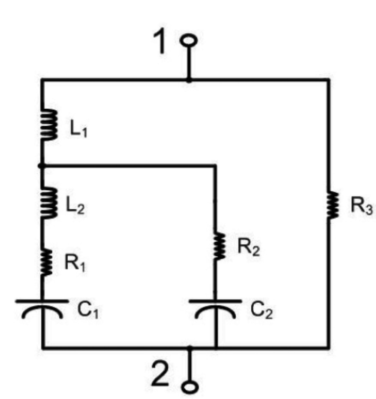


Figure 4: MLCC (4.7/μF) Equivalent Circuit Model

π-FILTER CHARACTERISTICS

SMT ferrite beads as frequency-selective nonlinear devices have the potential to solve a large range of interference problems. Unlike a magnetic metal, a ferrite is a magnetic dielectric that allows an electromagnetic wave to penetrate the ferrite, thereby permitting an interaction between the wave and magnetization within the ferrite. Ferrites are non-conductive ceramic materials made by sintering a mixture of iron oxides with either oxides of zinc or nickel and zinc. Figure 2 illustrates the impedance characteristics of a 0603 SMT ferrite bead selected for π-filter application.

Impedance of the SMT ferrite bead for this application is 181 Ω at 100 MHz, as in Figure 2. It is evident that at lower frequencies (less than 25 MHz) inductance of the bead is the dominant term. In the frequency range between 25 MHz and 400 MHz, the frequency-dependent, resistive, dissipative element dominates the impedance characteristics. At higher frequencies (above 400 MHz), parasitic capacitance of the SMT ferrite structure is the dominant term.

Figure 3 is an illustration of a simple electrical equivalent circuit lumped-model supplied by ferrite bead manufacturers. It is assumed that the values provided for the equivalent circuit model are only valid at the frequency of 100 MHz. Indeed, the model is a very simple representation of the actual electrical behavior and does not represent the frequency dependent terms. It should be used with this limitation. Nevertheless, it is a common practice to examine the ferrites at 100 MHz.

Two 4.7/µF at 25 V SMT X7R (1210, 3.2 mm × 2.5 mm) MLC parallel capacitors [7] complete the structure of the π-filter. Figure 4 is an illustration of the equivalent circuit model for the adopted capacitor, and Table 1 provides the individual component values at 2.29 MHz (SRF frequency). Figure 5 illustrates the impedance-frequency characteristic of the 4.7/µF MLC capacitor.

Utilizing the electrical model and component values provided as in preceding figures, one can develop a simple π-filter circuit simulation using PSPICE to assess the effectiveness of the EMI filter in the conducted emission frequency range. Indeed, one such simulation demonstrates an incredible 80 dB of insertion loss throughout the AM frequency band. The realistic objective would require us to demonstrate a practical application where an 80 dB of insertion loss can be realized. If not, what are the limitations? In order to investigate this further, a 2-sided test PCB (67 mm × 52 mm) was

L_1	56 pH
L_2	1.06 nH
C_1	4.23 µF
C_2	6.5 pF
R_1	4.28 mΩ
R_2	49.69 Ω
R_3	212.76 × 10^6 Ω

Table 1: MLCC 1210 (4.7 µ/F) Model Component Values

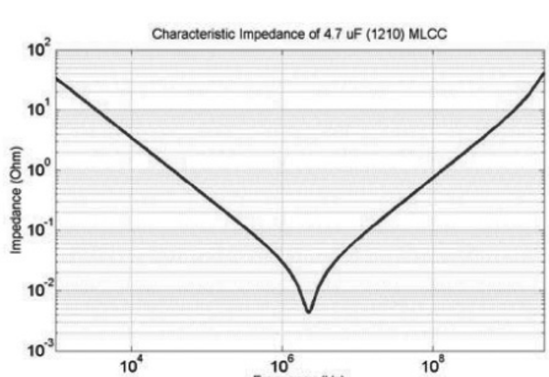


Figure 5: MLCC 1210, 4.7/µF Impedance Characteristic

constructed as illustrated in Figure 6. The lower side of the PCB was dedicated to a solid copper return plane. A 2.8 mm wide and 30 mm long PCB trace was realized and terminated into SMA ports with filter components attached, as illustrated in Figure 6.

A calibrated network analyzer (HP8753D) was utilized to measure the voltage transfer function ($|S_{21}|$) of the π-filter structure as in the test PCB.

The SMT ferrite bead was removed and replaced with a 2.7 nH ceramic core inductor and voltage transfer function ($|S_{21}|$) was captured. In addition, a large 4.7/µH ferrite core inductor was substituted for the 0603 ferrite bead and voltage transfer function ($|S_{21}|$) was recorded. Figure 7 illustrates the post-processed data.

In addition, a quality factor of 2.7 nH ceramic core inductor and ferrite bead were measured at 800 MHz: the 2.7 nH Ceramic Core 0805 Inductor gave Q ~ 63, considered "High-Q," and the BLM18PG181SN1 Ferrite SMT 0603 resulted in Q ~ 0.68, considered "Low-Q." It is a fundamental EMI filter design guideline to avoid the use of High-Q components. Therefore, the use of a ceramic core inductor must be avoided.

It is clear that a large and expensive 4.7/µH inductor at lower frequencies (below 1 MHz) has superior performance compared with the ferrite bead, as expected. However, it is important to note that for frequencies greater than 1 MHz, a ferrite bead is as effective as a large inductor, and in the frequency range (1 MHz – 10 MHz) it outperforms the large inductor by 3 dB. It is evident that a small 2.7 nH ceramic core inductor is not effective at the MW-AM band and should be avoided. The measured data in the "experimental PCB" is useful for design engineers to assess the filter effectiveness and provide design guidelines.

AUTOMOTIVE PCB

The product PCB implementation of a π-filter is illustrated in this section. Implementation rules prescribe that automotive electronic products are required to operate reliably under harsh environmental conditions. In several applications, printed circuit boards are treated via conformal coating to protect PCB and its electronic components. Several important manufacturing requirements would result due to the conformal coating process. For example, one important rule would require the PCB design engineer to avoid placement of via(s) under the electrolytic capacitors. Electrolytic capacitors have failure modes associated with chemical leakage. An incorrect electrolyte formula within a faulty capacitor causes the production of hydrogen gas, leading to bulging or deformation of the capacitor's case and eventual venting of the electrolyte. In the event of capacitor failure, a catastrophic electrical short circuit would result from the ground-fill island and through vias to the PCB ground plane. In the electronic restraint control module, a large size electrolytic capacitor (6.7 mF/25 VDC) is required for airbag deployment during loss of input power. Airbag deployment function cannot be compromised if the vehicle power delivery system is interrupted. In a high density printed circuit board, a 6.7 mF/25 VDC electrolytic energy reserve capacitor is indeed the largest physical component.

The integration of the π-filter is illustrated in Figure 8, where the location of C_1, C_2 and SMT ferrite components is indicated. π-filter components are arranged in the close proximity to the power management ASIC and chassis ground. The energy reserve capacitor (6.7 mF aluminium electrolytic) was mounted on the opposite side of the PCB. The energy reserve capacitor ground is illustrated in the PCB picture. It is important to note the absence of vias in the "copper island" pertaining to energy reserve capacitor ground, EMI filter C_1 and C_2 ground connections. Fundamental EMC design guidelines require the

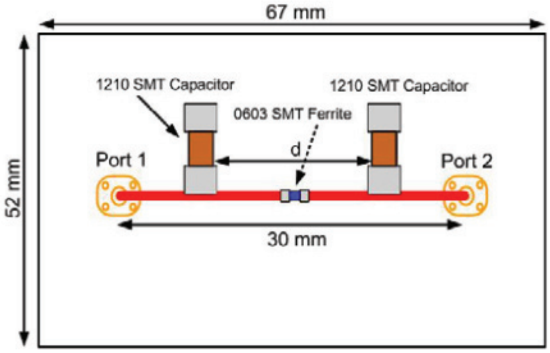


Figure 6: π-filter Test Circuit Printed Circuit Board Geometry

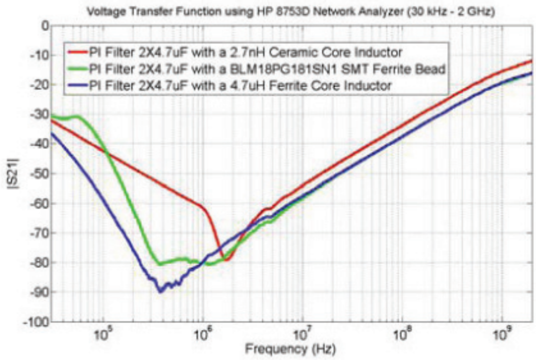


Figure 7: Voltage Transfer Function of π-filters

GOT GAIN?

improve your overall system sensitivity

Preamplifiers

20 MHz - 40 GHz
8 Models

Low-Loss Cables

DC - 40 GHz
4 Models

Like milk and cookies, preamplifiers go together with high-frequency low-loss cables. As frequency requirements increase, so do the losses encountered in antennas, cables and test instrumentation. Our preamplifiers provide the necessary gain to overcome these losses. The signal level at the receiver must be high enough to produce useful data. A.H. Systems has both preamplifiers and low-loss cables to match all antennas to 2, 4, 7, 18, 26.5 and 40 GHz. Our custom length low-loss cables match these frequencies and can be assembled and delivered in 2 days. Why wait when you can have it all now.

Preamplifiers... And Cables too.

Innovation Quality Performance

Phone: (818)998-0223 ♦ Fax (818)998-6892
http://www.AHSystems.com

A.H. Systems

ground-filled copper islands to be stitched to the ground plane using multiple vias. However, this requirement cannot be implemented here, as it is mandatory to avoid placement of vias for the manufacturing requirements of all the conformal coated printed circuit boards, as outlined earlier in this paragraph.

For EMI compliance, the product needs to be tested according to regulations. Conducted RF Emission test setup complies with the requirements of CISPR 25 [8] and is illustrated in Figure 9. It is important to note that the safety restraint control module is electrically bonded to the vehicle body during production through the base plate case. Therefore the DUT is placed directly on the CISPR 25 ground plane and bonded with the ground plane as seen in the setup picture. The test harness is 1700 (+300, -0) mm long and routed 50 mm above the ground plane.

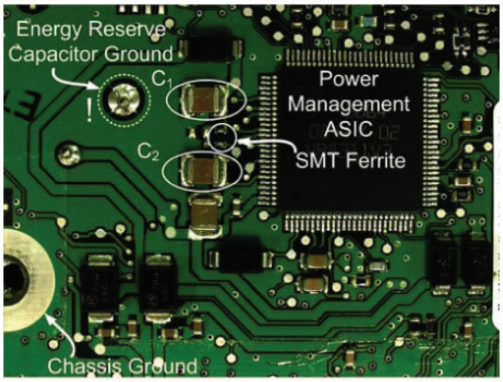


Figure 8: Printed Circuit Board (Board #1)

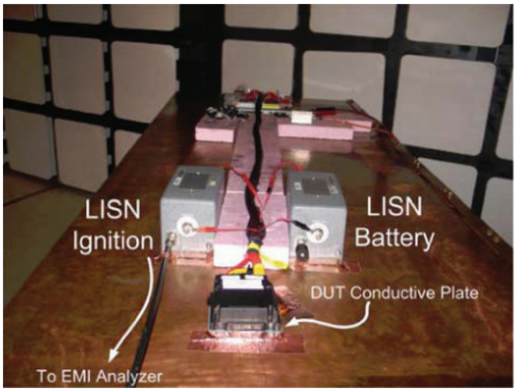


Figure 9: CISPR 25 Conducted Emission (Voltage) Test Setup

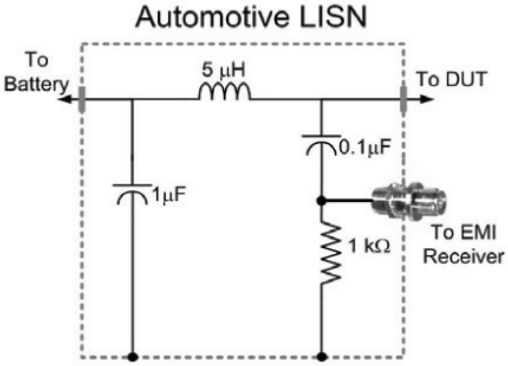


Figure 10: Automotive 50 Ω LISN Schematic

The Automotive Line Impedance Stabilization Network (LISN) for electrical schematic is shown in Figure 10.

