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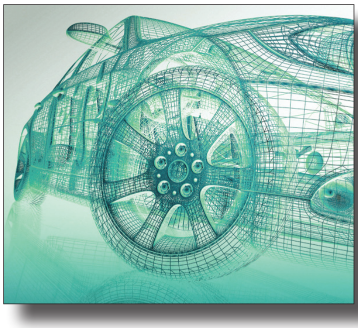
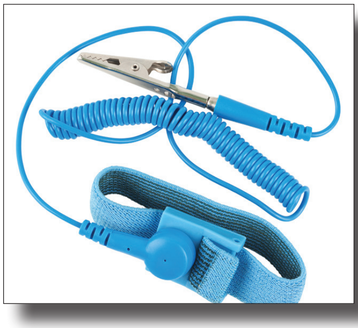




News in Compliance

FCC News

FCC Releases Consumer Complaints Report for Q4 2013

The U.S. Federal Communications Commission (FCC) has released its report on complaints made by consumers to the agency's Consumer & Government Affairs Bureau during the quarter ending December 31, 2013.

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

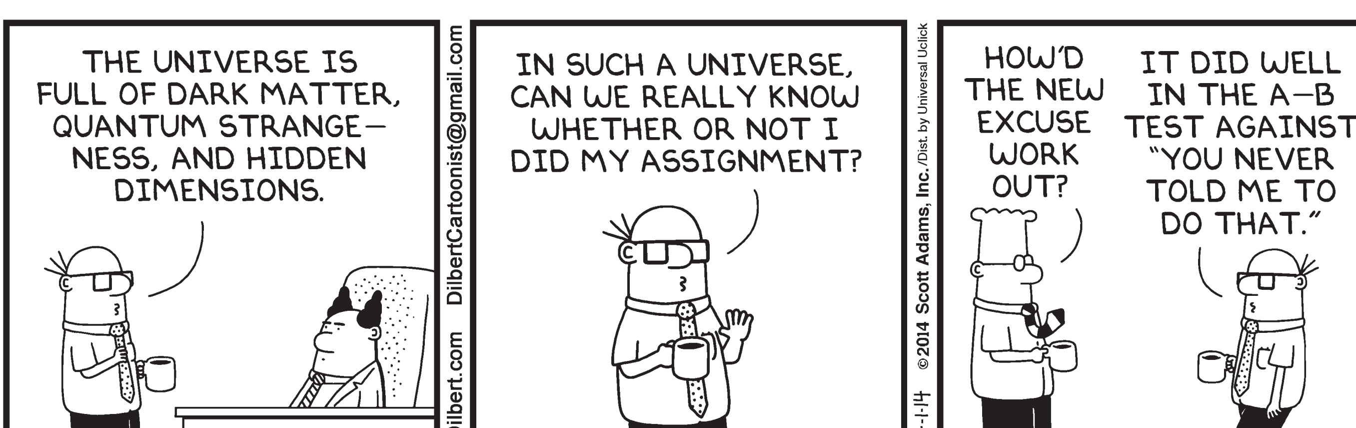
During the period from October through December 2013, the Bureau received a total of 51,501 complaints related to the services it regulates, including cable and satellite service, radio and television broadcasting, and telecommunications services. The total includes just over 36,000 complaints (69.9% of all complaints) related to violations of the TCPA in connection with wireline and wireless telephone services. TCPA-related complaints in connection with wireless services are showing significant growth, and account for more than 30% of all TCPA-related complaints. Unsolicited faxes accounted for just 1886 (about 5%) of TCPA complaints.

The complete text of the Commission's most recent quarterly report is available at incompliancemag.com/1405_01.

Commission Proposes Fine for Interference

The U.S. Federal Communications Commission (FCC) has proposed a fine of $25,000 against a Florida man for operating an unlicensed "online" radio station on FM frequencies.

In a Notice of Apparent Liability for Forfeiture issued in March 2015, the FCC cited Damian Anthony Ojouku Allen of Fort Lauderdale, FL for allegedly operating a pirate radio



FCC News

station, self-identified as "NGR Online Radio." In this instance, FCC agents from the Enforcement Bureau's Miami Office identified on three separate occasions in August and September 2013 unlicensed radio transmissions emanating from an FM transmitting antenna located on the rooftop of a Ft. Lauderdale commercial property. Using field strength measurement equipment, the agents determined that the transmissions exceeded the limits for operations under the Commission's Part 15 Rules.

As a result, detectives with the Fort Lauderdale Police Department arrested Allen for operating an unlicensed FM radio station and seized his transmitting equipment. Allen pleaded guilty to a third degree felony charge under Florida state law.

According to the FCC, this is not the first time that the Commission has cited Allen for the unlicensed operation of a radio transmitter. The Miami Office of the Enforcement Bureau previously cited Allen in 2010 and 2012 for operation of unlicensed stations in Pompano Beach and at other locations in Florida.

The complete text of the Commission's Notice of Apparent Liability is available at incompliancemag.com/1405_02.

News in Compliance

European Union News

EU Commission Updates Standards List for ATEX Directive

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

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

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

The complete list of standards can be viewed at incompliancemag.com/1405_03.

EU Commission Expands REACH Test Methods

The Commission of the European Union (EU) has authorized additional test methods that can be used to assess the properties of materials under its regulations related to the registration, evaluation, authorization and restriction of chemicals (REACH).

Published in the *Official Journal of the European Union* in March 2014, Commission Regulation No. 260/2014 authorizes the use of 17 new and updated alternative test methods for demonstrating compliance with various requirements of the REACH regulation. The Regulation provides extensive details on each of the new and updated alternative test methods, updating and expanding the Annex to Regulation 440/2008, which originally defined the test methods that could be used under the REACH Regulation.

The new and updated alternative test methods published in Regulation 260/2014 for physico-chemical properties, toxicity and eco-toxicity were adopted in order to reduce the number of animals used for testing and experimental purposes.

The complete text of Commission Regulation 260/2014 is available at incompliancemag.com/1405_04.

EU Expands Restrictions on Use of Chromium VI

The Commission of the European Union (EU) has implemented further restrictions on the use of materials containing chromium VI under its regulations related to the registration, evaluation, authorization and restriction of chemicals (REACH).

Published in the *Official Journal of the European Union* in March 2014, Commission Regulation No. 301/2014 sets limits on the concentrations of chromium VI used in leather articles and articles containing leather that come into contact with the human skin. The new restriction becomes effective as of May 1, 2015.

The new restriction comes as a result of a scientific dossier submitted to the Commission by Denmark authorities that demonstrates that exposure to chromium VI contained in leather articles of leather parts of articles can pose a risk to human health when the materials come in contact with human skin. Specifically, the dossier indicates that such exposure can induce new cases of sensitization and elicit allergic reactions in humans.

The complete text of Commission Regulation 301/2014 on chromium VI is available at incompliancemag.com/1405_05.

EU Commission Releases 2013 RAPEX Summary Statistics on Unsafe Consumer Products

The Commission of the European Union (EU) has released statistics on notices of unsafe consumer products that have been processed through the EU's rapid information

News in Compliance

European Union News

system (RAPEX) for the year ending December 31, 2013.

According to the Commission's report, 2364 notifications of products posing a serious risk to health and safety were processed through the RAPEX system during 2013, the highest annual number of recorded notifications on record. The 2013 notification total represents a 22% increase over 2012's 1938 notifications, and a 52% increase over 2011's 1556 notifications.

In past years, the Commission has attributed increases in notifications to the "increased circulation of unsafe products," but also to "vigilant and proactive" efforts for enforcement authorities in EU Member States to protect consumer safety through the removal of unsafe products from the market.

Of the 2364 notifications of products processed through the RAPEX system during the year as presenting a serious risk to consumers, 583 (25%) were related to clothing, textiles and fashion items, with an additional 580 (25%) related to toys, and 207 (9%) related to electrical appliances. There were also 160 notifications related to motor vehicles (7%), and 68 notifications (3%) related to childcare articles and children's equipment.

Regarding the country of origin identified in connection with products posing a serious safety risk, almost two-thirds of all notifications (64%) were related to products originating from China, including Hong Kong. 12% of unsafe products originated in EU Member States, while 10% failed to identify any country of origin.

To view the complete text of the EU Commission's 2013 annual report on RAPEX statistics, go to incompliancemag.com/1405_06.

A colorful infographic depicting highlights from the year's data is available at incompliancemag.com/1405_07.

FDA News

Medical Device Recalls Double in Past Decade

The number of recalls of defective medical devices has nearly doubled within a ten year period, according to data compiled by the U.S. Food and Drug Administration (FDA).

As reported by the *Wall Street Journal*, there were a total of 1190 recalls related to unsafe medical devices in 2012, up from just 604 recalls in 2003. An even more dramatic increase was observed in so-called Class 1 recalls, related to unsafe medical devices associated with a reasonable probability of death. According to the *Journal* report, there were 57 Class 1 recalls in 2012, compared with just seven in 2003.

The FDA's analysis of medical device recall statistics was reportedly prompted by a 2011 investigation by the U.S. Government Accountability Office (GAO), which noted that recalls of unsafe medical devices often occur long after a device has been placed on the market, thereby exposing consumers to greater risks.

Steve Silverman, the director of the FDA medical device center's office of compliance, told the *Journal* that the increase in medical device recalls may be related to increased inspections by the agency, as well as additional educational outreach efforts that have raised greater awareness.

But a spokesperson for the medical device industry noted that medical device manufacturers are also taking a more proactive approach. According to Wand Moebius, a senior vice-president of AdvaMed, "the increase in recalls reflected in the data can be attributed primarily to companies taking a more cautions, pro-active, patient-centric approach to quality, safety and reports of events to FDA."

CPSC News

Solar Panels Recalled Due to Fire Hazard

Centex Homes, a Nevada real estate development partnership, has announced the recall of SolarSave-brand solar roof panels installed on about 240 homes.

Centex reports that the recalled solar panels may be the origination source of two separate fire incidents involving homes sold by the company. No one was injured in either fire. Centex has directly contacted those customers it believes are impacted by the recall and has installed new solar panels at no cost. It has announced the voluntary recall in an effort to reach home owners with qualifying solar energy systems that may not have been contacted.

The recalled solar panels were distributed by Burlingame Industries of Rialto, CA, doing business as Eagle Roofing Products. They were manufactured by Open Energy Corporation and Applied Solar, Inc. of Solana Beach, CA, which are no longer in business.

More information about this recall is available at incompliancemag.com/1405_08.

Ace Hardware Recalls LED Clamp Lights

Ace Hardware Corporation of Oak Brook, IL is recalling about 15,000 LED clamp lights manufactured in Indonesia.

According to the company, the cord bushing inside the light base of the clamp light unit could fail. Such a failure could allow the cord wiring to pull out of the base and expose bare wires, thereby exposing consumers to potential shock and fire hazards. Ace reports that it has received any reports of incidents or injuries related to the recalled clamp lights.

The LED clamp lights were sold at Ace Hardware retail stores and other hardware stores nationwide, as well as through AceHardware.com, from September 2013 through December 2013 for between $10 and $22.

Further details about this recall are available at incompliancemag.com/1405_09.

Lenovo Recalls ThinkPad Notebook Battery Packs

Lenovo, Inc. of Morrisville, NC has announced the recall of about 34,500 ThinkPad-brand notebook computer battery packs manufactured in China.

The company reports that the recalled battery packs can overheat, posting a fire and burn hazard to consumers. Lenovo says that it has received two reports of battery packs overheating, resulting in damage to a computer, its battery pack and nearby property. However, no reports of injuries have been received.

The recalled battery packs were sold at computer and electronics stores and authorized dealers nationwide, and at Lenovo.com, from October 2010 through April 2011 for between $350 and $3000 when sold as part of a ThinkPad notebook computer, and for between $80 and $150 when sold separately.

Additional information about this recall is available at incompliancemag.com/1405_10.

A recall has been issued for SolarSave-brand solar roof panels by Centex Homes. Ace Hardware is recalling 15,000 LED clamp lights, sold at retail stores and online. Lenovo is recalling 34,500 ThinkPad-brand notebook battery packs due to overheating.

REALITY Engineering

The Linoleum Press Job and the Meatball

A Cautionary Tale

BY MIKE VIOLETTE

It rolls out in acres and covers millions of square meters of the planet. It is shiny and it is matte, it is gaudy and it is sublime, it is cheap and it is expensive, it is laid in homes, offices and schools and on surface ships and submarines.

It has a fascinating history, made early-on from linseed oil and first conceived as a substitute for Indian rubber. According to Armstrong©, it is a 'green' material, "made from natural materials like linseed oil, recycled wood flour, cork dust and limestone."[1]

It is Linoleum.

How does this common stuff intersect with the world of electromagnetic interference? And who ponders such questions? Well, I do, and those that make the stuff know that a stray bolt or staple will ruin the intricate presses that mold and form the patterns in the flooring that covers offices, kitchens, bathrooms and battleships.

EMC is pretty cool because one gets to learn a little about a lot and an outing to Ben Franklin's city a few years ago informed me on a few things, namely: listen carefully to the customer, never assume anything and be careful what you order for lunch.

A couple of Januarys ago, we were called to a scruffy area of Philly, cruising early one morning from DC and found our client's building: a pre-World War II low-slung faded red brick industrial building with steel-framed windows that hadn't been washed since Kennedy was President. A slightly-sweet odor hung in the cold air. Equipment groaned from inside the building and steam spat from corroded ventilation pipes, swirling and dissipating against the cold clear blue sky.

The creaking factory that made the flooring was suffering from 'noise of uncertain origin' that was causing one of the manufacturing lines to shut down. We arrived early in the morning and were greeted by Sal Monachino, a third generation import from Sicily with a thick Philadelphia accent and strong arms the size of tree limbs bulging under a heavy open-collared denim work shirt. I was attired engineer-style, khakis, a wide curry-yellow tie (my *best*) and an off-the-shelf jacket as I've found that it's always better to be over-dressed than under-dressed seeing as it's easier to take off the tie than to wish you had one.

"You guys the noise guys?" he asked, sizing us up.

We nodded.

"Well, we hope you can help us out." He waved us to follow him into the factory. "Line three has been shut down for a couple of weeks and my bosses are pretty pissed-off."

We followed Sal down a maze of fading painted cinder block hallways. This was a working factory. Real stuff was made here, far removed from the high-tech corridors of the previous week's work. I am sure that we were wearing the only ties in the whole joint.

"You can put your stuff down in here." Sal turned the doorknob and swung open the door to a small conference room and hit the light switch; three out of the four fluorescent fixtures flickered on. There were five or six mis-matched chairs—also seemingly from the Kennedy era—arranged around a battered dark green Formica-covered table.

"I'll get the plant manager and a couple of other guys," Sal said. "Help yourself to the coffee over there." We put down

REALITY Engineering

our briefcases and walked to the coffee pot, which looked like it was washed about the same time as the windows, steaming with a thick stinky black liquid. There was a stack of small Styrofoam cups next to the coffee pot. I pulled two free and loaded them with dry creamer and a load of sugar, making it drinkable.

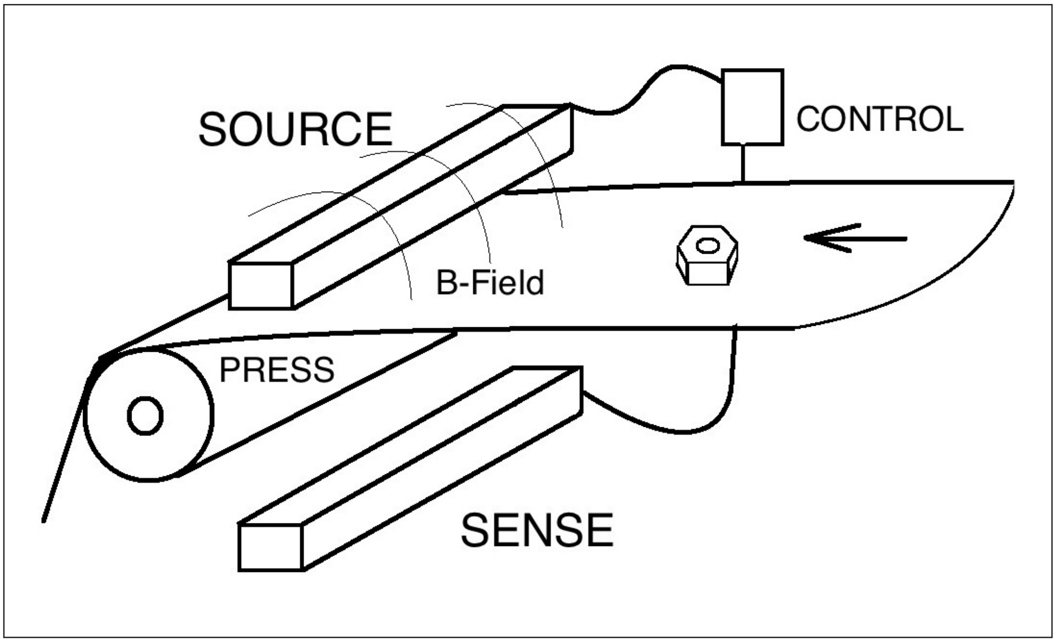


Figure 1: Sal's skectch

Sal came in a few minutes later with three other guys, less burly, obviously office-types and motioned for us to sit down. The tallest one had a nervous tic that caused his right eye to twitch.

"I'm Pat Megroin, plant manager." We shook hands and exchanged cards. We all sat down, Pat cleared his throat and started explaining his troubles.

"Line three has been down for the last couple of weeks and it's costing a lot in late orders, ticked off customers and frustrated owners." He paused, coughing slightly. "The line should be producing three thousand lineal feet per day, but we're barely getting five hundred. It keeps shutting itself down."

What's the symptom? we asked.

"The real trouble started about the time we installed a new crane in the area."

Sal nodded in agreement.

"You see, our product is printed, in a way, using a roll press that has been designed to form the patterns and colorize the product. These presses cost thousands of dollars. If something gets caught in the material, it can damage the surface of the press, so we have a magnetometer system to make sure no stray bolts or staples or what-have-you get into the production line."

Sal picked up the explanation and started sketching on a sheet of paper. "The magnetometer has a drive loop antenna, the 'source' and a receive or 'sense' antenna. If a piece of metal gets onto the sheet of material, the sense side detects the change in magnetic field and shuts the press down before the material can get wound up into the roll." Sal sketched something like Figure 1.

"The receive antenna has to be pretty sensitive because the line runs so quickly. Even a quarter-twenty nut can ruin a press and shut us down."

So what's with the crane? we asked.

Pat picked up the discussion. "The crane was part of a general overhaul on Line 3. The drive is electronic and we think it's spitting out a bunch of noise and getting into the magnetometer."

He looked down, shook his head slowly. "A quarter million dollars in that crane. My boss is about ready to throw it into the Schuylkill."

"Can you help us?" Pat asked.

We looked at each other and said we'd try.

"Great," Pat said. "We have a call with the owners at three p.m." Pat glanced at his watch, rose from his chair. "Hope you guys can figure this out."

Great, we thought, a whole six hours to fix this.

We unloaded the spectrum analyzer and cables and antennas and other gear from the station wagon and lugged it through the plant, past hissing spitting valves, oozing cauldrons of whitish goo, under and around plumbing and wire races. Sal yelled over the din: "This is line 2. It's working great, you can see. Here's the press." Spinning rolls of material were squeezed under pressure as yards and yards of material looped through the line.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Line 3 lay ahead and as much as Line 2 was alive, Line 3 was dead. Material hung like shrouds, loose and limp. Covers were off a dozen inspection points.

Sal showed us the main press. The shiny stainless steel cylinder had an intricately-etched pattern in it. "This is our biggest seller. The DIY guys buy miles and miles of this stuff." He paused, adding, "When we can make it…"

"This is the magnetic sensor." Sal banged on a long box ran along the width of the material. A similar box ran underneath. "The loops are in each of these boxes and are connected to the driver and receiver over there." He pointed to a gray NEMA enclosure bolted to a column. A couple of black coax cables ran from the long boxes, under and into the enclosure.

Figure 2

"The frickin' crane is there." He pointed overhead. A gleaming yellow I-beam was hung on tracks. The trolley was positioned in the middle, a loop of cables connected it to the runways that were bolted to the sides of the building.

"All of the electronics are inside the trolley. Ever since we had that thing installed, this line hasn't run right." Sal harrumphed. "Piece of *&%#," he added for emphasis.

We unpacked our gear and set things up. We would take a look at the radiated spectrum, just to get a feel for what was happening. We asked if we could run Line 3. He shook his head. "It'll take hours to get her going and the bosses need an answer today."

We shrugged our shoulders and looked at each other. Sal then brought over a tall smiling guy in work overalls with 'Victor' stitched above his breast pocket. "Call me Vic!" he said, pumping our hands. "Whatever youse need, lemme know!"

We asked Vic to start to move the trolley. He picked up the pendant. "Youse want the bridge, the trolley or the lift?"

Bridge first. Vic nodded and punched the button. The bridge started up, moving smartly along the rails. The analyzer display jumped. The new bridge employed solid-state drivers, new-at-the-time IGBT devices with wicked-fast slew rates and noise spectra that impressed.

We tried some stuff. We climbed the crane. We snapped on ferrites we had on any wire we could think of, we tried some shielding and grounding, this noise fay just laughed. Nothing made any difference; if the crane drive really was the problem, a field retrofit wasn't going to do much anyway.

It's hard to walk away from a nettlesome problem, a bastard thing that defies a solution. But we kept looking, tried and abandoned reasoning and mostly kept guessing, but with no great reveal.

Lunchtime came very quickly and we re-assembled in the conference room. Sal was surly. "Nothing yet, *consultants*?" We shrugged, gave him a quick rundown of what we found—rather what we didn't find. Sal softened a little. "Hell, let's go to lunch. It's Mary's twentieth year at the plant, so I want to take her, too." He winked at me. "Someplace classy. I'll go get her."

We bundled up and left the plant, our breath icing in the air as we trod three blocks to *Manny's Steak and Shake*, a dive that as Sal told it "fed my father and my father's father when they worked at the plant." The place held about twelve tables, faded candy-apply red with vinyl-cushioned chrome-framed seats that squeaked as we sat down.

The waitress came over to the table. She looked to be in her early fifties, a sizable gal with a big smile, fake-black hair and a big bosom. She gave Sal a hug. He beamed, clearly enjoying her… suppleness.

"Hello gorgeous," he crooned.

"Hello handsome. The usual?"

"Yeah, Marge, the special." He looked at us. "If it's Tuesday, it's meatloaf."

"Sure, honey. And the rest of you guys?" she polled.

Pat took the fried chicken, Mary the fruit plate (cantaloupe, strawberries and cottage cheese). The meatball sub looked good to me.

Meatball sub: what not to order with a first-time client. It came on a large oval plate with a heap of crinkly fries that glistened with oil. Marge laid it in front of me. "Enjoy, sweetie, specialty of the house." The sub lay splayed open, four large meatballs slathered in tomato sauce, rich mozzarella oozed from the roll. The edges of the roll lightly toasted.

Sal dug into the meatloaf, Mary toyed with her cottage cheese and I picked up the long sandwich, trying to negotiate a bite. I over-reached and the end-meatball, dripping with marinara, popped loosed and *blip* landed square on my chest. Sal burst out laughing. "So much for your fancy yellow tie!"

Next time I'll have a salad, I told myself, daubing a wet napkin on the spreading red blotch. I removed the stained garment and rolled it up into my pocket. We finished lunch and walked back to the plant, three p.m. coming quickly upon us.

At some point it becomes *pointless* to try to make measurements and it's important to talk with and listen to the client. Maybe we were over-looking something. We asked 'when the crane was put in, what *else* was done to the line?'

Sal replied, "Um, we did PM on the line, changed a bunch of belts, lubed the bearings on the big drive, right Vic?"

Vic replied. "And calibrated the magnetometer."

Can we have a look at that? we asked.

Sal shrugged. "Sure." We wandered over to the NEMA enclosure. The device was pretty simple: a circuit board, a couple of transformers and some RF circuitry. A pair of BNC connectors were mounted on a bulkhead, marked "IN" and "OUT".

"The drive signal goes to one loop from the OUT." He pointed at a red

I picked up the long sandwich, trying to negotiate a bite. I over-reached and the end-meatball, dripping with marinara, popped loosed and *blip* landed square on my chest. Sal burst out laughing. "So much for your fancy yellow tie!"

connector. "The received signal comes into here." He tapped a blue connector. Red out, blue in. We asked to see the business end of the system, the loop antennas. For this, we lay down and squirmed up under the line. I was the junior guy (not so much now) so it was my job to scrunch under. Sal handed me a flashlight mumbling, "Not sure what you're looking for…"

I wasn't so sure myself.

The two coax cables ran alongside each other. I followed the wiring to a bulkhead and looked at the connections.

"Red in, right? Blue out?" I shouted back at Sal.

Sal replied, "Yeah, that's right."

Nope.

The in and the out were reversed, so the multiple-turn loop, the *source*, was connected to the sense input, the many turns of wiring greatly amplifying any stray noise that may be in the area.

Sal was nonplussed. "Holy cr*p. When the guys calibrated this thing, they put

it back together backwards!" He shook his head and mumbled, "Geez. Wasn't the crane after all."

Indeed, the crane was vindicated. I flipped the connectors, the conference call went off with the good news that Line 3 was back up and the guys with the jackets and one tomato-spattered tie were done headed home.

Sometimes, "EMI problems" don't require ferrites, shielding or grounding to resolve, but listening to the client and having a bit of fortuity.

Just sometimes, as my pop used to say, "It doesn't matter if you're lucky or skillful, as long as you're effective." IN

NOTE

1. http://www.armstrong.com/flooring/products/linoleum

(the author)

MIKE VIOLETTE
is founder of Washington Labs and American Certification Body and he never bought another yellow tie. He can be reached at mikev@wll.com.

TECHNICALLY Speaking

Behavior of Air and Solid Insulations in Series

Product Safety Newsletter - August 1988

BY RICHARD NUTE

Dear Readers,

Over the past couple of years many of you have requested that we include more product safety related information in our issues. Of particular interest has been Rich Nute's series of "Technically Speaking" articles. And so… Mr. Nute has graciously agreed to work with us to bring you that series! Look for his column each month. We hope you enjoy the addition of "Technically Speaking" to the pages of In Compliance*.*

In the column "Ask Dr. Z," (*The Product Safety Society Newsletter*, July 1988[1]) Dr. Z made the statement that "the failure was probably due to rubbing between the wire and the ground trace which scoured the coating to a thin enough layer to fail the dielectric strength test." Probably not.

Recall the situation: A common-mode inductor in a power supply was resting on a ground conductor of a printed wiring board. The only insulation between the inductor and the ground conductor was that of the coating on the inductor wire.

The insulation system had failed a 1500 Volt rms electric strength test. Dr. Z and his client presumed that the solid insulation -- the coating on the inductor wire -- had been scoured so that there was little or no insulation between the inductor and the ground conductor.

Dr. Z implied that many power supplies (or, at least those submitted to several certification houses) successfully passed the electric strength (hi-pot) test. How this could happen with the construction as described? That is, why did not more units incur the scouring and the reduced insulation thickness? Why did the first failure not occur until early production and AFTER completion of certification?

Have you ever tried to strip coating from magnet wire? It is tough stuff! One spec I checked is 1350 grams to fail a single scrape. Have you ever checked the electric strength spec for magnet wire? Typically, they are very much higher than product hi-pot voltages (2400 Volts rms or more for AWG 38 up to 7000 Volts or more for AWG 18). So, we have a mechanically tough coating which, even if it could be scoured, would still have a very high electric strength.

I don't agree with Dr. Z's hypothesis that the coating failed because it was scoured thin by rubbing of the insulation against the circuit board. I believe there is another and more satisfying explanation (hypothesis) for the hi-pot failure.

Here is my hypothesis: More likely, the inductor insulation was intact, and the air broke down -- between the ground trace and the inductor insulation. The heat in the arc then burned the inductor (magnet wire) insulation.

I suggest that, in those situations where the magnet wire is in intimate contact with the ground, there is no breakdown. Similarly, if there is an air gap exceeding 1 millimeter, there is no breakdown. But, if there is an air gap of less than 1 millimeter between the magnet wire and the ground, then the air gap will breakdown!

This is certainly a curious hypothesis: The system only breaks down if there is an air gap, and then only if the air gap is less than 1 millimeter. And, it does so without regard to the electric strength of the coating on the magnet wire!

How can this be? On the surface, this does not seem rational.

CONDITIONS FOR DIELECTRIC OR INSULATION FAILURE

First, we need to identify the conditions for dielectric or insulation failure. Dielectric or insulation failure occurs when the applied volts/mm between conductors exceeds the withstand volts/mm of the dielectric or insulating medium between those conductors. For example, Table AI of IEC 664 gives voltage withstand values for various distances through air (an insulating medium). We find that air has an electric strength of about 1000 volts/mm for distances up to about 1 mm, decreasing to about 500 volts/mm at 10 mm.

On the other hand, Table AII of IEC 664 gives voltage breakdown values for various distances through air. We find that air breaks down at about 1250 volts/mm for distances up to about 1 mm, decreasing to about 620 volts/mm at 10 mm.

In between Tables AI and AII we have a sort of "no man's land." That is, we have a region where other factors such as electrode shape variation, air pressure variation, pre-ionization, etc., influence the actual withstand and breakdown voltages.

Solid insulation behaves exactly the same way. Except that the withstand

TECHNICALLY Speaking

Let us examine the behavior of two different insulating media in series. Two conductors separated by an insulating medium constitute a capacitor. Two insulators in series behave as two capacitors in series.

volts/mm is different for each material, and is always many times greater than the withstand volts/mm for air.

Therefore, one condition for insulation failure occurs when the applied volts/mm exceeds the withstand volts/mm of the insulation medium. See Figures 1a and 1b.

More specifically, a condition for insulation failure occurs when the INCREMENTAL applied volts/mm exceeds the INCREMENTAL withstand volts/mm of the insulating medium. That is, the applied volts/mm may not be uniform throughout the insulating medium.

INSULATION IN SERIES

Next, let us examine the behavior of two different insulating media in series. Two conductors separated by an insulating medium constitute a capacitor. Two insulators in series behave as two capacitors in series. This is true even though no conductor exists at the interface of the two insulating media because the dielectric media hold the charge, not the conductive plates of the capacitor.

When two capacitors are in series, voltage divides inversely proportional to the capacitance. That is, the smaller capacitor has the larger voltage drop across it.

With this physical law in mind, if we know the value of the two capacitors, we can determine how much voltage is dropped across each capacitor, and whether the volts/mm exceeds the breakdown value for each insulating medium.

Capacitance is directly proportional to the dielectric constant of the insulating medium. The dielectric constant of air is 1. The dielectric constants of solid insulating media are usually several times that of air. So, the greater the value of dielectric constant, the greater the value of capacitance. In general, given the same area and distance between conductors, the use of a solid

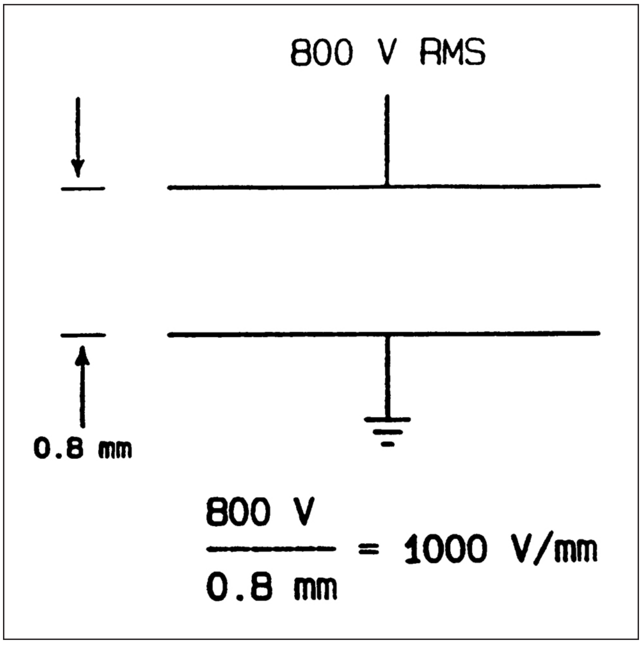

Figure 1a: Since 1000 V/mm is the same as the maximum withstand potential for air, this spacing will not breakdown.

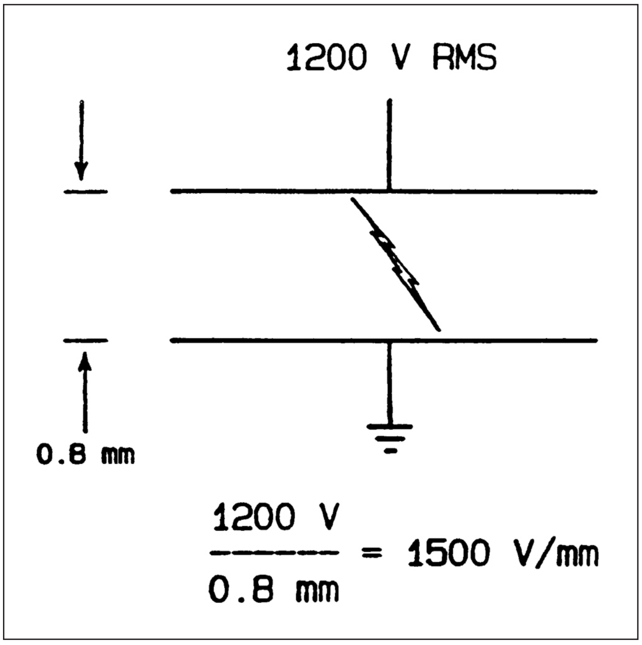

Figure 1b: Since 1500 V/mm exceeds the 1250 V/mm breakdown potential for air, this spacing breaks down.


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TECHNICALLY Speaking

In any construction where two insulations are in series, the voltage gradient between conductors is not likely to be linear.

insulation results in capacitance several times the value with air insulation.

Capacitance is inversely proportional to the distance between the conductors.

Given two insulators in series, and therefore two capacitors in series, the voltage across each insulation is inversely proportional to the dielectric constant, and directly proportional to the thickness of each insulator.

Now consider the insulation system Dr. Z was dealing with: a series system comprised of a very thin, high dielectric constant solid insulation (the magnet wire), and a relatively thick, low dielectric constant air insulation.

The very thin, high dielectric constant has relatively little voltage across it, while the thick, low dielectric constant air has most of the voltage across it!

Now, we need only determine whether the volts/mm in air exceeds the breakdown voltage for air. (We can ignore the solid insulation as its withstand voltage exceeds the test voltage.)

Next, some equations:

$$C = k\frac{A}{d}$$

Where
C is Capacitance,
k is the dielectric constant,
A is the area of the plates, and
d is the distance between the plates.

For two capacitors in series, we will assume that the area, A, of the plates is the same.