Conducted noise measurements for PCB #1 is presented in Figure 1. It is clear that the PCB #1 implementation exceeds the CE compliance requirements at SMPS switching frequency and its harmonics. A number of changes to the EMI component values, or types, failed to mitigate the CE noise. It is a fundamental EMI design guideline to position the π-filter components at the power entry pin and electrically bond to the chassis ground with a low impedance connection. It is clear that the filter components are strategically located as required per EMI guidelines. In order to investigate the effectiveness of the EMI filter, it was decided to remove the filter components, and replace the ferrite bead with a 20 mn resistor. The CE noise spectral content and its amplitude remained identical in both scenarios. Indeed, the presence or absence of the EMI filter resulted in identical CE data, revealing a serious design error. It was suggested that the implementation of the EMI filter on PCB #1 was radically different from the test board (Figure 6) or simulation results. Therefore, EMI filter electrical behaviour was difficult to predict and it cannot be explained using conventional electrical network theory.

In one final attempt, EMI filter components were removed and placed on a small (1 cm × 1 cm) 2-sided PCB, with the lower side dedicated to the return plane. The modified small EMI-filter PCB was placed over the main product PCB, and configured between the ASIC power input pin and the module power input pin. The EMI filter PCB was connected to the main PCB ground structure at “chassis ground” with a short wire to reduce connection inductance. The CE measurements with this modification resulted in a 40 dB suppression of SMPS noise components. Therefore, the EMI filter implementation of PCB #1 required major analysis.

PCB #2, illustrated in Figure 11, was developed as a result of the CE failures observed in the previous PCB and Figure 12 illustrates the CE measurements for both printed circuit boards. It is clear that PCB #2 meets the EMI requirements and provides the performance as expected from electrical simulations and measurements in the test PCB.

ANALYSIS

A close examination of Figure 8 and Figure 11 reveals the most critical differences between two different printed circuit boards. It is important to note that the ground connection of π-filter capacitor C_1 plays an important role in the effectiveness of the EMI filter. In Figure 8, referring to PCB #1, C_1 and a large energy reserve capacitor are connected to the same "ground copper island." The presence of the high-frequency charge currents (490 kHz and its harmonics) for the energy reserve capacitor is a major problem for the "ground copper island." Further investigation of C_1 using an Agilent 85024A high-frequency current probe revealed the presence of SMPS noise currents. A reference plane which is relatively free from high-frequency RF currents is required where the EMI filter is referenced to the RF-free reference plane, i.e, the chassis or "quiet ground." It is obvious that the "ground copper island" cannot be termed as ideal, or chassis ground. In order to verify the filter ground concept, several short electrical connections were introduced between the "ground copper island" and chassis ground. Measured CE data revealed an astounding improvement in the behavior of the filter. As a result of the reported investigation, PCB #2 was designed and generated the CE data presented in Figure 12. It is evident that the PCB #2 provides 40 dB of noise mitigation as required. It is important to note the mounting strategy and ground connection of EMI filter capacitors are critical.

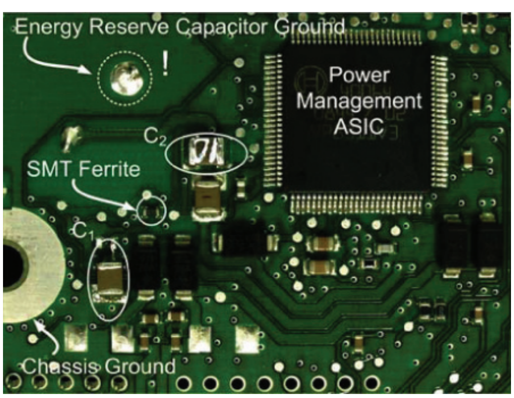


Figure 11: Printed Circuit Board (Board #2)

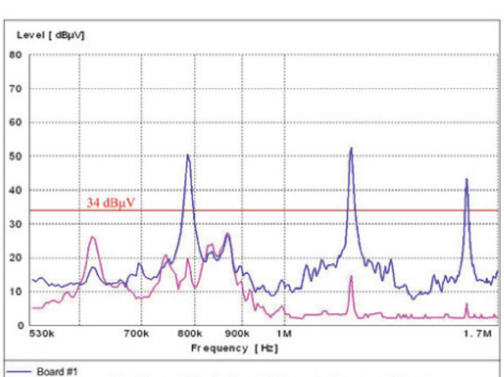


Figure 12: Comparison of Conducted Emissions (Voltage) of Board #1 and #2; Measurements in the MW-AM Band

CONCLUSION

This study is an examination of the fundamental problems encountered in simple EMI filter implementations for printed circuit boards. Engineers are challenged to design products for automotive applications under harsh environmental conditions with stringent EMI requirements. Analytical tools that conform to required guidelines for engineers developing automotive products with multiple requirements, often in conflict with one another, can be limited. In this report, an error in the PCB implementation of a π-filter due to manufacturing requirements which override best EMI practices is outlined. The engineer's ability to adhere to low-cost technology with solutions for thermal, EMI, manufacturing constraints and several other major requirements determines the success of an automotive product. ■

REFERENCES

1. Ford Motor Company, EMC-CS-2009, September 2009.
2. General Motors Corporation, GMW3097 Rev. 5, May 2006.
3. DaimlerChrysler Corporation, DC-11224, May 2007.
4. Chrysler Corporation, CS-11809, May 2009.
5. C. Rostamzadeh, S. Connor, B. Archambeault, "Numerical and Experimental Investigation of Power Supply Noise Decoupling Strategies on Single-Sided Printed Circuit Boards," *Proceedings of the EMC 2007 IEEE International Symposium*, Honolulu, HI, pp. 1-5, July 2007.
6. K. Keskinen, "Modeling a Ferrite Bead on High Speed Serial Links," CORESIM Inc., April 14, 2004.
7. C. Rostamzadeh, H. Dadgostar, F. Canavero, "Electrostatic Discharge Analysis of Multi Layer Ceramic Capacitors," *Proceeding of the EMC 2009 IEEE International Symposium*, Austin, TX, pp. 35-40, August 2009.
8. CISPR 25 Edition 3.0, March 2008, IEC Central Office, Geneva, Switzerland.
9. A. Keenan, "Board Level EMI Suppression Using Ferrite Components," *2003 IEEE International Symposium on Electromagnetic Compatibility,* pp. 1252-1254, May 2003.
10. V.P. Arafiles, "Reducing High Frequency Conducted Noise," *2002 IEEE International Symposium on Electromagnetic Compatibility,* pp. 334-339, August 2002.

11. L. Hill, J. Bruce, "Utilizing Overlooked Characteristics of Ferrites for Improved Printed Circuit Board EMI Suppression," *17th International Zurich Symposium on Electromagnetic Compatibility,* pp. 383-386, February 2006.

12. Jun Fan, L. Shaofeng, J.L. Drewniak, "Including SMT Ferrite Beads in DC Power Bus and High-Speed I/O Line Modeling," *2001 IEEE International Symposium on Electromagnetic Compatibility,* Montreal, QC, pp. 336-339, August 2001.

13. A. Roc'h, R. Iannarelli, F. Leferink, "New Materials for Inductors," *2009 International Symposium on Electromagnetic Compatibility - EMC Europe,* pp. 1-4, June 2009.

The engineer's ability to adhere to low-cost technology with solutions to thermal, EMI, manufacturing constraints and several other major requirements determines the success of an automotive product.

14. B. Ho, K.Y. See, W.Y. Chang, "Measurement of EMI Suppression of a Ferrite Core Under Realistic Operating Conditions," *Electromagnetic Compatibility Newsletter,* no. 218, pp.60-65, Summer 2008.

15. Qin Yu, T.W. Holmes, K. Naishadham, "RF Equivalent Circuit Modeling of Ferrite-core Inductors and Characterization of Core Materials," *IEEE Transactions on Electromagnetic Compatibility*, vol. 44, no. 1, pp. 258-262, February 2002.

***Cyrous Rostamzadeh**, Robert Bosch LLC, Automotive Group, Cyrous.Rostamzadeh@us.bosch.com*

***Flavio Canavero**, Politecnico di Torino, flavio.canavero@polito.it*

***Feraydune Kashefi**, Khavaran Institute of Science & Technology, Fred.Kashefi@gmail.com*

Automotive EMC Case Study

HMI Graphics Influence on Radiated Emissions

Steve Mainville
Johnson Controls, Inc.

A case study describing the influence of TFT LCD graphics on automotive radiated emissions testing and its impact to the FM band receiver. The underlying root-cause of the EMI issue is determined using a novel technique that decodes the display's graphics into the transmitted RGB data and predicts the data's impact to radiated emissions. The countermeasure implemented to resolve the issue is equally novel and does not involve any hardware optimizations. The use of test images to be used in component level EMC testing is also discussed.

In the automotive industry, thin-film transistor liquid crystal displays (TFT LCDs) are being utilized more frequently in navigation units, rear seat entertainment DVD systems, and instrument clusters. As these systems become more complex, so do the EMC issues.

While there are hardware factors to consider such as grounding contacts, interconnect cables, and filtering, an often overlooked factor is the application software for the human-machine interface (HMI.)

The software development typically follows the hardware development. However, when software changes are made after the hardware design is frozen and validated, there is a potential to introduce new EMC issues late in the product design cycle. In the case study presented in this article, late changes made to the product's HMI graphics introduced a vehicle level radiated emissions issue.

PRODUCT DESCRIPTION

The product in this study is a high end instrument cluster with two 4.2" TFTs driven by a graphics controller. The TFTs are WQVGA (480x272), 18 bits-per-pixel (bpp) displays. The displays are located about a centimeter above the PCB surface and are equally spaced horizontally about the PCB's center line. Each TFT is connected to the main PCB by a flexible flat cable (FFC).

The HMI graphics are assembled by the graphics controller from the combination of multiple bitmap (BMP) images and alpha masks. From the graphics controller, display information is sent to the TFT via the RGB (Red, Green, Blue) bus. At the TFT display, image data is received and interpreted spatially as pixels displayed as the appropriate combinations of red, green and blue intensities.

The graphics data for each display is transmitted by an 18-bit wide parallel RGB bus that is referenced to a 10.34 MHz pixel clock. For this product, six bits of parallel data are used for each of the red, green, and blue components of the transmitted pixel data. This is referred to as RGB666 format data.

Also part of the transmission of graphics data are the display enable and synchronization lines. Since the focus of the case study is the transmitted graphics data's effect on radiated emissions, the display enable and synchronization lines will not be discussed as they are independent of transmitted image. The data patterns transmitted on these lines are constant regardless of the RGB data content.

Worth noting is the use of spread spectrum technology was pursued, but was not implemented because the graphics controller supplier could not guarantee adequate functionality when implemented.

DESIGN PROCESS

The product design process starts with the creation of an EMI control plan. [1] At this time potential EMC concerns are identified and mitigation plans are developed for each item. Floorplanning, constraint development, pre-compliance test strategy and simulation strategy are addressed at this phase also.

After the first PCB goes into layout and critical EMC, thermal and SI/timing simulations indicate acceptable design criteria, the board is built. At this point the first prototype will generally have minimal software functionality to keep the board alive.

After the EMC issues are identified in pre-compliance testing, root-causes are identified and addressed in the second prototype PCB layout. During the second prototype phase, the expectation is to satisfy all EMC requirements. The software development lags behind the hardware design and has greater functionality than the first phase, but is not mature and therefore continues to be under development in contrast to the hardware readiness.

In this case study, the lag between the hardware and software design maturity exposed a gap in EMC issue identification.

For the cluster in this case study, the primary concern after the second prototype phase PCB was built was the emissions in the FM band caused by noise radiating from the pixel clock lines (10.34 MHz). The component level data for CISPR 25 radiated emissions [2] showed a borderline pass with the pixel clock's 9^{th} and 10^{th} harmonics (93.0 and 103.4 MHz) at the 12 dBuV limit. No other emissions were near the limit. While marginally passing component level was a concern, passing vehicle level FM audio interference testing was a larger concern as component level borderline performance does not guarantee a vehicle level pass. Also, based on customer's scheduled vehicle testing date and our final production timing, there would not be any time to react with hardware improvements if there were non-compliances.

FM BAND VEHICLE LEVEL FAILURE

When the vehicle level FM audio interference test was run, a failure was reported. The pixel clock harmonics were compliant, but an issue was reported at 87.9 MHz – a frequency that had never shown up at the component level. This was confusing because the same exact sample evaluated a few months earlier showed no component level issues at 87.9 MHz.