The voltage across anyone insulation within the capacitor is:

$$V = \frac{d}{k}$$

The total voltage is the sum of the voltages across each individual insulation. The percent voltage across the air in a series construction of air and solid insulation is:

$$\%V = \frac{\frac{d_{air}}{1}}{\frac{d_{solid}}{k}} + 100\frac{d_{air}}{1}$$

The voltage distribution of a series construction of air and solid insulation for various values of dielectric constant, k, are shown in Figure 2.

In a series system of air and solid insulations, and where the dielectric constant of the solid insulation is quite high, it may be necessary to also meet minimum spacing requirements in air to prevent exceeding the breakdown potential of air.

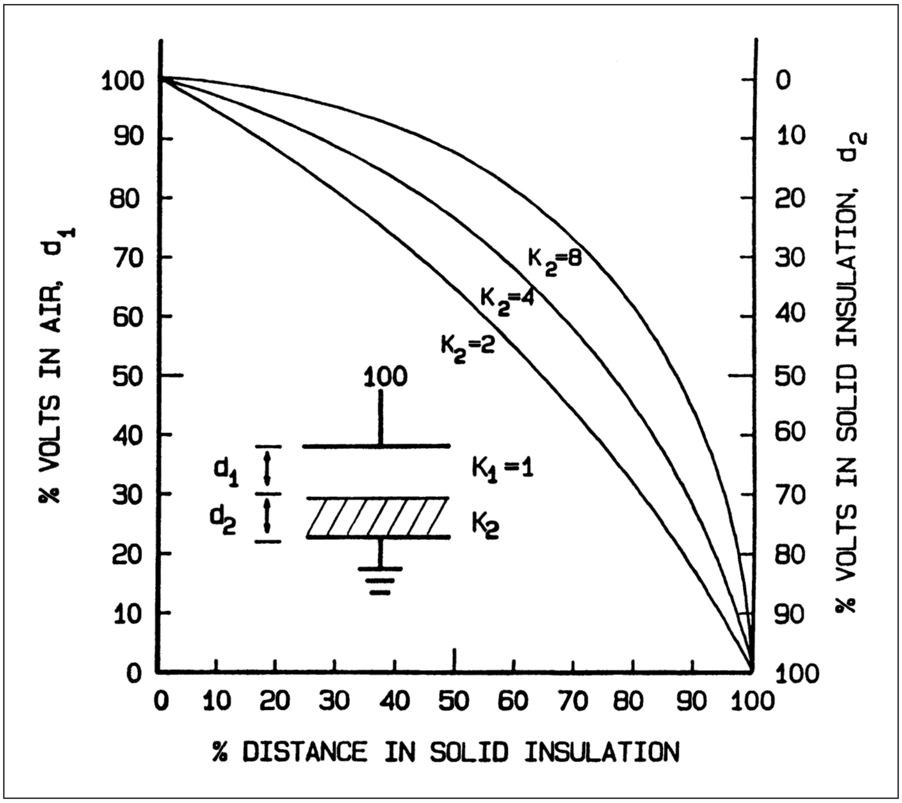

Figure 2: Voltage distribution: air and solid insulation in series

CAPACITANCE

One final factor needs to be considered: the value of capacitance. Conduction in a gas has four distinct forms: corona, glow discharge, spark, and arc. IEC 664 states:

"One form may give place to another in quick succession depending on attendant conditions. Arc formation depends upon the presence of an electric field which tends to strip electrons from the positively charged nuclei of the atoms of the gas between the electrodes. Under the right conditions, these electrons collide with other electrons and release them from their atomic bonds in a cascading fashion. The net result is a flow of electrons, i.e., electric current and arc discharge."

Note the condition of electric current. The magnitude of the current is a function of the value of capacitance. If the capacitance is very small, the current magnitude will be very small, and the succession of forms of conduction (corona, glow discharge, spark, and arc), will be limited such that a full breakdown as evidenced by an arc may not occur.

Therefore, for this process to occur, capacitance of the solid portion of the air-solid insulation system must be large enough to provide the current necessary to sustain an arc.

Fortunately, in most constructions, the value of capacitance is so small as to limit conduction in a gas to corona during the hi-pot test.

CONCLUSION

Don't ask Dr. Z.

In any construction where two insulations are in series, the voltage gradient between conductors is not likely to be linear. Care must be taken such that voltage gradients (volts/mm) do not exceed the breakdown values for each insulation. This is especially true where one insulation is air and the distance in air is less than the distance needed for air alone (as was the case for Dr. Z's client).

Obviously, in this case we don't know whether or not the insulation was scoured or the air was subject to breakdown conditions. But, Dr. Z's example gave me a good excuse to describe a phenomenon that I have experienced on many occasions. Perhaps you, too, have had this experience; if so, I hope this explanation fits the facts of your situation. IN

REFERENCE

1. http://ewh.ieee.org/soc/pses/Downloads/newsletters/88v01n6.pdf

(the author)

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

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

MR. Static

Charges Are Forever

BY NIELS JONASSEN, sponsored by the ESD Association

In 1795, Charles-Augustin de Coulomb observed that an insulated charged body exposed to atmospheric air would gradually lose its charge.

INTRODUCTION

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

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

~ The ESD Association

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Compliance Engineering Magazine,
Mr. Static Column

But because his contemporaries did not appreciate the importance of his observation, another hundred years passed before it was realized, with the discovery of atmospheric ions, that atmospheric air has a certain conductivity.

Although Coulomb's observation was very important, his formulation was wrong. In fact, charges don't disappear. Like Ian Fleming's diamonds, they are forever. Once you've placed a charge on a body, there's no way you can remove it again.

Admittedly, I have, for the sake of the argument, made this statement slightly too strong. There is one exception: If you have a conductor, negatively charged, and the conductor is connected to ground by a metallic wire, then the excess of electrons will bleed away through the wire. But that's the only exception.

In all other cases, what we call electrostatic decay or discharge, where charges seem to disappear from a charged body, are processes where charge carriers with opposite charges are attracted through the surrounding medium.

EXAMPLES

Let's clarify this complex explanation by looking at an example in more detail. Suppose you have a positively charged plastic box. This means that, one way or another, you have removed electrons from some of the molecules on the surface of the box. We assume that the box is made of an insulative material and that, consequently, no charge-movement is possible along the surface or through the bulk of the box material. If now the surrounding medium—normally air—contains ions, the negative ones will be attracted to the box and plate out on the surface as long as there is a net field directed away from the surface.

But what happens to the ions once they have plated out on the surface? Well, we don't know. First of all, it's rather unlikely that each ion lands directly on top of a molecule that has lost one or more electrons. And even if it does, why should the electronegative oxygen molecule in the core of the negative ion cluster give up its extra electron to the apparently electropositive plastic molecule of the box material?

But let me describe a little experiment that demonstrates my point. In Figure 1 is shown a sheet of plastic

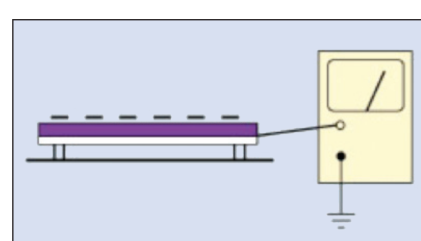


Figure 1: A plastic sheet placed on an insulated metal plate is connected to an electrometer in charge-measuring mode.

placed on an insulated metal plate connected to an electrometer in the charge-measuring mode. The plastic was charged negatively by being rubbed by my remaining piece of Kratzenstein's cat (see "Ben Was Not Alone," *Compliance Engineering*, January/February 1998). The sheet was placed on the metal plate with the charged side in contact with the metal; a total charge of -4.5×10^{-7} C was read on the electrometer. (The negative signs of the charges are shown on the top of the plastic to make the figure clearer, but it actually doesn't matter.) After 24 hours the sheet was removed from the metal plate, and the charge was remeasured to -4.4×10^{-7} C.

Here was a plastic surface where a number of molecules had received one or more extra electrons, in close contact with a metal in which electrons are (almost) free to move, and still hardly any of the charged molecules had been neutralized. The electrons were not able to cross the border between the plastic and the metal, even over a prolonged period. What little neutralization that did happen was probably due to positive air ions plating out on the back side of the plastic.

But let's carry a similar experiment a little further. In Figure 2 is shown a sheet of plastic, again charged to a total of -4.5×10^{-7} C. (In this and the following experiments, the charge on the plastic sheets was measured by lowering the sheets in a Faraday pail connected to an electrometer in the charge-measuring mode.

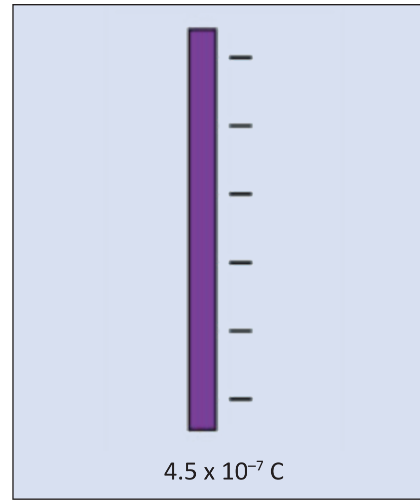


Figure 2: A sheet of plastic negatively charged.

MR. Static

When the plastic sheet is brought near a sharp corona electrode connected to an electrometer, as shown in Figure 3, the electrometer displays a charge of -3.7×10^{-7} C and the plastic, a remaining charge of -0.8×10^{-7} C. It thus appears as though a charge has been transferred from the plastic to the electrometer.

But this is only an illusion. What happens is that the charge on the plastic creates a field at the corona electrode exceeding the breakdown field strength, and ionization takes place in the immediate vicinity of the electrode. Thus, positive and negative ions are formed in equal numbers, and negative ions are moved in the field to the electrode, where they are being neutralized and are charging the electrometer. Positive ions are moved to the plastic, where they plate out and partly neutralize the field from the negative charge. This process stops when the field from the net charge on the plastic at the tip of the corona electrode is too low to cause ionization.

In order to show that this is what happens, the experiment just described was repeated in a slightly different manner. In Figure 4 is shown again a sheet of plastic charged to -4.5×10^{-7} C. In front of this charged sheet is a similar sheet of uncharged plastic. After the two sheets are moved toward a corona electrode connected to an electrometer, the negatively charged sheet still shows the original charge, -4.5×10^{-7} C.

The electrometer has received a charge of -2.7×10^{-7} C (Figure 5), but obviously not from the negatively charged sheet, since it kept its original charge. The uncharged sheet now carries a positive charge of 2.6×10^{-7} C. Therefore, the field at the corona electrode, caused by the negatively charged sheet, has created negative and positive ions moving in opposite directions.
If the originally uncharged sheet had not been present, the positive ions would have moved to the negative sheet, reducing its total charge. And since the electrometer received a negative charge close to what is "missing" on the negative sheet, we might have concluded, that (negative) charges were being transferred from the negative sheet to the electrometer.

Obviously, this would be a wrong conclusion. The neutral sheet and the electrometer simply shared the negative and positive ions formed in the air.

The process described above is typical for all processes where an apparent loss of charge is connected with an ionization process, i.e., a process where the charge distribution creates high-enough fields to create mobile charge carriers—ions. In many cases such a process stops before total neutralization

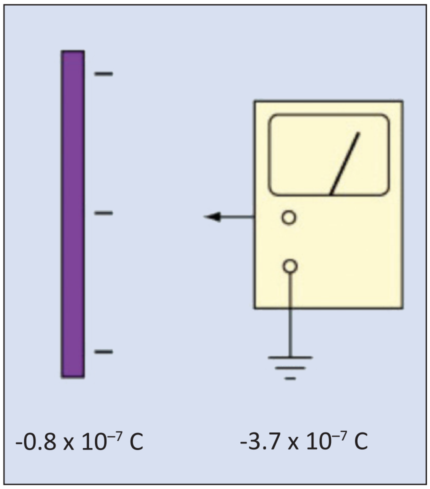


Figure 3: The plastic sheet is placed near a sharp corona electrode, ultimately causing ionization to occur in the electrode's immediate vicinity.

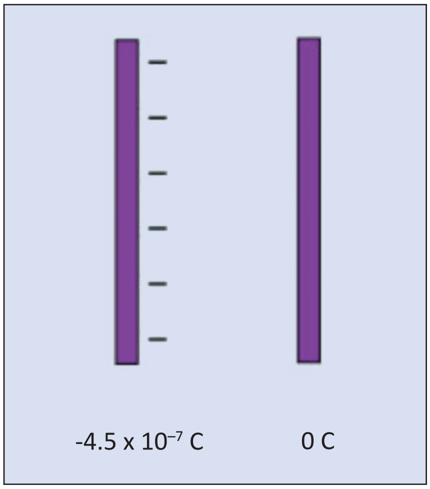


Figure 4: A charged plastic sheet placed behind an uncharged one and moved toward the corona electrode retains its charge.

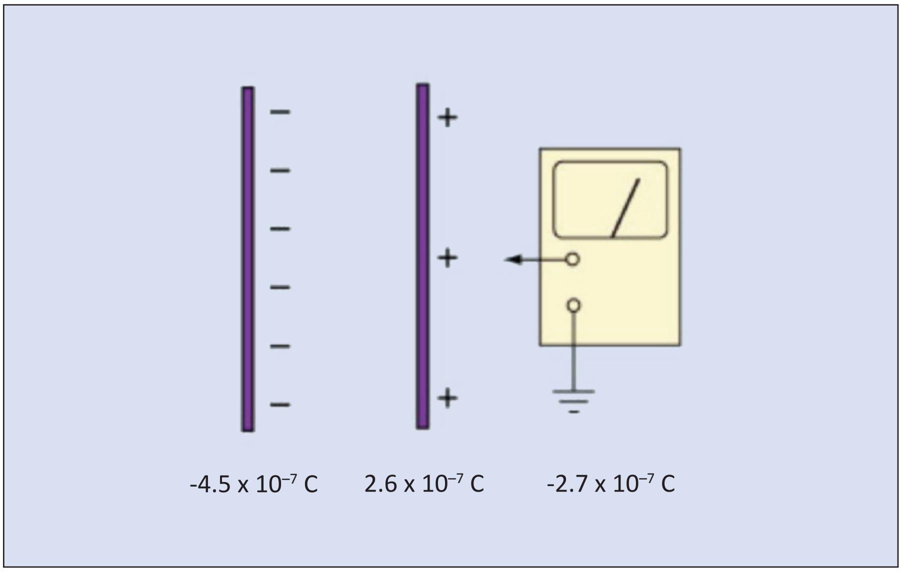


Figure 5: The uncharged sheet (Figure 4) now carries a positive charge.

has taken place, because the field strength becomes too low.

It is a different situation if the medium surrounding the charge already contains mobile charge carriers, i.e., if it has a certain conductivity. This could be, for instance, a surface treated with an antistatic agent, i.e., a material containing positive and negative electrolytic ions. If a part of the surface is, say, positively charged, the field from the charge will attract negative ions from the surface layer to neutralize the field from the positive charge, and in this case the neutralization may be almost total.

But again, the charge itself does not move. All that happens is that the field changes and maybe becomes zero.

CONCLUSION

Charges (normally) don't disappear from a charged body. But they may appear to do so. All that actually happens, however, is that the field from oppositely charged charge carriers is superimposing the field from the original charges. What the originally charged molecules do when the oppositely charged carriers arrive (because of their mutual attraction), we don't know.

I leave you with this: Isn't it fascinating that a Teflon molecular structure, which once, perhaps accidentally, was impregnated with a few extra electrons, may never again attain its original, virginal state? IN

(the author)

NIELS JONASSEN, MSC, DSC,

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

EMC Education

The View from the Chalkboard

BY MARK STEFFKA

I heard a statement recently that I think is very true. It said: "We use classrooms designed in the 19th century and then assign 20th century instructors to teach 21st century students."

As a result, for this edition of *View from the Chalkboard* I have decided to talk about some of the various methods we (the University of Michigan – Dearborn) have discovered to utilize today's technology (specifically the capabilities of audio and video resources on the internet) that can be utilized to develop effective and efficient methods to enhance the learning of EMC.

I believe these techniques can especially be useful for those universities that perhaps only periodically have courses on EMC, and the many that have no formal lab facilities available at all. Use of the internet's features can also provide insight into the various complex phenomena that are involved in EMC that many times otherwise would rely on students' own visualization abilities. I have seen that when I have discussed many of the complex aspects of physics, mathematics, and engineering, students more easily understand and are more interested by viewing videos and animations of these concepts.

At the University of Michigan – Dearborn, the undergraduate course (ECE 319) is an introduction to EMC and has both "lecture" and "lab" components. I am fortunate in that I can focus on the "lecture" aspect of the course and I have a talented lab instructor (who is a former EMC student of mine) Chris Semanson, who also shares my belief that the internet's resources can be very useful and powerful to assist our teaching of EMC. So what follows are Chris' words and it is our intention that in addition to helping you, this will also start a discussion of other resources that perhaps you have been successfully using.