Following notification of the FM audio interference failure, the cluster was retested for CISPR 25 radiated emissions at the component level. This time, the 87.9 MHz emission was the only failure at about 17 dBuV (Figure 1). For this frequency, that was nearly 10 dB higher than the component level data collected prior to the vehicle level testing. Also of significance was that emissions at 98.2 MHz and 108.5 MHz had increased. It was noticed that the delta between the three frequencies was 10.34 MHz – the same frequency as the pixel clock, but not a harmonic of the clock's fundamental frequency. The three frequencies lay exactly midpoint between the pixel clock's harmonics which could indicate that these may be odd harmonics of a source running half the frequency of the pixel clock (5.17 MHz).

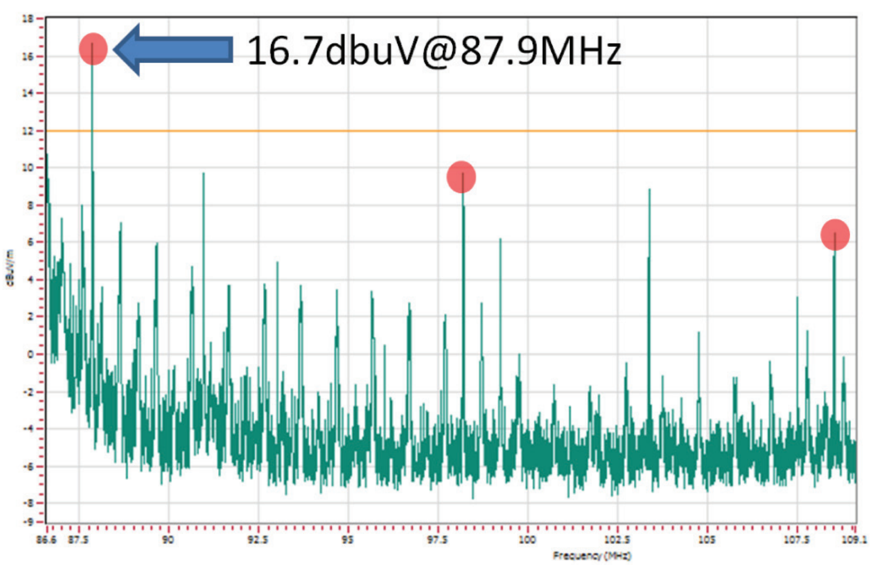


Figure 1: CISPR 25 FM band radiated emissions for software B

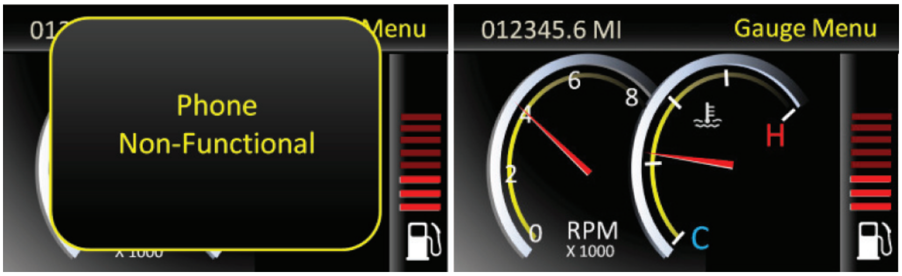


Figure 2: HMI test screens for SW A (left) SW B image (right)

If an alternating bit pattern (101010...) were transmitted on any of the RGB lines, it could resemble a clock source. The graphics processor and TFT used in this product design sends one bit of display data per pixel clock cycle. If an alternating bit pattern is transmitted, it takes two pixel clock cycles for the "fake-clock" cycle to be completed. Since the data's fake-clock cycle duration is twice the length of the pixel clock's cycle, the frequency will be one-half the pixel clock's (5.17 MHz).

It was discovered during the troubleshooting that there was a software upgrade after the passing component level tests and before vehicle testing occurred. One change between the original software (here on referred to as SW A) and the software tested in vehicle (here on referred to as SW B) was that the HMI graphics were fully developed for SW B. For SW A, a placeholder graphic was used for a feature that was not yet implemented in the software (Figure 2).

The change in the graphics combined with the frequencies of the negatively affected harmonics aligning with a two-bit data pattern indicated a further investigation should be made into the graphics change.

As mentioned, the possibility of alternating bit patterns on the RGB data lines was thought to be the most likely cause of deterioration in performance between SW A and B. One challenge would be to identify where in the image this pattern of 1s and 0s existed. Also, if the pattern was found, could anything be done about it?

From a hardware perspective, the best option was to identify the noisy RGB nets and filter accordingly. This course of action was far less favorable because the production level PCB design had already been released.

Since a software solution was preferable, LabView code was developed to read bitmaps for the HMI graphics and reproduce the transmitted RGB data patterns. The hope was that one of the BMPs used to construct the HMI graphics could be identified as the primary noise source and be quieted through pixel modifications.

SIMULATING RGB DATA PATTERNS FROM BITMAP IMAGES

To understand how the RGB data patterns can be extracted from a bitmap image, it is helpful to understand bitmap images and how the processed data is output to the RGB bus.

Bitmap Images

A bitmap image represents an image through a grid of pixels defined by RGB triplets (r,g,b.) [3] These pixels form points of color which contribute to an overall finished image. Each component of the RGB triplet is represented as an integer to indicate its intensity in the pixel. Black would be indicated by an RGB value of (0, 0, 0). White would be represented by the RGB value (255, 255, 255) where red, green and blue are at maximum intensities. The maximum value of 255 is true for 24 bit bitmap images (8 bits/color). The maximum value is defined by the following equation:

$$RGB\ component\ value_{Max} = 2^{bits\ per\ color} - 1 \quad (1)$$

Depending on the hardware and RGB data format used in a graphics application, there can be less than 24 bits of data output from the graphic processor. Formats such as RGB555 (15bpp), RGB565 (16bpp) and RGB666 (18bpp) are commonly used in the automotive industry and require the graphics data to be scaled down from the BMP color depth of 24bpp.

When the color depth is reduced from 24bpp, the graphics designer needs to account for the loss in resolution and will sometimes have to implement dithering

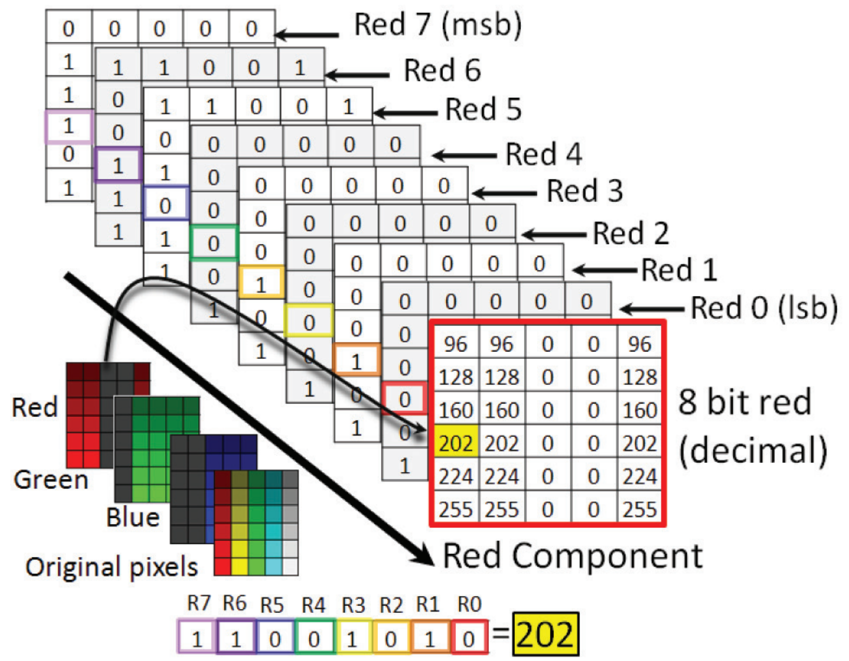


Figure 3: Bitmap pixels conversion from RGB components to binary bit planes

techniques to prevent banding. Banding is when abrupt changes in color occur due to the loss of color depth. Dithering gives the illusion of seamless transitions between colors.

To explain how the RGB data sequences are extracted from graphics data, this explanation will be kept simple by assuming the graphics processor utilizes an RGB888 (24 bpp) format from which the data is being output in parallel to a 24 bit wide RGB bus. Within the bus, each color component has eight lines. Each line sends data for one of the eight bit positions of the color's value (Figure 3).

During a pixel clock period, the 24 bits of RGB data defining a single pixel are transmitted. Pixels are transmitted in horizontal lines. At the end of each line the transmission continues from the beginning of the next line. This continues until the last line is sent at which time it returns to the top, continuing with the next frame. At the beginning and end of the horizontal line data, there are the front and back porches which are margins around the graphics data for horizontal line synchronization. There are front/back porches in the vertical direction which exist before the first and after the last line of image data. The data for these porches are sent as binary 0s.

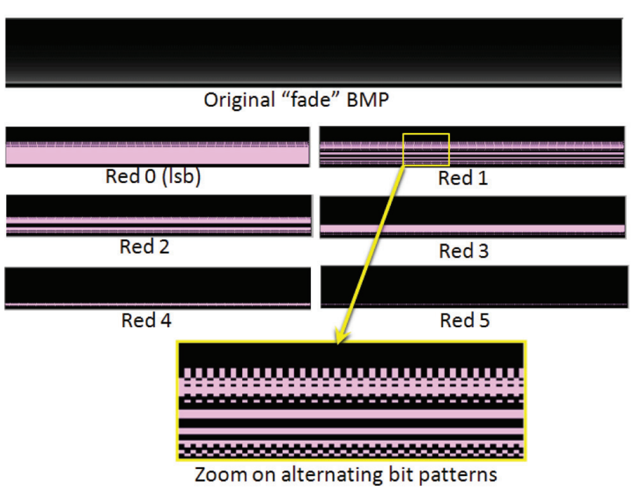


Figure 4: Bit planes for original "fade" BMP object

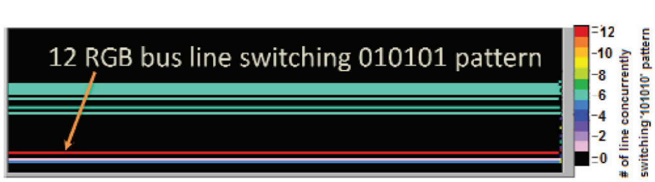


Figure 5: Number of RGB bus lines exhibiting occurrences of 101010 data pattern within "fade" BMP object

Based on the sequence of pixel transmission and the conversion of the pixel's color components to binary, the data patterns on each of the RGB data lines can be determined.

Graphics Analysis Software

The graphics analysis software allowed the conversion of the loaded graphics data to representative data streams for each of the RGB data lines. From these data sequences, potential noisy graphics can be identified. The software had the ability to show each of the 18 RGB data line's frequency content in addition to its binary image otherwise known as a bit plane [4].

The frequency content of a data stream allows noise producing patterns to be identified. From the frequency profile, a noise source's fundamental frequency can be identified. With the following equation, the number of bits in the pattern can be identified:

$$\#\ of\ pixels\ in\ pattern = \frac{f_{Pixel\ Clock}}{f_{Pattern}} \qquad (2)$$

When the number of bits in the pattern is known, the corresponding bit plane can be searched for the pattern to reveal the locations of potential EMI issues within the image. It is important to note that these patterns need to be searched for in the frame's horizontal lines – the same direction the data is transmitted. The presence of these patterns in the vertical direction is not relevant to the frequency of interest.

Putting the Software to Use

From the BMP objects, a composite BMP was constructed for the HMI screen that caused the issue at 87.9 MHz. Next, using the analysis software, the image was analyzed for frequency content. Several of the RGB data lines indicated higher frequency content at 5.17 MHz – the fundamental frequency of the 87.9 MHz harmonic. This confirmed a two pixel pattern was the source. Examination of the bit plane images revealed the same region in twelve of the 18 bit planes as having varying degrees of the alternating bit pattern (Figure 4). The region of the HMI screen causing the issue was a horizontally oriented "fade" object.

Using another feature in the analysis software that highlights the number of RGB bus lines concurrently transmitting the alternating bit pattern, it was revealed that one of the frame's rows had twelve RGB lines concurrently transmitting the pattern (Figure 5). The reason the emissions issue did not present itself in SW A was the placeholder graphic masked the majority of the fade.

The alternating bit patterns were present in the three least significant bit layers (lsb) for each color component. The color intensity contribution of the lower significant bits to

the image is less and is hard to detect by eye. This makes detecting patterns by eye near impossible.