USING YOUTUBE AND SIMULATION TO ENHANCE STUDENTS' EMC LEARNING

Chris Semanson
University of Michigan – Dearborn

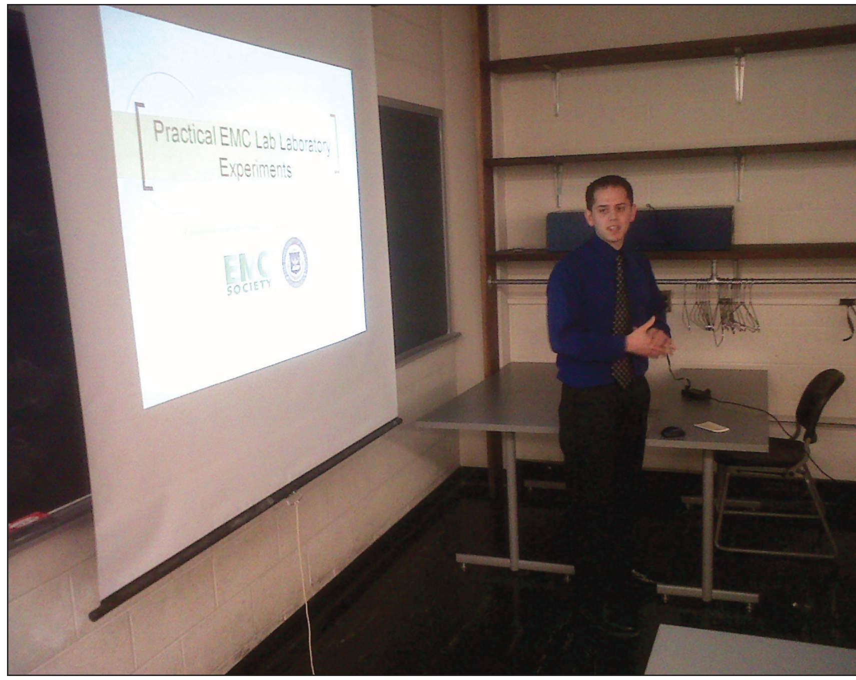


photo by Scott Lytle

Until recently universities and other educational endeavors required expensive capital lab investments in their undergraduate laboratories to be able to demonstrate state of the art concepts in Electrical and Computer Engineering. Traditionally not having access to equipment such as antennas and spectrum analyzers, lectures run the risk of limiting the professor to explain a difficult concept but be unable to live-demonstrate core engineering concepts such as measurement techniques, unintended emissions, or electromagnetic interference.

And while traditionally this was accepted there are now services, such as YouTube, that allow professors and enthusiasts to pool their creative talents to demonstrate and show these otherwise difficult to demonstrate and visualize concepts. In addition to YouTube, simulation software easily allows a professor and student to demonstrate, reliably, complex electromagnetic interactions helping to visualize difficult concepts. These examples make it evident that purely lecturing on a concept without relating it to a real world demonstration will soon become a thing of the past.

Together, videos like the ones contained in this article allow an instructor access to a wide variety of videos and demonstrations that, when used effectively, reinforce the lecture topic. One example of such a video, demonstrated with a tube amplifier, is shown below:

- http://goo.gl/m0zFRn

EMC Education

These examples are by no means exhaustive, but they're meant as a starting point if you're interested in combining existing material on electromagnetic compatibility, with real world experiments and demonstrations in any educational setting from undergraduate to experienced engineers.

photo by Scott Lytle

In one, less than two minute video, important concepts such as grounding, shielding, common mode currents, and the human body as an antenna were demonstrated in a clear concise manor. Additionally, precompliance and measurement techniques can be covered as demonstrated as shown in these YouTube videos using popular equipment:

- http://goo.gl/k8fImD
- http://goo.gl/PHNhg6

In this demonstration the Engineer is showing how to do some simple precompliance measurements, and showing the usage of a near field probe something that is generally not taught in an undergraduate curriculum. And finally, in a rather imaginative fashion, this video shows how an Arduino project, accidentally, turned into a music player via radiated emissions:

- http://goo.gl/K8hmgN

These examples are by no means exhaustive, but they're meant as a starting point if you're interested in combining existing material on electromagnetic compatibility, with real world experiments and demonstrations in any educational setting from undergraduate to experienced engineers.

Hopefully this month's discussion has helped you with some of the resources that may exist to assist with your work in teaching EMC (in either an academic or in house industry settings). If you would like to know more or if you have suggestions for various internet resources that you have used and would like to share with others – please feel free to contact us!

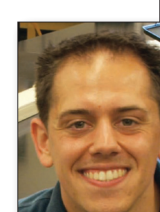
(the authors)

MARK STEFFKA, B.S.E., M.S.

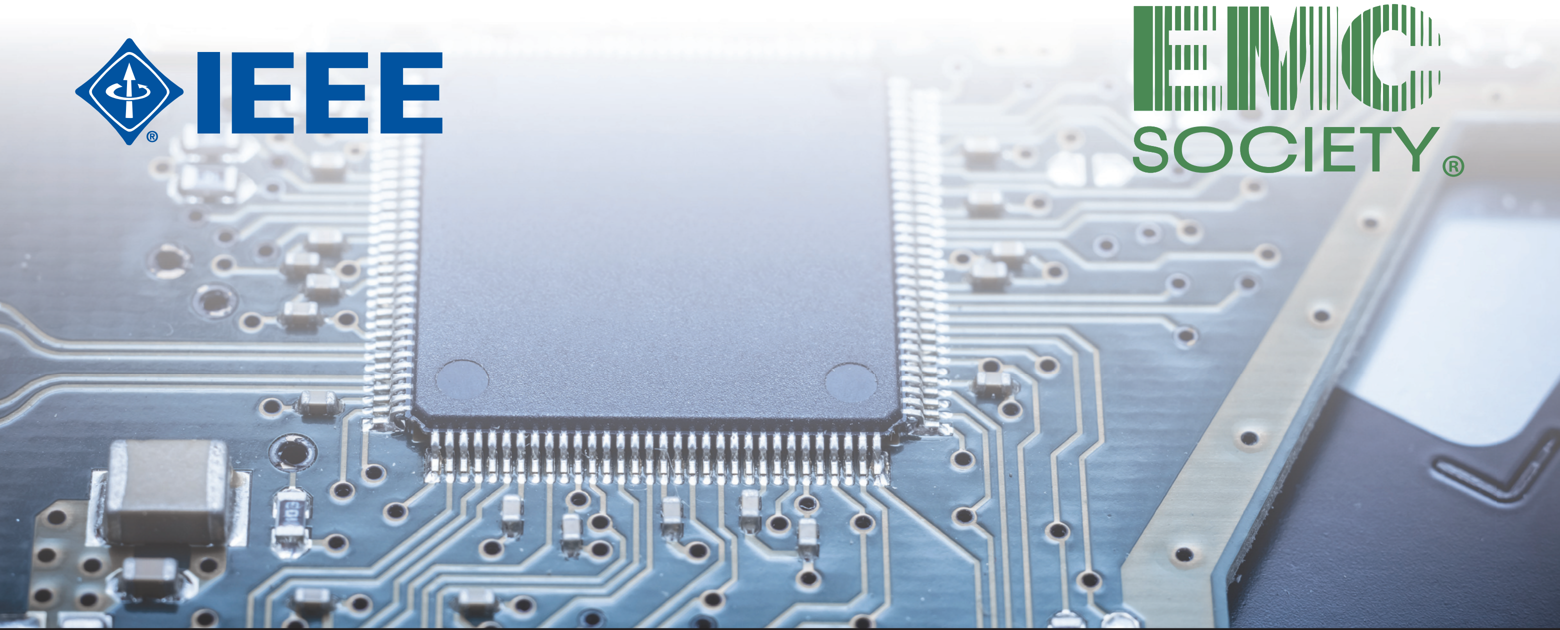
is a Lecturer (at the University of Michigan – Dearborn), an Adjunct Professor (at the University of Detroit – Mercy) and an automotive company Electromagnetic Compatibility (EMC) Technical Specialist. His university experience includes teaching undergraduate, graduate, and professional development courses on EMC, antennas, and electronic communications. His extensive industry background consists of over 30 years' experience with military and aerospace communications, industrial electronics, and automotive systems.

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

CHRIS SEMANSON



Chris currently works at Ford Motor Company in the Powertrain Controls group doing Embedded Controls where part of his job is to focus on modeling and simulation. In addition he works at University Of Michigan – Dearborn as the Lab instructor for the Electromagnetic Compatibility class that Professor Mark Steffka teaches. These labs are based on a series of experiments originally designed by IEEE's EMC Society. In addition to the EMC class, he also teaches digital signal processing and guest lectures in analog and digital communications which is also taught by Mark Steffka. His degrees are from the University Of Michigan – Dearborn.



2014 Student EMC Hardware Design Competition

The IEEE EMC Society is pleased to announce the 2014 Student EMC Hardware Design Competition, administered by its Educational and Student Activities Committee (ESAC). The objective of the competition is to provide students interested in the field of EMC a hands-on opportunity to apply their knowledge.

The competitors are required to design a step-down (12 V to 5V) switch-mode power supply. An unpopulated PCB board, board schematic and a driver IC will be provided by the Student Design Competition Chair after reception of the Entry Form.

The winning team will receive a prize of $900 as well as the cost of attendance for one team member to the 2014 IEEE International Symposium on EMC held in Raleigh, NC, August 3-8.

The second-place team will receive a prize of $500.

For more information scan the QR code with your smart phone device or visit us at **emcs.org/committees/education/design_competition**

The competition is open to college-level teams both at the undergraduate and graduate level.


SRC
MAIN

A Challenge of Portable Radio Transmitters Used in Close Proximity

BY JOHN MAAS

Intentional RF transmitting devices seem to be everywhere. Smart phones, tablets and similar devices provide the ability for users to be connected to the internet any time, from any location using nearly any device.

Other than the Boundary Waters Canoe Area Wilderness and the inner canyon of the Grand Canyon, it may be difficult to find any location without WiFi available. RFID tags and transponders are used for inventory in retail stores, monitoring the location of equipment of all kinds and tracking patients in medical settings. We even see active RFID tags imbedded in electronic equipment undergoing EMC testing. (The experienced EMC professional can probably imagine the challenge this practice creates during an RF emission test!)

A sampling of transmission systems is shown in Table 1.

No doubt, the great expansion of this technology has improved society in many ways. The benefits of these devices are quite significant. An unintended side effect of the proliferation of transmitting devices, however, is the increased potential for malfunctions of electronic equipment in operation close to where the transmitters are used. Not only are more transmitting devices in use in all environments, the separation between any given transmitter and equipment that may be affected is generally decreasing. The separation distance is often uncontrolled with separations of a

Transmission System	Frequency Range	Typical RF Power	Access Technique/ Modulation
TETRA/TETRAPOL	380 to 676 MHz (not continuous)	10 W (RMS)	TDMA, FDMA, DQPSK
GSM	824 to 1901 MHz (not continuous)	1 or 2 W	AM, PSK
DECT	1.88 to 1.9 GHz	250 mW	GMSK
UMTS	1.92 to 1.98 GHz	250 mW	QPSK
WLAN	2.4 to 2.835 GHz 5.15 to 5.725 GHz	100 mW 1 W	OFDM
Bluetooth	2.4 to 2.4835 GHz	100 mW	FHSS
LTE	790 to 862 MHz 2.5 to 2.69 GHz		OFDMA, SC-FDMA

Table 1: A sampling of transmission systems

The types of equipment that may be adversely affected is nearly endless, including desk-top computers, point-of-sale terminals, gas pumps, vehicle control systems, computer systems and other portable electronics, to name just a very few.

few centimeters not being uncommon. Contrast this proximity with the several meters or more of separation typical in the days before the use of portable devices with transmitters became so prevalent.

The types of equipment that may be adversely affected is nearly endless, including desk-top computers, point-of-sale terminals, gas pumps, vehicle control systems, computer systems and other portable electronics, to name just a very few.

This new-world reality creates some interesting challenges and opportunities for EMC professionals. What are the devices we must consider as sources of interference? What devices need to be hardened against new or changing interferences? How do we determine adequate immunity levels? Are existing test methods and standards sufficient? If not, are wholesale modifications required, or can existing standards be used with some (minor?) modifications? Which characteristics of the transmitted signals are important to the evaluation of disturbance potential?

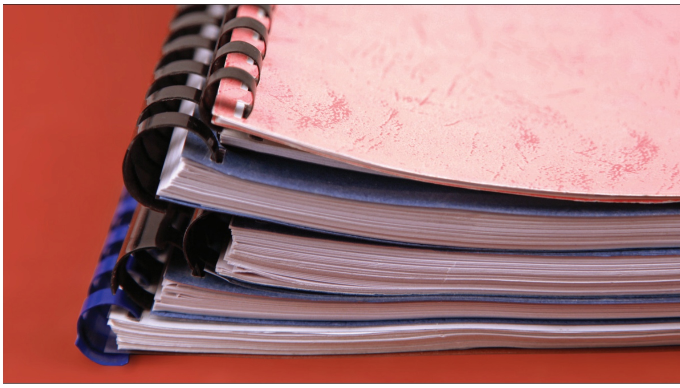
These questions, and more, are being considered in multiple segments of industry, including standards developing organizations and various user segments. This article will explore some of the aspects of this situation, including the possibility of developing a new international test standard focused on close proximity immunity. The challenges that will need to be addressed to provide repeatable, meaningful test results will be explored.

ANOTHER STANDARD?

One may ask why do we need a new test standard for this phenomenon. IEC 61000-4-3 covers immunity of electronic equipment to radiated RF electromagnetic energy, establishing both test levels and test procedures. The current edition of this standard even states "Particular considerations are devoted to the protection against radio-frequency emissions from digital radiotelephones and other RF emitting devices." [1]. IEC 61000-4-21 includes a detailed description for the test setup, chamber validation procedure and test procedures required to perform radiated immunity testing in a reverberation chamber [2]. IEC 61000-4-20 provides details for performing immunity tests on in-scope equipment in transverse electromagnetic (TEM) devices. [3]

These standards are excellent documents for their intended purposes and certainly can be used to simulate disturbances created by portable transmitters used at distance from equipment potentially suffering interference. They may not always produce a satisfactory characterization of equipment immunity to portable transmission sources used within a very short distance, say 20 cm or less. Test limits in the range of 3 to 10 volts/meter are typical when the disturbance source is a fair distance away. However, field intensities in close proximity to smart phones can be 100 volts/meter or more. Some equipment manufacturers and users reduce the risk of interference by specifying minimum separation distances that must be maintained between their equipment and portable transmitters. A typical specified separation distance is in the range of 1 to 3 meters. At the same time, we are seeing a move toward having service personnel use their smart phones very close to installed equipment while performing service. A practice gaining popularity is to place QR codes on equipment covers for service personnel to scan for accessing service information related to the equipment. Doing so while keeping smart phones 3 meters from the equipment would be, shall we say, a challenge.

Multiple industry segments have highlighted the problems of trying to use these existing standards to evaluate immunity of equipment to cell/smart phones used in close proximity. Notably, the automotive industry and the medical device industry have raised concerns with the suitability of existing test methods that could be used for this purpose. Groups within these industry segments reached the conclusion that the existing RF immunity test standards do not represent the close-proximity electric and magnetic field



One of the first things we considered was whether the existing IEC standards could be used for this purpose, either wholly or in part.

characteristics accurately enough and could produce results that are not fully in line with malfunctions created by interference sources used in close proximity in real-world situations.

The concerns raised by these groups helped initiate a new project in IEC to develop a new basic standard for immunity to devices used in close proximity. This project is in its early stages in Working Group 10 (WG10) of IEC SC77B.

WG10 is considering all aspects of interference caused by portable transmitting devices in close proximity and comparing them with characteristics of existing standards to determine where those standards are a good match and where they are not appropriate. The characteristics that need closer scrutiny include:

- Field strengths very close to cell/smart phone versus common test levels
- Input power levels required for achieve those very high field strengths
- The significance of using near field sources as opposed to far field sources
- The significance of the source type, such as electric field or magnetic field and
- Modulation schemes.

One of the first things we considered was whether the existing IEC standards could be used for this purpose, either wholly or in part.

EXISTING STANDARDS

The practice of using a linearly polarized antenna to create a uniform field area (UFA) in which the equipment being evaluated is immersed is described in IEC 61000-4-3. The standard states its test methods can be applied up to 6 GHz and that disturbances from portable transmitting devices such as cell phones have been given consideration. The method of independent test windows facilitates testing at frequencies greater than 1 GHz, the frequency typical for many types of portable transmitters. These factors certainly seem to indicate this standard could be used to test for immunity to disturbances from portable RF transmitting devices. Some test labs have had good experience in doing just that. However, the input power levels required to establish field strengths on the order of 100 volts/meter can be quite large. They are possible to achieve, but large. For the independent windows method, the test distance between the transmitting antenna and EUT is 1 meter. Consequently, this method does not reproduce the near-field effects that exist in real-world close proximity situations. In some cases, not reproducing the near-field effects may not be an issue, particularly for equipment where the intensity of the disturbances is the predominant effect. In such cases, IEC 61000-4-3 could be applied. Where this is not so, a different test method and standard would be needed.

Reverberation chambers can be used to immerse the equipment under test (EUT) in a field that is statically isotropic, homogeneous, unpolarized and uncorrelated. As described in IEC 61000-4-21, the entire EUT is exposed to simulated disturbances without the need to rotate the EUT or to move the transmitting antenna to multiple, discrete positions. Fairly high field strengths can be generated using moderate input power levels, thereby avoiding input power level concern when testing according to IEC 61000-4-3. Similar to the practice of using a linear antenna to generate a uniform field area, the near-field effects that happen when the transmitting device is very close to the equipment experiencing interference are not reproduced in a reverberation chamber.

Based on the analysis that is summarized briefly here, the current position is that these standards certainly can be used to evaluate the immunity of equipment to interference from portable transmitting devices, including cell phones. However, they are best suited to evaluate situations when the transmitting device is far enough away that it would not be considered as being used in "close proximity." Therefore, an independent standard defining a test method that

An international standard must meet certain formal and informal criteria before it can be published and put into use. This requirement is especially true for a basic standard that is likely to be applied to a wide variety of equipment types.

more fully replicates the particular characteristics of disturbances from transmitting devices used in close proximity to the equipment suffering interference and can be used when the test methods in the existing standards is not appropriate, adequate or sufficient should be developed.