The msb layer, when viewed as an image, shows the roughest and most critical contribution of the color component. The second msb layer contributes half the intensity of the msb. Each subsequent layer contributes half the intensity of the layer prior to it. The lsb layers are the most difficult to see and generally contain the highest number of data transitions.

ROOT CAUSE AND SOLUTION

The cause of the repetitive pattern nature in the fade pattern was due to dithering. To correct the occurrence of the alternating bit patterns, the fade object was redrawn to avoid or reduce the cumulative bit patterns found earlier and retested at a component level for radiated emissions in the FM band. The noise level at 87.9 MHz dropped about 7 dB and the other odd harmonics of 5.17 MHz at 98.2 MHz and 108.5 MHz dropped sharply (Figure 6). The pre-compliance radio listening test was run and also showed a dramatic improvement.

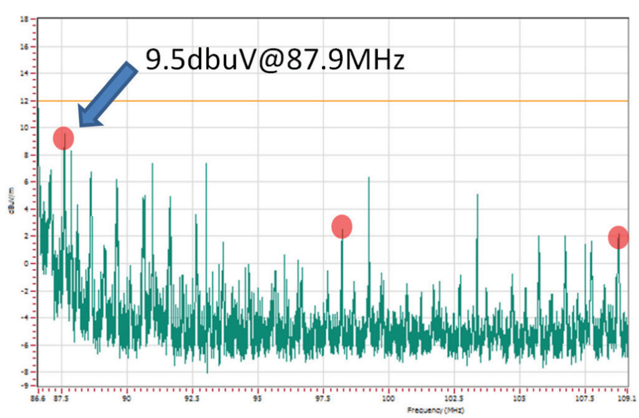


Figure 6: CISPR 25 FM band radiated emissions for corrected fade object

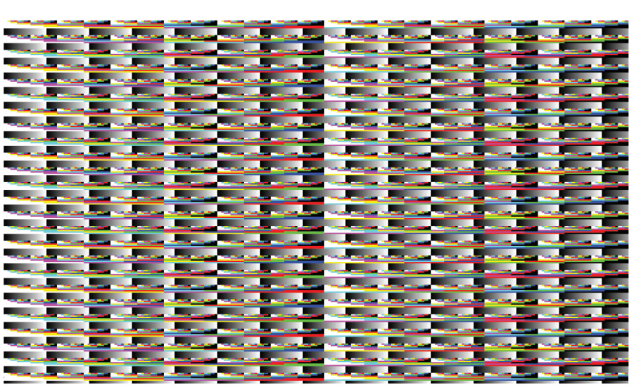


Figure 7: Test pattern design for product in the case study

TEST PATTERNS

As this case study has shown, testing with an unfinished HMI image in the early design phases can lead to unexpected issues showing up if there is a change to the tested graphics. Potential issues can also go untested when the product's worst case HMI selection has not been chosen for testing. It is very possible an untested sub-menu will produce higher emissions than the HMI configuration chosen for testing. A robust test pattern causing the RGB bus to be exercised in a realistic worst-case manner reduces the need to evaluate all HMI configurations. Since it is not feasible to test every option in every submenu, a robust test pattern causing the RGB bus to be exercised in a realistic worst-case manner can assure the product is being adequately tested. With a robust test pattern available early in the design cycle, potential issues can be identified and mitigated without having to wait for final graphics to become available.

The challenge in defining a test pattern is determining what defines a realistic worst-case image. With the sample set of graphics limited to a few products, there is not enough data for the author to determine what criteria would define a realistic worst-case test pattern that could apply to the entire automotive industry.

Further complicating the implementation of a common standard to which a test pattern is defined is there are multiple factors that vary from product to product that affect the resulting data streams. For example, the method with which an image is converted from the original graphic to the transmitted binary data sequences is dependent on the graphics processor and the display requirements of the display. A pattern designed for one product may be ineffective for another product if there is a difference in color and display resolution. If quantizing and rescaling to the test image occurs, data interpolation may cause the intended data to be altered and ineffective. Also, a test pattern created for use on a parallel RGB bus will be ineffective for a product transmitting RGB data by low-voltage differential signaling (LVDS).

If it is understood how an image is converted to be read by the graphics processor, subsequently processed and output to the RGB data lines, a test pattern can be created. The test pattern will likely have to be unique to the product unless there are hardware commonalities with other products. Certain criteria pertaining to the data sequences on the RGB nets should be met when designing the test pattern. By starting with defining the binary data sequences on each of the RGB lines, a pixel pattern can be establish to create a test image.

Using this method of building the pattern in reverse by starting from the binary data sequences, a test pattern was developed for the product in the case study (Figure 7). The two main factors considered when defining the data sequences for the 18 RGB nets were the noise frequencies to generate and the number of nets to be simultaneously sending the same sequences.

When deciding the fundamental frequencies to generate, consideration was given to the frequency ranges that were to be tested. In the case study, a two bit sequence producing a 5.17 MHz fundamental frequency was responsible for FM band issues. Also, other lower level harmonic emissions were present in the measurements as a result of bit patterns that were from four and ten bit cycles. These cycles produced harmonics of 2.59 MHz and 1.03 MHz respectively.

One intention for the test pattern design was to stay consistent with the problematic fade graphic and to keep the fundamental frequencies above 1 MHz. For the test pattern's design, cycles of two, three, four, five and ten bits were distributed between the 18 RGB nets. To expose all nets to the different data cycles, the data sent on each net was alternated between the different bit cycles after every line within the frame.

The second intention was to replicate the occurrences of simultaneous data cycle transmissions over multiple nets. In the case study there was one line of pixels in the frame that produced the toggling bit pattern on twelve of the 18 nets. It is difficult to say whether twelve nets concurrently toggling the '101010' pattern is a realistic worst case or an outlier due to bad dithering within the fade pattern. For seven of the frame's lines, six nets concurrently transmitted the toggling bit pattern. When examining the entire library of graphic images used in the design, it was not uncommon to see six nets simultaneously sending the same pattern. This was particularly true in gradients.

For the product in this case study, hundreds of graphic objects were evaluated and fewer than five percent showed any significant frequency content. The ones that did have notable frequency content had one thing in common – they contained gradients. In particular, the gradients were fades between gray and black. Gray gradients exercise the RGB bus more severely than other colored gradients because red, green and blue components are needed to build the different shades of gray.

Since gradient fades of gray to black were the common factor between all the graphic objects showing elevated frequency content, lines of gradient fades were integrated into the test pattern.

CONCLUSION

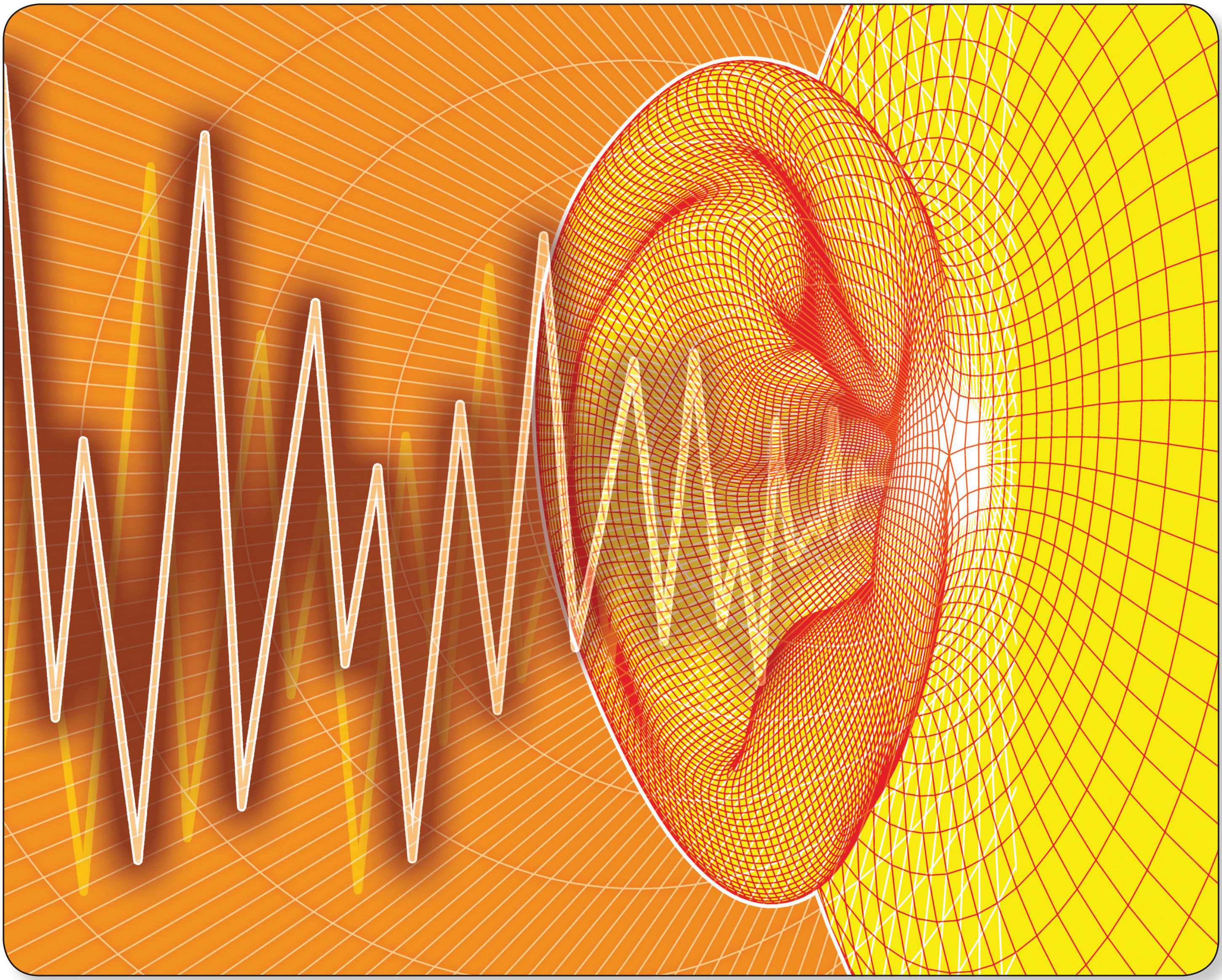
The experience gained through this case study shows the value of having a test image that effectively exercises the RGB bus early in the design cycle. A realistic worst case test pattern will allow future products to have EMC issues identified and mitigated in the early design phases. Also, it is not possible or realistic to have all HMI graphic combinations evaluated, but a realistic worst case test pattern reduces the concern for untested HMI configurations presenting issues late in the product design cycle.

This case study shows that it is possible for a graphics object covering a small percentage of a frame to cause radiated emission and radio listening issues. The possibility of a single graphics object affecting performance is very real. By not having an image that adequately exercises the RGB bus, the supplier and the original equipment manufacturer (OEM) can gain a false sense of security and be unpleasantly surprised when it is too late to make an easy fix. ■

REFERENCES

1. S. Mee, S. Ranganathan, R. Taylor, "Effective use of EMC Analysis Tools in the Automotive Product Development Process," 2005 IEEE International Symposium on Electromagnetic Compatibility, August 2005, Chicago, IL.
2. International Electrotechnical Commision, "International Special Committee on Radio Interference Document 25 (CISPR 25)," International Electrotechnical Commission Central Office, November 2002.
3. Maureen C. Stone, "Representing Colors as Three Numbers," *IEEE Computer Graphics and Applications*, Volume 25, Issue 4, pp. 78-85, July/August 2005.
4. Ramiro Jordán, Roberto Lotufo, 1995, "Bit Plane Splicing," http://www.dca.fee.unicamp.br/DIPcourse/htmldip/c4/s12/front-page.html.
5. S. Ranganathan, S. Mee, "Automotive EMC Measurement Techniques Based on New Technologies and Vehicle Packaging," IEEE International Symposium on Electromagnetic Compatibility, August 2008, Detroit, MI.

***Steve Mainville**, Johnson Controls, Inc., Automotive Experience, steven.m.mainville@jci.com*



ETSI EN 300 132-2 Compliance Testing

Zijun Tong, MET Laboratories

Telecommunication equipment is being widely used in everyday life. The undesired electromagnetic noise emissions from this equipment could interfere with the signals in other communication equipment in the vicinity. When the noise is in the audio range of 25 Hz to 20 kHz, it may also affect the quality of signal transmissions in telephone lines. In audio systems, this undesired audible noise can be in the form of hissing, humming and other sound disturbances.