TEST METHODOLOGY AND CHALLENGES

One of the challenges to be worked through is how to define what it means for the transmitting device to be in close proximity to the equipment experience the disturbance. We could consider the transition from near field to far field, the intensity of the disturbance signal, an arbitrary physical separation or some other characteristic. However it is defined, this characteristic is important to establishing all the technical details in the standard.

An international standard must meet certain formal and informal criteria before it can be published and put into use. This requirement is especially true for a basic standard that is likely to be applied to a wide variety of equipment types. Test methods that are perfectly acceptable for a small, hand-held device may be totally impractical and produce questionable results for large industrial equipment. The people tasked with writing the standard must always keep in mind the bigger picture, considering how the standard may be used, the types of equipment that are likely to be evaluated against it and the state of the art in test equipment and the disturbance sources the standard intends to simulate.

The future standard is in the early stages of development. The work so far has identified some possible test methodologies as well as a number of issues that must be resolved before publication.

The test method being considered is based on the concept of a small RF coupler or antenna being scanned across the surface of the EUT. The coupler would be located some small distance away from the EUT surface, perhaps on the order of a few centimeters. To aid in repeatability of test results, the surface to be tested would be divided into a rectangular grid pattern and the coupler moved in discrete steps according to the size and shape of cells in that grid. See Figure 1 for an example of how the EUT may be partitioned into test grids. The RF coupler shown is intended to be of generic design and not an indication of what an actual coupler would be.

The test is conceptually simple, but some specific details are not quite so simple to develop. The details that need to be resolved before a useful basic test standard can be published include the following.

Defining the RF coupler

The coupler could be defined in terms of its electrical or mechanical parameters. It needs to be defined in a manner that allows commercial production by multiple suppliers. Facilitating construction by individual test laboratories could be considered as well. It must be able to withstand the input power needed to meet expected test levels. Some degree of uniformity of the field generated is also a must. Given the wide frequency range that must be considered, which could include approximately 800 MHz to 6 GHz, it is likely that multiple couplers would be needed. The definition would need to support this practical reality.

Calibration or verification of the RF coupler

Verifying that the RF coupler is functioning is not likely to be a major challenge. Defining a calibration procedure that will satisfy the rigors of laboratory accreditation requirements will probably be more difficult, not to mention essential to the reproducibility of test results.

Establishing a level-setting procedure

Given that the RF coupler will be placed very close to reflecting surfaces that may be very large relative to the size of the coupler, the effects of reflections from those reflecting surfaces must be considered. Can test levels be established in an environment with no reflecting surfaces nearby? Can forward power to the coupler be used as the test level without regard to effects from the reflecting surfaces under test?

Test time

Stepping the RF coupler across the surfaces to be tested will take some time. The amount of time, of course, depends on the size of the cells in the rectangular grid and the total size of the surfaces to be tested. Larger cells will reduce test time but must be balanced against the uniformity of the field radiated by the coupler. Add in a number of discrete frequencies or multiple frequency ranges, and the time required for the test can be very long, especially for large equipment being tested. One estimate for a full rack of computer or telecommunication equipment pegged test time in terms of days not hours.

Modulation schemes

Traditionally, amplitude modulation (AM) with a 1 kHz tone has been used for RF immunity testing. Evaluations and experiments have shown that AM sufficiently predicts performance for many other modulation signals. Is this still true given the large number of different modulation schemes being employed in RF transmitting devices today? If additional modulation schemes will be required, which ones need to be used and how do we decide how many difference schemes are necessary and sufficient?

CONCLUSION

Technology – isn't it grand? As technology evolves at a pace that seems only to get quicker, society reaps many benefits and improvements to daily life. For new technologies and applications to continue providing benefits, the unintended consequences must be considered. The test methods and associated standards for quantifying the effects of unintended consequences must also be examined and, in some cases, evolve along with the technology.

The proliferation of portable intentional RF transmitting devices is one of those shifts providing significant benefits and the potential for undesired consequences. The standards community recognizes these consequences and the need for test standards to evolve to address them. The future standard for close proximity immunity testing will be one more tool in the EMC professional's toolkit to facilitate a seamless transition and enable progress well into the 21st century and beyond. IN

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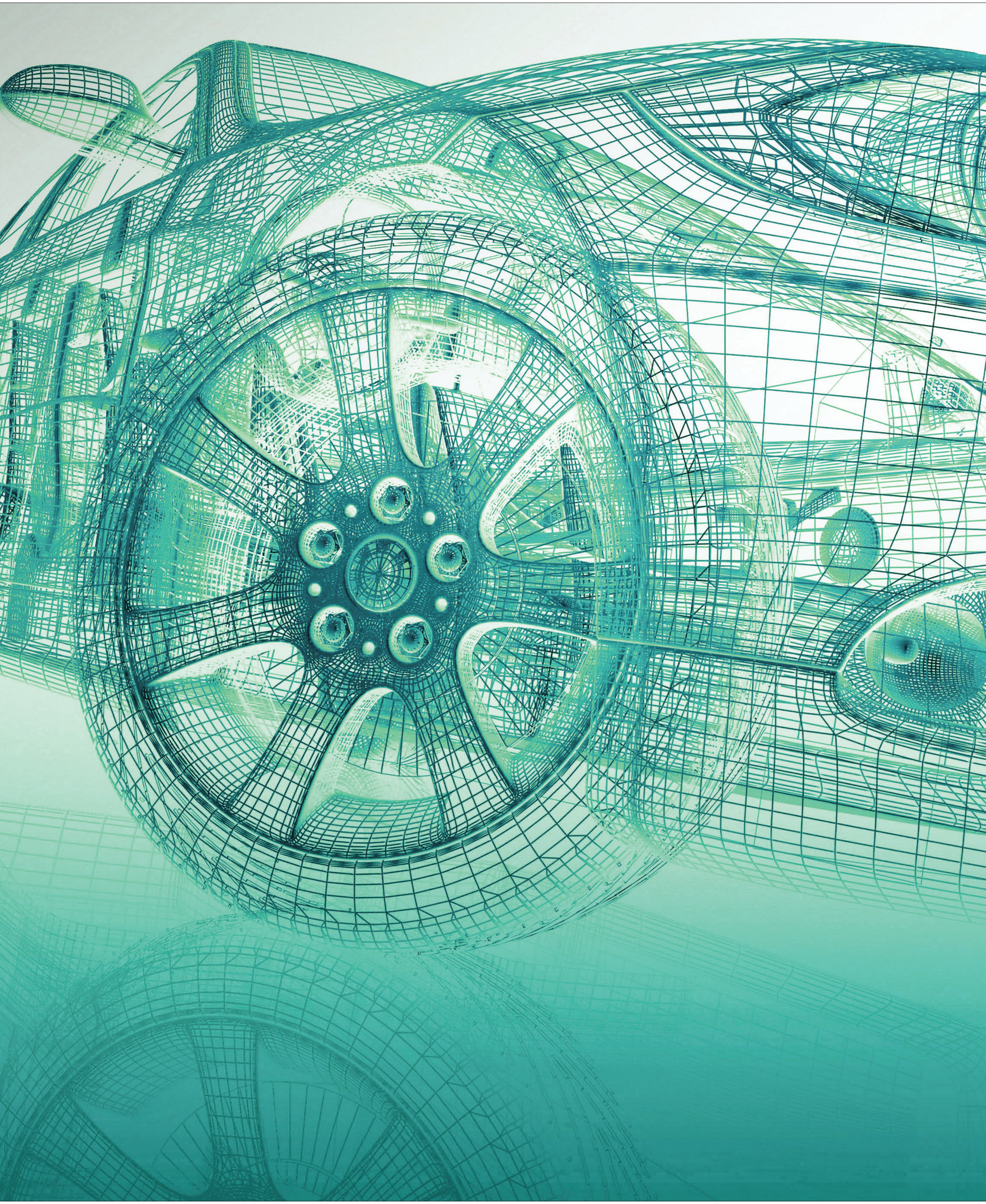

Efficient Suppression of Interference in Modules at the Developer's Workplace

BY GUNTER LANGER

This article deals with improving EMC measuring methods that are used during the development of automobiles in the field of interference emissions. Development-stage investigations are normally performed with measuring systems that have actually been conceived for vehicle component tests. EMC measuring methods that are tailored to the development stage, however, are much better suited for this task since they help save time and costs. One such measuring method is presented here as a practical example.

We will begin by analyzing the characteristics of the current measurement methods and how they are used in conventional interference suppression.

Every module that is intended for use in a test vehicle has to be released for this purpose after the EMC component test. The developer initially performs this test with a sample module that allows him to assess the current situation. If he is lucky, the module will pass the test at the first attempt. If not, the EMC engineer has to rework the sample module accordingly. To find out more about interference emission, the developer or EMC engineer uses defined measurement setups such as an antenna measurement system, stripeline measurement system, etc. The module and cable harness is mounted on the test bench to measure the radiated emission.

With the antenna measurement method, the module and cable harness rest on a table. The cable harness is aligned to the antenna at a distance of one meter. The cable harness will typically be the source of the emission that can be measured with the antenna. The module itself is usually too small for its emissions to reach the antenna and be measured there. Near fields may be generated on the module by microcontroller operation, for example, but their intensity at the antenna is insignificant. The antenna only measures the module's near fields indirectly, namely as radiated emissions from the cable harness. Both internal RF currents and voltages as well as near fields may stimulate the cable harness to emit near fields. The situation is very similar in stripeline measurements. The cable harness is positioned under the stripeline conductor and couples RF into it. Not all of the module's near fields will couple to the stripeline conductor, especially if the module is beside the stripeline during the test.

The listed measuring methods and their characteristics show that they are not particularly suitable for a root cause analysis of a module's interference

In practice, developers also use the antenna or stripeline measuring methods to optimize modules in terms of EMC. These measuring methods, however, are hardly suited to achieve a satisfactory optimization.

emissions. This means that these measuring methods can be used to assess RF emitted by the cable harness, but not to assess a module's potential near field coupling to its environment in a vehicle. The significance of near-field coupling in a vehicle will be demonstrated taking the passenger compartment electronics (Figure 1) as an example:

The module is located at the front of the passenger compartment directly under the roof lining. The magnetic field of the microcontroller encircles the passenger compartment lighting cable and induces a voltage in this. This voltage stimulates the cable to function as a transmission antenna. The resulting radiated emission may interfere with sensitive vehicle components.

In practice, developers also use the antenna or stripeline measuring methods to optimize modules in terms of EMC. These measuring methods, however, are hardly suited to achieve a satisfactory optimization. The antenna or stripeline is unable to measure a module's near fields at the level that is required for optimization. The near field of the microcontroller (Figure 2) does not even reach the antenna. It is not detected by the measurement but may nevertheless cause interference in the vehicle later on (Figure 1).

This, however, has two decisive disadvantages:

1. The module's near fields, whose effect is visible in Figure 1, are not sufficiently analyzed (Figure 2).
2. The use of this measuring method during development is cumbersome, costly and time consuming.

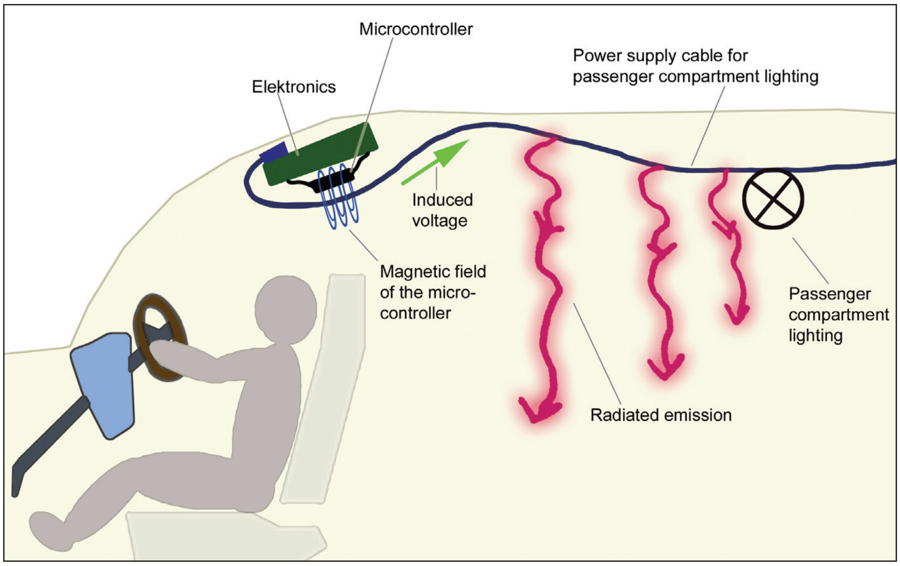

Figure 1: Passenger compartment electronics with near-field coupling to the cable

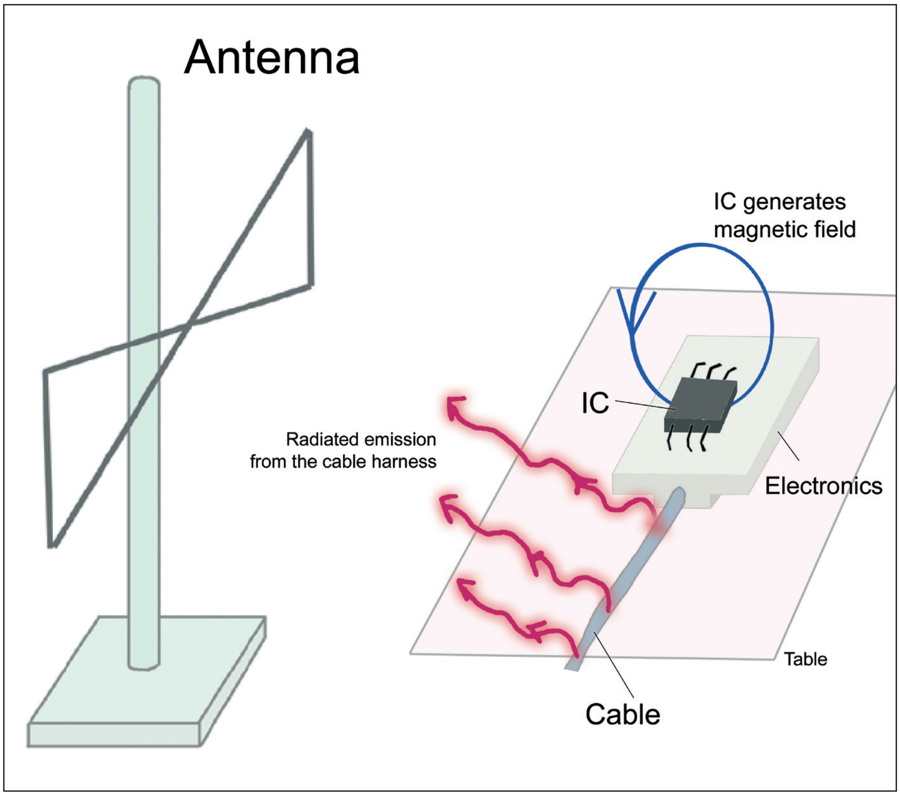

Figure 2: Measurement of radiated emissions from passenger compartment electronics with an antenna

Efficient and productive EMC measuring methods are needed during development. All disturbances, particularly those that are effective in practice, should be able to be measured flexibly and, if possible, directly at the developer's workplace.

The drawbacks mentioned under point 2 are due to the following:

1. The device under test is connected to a cable harness. It has to be disconnected from the cable harness and taken to the developer's workplace for modifications that are performed outside the cabin. This takes a lot of time.
2. The measurement setup often has to be reproduced for further measurements with an antenna or stripeline. But in most cases, the module and cable harness cannot be returned to an absolutely identical position. This results in measurement deviations.
3. The developer has no direct access to the device under test during the measurement process since this is located in the closed cabin. The developer cannot carry out direct changes in terms of EMC optimization. Not even minor modifications are thus possible to improve the test result without great inconvenience. The setup is very inflexible when it comes to manipulating the device under test.
4. The frequency response characteristics measured and the modification protocol cannot be compared immediately and flexibly. Here again, complex comparisons take a lot of time.

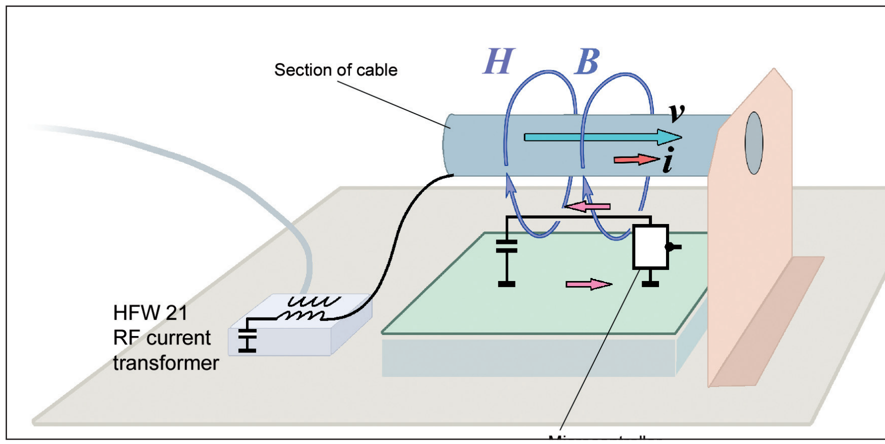

Figure 3: Functional principle of emission measurements with a RF current transformer during development

This shows that conventional measuring methods are inadequate. Efficient and productive EMC measuring methods are needed during development. All disturbances, particularly those that are effective in practice, should be able to be measured flexibly and, if possible, directly at the developer's workplace.

The diagram in Figure 3 shows what has to be done with the measurement setup and which requirements this has to meet:

1. The developer must be able to measure the cable's RF current and trace his measurement directly with a spectrum analyzer (Figure 3). The measurement is carried out with a RF current transformer that is short-circuited to ground. Wires that are interference-free or not involved should be disconnected or their resistance increased with

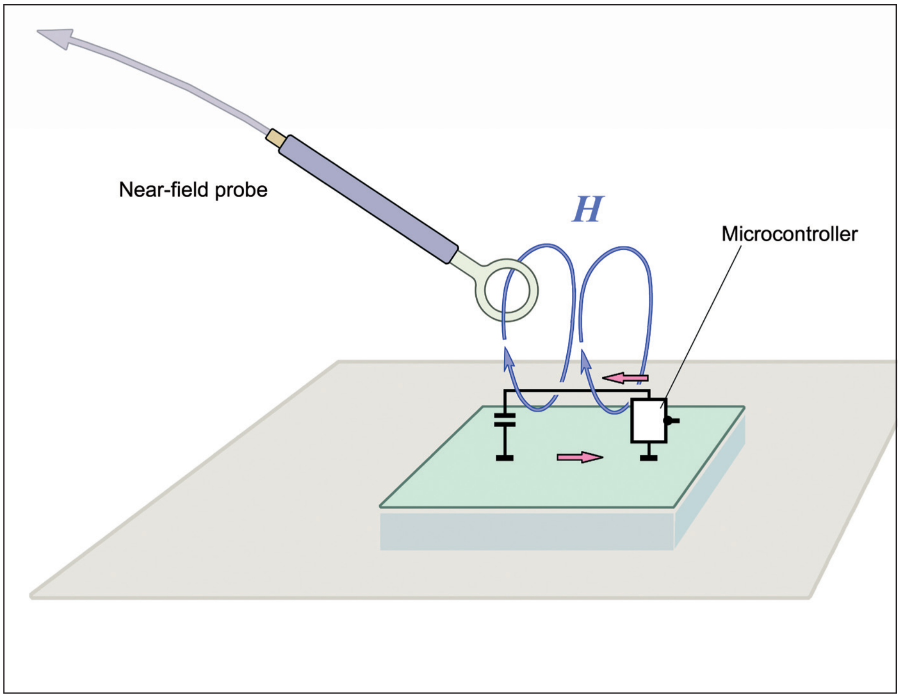

Figure 4: Functional principle of near-field measurements with near-field probes in emission measurements during development

ferrites. Ideally, the cable harness is limited to the power supply.

2. The developer can detect the cause of the interference on the module with a near-field probe. The near-field probe measurement (Figure 4) must be able to be traced directly with a spectrum analyzer.
3. Both measuring methods must be able to be recorded flexibly and allow the developer to compare measurements of both the same, though also different types.

Figure 5 shows a test bench that is suitable for the workplace of a developer or EMC engineer in the development stage. The shielding cabin here is implemented in the form of a shielding tent and can be placed on its conductive groundplane to shield the measurement setup from external electromagnetic fields. Power supplies

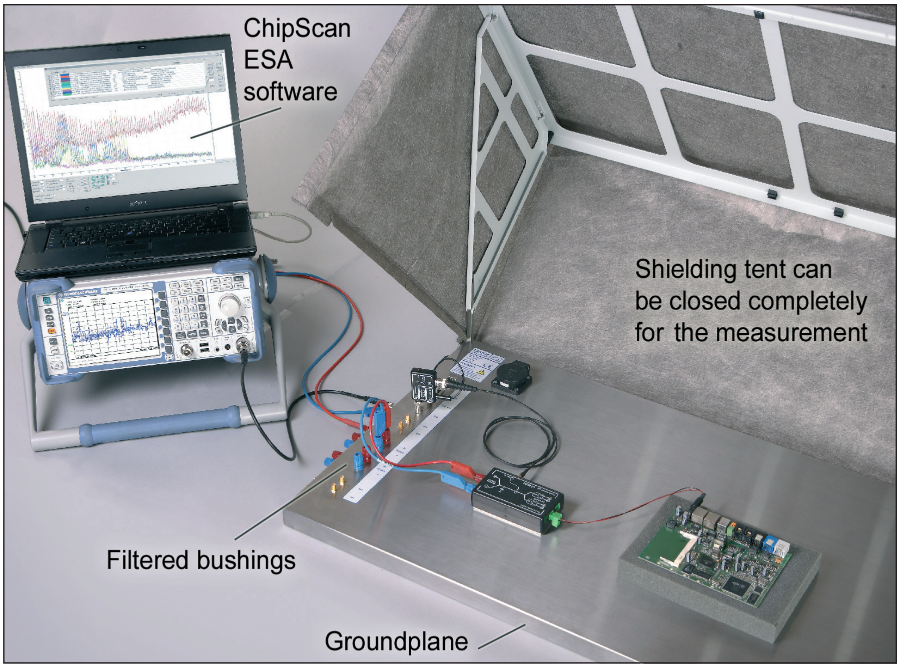

Figure 5: Practical measurement setup of a RF current transformer with an electronic module (ESA1 test bench). The RF current transformer supplies the electronic module with power in this example.

and signals are led to the outside through the groundplane via filters. The front of the shielding tent can be folded up and down slightly. The entire shielding tent can be opened wide to allow easier modification of the device under test (Figure 5). The near-field probes can be connected to the spectrum analyzer through a shielded bushing in the groundplane.

The module to be tested is connected to the current transformer via a reduced cable harness. The device under test can remain in the shielding tent or is simply disconnected to carry out modifications.

The module's environment in the vehicle can be simulated with corresponding parts in the shielding tent. As far as the passenger compartment electronics (Figure 1) are concerned, the developer can simulate the relevant section of the cable with a corresponding tube. (Figure 5) A current transformer (HFW21) or a line-impedance stabilization network (NNB21) is used to assess the induced voltage.

The frequency response characteristics that are measured are documented with a PC and customized software (Figure 6). This software allows the developer to record, color, annotate, calculate and visualize any number of curves of a spectrum analyzer. This enables a flexible, easy and fast comparison of the different steps of the measurement process. The developer can simply export images and data from the software for documentation and statistical analysis.

It is important for developers and EMC engineers to be able to find the causes of interference on modules and also test the effect of modifications immediately at their workplace. This results in noticeably lower costs and less time for the development of modules and devices.

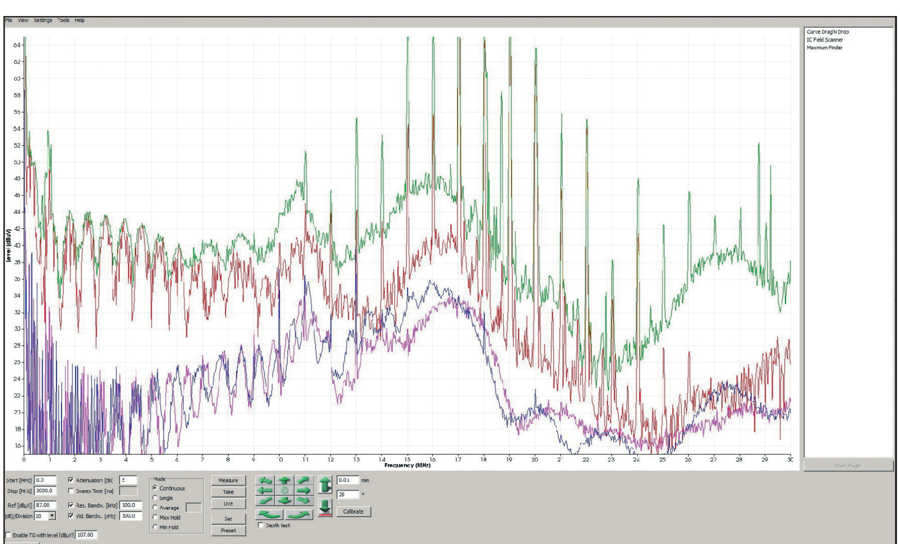

Figure 6: Remote control of the spectrum analyzer and documentation of the results with ChipScan ESA

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Status
OUTSIDE 33°C
Audio OFF
SECURITY
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Electromagnetic Analysis of Cable Harnesses in an Automotive Environment

This article shows how electromagnetic simulation tools can be used to investigate effects of high-speed signals in cable harnesses in a vehicle: cross talk, radiation and interference with a receiving antenna. Results are presented for two types of digital sequences and compared with standards. Cable shielding is designed to be adequate without adding unnecessary weight.

BY DR. M.H. VOGEL

Vehicles are experiencing a continual growth in the number of electronic systems (*e.g.* cruise control, airbag deployment, power steering, "infotainment", *etc.*). These systems and their respective components are usually governed by digital logic on printed circuit boards. Signals are communicated through cables, which are bundled in complicated harnesses throughout the vehicle. Figure 1 illustrates only one of several harnesses that can easily contain more than a hundred cable instances and fifty connectors. Consequently, cross talk and electromagnetic compatibility (EMC) are major concerns.

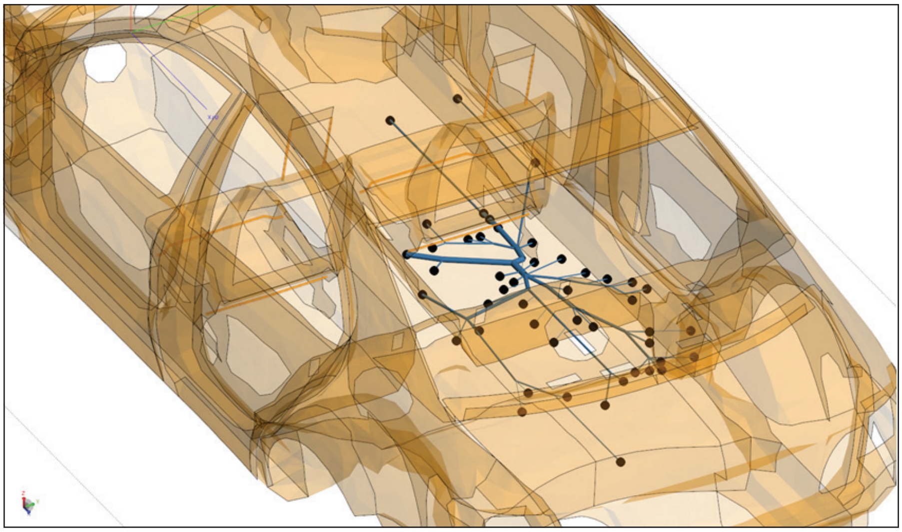

Figure 1: Example of a cable harness in a car model (Courtesy Daimler AG)

This article demonstrates, by means of a case study, how simulation tools can help minimize the resources required for EMC testing, which is often time consuming and expensive.

CASE STUDY

A simplified yet representative example comprised of two cable bundles as well as an antenna integrated in the rear windshield is illustrated in Figure 2. The study was conducted with a commercial software package [1]. The cable bundles each contain four signal wires as shown in Figure 3 where red and green indicate dielectric materials. Although a shield is shown in the figure, early simulations were done without cable shielding. The signal conductors can be used for both single-ended signaling and differential signaling, simply by adjusting the circuits in the software's integrated Schematic Views.

EMC engineers are concerned with cross talk within a bundle, cross talk between bundles, un-intended radiation to the environment, and interference with signals received by the antenna. Unintended radiation from electronic systems within a vehicle requires compliance with international regulations (*e.g.* CISPR 25) [2,3]. Unintended radiation from general electronic systems requires compliance with similar regulations (*e.g.* FCC Part 15 [4]). To investigate compliance, proper accounting will have to be made for the spectrum of the digital signal.

CABLE ANALYSIS

For any cable-harness cross section, a 2D static finite element method (FEM) solver, determines the per-unit-length inductance, capacitance, resistance and conductance. Any complexity is possible, including twisted wires and shields inside shields. Cables can automatically be rearranged in the bundles to enable realistic simulation of the variations that may occur in practice. The link between fields outside and inside the cable harness is governed by the computed transfer impedance and transfer admittance.

The Multi-Conductor Transmission Line (MTL) theory is used to analyze complex cable problems. Simply put, a multi-conductor transmission line model is a distributed resistance, inductance, capacitance and conductance (RLCG) parameter network for an arbitrary cable cross section where the voltages and currents can vary in both magnitude and phase over the length of the cable. The transfer matrix links fields inside the cable with those outside. Cables can be radiating into their environment, be subject to irradiation from their environment, or both. Standard MTL technology is limited in application to situations where cables run close to a ground plane, where it is assumed that the current return path is in the ground plane directly below the cable. Combined Method of Moments (MoM)/MTL technology, is not restricted in this way and can solve problems with unrestricted cable paths.

CROSS TALK

The two signal conductors outside the center of the bundle in Figure 3 were excited with a 1-V differential signal (0.5 V per signal line). All terminations

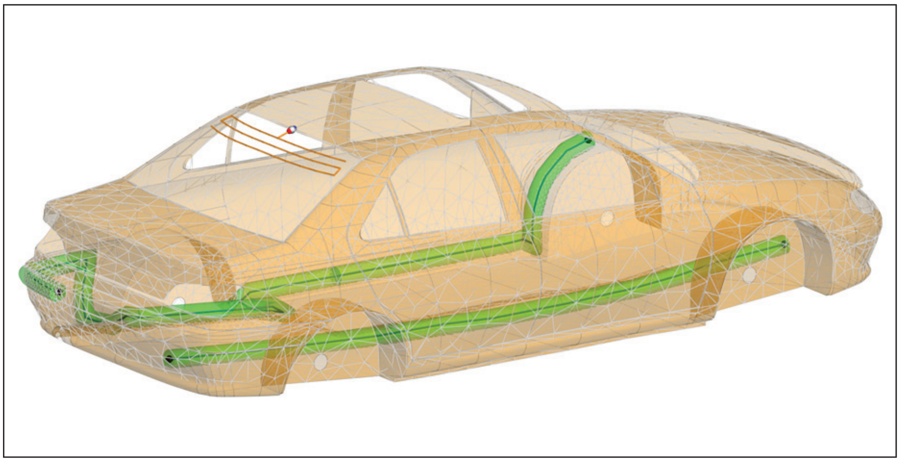

Figure 2: Model used in the case study

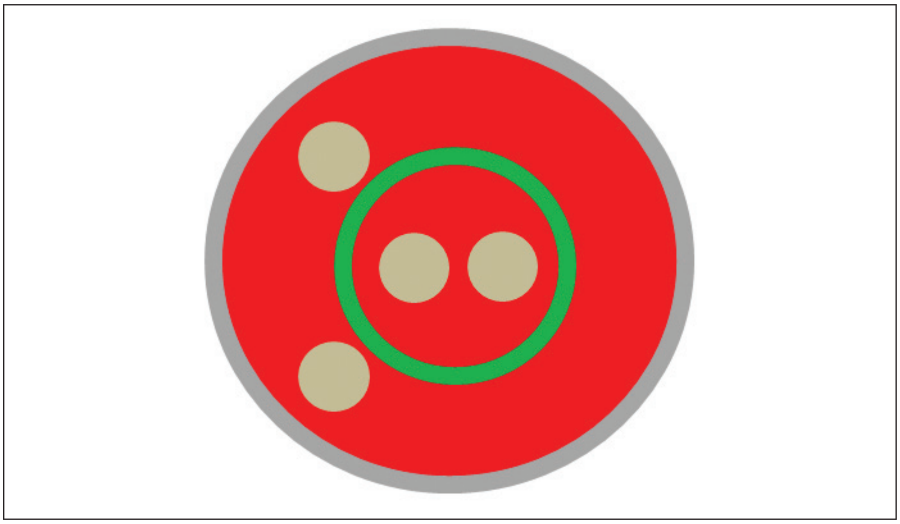

Figure 3: Cross section of a cable

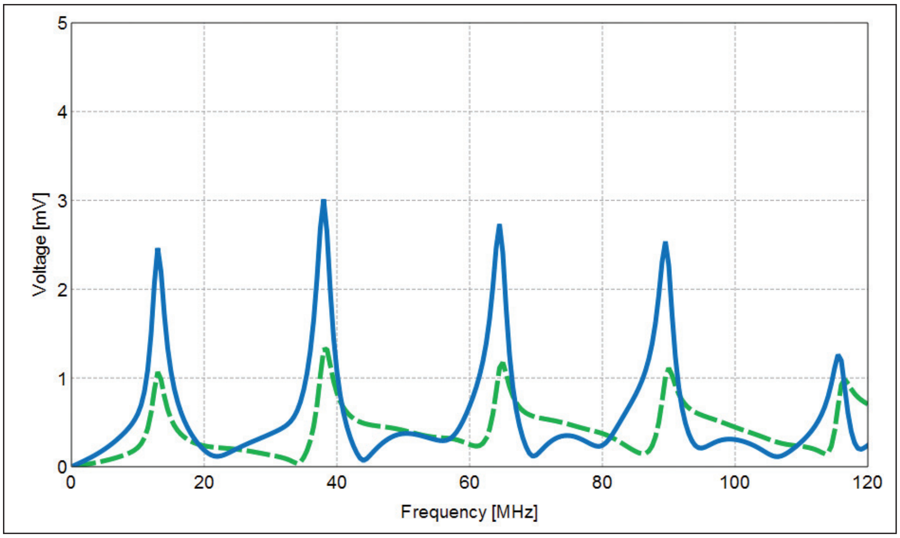

Figure 4: Cross talk between differential pairs in the same bundle. Blue: NEXT. Green: FEXT.