Unlike instrumentation devices, the human ear is an exceedingly unlinear sensor. For most people, hearing sensitivity peaks are about 1 kHz. To account for this nonlinearity, a psophometer with a psophometric weighting filter that satisfies the ITU-T Recommendation O.41 requirements needs to be used to measure the wideband noise emissions level. The weighting filter acts like a narrow band pass filter that emphasizes the frequency range of interest. Thus, a weighted measurement of noise emulates the degree of loudness the human ear will perceive. The noise power is measured in units of picowatts psophometrically weighted (pWp). The idea behind the weighted measurement is based on the observation that the human ear does not respond to the audio frequencies with the same power level equally. [5]

Looking at the psophometric weighting curve provided in the ITU-T Recommendation O.41, the band-pass curve is bell shaped and has virtually no insertion loss at, and in the neighborhood of, 1 kHz, while exhibiting a very severe attenuation (approximately -80 dB) at a frequency in the range of 20 Hz to above 5 kHz. In order to limit the amount of undesired emissions in telephone circuits, in the mid 1990s the European Telecommunication Standards Institute (ETSI) produced the first edition of ETSI 300 132-2, a standard which sets the requirements for audio frequency noise emissions and susceptibility seen at interface 'A' for -48 VDC powered telecommunication equipment.

The interface 'A' point is a physical location of the interconnection between the DC power supply and the telecommunication equipment. According to ETSI 300 132-2, this can possibly be any physical point situated in between the power supply and the equipment upon mutual agreement between related parties. Nevertheless, the interface is typically located at the input power terminals of the telecommunication equipment. [1]

There are difficulties in measuring undesired audible noise at the power terminals of telecommunication equipment for compliance to the ETSI 300 132-2 standard. One of the most noticeable difficulties is taking the conducted emissions measurements at interface 'A' where the limit imposed by the standard is quite tight especially for the psophometric wideband noise that can be as low as 2mV.

Most equipment uses DC voltage that is derived from the direct full wave rectification of AC power source. If the equipment under test (EUT) is powered by AC/DC power supply, then there will inevitably be an AC noise ripple riding on the DC output resulting from the rectification in the power supply. Note that the 7^{th} and 9^{th} harmonics of the 120 Hz rectification ripple precisely at the top of the psophometric bell curve. That implies that these harmonics produced by the power supply pass unabated (approaching 0 insertion loss). This noise ripple can be several times greater than the limit found in the standard. It is not uncommon to find ripple noise in power supplies from 50mV to 100mV, particularly under loaded condition.

If you try to measure the EUT emissions while it's being powered by AC/DC power supply, the chance for a failure may be very high, and the EUT may not be the one that's generating the noise. The solution will be to power the EUT with batteries or any other electro-chemical supplies that are virtually noiseless in the 25 Hz to 20 kHz frequency range.

This, however, introduces another difficulty. Often the EUT takes a while to power up and boot up into its mode of operation for testing. Even when powering up the equipment with a set of large batteries, it is possible to deplete the batteries before completing the measurements. For instance, if the equipment draws about 50 Amperes, then a bank of fully-charged batteries, in good state of health, would not last through the entire testing. This implies that testing time will need to be extended to account for the extra time required to recharge the batteries and reboot the EUT for normal operations. On the other hand, if the equipment only draws about 10 Amperes, then the batteries may last throughout the duration of the test.

A sound solution is to use a commutable power supply that can switch between AC/DC power and battery power without interrupting the supply to the EUT even for the smallest amount of time. That way we can power the EUT with AC/DC power supply during the initial setup and general activities, and switch to battery power only when taking the emission measurement. With this method, the batteries will only be used for the few minutes required to perform measurements, instead of hours. Manually switching the power supply will not work well, since it implies powering down the equipment and then rebooting it again.

When searching for a switching power supply that has the capability to switch between power sources without turning off the equipment under test, we couldn't find any. However, we were able to design and build a custom piece of test equipment that is capable of switching power supplies without powering down the equipment under test. This way, we are sure that all of the setup, booting and various other procedures are done with the AC/DC power supply, and battery power is reserved only for measurement time.

Developing a custom piece of equipment is expensive and definitely not cost-effective. Most people use AC/DC power supplies. Those supplies are convenient, available in the market and do not discharge in time. However, when it comes to emission measurements, they produce excessive noise that results in invalid measurement. There is no alternative but to supply the EUT with a clean DC power source, such as a battery bank.

Figure 1 depicts the custom-made equipment. The circuit other than the power switch box pictured in the figure is a line impedance stabilization network (LISN) that is similar to the one shown in ETSI 300 132-2. Input A in the figure gets the RF energy injected from a power amplifier for immunity testing. T1 is a 10:1 transformer that has 100 mΩ output impedance, and it can take 100 amperes of DC current. Switch S1 is a 100 amperes SPDT mercury commutator that allows test engineers to switch between emission and immunity testing. It uses a mercury commutator since it is reliable and gives better results. L1 is a 15µH inductor with a maximum current rating of 100 amperes. The value of capacitance for C1 and C2 are 10 mF and 1.2 mF respectively.

Note that a capacitance of 1.2 mF is hard to find, and it may be necessary to connect multiple capacitors together to make the desired one. Furthermore, the C2 capacitor is composed of either polycarbonate or any other films capacitors. Finally, R1 is a 50 Ω resistor. The LISN has two outputs. Output A is used to supply the DC voltage at interface 'A' of the telecommunication equipment, while output B is used by a psophometer to measure the audible noise, and a spectrum analyzer to monitor the RF energy injected into interface 'A' of the equipment. We will not go over the communtable power supply in detail here since is its own topic and out of the scope of this article. However, the basic architecture of the machine is based on an electronic circuit that could "manipulate" and modify the excursion time of electromechanical relays.

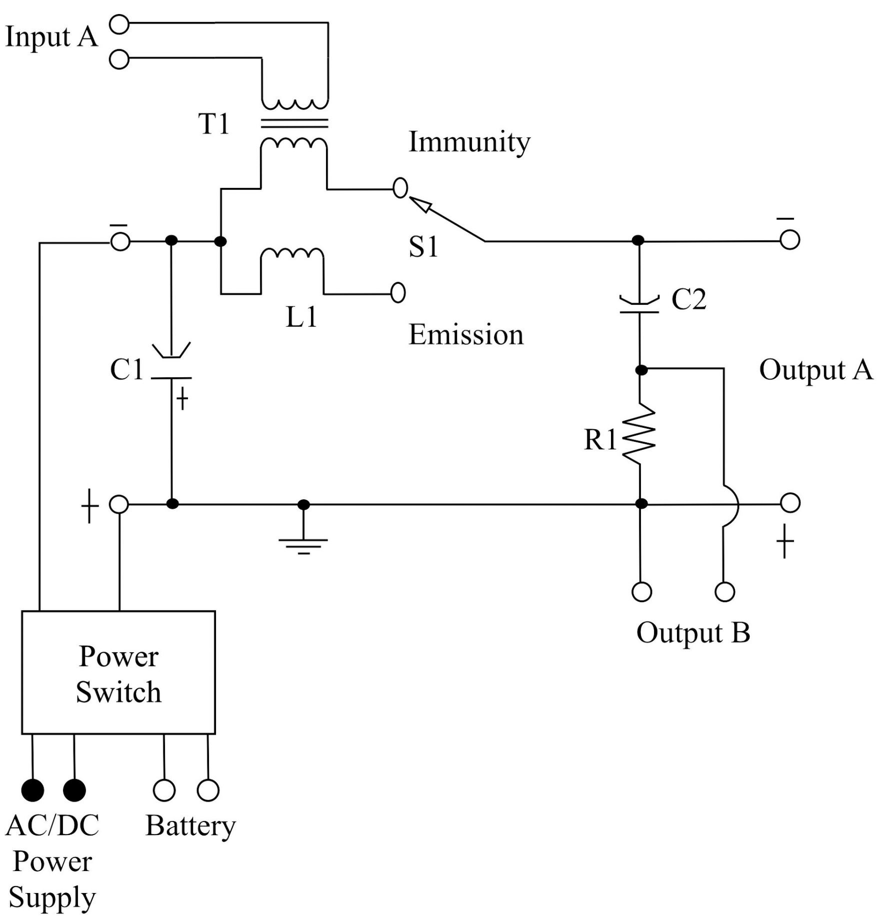


Figure 1: Custom test equipment capable of switching power supplies without powering down the equipment under test

As mentioned above, there are two "unusual" capacitors needed in the construction of an ETSI 300 132 type of LISN. We will now go over these in detail. The first one is a large aluminum electrolytic located directly across the power source input lines (C1 in Figure 1).

The smallest capacitance for this condenser will be in the order of 10 mF, with a voltage rating of at least 63 VDC, preferably 75 or 100 VDC. Someone may question the usefulness of this capacitor, particularly if the -48 VDC power supply is an electrochemical source. Unfortunately, some of the measurements called upon for this LISN have such minute limits, i.e. the wideband psophometric emission measurements at 2mV, that can be easily perforated by ambient noise. Even though the LISN may be powered by a battery bank, the interconnecting cables could cross the line of force of stray magnetic field present in the measuring chamber environment, with the subsequent induction of noticeable voltages.

Proper layout and other precautions could attenuate these undesirable common mode effects, but probably not at levels to be considered irrelevant. Note that the 7th and 9th harmonic of 120 Hz lays at points of the psophometric filter bandpass where the insertion loss is approaching zero decibels.

Any inductive pick-up from the power cables, at these frequencies, can seriously interfere with the wide-band psophometric measurement or even literally perforate the limits. A large aluminum capacitor, at minimum 10 mF or better yet 50 or 100 mF, will exhibit reactances (at 1 kHz) in the order of milliOhms. In fact, the ESR of the device may be significantly higher than the reactance. Even if a single capacitor with a capacitance of 100 mF can be found, at a stiff price, the preferred solution would be a paralleling bank of 10 or 20 lower capacity canisters. That way, all the ESR of the components would also be paralleled, with a drastic reduction into the single digit milliOhm region.

The de-coupling capacitor is the one located at the signal-out port of the LISN, which is near output B in Figure 1. Its function is to decouple the -48 VDC from the measuring instruments. According to ETSI suggestions, this capacitor must have an Xc<<Z. That is, the capacitor reactance should be at least an order of magnitude lower than the 50 Ohm output resistor. In other words, its reactance should be no more than five Ohms. But reactance at what frequency?

Well, given that the range of audio frequencies entertained by ETSI 300 132 start at 25 Hz, we can quickly determine that our capacitor should have a minimum of about 1.2 mF capacitance. Of course, the working voltage of this capacitor better be 100 VDC or more.

The dielectric leakage and overall reliability of this capacitor is crucial. A failure of this component will, most likely, imply the instantaneous destruction of the measuring instrument, be it a specialized wideband psophometer or a narrow band low frequency spectrum analyzer. We are not aware of any of these instruments that could tolerate -48 VDC on their inputs.

Here comes the dilemma: What type of capacitor can this device be? The easiest solution would be an aluminum electrolytic. A device of 1.2 mF at 100 VDC can be easily obtained at minimal volume and cost. The drawback is that aluminum electrolytics present notoriously variable high leakages and are significantly affected by environmental conditions (particularly temperature) and previous history. A partially polarized aluminum capacitor presents leakages an order of magnitude greater than a “matured” capacitor. These leakages translate into a steady DC bias voltage at the input of the measuring instrument – a rather unhealthy and undesirable condition.

To add to the difficulties with aluminum electrolytics, the statistical probability of device degradation, or worse yet, short circuiting, is probably the highest of all the capacitor families. What other choices do we have? We can choose from a variety of other technologies, such as ceramics, tantalums or film capacitors to name the most common. Discarding ceramics and tantalums because of large tangents in high capacitance devices, we are left with film capacitor.

Both polypropylene and polyester films are a good fit for our application. The problem with these technologies is that their volume/capacitance ratio is order of magnitude larger than aluminum electrolytics and their usual maximum capacitance is in the order of few microfarads. In fact, unless we are willing to pay a hefty price, 20 to 30 microfarads is probably the highest capacity attainable at a modest price. That implies paralleling 40 to 60 of these devices. At first sight, it may appear as a monster. But a very tame and reliable one.

Although the machine does the job, we have identified a list of possible improvements to be made, and they are mostly related to power switching schemes. The core of the LISN, however, remains the same in all cases.

Concluding, we have two choices: a rather tiny and inexpensive aluminum electrolytic or a “monster” bank of film capacitors. If we are to choose aluminum, the very least of the precautions that we should religiously follow is to power the LISN for at least half an hour and measure the DC bias present on the output port before connecting any instruments to it. It should be only a few milliVolts. These precautions will spare us from potential catastrophes.

Now let’s look at charging the input capacitor C1. As we have seen, a large input capacitor is indispensable if we are determined to retain some peace of mind in an increasingly electromagnetic, and otherwise polluted, world.

The problem inherent with such a large capacitance is that we cannot just “flip a switch.” At time = zero, the current is only limited by the Thevenin impedance of the source and the copper resistivity of the cables and switch. All these resistances, in the case of lead-sulphuric acid batteries and hefty power cables, will sum-up to only a few milliOhms. The in-rush currents will be in the third order of magnitude or even more. Something will give up molten metal splatters or worse.

The reasonable way to solve this problem is to pre-charge the LISN input capacitor before energizing the EUT. For example, we could implement a system where the input switch feeds into a five Ohm wirewound charging resistor. Suppose we have a very large total capacitance of 100 mF, in this case our time constant would be 500 milliseconds. At about five time constants, or about 2.5 seconds, the capacitor will be virtually fully charged and, at this point, we can safely energize an Hg contactor to short the five Ohm resistor and subsequently energize the EUT.

The power dissipation rating for the wirewound resistor can be only 50W, as its duty cycle is very limited. Do not forget to discharge the capacitor after the LISN is disconnected from service. The same five Ohms resistor used to charge the input aluminum capacitor can be used to discharge it by shorting the LISN power input terminals.

Of course, prior to doing that shorting, the power lines have been disconnected from the power source and the LISN is totally deactivated, including the Hg contactor that shorted the charging power resistor supplying current for the EUT operation. The engineer operating the LISN must be fully alert, as any mistake could potentially see huge sparks.

Another important piece of equipment to consider when making a measurement of the audible noise is the psophometer. As we know, to emulate the noise response of the human ear, psophometers need to have some kind of frequency-weighting filter installed. If a filter is not used, the noise power measured in pWp would be a measurement of the total amount of the noise power across the interested frequency range. This is because when noise is measured in a voice channel, the entire bandwidth of the channel is considered, and the measured noises across the channel are combined together to produce the final reading. [3]

When it comes to sound level measurement, there are a number of frequency-weighting curves, such as A-weighting, B-weighting or C-weighting curves, that are available to choose from, and each has its own characteristics. Those weighting curves refer to various sensitivity scales. By comparing those curves, you will notice that the A-weighting curve has a lot of attenuation in the low frequencies, and it can be used to eliminate low frequency components that are not sensitive to the human ear. Thus, the curve de-emphasizes low frequency components. Furthermore, the A-weighting curve only gives a good representation of the human ear response at low sound levels, and it's mainly good for single tone sounds. [8]

The B-weighting curve, on the other hand, is not frequently used since it focuses on medium-level tones. [6] The C-weighting curve simulates the effect of high-level tones. [6] However, the C-weighting curve is kind of flat, and it provides minimum attenuation in the low frequency range. Hence, the C curve is not a good choice to use to simulate the behavior of the human ear.

For telecommunication equipment a filter with psophometric weighted curve that is similar to the curves mentioned above is used since the curve resembles the response of the human ear. [7] The filter is essentially a band-pass filter. The psophometric-weighting curve specifies the relative weight coefficient in dB in the frequency range of approximately 17 Hz to 6000 Hz. [4] According to the ITU-T O.41 recommendation, the reference frequency of psophometric curve is 800 Hz, which means for the same sound pressure level, the amount of noise perceived by the human ear at other frequencies around it are either more or less than the noise at the reference frequency. [3]

Let's look at a hypothetical example. Assume we have an audio signal generator that injects a -5 dBm signal at 900 Hz into a telephone circuit. On the receiving side, the ear perceived it as a certain level of noise or annoyance. Then we inject the same signal at 500 Hz, and the perceived level of annoyance is 10 dBm less than the annoyance at 900 Hz. This means that for the same listener to be able to feel the same amount of annoyance, the signal injected at 500 Hz needs to be 10 dBm more than the one at 900 Hz.

When a psophometric filter is applied to a white noise in the band 0 kHz to 4 kHz, the effect is to suppress the noise level by 3.6 dB. [2] White noise is basically a noise signal that has all the characteristics of sounds of all different frequencies combined together, and it has pretty much the same amount of noise power across the frequency spectrum.

An unweighted curve, on the other hand, can be characterized by a flat line where the noise response to frequency is pretty much the same across majority part of the audio spectrum. When we apply the white noise again to a flat filter, the noise measured at distinct frequencies will always be the same across a band of frequencies where the weighting curve is flat. [3] Thus it is clear that a weighted measurement has less noise power in pWp than an unweighted measurement, which is due to the noise attenuations of the weighting curve.

The custom test equipment works just as envisioned and improves the efficiency of testing by shortening the amount of time required to do a conducted emissions test at interface 'A.' It allows the test engineer to test very large telecommunication systems that even draw 100 Amperes using a relatively small battery bank.

Although the machine does the job, we have identified a list of possible improvements to be made, and they are mostly related to power switching schemes. The core of the LISN, however, remains the same in all cases. Some telecommunication systems have multiple shelves on the same rack with its own DC power ports. With the current design of the machine, the power switch box is placed between the power source and the LISN, and the output of the LISN is only connected to one of the shelves. A possible improvement is to have a power switch between the LISN and the EUT that will allow test engineers to select which shelf on the rack gets the battery power. ■

REFERENCES

1. ETSI EN 300 132-2, "Environmental Engineering (EE); Power supply interface at input to telecommunications equipment; Part 2: Operated by direct current (dc)," European Telecommunications Standards Institute, 2003.
2. Flood, J. E., *Telecommunication Networks,* 2nd Ed., IET, 1997.
3. Freeman, Roger L, *Fundamentals of Telecommunications,* 2nd Ed., Wiley-IEEE Press, April 2005.
4. ITU-T Recommendation O.41, "Specifications for Measuring Equipment," International Telecommunication Union, 1995.
5. Kizer, George Maurice, *Microwave Communication*, 1st Ed., Wiley-Blackwell, 1990.
6. LabVIEW™, "Sound and Vibration Toolkit User Manual," National Instruments, 2005.
7. Miceli, Andrew, *Wireless Technician's Handbook,* 2nd Ed., Artech House, 2003.
8. Richard L. St. Pierre, Jr., and Daniel J. Maguire, *The Impact of A-weighting Sound Pressure Level Measurements During the Evaluation of Noise Exposure*, NOISE-CON, 2004.

Zijun Tong *is an EMC Project Engineer with MET Laboratories. MET is an independent lab that specializes in electromagnetic compatibility, product safety, and environmental simulation testing. Zijun can be reached by email at ztong@metlabs.com.*

A REGULATORY ROADMAP

That's Just Regulations... *Right?*

Peter S. Merguerian, Go Global Compliance Inc.
Dennis W. Bartelt, Bartelt Consulting Corp.

Pressure to get product to market is stressful, as well as full of scenarios that most engineers and designers would like to forget about. Yet in the beehive of activity, the regulations that a product must comply with are critical to those design engineers, as well as other teams. So much, in fact, that a slight misstep early on or during the product life cycle can create devastating circumstances. Driven by market or other business issues some may succumb to the "limp factor" (LF): get it to work and ship at all costs for the first country or countries of use and worry about the others at a later time when the pressure is off. So, how can we prevent the LF from occurring?

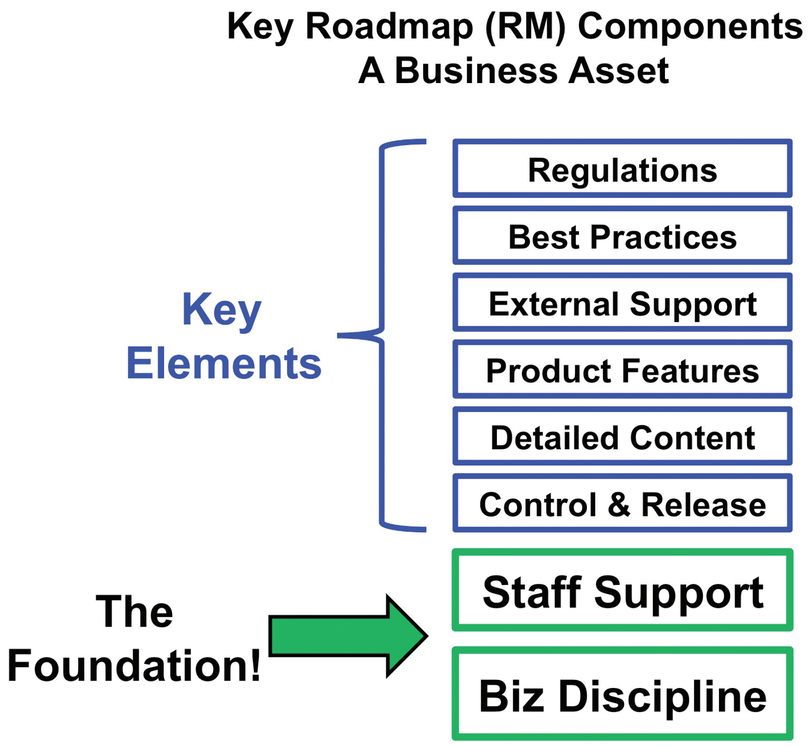
Despite good intent, business operations may lack the understanding of what engineering and other teams need to determine the correct regulations, as well as how these same teams could be impacted by them in their daily jobs. Biz ops may believe word of mouth or an occasional e-mail is adequate. Information may dribble out from multiple sources, or it may be released in phases. All this non-value added activity is spoon feeding with potential for major issues down the road. Simply, a "Regulatory Roadmap" (RM) is needed. But what is it and what does it mean beyond a name that sounds good?

The RM is a global regulatory perspective for the product. But a slight twist exists; there is more than just the regulations. A robust RM should provide visibility across the organization, beyond that of engineering, and clearly link key product or customer criteria to the applicable regulatory requirement and the business team it touches. Groups such as distribution, quality, technical operations and sales and marketing can use the RM to see how they fit into the aggregate regulatory requirements and the impact on them. The effectiveness of the RM is only as good as the upfront effort placed into it along with the follow-up to maintain its accuracy over time. In preparing and developing the RM several key factors need consideration.

Business Discipline: This is required by all the business teams including sales and marketing, product planning, engineering, manufacturing, quality, distribution and supply chain to make the RM part of the jargon and working plan of the organization. It should be embedded as a deliverable to all organizations and made part of the program management scheme that monitors the product design, shipment and launch cycle. Practically speaking, the RM is active throughout the product lifecycle, from birth to end of life, and continued focus on it is required to maintain accuracy. Key staff, or champions, should be assigned to make this a real, live, breathing task as opposed to being a one time, one shot picture. One has to remove the organizational mindset that "it was complete when we first launched the product so that should be good enough."

Staff Support: The RM is rarely a static entity. The champions noted above should partner with the right players to collect key information regarding the product and finalize on a method to deploy the RM on a routine basis throughout the product lifecycle. These champions should be multi-disciplinary, having representatives from all functional teams. These players will determine who and what assignments are needed to complete the entire RM, as well as select a delivery method such as Excel or a database program. Unless one can guarantee they know other champions' job and role, it is dangerous to "not invite" all the representatives to the RM building process. They must work as a team to prepare and distribute the RM to all parties needing it.

Control and Release: The RM should be under documentation and version control, be integral to the quality system, and be in the teams' hands well ahead of critical milestones where this information would be needed to make product decisions. One example is the initial conceptual block diagram design of the product, where the product's architecture is fundamental to meeting many specifications on a broad level.



Detailed Content: The content of the RM should not be underestimated or simplified. This can be a dangerous situation leading to serious implications. The key point is to get all business functions involved in its development so that the contents inside the RM can include each business operations input. It should include the general terminology such as Americas, EMEA, Russia and CIS, or Asia Pacific, but in addition be specific by the product model or type, down to the country, customer, launch date, how it will be identified to the market place, key specification or feature requirement and pertinent information on the market segment such as commercial or consumer, or governmental. The specifics on the product's distribution plan such as direct import, dealers or distributors need to be identified for purposes of meeting import regulations that could be problematic if not accounted for.

Product Features: It is extremely important to consider product feature additions or upgrades and when and where they occur and in which product. Other factors must also be considered such as indoor/outdoor use, transmitter frequency bands, channels and power limits, interfaces to the network, etc. These can trigger added regulatory requirements and may complicate the filing and certification procedures. Also, certain products may have specific requirements that need to be captured on the RM, including items such as labeling, packaging or manuals with safety instructions that must be included with the product as part of maintaining regulatory approval.