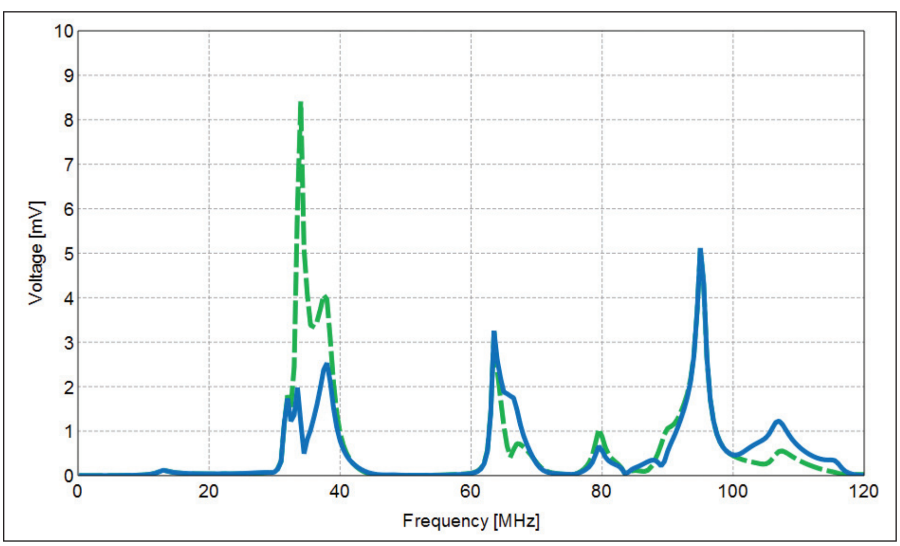

Figure 5: Differential cross talk between bundles. Blue: NEXT. Green: FEXT

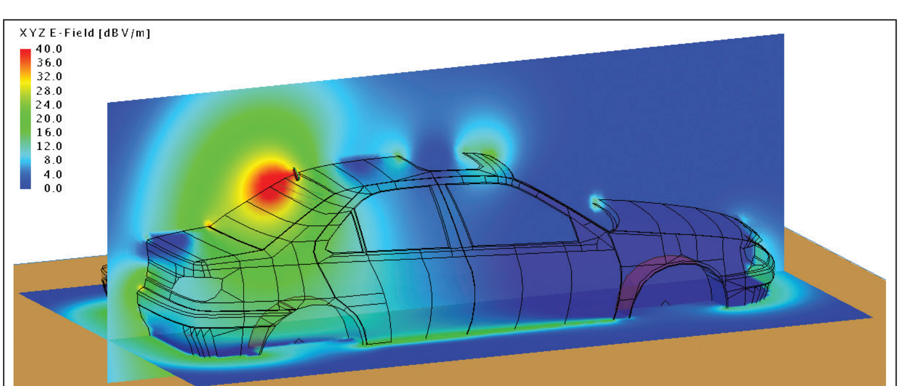

Figure 6: Fields at 34 MHz due to differential aggressor

were 50 Ohm. Figure 4 shows the induced differential voltage on the other pair at both ends.

The cross talk is limited to 3 mV. For a digital signal with speed in the Mb/s range, differential signaling would be safe, unless dozens of differential pairs are packed in one bundle. Single-ended signaling, on the other hand, turned out to have an unacceptably large cross talk for signal speeds in the Mb/s range.

Figure 5 shows the cross talk between the two cable harnesses of in Figure 2 for the case of differential signaling. Note that the cross talk is mostly well below 1 mV, but several resonances occur. The first resonances are at 34 and 38 MHz. At 34 MHz, the aggressor radiates strongly while the victim is only moderately receptive. At 38 MHz the victim, which has a different electrical length, is highly susceptible while the aggressor radiates only moderately. For cross talk, three components are needed: an aggressor, a victim and a path between them. In this case, a field plot is very revealing. Figure 6, in which no source is connected to the antenna, shows that the windscreen antenna is an essential part of the path.

This was verified by running the simulation again without the antenna present. Strikingly, while a cross talk of 8 mV was reached in Figure 5 with the receiving antenna present, the maximum (in the frequency range below 40 MHz) was only 0.025 mV when the antenna was removed, a reduction of 50 dB! While individual systems may appear safe, problems appear when the complete vehicle is analyzed. This underscores the need for EMC testing of the entire vehicle. Since EMC measurements of the complete vehicle can only be done late in the design process, identifying and addressing EMC problems with software simulations early in the design process can minimize costly modifications.

RADIATION AND COMPLIANCE WITH EMC REGULATIONS

Figure 7 shows the maximum electric-field magnitude at 10 m as a function of frequency, based on an excitation with a differential voltage of 1 V (0.5 V per signal line) at every frequency. In order to compare this result with regulations, it needs to be weighed with respect to the spectrum of the actual signal on the differential line.

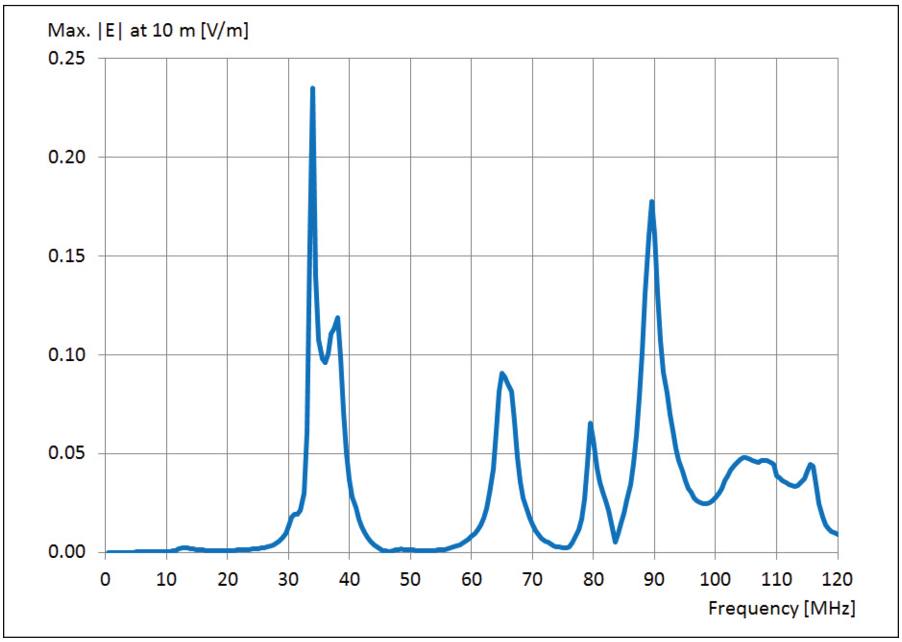

Figure 7: Maximum E field at 10 m distance as a function of frequency

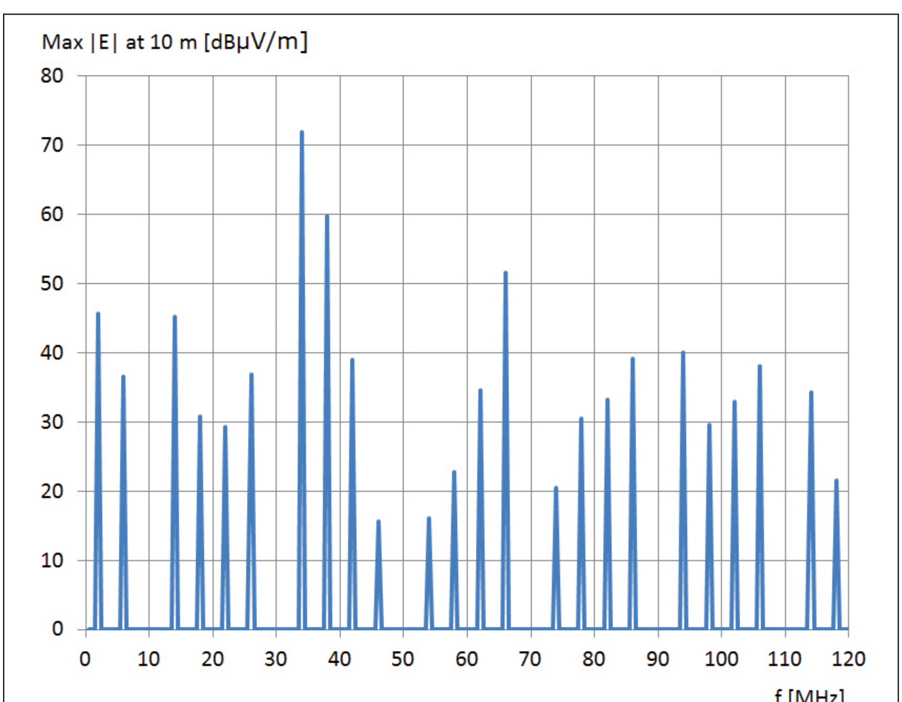

Figure 8: Maximum |E| at 10 m for a 5V differential clock signal

Let the signal on the differential transmission line be a 2 Mbit/s digital signal with a rise and fall time of 100 ns. The resulting spectrum depends strongly on whether the signal is a regular stream of bits, like a clock pulse, or an irregular stream of bits, like a pseudo-random binary sequence (PRBS). In the first case, the spectrum is a set of delta functions ("spikes") at the odd harmonics of the bit rate, while in the second case, the spectrum is continuous. The equations can be found in [5].

For a 5 V differential clock signal (2.5 V per signal line), the resulting radiated field at 10 m is presented in Figure 8. Note that the spikes occur at the odd harmonics of 2 MHz. Also note that no harmonics are visible at 10, 30, 50, … MHz. This is due to a sinc function involving the rise time.

While Figure 7 shows little radiation below 30 MHz, Figure 8 shows significant spikes below 30 MHz because most of the signal's spectral content is there. Above 30 MHz, the signal has less spectral content but the cable radiates more effectively. The radiation at 34 MHz, a resonance due to the electrical length of the cable, exceeds the radiation at all other frequencies in both plots. The FCC Class A limit at 34 MHz is 39 dBμV/m at 10 m. Clearly, the limit is exceeded by a significant amount.

For a 5 V differential PRBS signal (2.5 V per signal line), the resulting radiated field at 10 m is presented in Figure 9. The straight application of the equations for the continuous spectrum gives a field in units of V/(m Hz), i.e. Volts per meter per Hertz bandwidth. To obtain V/m, we have to specify a receiver bandwidth. To produce Figure 9, a receiver bandwidth of 120 kHz [2] has been used.

The radiated emissions of the PRBS are a lot less worrisome than those of the regular pulse, simply because the PRBS spreads its radiated power over all

In order to comply with regulations, the cables will need to be shielded. The main benefit of these simulations is that they reveal how much shielding is needed to achieve first-pass success in tests. This is important, since repeated testing is expensive, while adding too much shielding to all the cable harnesses in a vehicle adds a lot of weight and reduces the routing flexibility.

frequencies. Still, at 34 MHz the limit of 39 dBμV/m is exceeded.

In order to comply with regulations, the cables will need to be shielded. The main benefit of these simulations is that they reveal how much shielding is needed to achieve first-pass success in tests. This is important, since repeated testing is expensive, while adding too much shielding to all the cable harnesses in a vehicle adds a lot of weight and reduces the routing flexibility.

Several types of shielding can be specified: selected from a database of popular cable types, solid shields with a specified material and thickness, user-defined by means of the frequency-dependent impedance transfer matrix, and braided shields. For a braided shield (Figure 10) one specifies the relevant parameters and materials of the weave pattern, upon which the frequency-dependent transfer matrix is determined using the Kley formulation [6, 7]. This formulation accurately models the coupling mechanism due to the field penetration through the shield apertures.

With a shield of 32 carriers of seven 0.12-mm filaments each around each cable, which, for a shield radius of 5 mm leaves openings, the radiation is reduced sufficiently (see Figure 11) to satisfy the FCC regulations, if they were applied to vehicles. While CISPR-25 applies to automotive systems, it is used more for individual systems and harnesses than for radiation from entire cars. CISPR-25 limits between 30 and

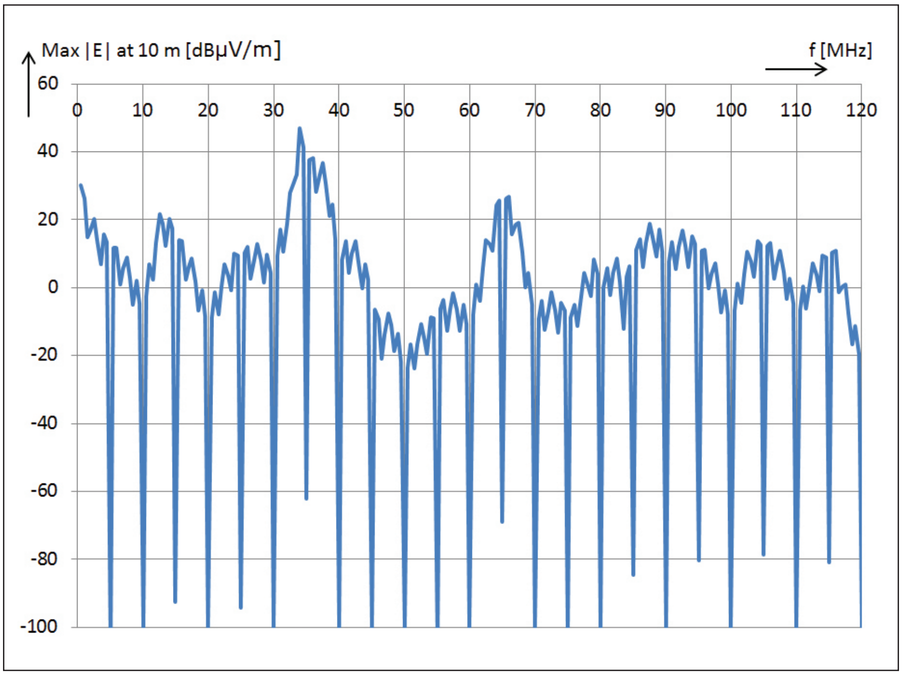

Figure 9: Maximum |E| at 10 m for a 5V differential PRBS

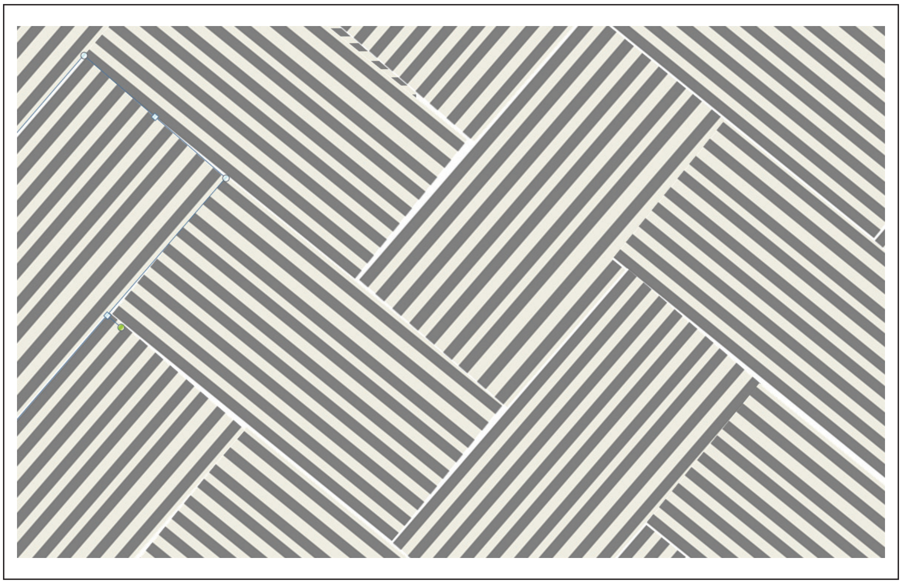

Figure 10: Braided shield

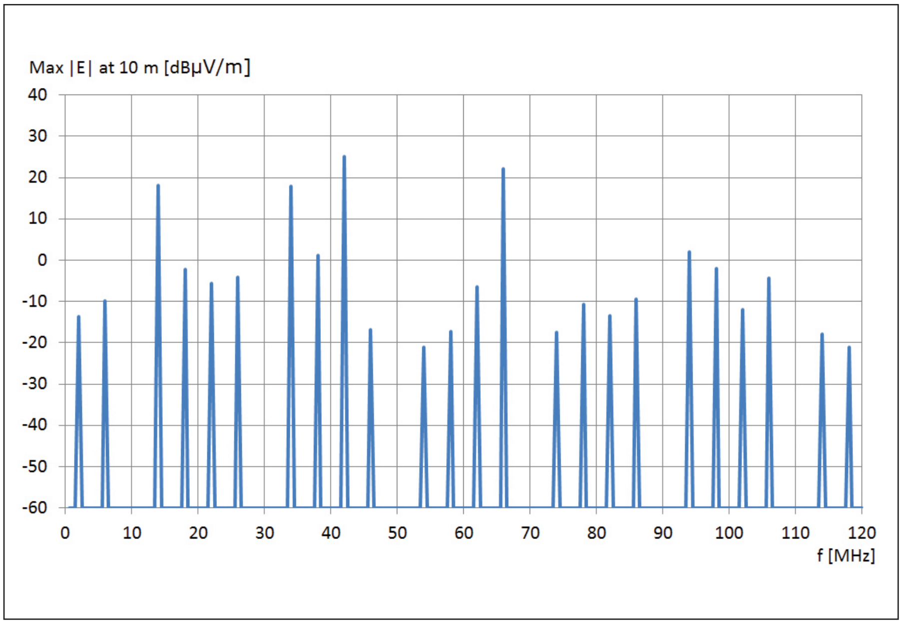

Figure 11: Maximum |E| at 10 m for a 5V differential clock signal in a shielded cable

54 MHz range from 22 to 46 dBµV at 1 m distance, depending on the class, which corresponds to 2 to 26 dBµV at 10 m distance. The individual system with harness might well pass in a standard test, while with the windshield antenna present the radiation, as shown in Figure 11, might be too high.