External Help – Labs/Consultants: There are most certainly internal experts within a business that are responsible in one way or another for the regulatory compliance of a product. Some companies design products with a "take it one country at a time" attitude due to their internal capability, only to find out that the next country may have requirements quite different or more strict regulatory wise. Generally companies have individuals with a "basic" handle on the scope of the regulations. However, unless there is an ongoing process to keep up to speed on the latest regulatory requirements, it makes good business sense to identify competent business(es) whose job it is to be 100% current on the latest requirements. During the RM development processes identify competent firm(s) and share the RM under a non-disclosure agreement. They should be able to assist in pointing out the regulation requirements, as well as be the check and balance. In selecting the external firm(s) make sure in the initial discussions that they indeed have the scope to handle the RM. Summarize the RM into major discussion areas first such as RF, packaging, EMI, safety, energy efficiency, product environmental (RoHS, REACH), etc., and then go into detail, as well as provide a global indication of the countries. Surprisingly some firms do not have the internal expertise to know everything and as such they must bring in others to assist. This is not generally a bad business practice, but be aware of it. Probe on their internal processes and how they keep current, what the limitations of their company are and how gaps can be addressed. Do you detect they will be proactive or reactive to your needs?

> ***The impact on the business for not knowing a regulation is non-forgiving, can easily degrade market share, drive customers toward competition, or potentially lead to the dreaded "r" word RECALL.***

Sharing Information Best Practices: One meeting rarely completes the RM analysis. Several will be needed before you finalize it. Remember, these firms are in business to help, but if you do not provide a clear discussion and spend the time working with them so they fully understand your product, the results you get may indeed be incomplete. Share with them the aggregate business picture, point out your concerns, communicate the unknowns or other concerns you have and, most importantly, represent equally each of your internal business functions and how they touch the product. Best case, there will be no regulation and some business functions may not be impacted at all. Worst case, a product could be shipped non-compliant, and no one is aware of it. The product may get stuck in customs due to a missing mandatory regulatory Mark; it may be tested by the competition and non-compliance reported to the regulator(s); it may need to be recalled due non-compliant critical components or materials supplied in the marketplace.

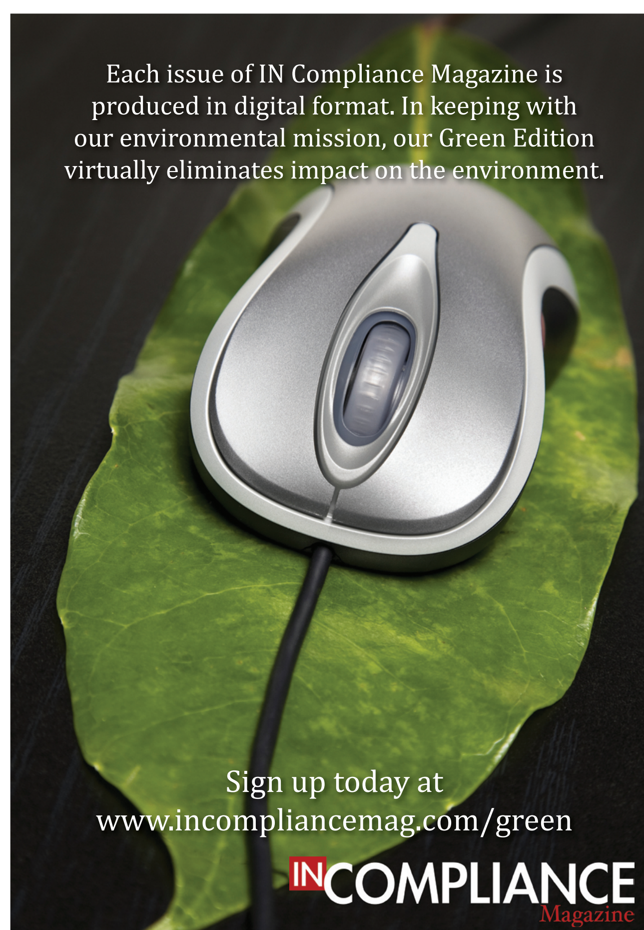
Capturing Regulations: Should you need their help, use your external business support described above to help complete the RM. In the context of the previous items, the appropriate regulation(s) need to be entered by name, reference number, version, date and key specification. More than likely one may find that a "lowest common denominator" regulation may indeed cover more than one product requirement. Challenge in all cases any RM item that does not have a regulation associated with it.

Understand why or why not, and be cautious if there is an indication that the regulation is vague or non-descript. Vague items quickly spiral into being non-issues, i.e. the "limp factor," yet in reality the homework was not done to rule it out one way or the other. It may indeed be correct that none exists and if such is the case that item could be removed from the RM for simplicity sake. In addition, recognize that regulations are not static and in most cases will change over time. Your RM needs to take this into consideration and capture these changes and when they occur. When considering any regulation always have a forward looking view of at least 2+ years (can vary based on your product design and release cycle) to prevent surprises. No one wants to release a service or product only to find that a new regulation kicks in one month after initial release! By having a forward looking view, knowing when new regulations will be effective, and how they are going to impact shipping product, you can make design allowances and changes so that when the new regulations become effective your product lineup can be ready.

Cautions: Some may feel that regulations are centric to a specific organization or function, or wrongly assume the other team "has it under control." Efficiency wise, the RM provides a level playing field to all parties integral to the product. It documents the commitment to do it right the first time, ensures that all functional organizations have their vested interests included, and serves as a foundation upon which future products can be built upon. If done correctly the RM is an asset, but doing it for the first time can appear as overkill. However, the impact on the business for not knowing a regulation is non-forgiving, can easily degrade market share, drive customers toward competition, or potentially lead to the dreaded "r" word - recall. ■

__Peter S. Merguerian__ is President and CEO of Go Global Compliance Inc. (www.goglobalcompliance.com) and provides regulatory engineering consulting and global certifications for companies worldwide. He has 30 years global regulatory compliance experience with an emphasis on safety, EMC, wireless and telecoms where he had corporate-wide responsibility in various global test laboratories for Market and Conformity Surveillance, Regulatory and Testing Services, Global Engineering, Accreditation and Global Certifications. Mr. Merguerian holds a Bachelor of Science Degree in Electrical Engineering from the Illinois Institute of Technology, Chicago. He speaks five languages and owns and moderates two popular global regulatory groups, one on Linked In: "Global Regulatory Compliance" and the other his blog at www.goglobalcompliance.com/blog. Mr. Merguerian can be reached at peter@goglobalcompliance.com.

__Dennis W. Bartelt__ is President of Bartelt Consulting Corp. (BCC). He has 30+ years of past experience in telecommunications and consumer products with Motorola Mobility Inc.(formerly the cellular division of Motorola Inc.). His credentials include product design, software quality, service and repair, product safety, regulatory and environmental compliance, customer satisfaction and process enhancement. Under his leadership the teams he managed provided approvals for more than 100,000 unique products. Dennis has a Master's Degree in Electrical Engineering Technology from Northern Illinois University along with 30 hours pre-doctorate work. He is currently consulting with industry firms and specializes in process enhancement in the product regulatory and safety compliance areas. Dennis can be reached at barteltconsultingcorp@yahoo.com or dennis@goglobalcompliance.com.



Aitech Rugged Group Names Moshe Tal as CEO

Aitech Rugged Group has announced the appointment of Moshe Tal as the company's new CEO. Mr. Tal replaces Roger Rowe, who retired as CEO and chairman in September 2010 after a six-year tenure that grew Aitech's business from $9 million to $26 million in revenue.

Having been with the company since November 2009, Mr. Tal has worked closely with several facets of Aitech's business, including business development and engineering as well as sales and marketing. He has more than 25 years of product design and engineering experience, principally associated with analog and digital signal processing technologies, and holds a B.Sc. in Electronic Engineering from Tel Aviv University.

Aitech is a leading supplier of commercial and military embedded computing solutions to prime contractors in the military/aerospace and space markets with business units located in Chatsworth, California for its space and mil/aero activities, and in Herzilya, Israel specifically for its mil/aero business only. For more information please call 888-Aitech-8 (888-248-3248), visit www.rugged.com or e-mail sales@rugged.com.

American Certification Body Inc. (ACB) Receives Recognition for Japan

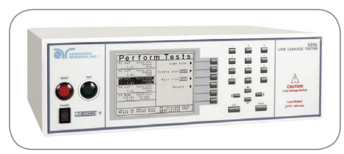
ACB has been approved in the first round of Certification Bodies recognized to perform Certification for wireless devices to Japanese Radio Law, increasing market-access for manufacturers on both sides of the Pacific.

Under a bi-lateral agreement, the US and Japan have effected the implementation of a Mutual Recognition Arrangement that allows the acceptance of certification decisions under each respective country's regulations. This new arrangement—and ACB's program—now offers more options for device manufacturers.

To obtain an approval, one must generate a report and demonstrate conformance (and submit to a Certification Body). To determine what data must be collected, it is necessary to refer to the ordnances that cover the specified equipment, notably the "Ordinance concerning Technical Regulations Conformity Certification of Specified Radio Equipment (aka Ordinance of the Ministry of Posts and Telecommunications No. 37, 1981)." This document lays out the various types of equipment and what data are to be collected and what instrument is used to collect the data. For more information visit www.acbcert.com.

New Features Enhance Effective Testing for Medical Device Manufacturers

Associated Research, Inc. has announced the addition of new enhanced features to their LINECHEK II model 620L Line Leakage tester for more effective compliance testing for medical device manufacturers. The 620L is a fully automated Line Leakage tester that is able to perform the most commonly required Line Leakage tests as called out in such specifications as UL2601, UL60601-1, IEC601-1, IEC60601-1, and EN60601-1 among others. The 620L also has the common measuring devices already incorporated into the instrument.



The 620L now provides added functionality to help medical device manufacturers comply with agency specifications for electrical safety compliance testing. A new MD Voltage Display feature allows medical device manufacturers to measure the voltage drop across measuring devices as called out in IEC60065 & IEC60990. A new Leakage Current Display capability allows the 620L to now fully comply with specifications requiring AC, DC and AC+DC leakage measurements. The 620L can also now record maximum RMS or Peak leakage current during a test.

For more information on LINECHEK II please visit www.asresearch.com/products/linechek2/Default.aspx.

David Seabury Joins Panashield

Panashield has announced the appointment of David Seabury as Director of Sales - Americas. David has extensive background in the design, manufacture and installation of RF shielded enclosures and anechoic chambers for EMC, wireless and microwave applications. His background includes founding IBEX Group, Chase EMC USA and Chase Systems where he promoted a range of products synergistic with chamber installations. IBEX and Chase were closely partnered with Panashield from 1991 until 2003. Recently David held positions with ETS-Lindgren as Senior Product Manager and Regional Sales Director. Visit www.panashield.com for more information.

QuadTech Marks 20 Years in the Test and Measurement Industry

QuadTech is celebrating it's 20th anniversary. Founder and Chairman of the Board, Phil Harris, created QuadTech in March of 1991 when he bought the Precision Instrument Division of General Radio (GenRad), an electronic test equipment manufacturer and one of the most respected names in the test and measurement industry.

Today, QuadTech is focused on selling testing solutions, ranging from basic hipot testers, cable testers, lcr meters, ac/dc programmable power sources and dc electronic loads to automated electrical test solutions, featuring QuadTech's proprietary automation software. QuadTech test systems can test to some of the most stringent testing standards, like IEC 60601-1.

While QuadTech's product offerings have evolved over the last 20 years, the company philosophy and mission have remained steadfast: Make the Customer Successful. From the top down, QuadTech employees are focused on supporting the customer. Visit www.quadtech.com for more information.

Rohde & Schwarz and VDE Inspire Young Engineers

Rohde & Schwarz will put inspired engineering students to the test on the subject of radiomonitoring. Increasing radio density and ever more complex radio transmission methods confront this field with huge challenges. For the eighth time, the company, together with the German Association for Electrical, Electronic and Information Technologies (VDE), is organizing its international case study competition. Under the banner of "Keep pace with the future! The future of radiomonitoring is in your hands!" participants will have to solve real-world tasks.

Rohde & Schwarz gives engineering students the opportunity to experience what developers really do in their work. The students will have to solve various exercises in the field of radiomonitoring – a cutting-edge issue. Due to the increasing radio density and the growing number of different radio transmission standards, monitoring radio traffic is becoming more and more complex. Monitoring systems must keep pace with this trend. "The case study competition confronts students with concrete, real-world challenges," says Hans Knapek, Head of Human Resources at Rohde & Schwarz. "In addition, the participants have the chance to get to know our innovative family-run company."

Visit www.rohde-schwarz.com for full details.

New Switch with Built-in Undervoltage Release Protects Operator Safety

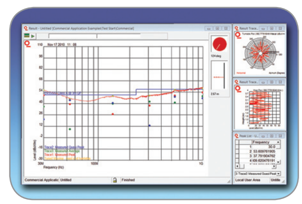
Schurter is pleased to announce a new 2-Pole appliance switch with built-in undervoltage trip release. The new series, dubbed UP1, prevents uncontrolled restarts by monitoring and tripping under conditions of extreme voltage drop, or when the supply voltage is interrupted. Even when the supply voltage returns in full, the machine or equipment does not automatically restart, but must be manually switched on again. Using such a device can prevent harmful situations for operators, as well as others in the surrounding work area.

The UP1 with pushbutton or rocker actuation is a circuit breaker with undervoltage protection, and without overload protection. The pushbutton version is available in both snap-in and screw-on (flange) mounting, while the rocker version is designed for snap-in mounting. IP rated protection covers are offered to prevent ingress of water spray and dust in machinery that operates in harsh environments, such as construction sites, woodworking, metal or masonry shops. The covers can be supplied factory mounted with the breaker or separately for customer mounting.

Applications for undervoltage protection include products such as landscaping equipment, wood chippers, floor cleaning and sanding devices, electrical tools like circular saws, band saws, grinding machines and drills. Other application examples include fuel pumps, coffee-milling devices, fruit juice squeezing machines and fruit juice centrifuges. More information on the new UP1 can be found on Schurter's website www.schurterinc.com/new_cbes.

Teseq Offers Upgraded Test Software with Industry-specific Test Packages

Teseq Inc. has released Compliance 5 emission and immunity test software. Compliance 5 is a single, integrated test platform capable of performing all RF EMC testing needs. The upgraded software is simple to use with the included commercial application package that aids in speeding set-up and making compliance testing quick and easy. Other application packages for military and aerospace are available as an option. Packages for reverberation chambers and automotive testing will be available in the next few months.



Compliance 5 makes custom reporting easy. Its powerful, flexible reporting package features pre-formatted templates that can include company logo, text, graphs, tables, test details and pictures, saving time and reducing the burden put on a test engineer's time.

Teseq's Compliance 5 is used in test laboratories worldwide to deliver fully-compliant, fast, efficient and repeatable testing in military and aerospace applications, reverberation chambers, commercial/consumer products and the automotive industry. For more information, please visit www.teseq.com or contact MaryJane Salvador, Tel: (732) 417-0501 ext. 239; e-mail: maryjane.salvador@teseq.com.

TUV Rheinland Receives Accreditation to Provide Chemical and Mechanical Testing on Consumer Products and Toys

TÜV Rheinland's new consumer products testing laboratory in Bentonville, AR was recently accredited to ISO/IEC 17025:2005 by the American Association for Laboratory Accreditation (A2LA) and officially approved as a third-party testing laboratory by the Consumer Products Safety Commission (CPSC) to provide certain chemical and mechanical testing on consumer products such as children's toys and textiles.

The new laboratory's focus is on providing chemical and mechanical testing and assessment services for consumer products including wearing apparel, costumes, upholstery, and home furnishings as well as toys, and children's products. With its recent ISO 17025 accreditation, the global quality standard for testing and calibration laboratories, the Bentonville, AR laboratory is recognized for technical competence in specific areas of chemical testing such as lead and phthalate content. In addition, the laboratory is able to perform a variety of tests for evaluating mechanical safety and flammability requirements.
For more information, visit www.tuv.com/us.

W. L. Gore & Associates Makes *100 Best Companies to Work for in America* List

With its unique, non-hierarchical, team-based culture, global manufacturing company W. L. Gore & Associates has once again earned a spot on FORTUNE magazine's annual list of the 100 Best Companies to Work for in America. The company is ranked No. 31. This marks Gore's 14th consecutive appearance on the list, making it one of a select few workplaces to appear in every edition of the rankings.

Since its founding in 1958, Gore has avoided traditional hierarchy, opting instead for a team-based environment that fosters personal initiative, encourages innovation and promotes direct person-to-person communication among all associates. Decisions are based on knowledge and experience, rather than title or particular position. And all associates are encouraged to grow in knowledge, skill and responsibility, and to make their own commitments. This unique corporate structure has proven to be a significant contributor to associate satisfaction, as well as a driving force behind the company's success.

In addition to appearing on all of the FORTUNE 100 Best Companies to Work for in America lists, Gore earned recognition in three earlier books by the same name. The company is also consistently named a top workplace in a number of other countries. Visit www.gore.com for more information.

Seminars, Training & Webinars
June 2011

June 2
FCIA Education Program
UL University
Northbrook, IL
www.incompliancemag.com/events/110602_1

June 2
A/V, Information and Communications Technology Equipment Safety Requirements: Intro to IEC 62368-1
UL University
Toronto, ON
www.incompliancemag.com/events/110602_2

June 6 - June 10
Photovoltaic (PV) System Installation Training
UL University
Research Triangle Park, NC
www.incompliancemag.com/events/110606_1

June 6 - June 10
Lean Green Belt Workshop and Certification
UL University
Northbrook, IL
www.incompliancemag.com/events/110606_2

June 7 - June 8
Safety of Household and Similar Electrical Appliances; IEC 60335-1, 4th Edition
UL University
Research Triangle Park, NC
www.incompliancemag.com/events/110607_1

June 7 - June 8
Industrial Control Panels UL 508A and Short-Circuit Current Ratings
UL University
Hartford, CT
www.incompliancemag.com/events/110607_2

June 7 - June 9
Safety of Household and Similar Electrical Appliances; IEC 60335-1, 4th & 5th Edition (BUNDLED)
UL University
Research Triangle Park, NC
www.incompliancemag.com/events/110607_3

June 7 - June 9
Designing for Compliance to IEC 60601-1, 2nd Edition and Transition to the 3rd Edition (Bundled)
UL University
Melville, NY
www.incompliancemag.com/events/110607_4

June 7
Designing for Compliance to UL 1598: Electric Luminaires
UL University
Northbrook, IL
www.incompliancemag.com/events/110607_5

June 8 - June 9
The CE Marking: Strategies for European Compliance
UL University
Brea, CA
www.incompliancemag.com/events/110608_1

June 8
LED Luminaires - Designing for Compliance to UL 8750
UL University
Northbrook, IL
www.incompliancemag.com/events/110608_2

June 8
Is Repeated Hipot Testing Destructive?
Associated Research
Webinar
www.incompliancemag.com/events/110608_3

June 9
Safety of Household and Similar Electrical Appliances; IEC 60335-1, Transition to 5th Edition
UL University
Research Triangle Park, NC
www.incompliancemag.com/events/110609

June 14 - June 15
Lightning Protection Installation Standard Review
UL University
Denver, CO
www.incompliancemag.com/events/110614_1

June 14 - June 16
Designing for Compliance to IEC 60601-1, 2nd Edition and Transition to the 3rd Edition (Bundled)
UL University
Boston, MA
www.incompliancemag.com/events/110614_2

June 14 - June 16
Fundamentals of EMC Compliance Testing
ETS-Lindgren
Austin, TX
www.incompliancemag.com/events/110614_3

June 14 - June 17
MIL-STD-461F
WL Academy
Gaithersburg, MD
www.incompliancemag.com/events/110614_4

June 14
Understanding Ground Resistance Testing A One Day Training Seminar
AEMC Instruments
Long Island, NY
www.incompliancemag.com/events/110614_5

Join us for this 3-Day Intensive Course
presented by renowned EMC expert Henry Ott

Electromagnetic Compatibility Engineering

a course in noise and interference control in electronic systems

May 24-26, 2011 Westford, Massachusetts

TOPICS INCLUDE:

- **Cabling**
- **Grounding Principles**
- **Digital Layout & Grounding**
- **High Speed Digital Decoupling**
- **D-M Emission Modeling**
- **Common-Mode Filtering**
- **Transmission Lines**
- **Mixed Signal PCBs**
- **RF & Transient Immunity**
- **Conducted Emission**
- **Shielding**

In this three-day intensive course

we cover practical aspects of noise and interference control in electronic systems and we provide a working knowledge of EMC principles.

Ideas are illustrated with examples of actual case histories and mathematic complexity is kept to a minimum.

Participants will gain knowledge needed to design electronic equipment that is compatible with the electromagnetic environment and in compliance with national and international EMC regulations.

Who Should Attend

This course is directed toward electrical engineers. However, mechanical engineers, reliability and standards engineers, technical managers, systems engineers, regulatory compliance engineers, technicians and others who need a working knowledge of electromagnetic compatibility engineering principles will also benefit from the course.

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

EMC Exhibits and evening reception - Wednesday, May 25, 2011

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

Presented by Henry Ott Consultants
in partnership with IN COMPLIANCE Magazine
www.incompliancemag.com

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.

EVENTS

June 15 - June 16
Data Acceptance Program: Requirements for Participation
UL University
San Jose, CA
www.incompliancemag.com/events/110615

June 20 - June 24
Electronics Laboratory Technician Training
UL University
Research Triangle Park, NC
www.incompliancemag.com/events/110620

June 21 - June 22
ITE: Designing for Compliance to UL 60950-1 2nd Edition
UL University
Toronto, ON
www.incompliancemag.com/events/110621_1

June 21 - June 23
Non-Destructive Testing: Visual Testing
UL University
Northbrook, IL
www.incompliancemag.com/events/110621_2

June 22 - June 23
Test, Measurement and Laboratory Use Equipment: Designing for Compliance to UL 61010-1, 2nd Edition
UL University
Orlando, FL
www.incompliancemag.com/events/110622

June 24
Electric Signs: Designing for Compliance to UL 48
UL University
Cincinnati, OH
www.incompliancemag.com/events/110624

June 28 - June 30
Designing for Compliance to IEC 60601-1 3rd Edition
UL University
San Jose, CA
www.incompliancemag.com/events/110628

Compliance Marketplace

ADVERTISERS

Learn how to make EMC compliance tests in a three-day, hands-on course taught by experts.

Our ***hands-on teaching*** method means ***you'll learn firsthand*** how to perform radiated and conducted emissions and immunity tests according to published standards.

Your ***instructors are experienced EMC experts*** with practical lab experience. You'll be taught exactly what to do, and know why you're doing it. Then, ***you'll apply what you've learned by making actual measurements in our 3 meter EMC chamber***. By taking this course, you'll avoid costly, time consuming trial-and-error methods, and learn practical, proven techniques that will have you ***become productive more quickly***.

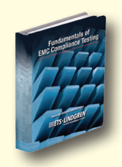
Your tuition includes three days of personal instruction: a mix of classroom discussion and practical in-chamber testing.

You'll also receive ***a study guide and class notes*** so you can focus on learning, instead of taking notes. The study guide is a valuable reference tool you'll refer to often when you return to your lab.

Class size is limited to twelve students for personalized and individual attention.

AUTHORIZED IACET PROVIDER

Earn Two CEU Credits
Complete the requirements for this course and earn two CEU credits.



Course Study Guide
Your free study guide is packed with practical info, illustrations, and the tips and techniques taught in class.

This course is ideally suited for:

- EMC engineers or lab technicians who want to expand their knowledge of EMC testing
- Engineers or lab technicians new to EMC requirements
- Design engineers and anyone outsourcing their testing who wants to know the standards and test methods that will be applied to their products
- Non-engineers such as, business analysts or trade journalists, who want to understand the fundamentals of EMC testing
- Anyone preparing their lab for ISO/IEC 17025 accreditation
- Anyone preparing themselves for the iNARTE® personnel certification exam

Need more info?
www.ets-lindgren.com/learning

Enabling Your Success™

ETS·LINDGREN™
An ESCO Technologies Company

Phone +1.512.531.6400 • info@ets-lindgren.com
Offices in the US, Finland, UK, France, Germany, Singapore, India, Japan, China, Taiwan

YOU HAVE A CHOICE

EMC Chambers

Built to Perform!

Built to be the Best!

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

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

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

EMERSON & CUMING Anechoic Chambers
an Albatross Projects company

BSS BRADEN SHIELDING SYSTEMS

RAINFORD EMC SYSTEMS

9260 Broken Arrow Expressway • Tulsa, OK 74145 • Phone 918 / 624 2888 Fax 918 / 624 2886
Email: info@bradenshielding.com Website: www.bradenshielding.com