The difference in levels between Figures 8 and 11 (without and with shielding) varies with frequency. One reason for the frequency dependence is that the shielding factor is frequency dependent; another reason is that with the added shield the cross section of the cable has changed, so the amount of crosstalk to other signal lines in the cable has changed. The latter is strongly frequency dependent.

INTERFERENCE WITH SIGNALS RECEIVED BY THE ANTENNA

Windscreen antennas are typically embedded in a number of dielectric layers of varying dielectric properties. For such antennas a Method-of-Moments based formulation that meshes only the metallic antenna elements in a windscreen antenna, while rigorously taking all dielectric layers into account with special methods is used. This avoids having to mesh the layers with a triangle size of the order of the layer thickness, which would require impractical simulation times.

The antenna is connected to a ten-element matching circuit, which provides an excellent match ($S_{11} \leq -23$ dB) between 89 and 91 MHz.

A 5-V differential signal was connected to a pair of signal lines inside a shielded cable. The resulting voltage on the receiving antenna terminals, after passing through the matching circuit, is illustrated in Figure 13.

Note that the peak at 34 MHz in Figure 13 is weak compared to Figure 7, due to the matching circuit. The results for a shielded cable, illustrated in Figure 13, do not indicate a peak at 90 MHz, while Figure 7 does show a peak for the unshielded case. In addition to reducing radiated fields, a shield also changes the characteristic impedances "seen" by the signals and the coupling between the two pairs of signal lines.

Figure 14 shows the received voltage that passes the matching circuit when the differential signal is a 5-V regular binary pulse with repetition frequency 2 MHz and with rise- and fall times of 100 ns. The maximum is 8 dBµV. CISPR-25 specifies a maximum of 6 dBµV. Therefore, engineers are required either to shield the bundles better, or work with a lower voltage, or ensure that this kind of signal can never travel on this cable.

CONCLUSION

Cross talk, radiation and interference for a vehicle with cable harnesses and a windshield antenna have been analyzed. Instrumental in this case study were the capabilities to include radiating and irradiated cable harnesses of arbitrary complexity, and to model

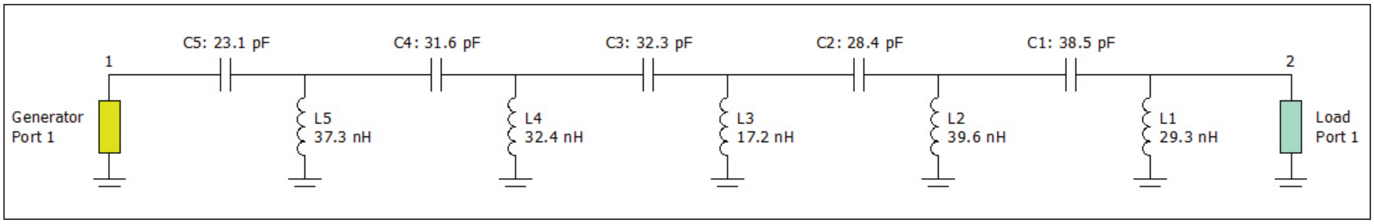

Figure 12: Matching circuit designed with Optenni Lab and integrated in the model

windshield antennas efficiently. Taking the spectra of digital signals into account, comparisons with regulatory standards were made.

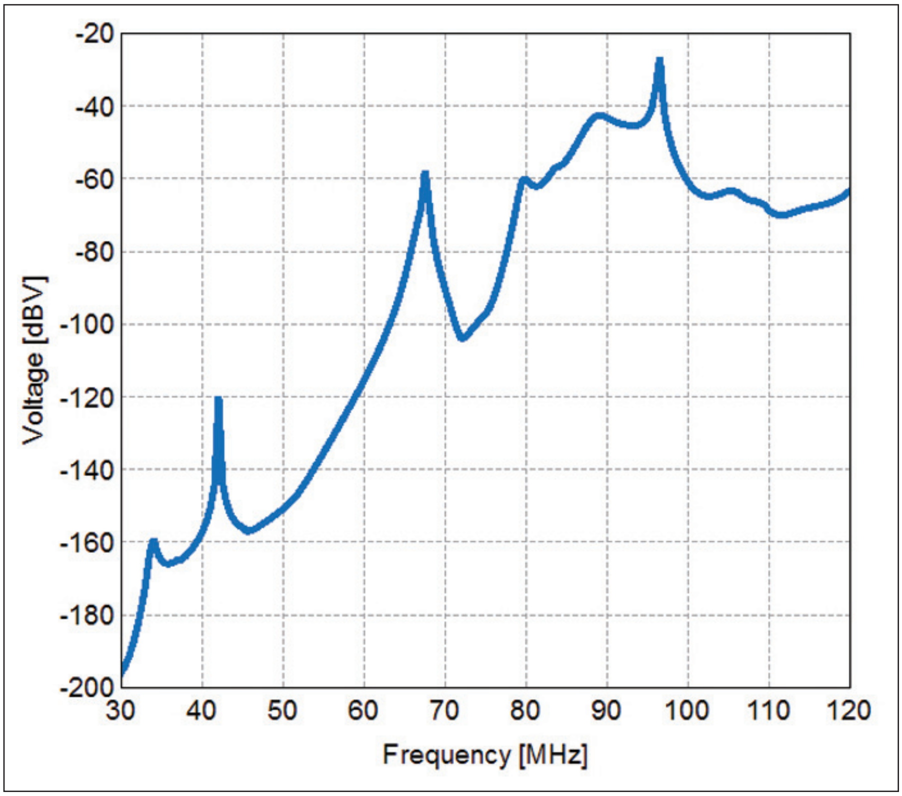

Figure 13: Voltage received by antenna with matching circuit

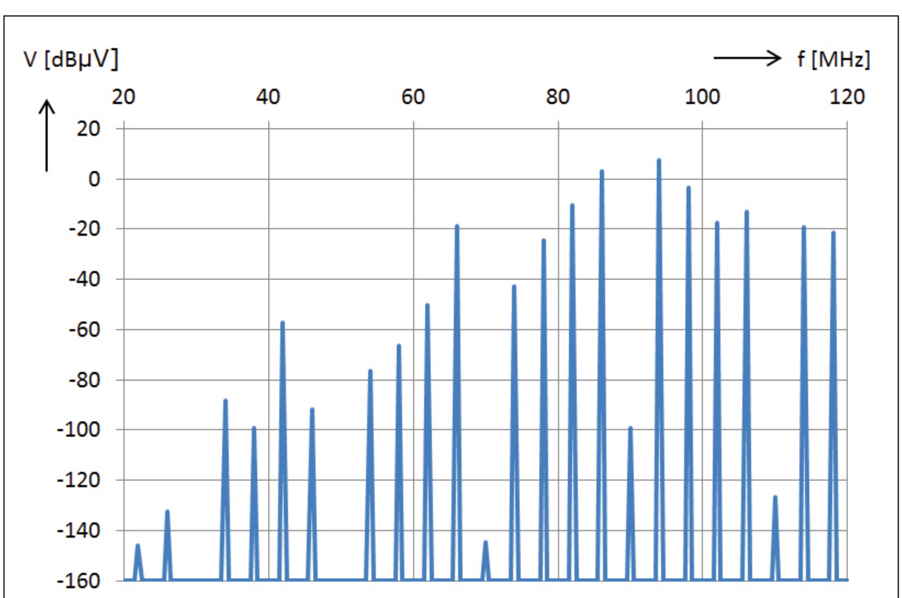

Figure 14: Voltage received by antenna and passed by the matching circuit

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Fundamentals of Electrostatic Discharge

Part Three: Basic ESD Control Procedures and Materials

BY THE ESD ASSOCIATION

In Part Two, *Principles of ESD Control – ESD Control Program Development,* we introduced six principles of static control and six key elements of ESD program development and implementation. In Part Three, we will cover basic static control procedures and materials that will become part of your ESD control program. First, we review the principles.

BASIC PRINCIPLES OF STATIC CONTROL

We suggested focusing on just six basic principles in the development and implementation of effective ESD control programs:

1. **Design in protection** by designing products and assemblies to be as robust as reasonable from the effects of ESD.
2. **Define the level of control** needed in your environment.
3. **Identify and define** the electrostatic protected areas (EPAs), the areas in which you will be handling ESD sensitive parts (ESDS).
4. **Reduce Electrostatic charge generation** by reducing and eliminating static generating processes, keeping processes and materials at the same electrostatic potential, and by providing appropriate ground paths to reduce charge generation and accumulation.
5. **Dissipate and neutralize** by grounding, ionization, and the use of conductive and dissipative static control materials.
6. **Protect products from ESD** with proper grounding or shunting and the use of static control packaging and material handling products.

At the facility level our ESD control efforts concentrate on the last five principles. Here in Part Three, we will concentrate on the primary materials and procedures that reduce electrostatic charge generation, remove charges to ground, and neutralize charges to protect sensitive products from ESD.

IDENTIFYING THE PROBLEM AREAS AND THE LEVEL OF CONTROL

One of the first questions we need to answer is "How ESD sensitive are the parts and assemblies we are manufacturing or handling?" This information will guide you in determining the various procedures and materials required to control ESD in your environment.

How do you determine the sensitivity of your parts and assemblies or where can you get information about their ESD classification or withstand voltage? A first source would be the manufacturer or supplier of the component itself or the part data sheet. It is critical that you obtain both Human Body Model (HBM) and Charged Device Model (CDM) ratings. You may find that you need to have your specific device tested for ESD sensitivity. However, be aware that the correlation between voltages used for device qualification and static voltages measured in the field is weak.

The second question you need to answer is "Which areas of our facility need ESD protection?" This will allow you to define your specific electrostatic protected areas (EPAs), the areas in which you will be handling sensitive parts and the areas in which you will need to implement the ESD control principles. Often you will find that there are more areas that require protection than you originally thought, usually wherever ESDS devices are handled. Typical areas requiring ESD protection are shown in Table 1.

GROUNDING

Grounding is especially important for effective ESD control. It should be clearly defined, and regularly evaluated.

The equipment grounding conductor provides a path to bring ESD protective materials and personnel to the same electrical potential. All conductors and dissipative materials in the environment, including personnel, must be bonded or electrically connected and attached to a known ground, or create an equipotential balance between all items and personnel. ESD protection can be maintained at a charge or potential above a "zero" voltage ground reference as long as all items in the system are at the same potential. It is important to note that insulators, by definition non-conductors, cannot lose their electrostatic charge by attachment to ground.

Receiving
Inspection
Stores and warehouses
Assembly
Test and inspection
Research and development
Packaging
Field service repair
Offices and laboratories
Clean rooms

Table 1: Typical Facility Areas Requiring ESD Protection

ESD Association Standard ANSI/ESD S6.1-*Grounding* recommends a two-step procedure for grounding EPA ESD control items.

The first step is to ground all components of the workstation and the personnel (worksurfaces, equipment, etc.) to the same electrical ground point, called the "common point ground." This common point ground is defined as a "system or method for connecting two or more grounding conductors to the same electrical potential."

This ESD common point ground should be properly identified. ESD Association standard ANSI/ESD S8.1 – Symbols, recommends the use of the symbol in Figure 1 to identify the common point ground.

The second step is to connect the common point ground to the equipment grounding conductor (AC ground) or the third wire (typically green) electrical ground connection. This is the preferred ground connection because all electrical equipment at the workstation is already connected to this ground. Connecting the ESD control materials or equipment to the equipment ground brings all components of the workstation to the same electrical potential. If a soldering iron used to repair an ESDS item were connected to the electrical ground and the surface containing the ESDS item were connected to an auxiliary ground, a difference in electrical potential could exist between the iron and the ESDS item. This difference in potential could cause damage to the item.

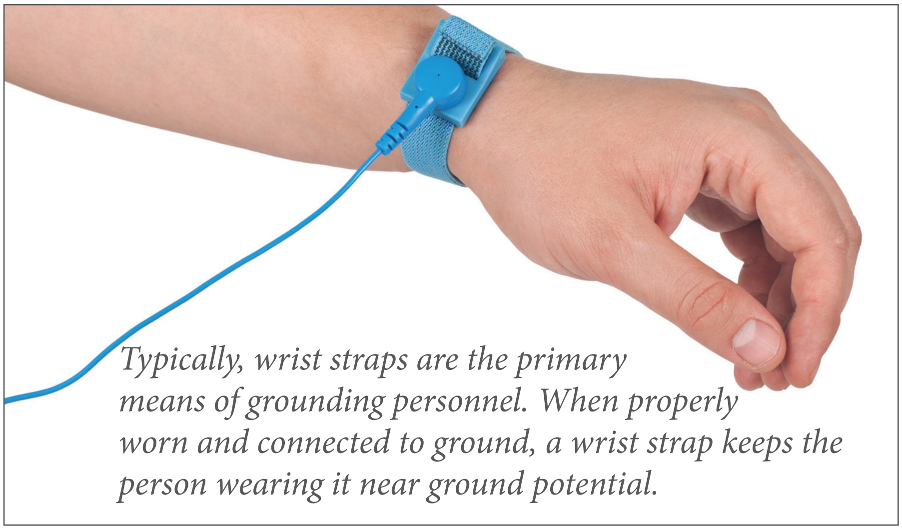
Any auxiliary ground (water pipe, building frame, ground stake) present and used at the workstation must be bonded to the equipment grounding conductor to minimize differences in potential between the two grounds. Detailed information on ESD grounding can be found in ESD Association standard ANSI/ESD S6.1, Grounding, and the ESD Handbook ESD TR20.20, and/or CLC/TR 61340-5-2 User guide.

CONTROLLING STATIC CHARGE ON PERSONNEL AND MOVING EQUIPMENT

People can be one of the prime generators of static electricity. The simple act of walking around or the motions required in repairing a circuit board can generate several thousand volts of electrostatic charge on the human body. If not properly controlled, this static charge can easily discharge into an ESD sensitive device – a typical Human Body Model discharge. Also, a person can transfer charge to a circuit board or other item making it vulnerable to Charged Device Model events in a subsequent process.

Even in highly automated assembly and test processes, people still handle

Figure 1: Common Point Ground Symbol



Typically, wrist straps are the primary means of grounding personnel. When properly worn and connected to ground, a wrist strap keeps the person wearing it near ground potential.

ESDS… in the warehouse, in repair, in the lab, in transport. For this reason, ESD control programs place considerable emphasis on controlling personnel generated electrostatic discharge. Similarly, the movement of mobile equipment (such as carts or trolleys) and other wheeled equipment through the facility also can generate substantial static charges that can transfer to the products being transported on this equipment.

WRIST STRAPS

Typically, wrist straps are the primary means of grounding personnel. When properly worn and connected to ground, a wrist strap keeps the person wearing it near ground potential. Because the person and other grounded objects in the work area are at or near the same potential, there can be no hazardous discharge between them. In addition, static charges are removed from the person to ground and do not accumulate. When personnel are seated on a chair which is not EPA appropriate, they are to be grounded using a wrist strap.

Wrist straps have two major components, the wristband that goes around the person's wrist and the ground cord that connects the wristband to the common point ground. Most wrist straps have a current limiting resistor molded into the ground cord on the end that connects to the wristband. This resistor is most commonly one megohm, rated at least 1/4 watt with a working voltage rating of 250 volts.

Wrist straps have several failure mechanisms and therefore should be tested on a regular basis. Either daily testing at specific test stations or using a continuous monitor at the workbench is recommended.

FLOORING, FLOOR MATS, FLOOR FINISHES

A second method of grounding personnel is a Flooring/Footwear System using ESD flooring in conjunction with ESD control footwear or foot grounders. This combination of conductive or dissipative floor materials and footwear provides a safe ground path for the dissipation of electrostatic charge, thus reducing the charge accumulation on personnel. In addition to dissipating charge, some floor materials (and floor finishes) also reduce triboelectric charging. The use of a Flooring/Footwear System is especially appropriate in those areas where increased personnel mobility is necessary. In addition, floor materials can minimize charge accumulation on chairs, mobile equipment (such as carts and trolleys), lift trucks and other objects that move across the floor. However, those items require dissipative or conductive casters or wheels to make electrical contact with the floor, and components to be electrically connected. When used as the personnel grounding system, the resistance to ground including the person, footwear and floor must be the same as specified for wrist straps (<35 megohms) and the accumulation body voltage in a standard walking voltage test (ANSI/ESD STM97.2) must be less than 100 volts.

SHOES, FOOT GROUNDERS, CASTERS

Used in combination with ESD flooring, static control shoes, foot grounders, casters and wheels provide the necessary electrical contact between the person or object and the flooring. Insulative footwear, casters, or wheels prevent static charges from flowing from the body or mobile equipment to the floor to ground and, therefore, have to be avoided.

CLOTHING

Clothing is a consideration in some ESD protective areas, especially in cleanrooms and very dry environments. Clothing materials, particularly those made of synthetic fabrics, can generate electrostatic charges that may discharge into ESDS or they may create electrostatic fields that may induce charges. Because clothing usually is electrically insulated or isolated from the body, charges on clothing fabrics are not necessarily dissipated to the skin and then to ground. Static control garments may suppress or otherwise affect an electric field from clothing worn underneath the garment. Per ANSI/ESD S20.20 and the Garment standard ANSI/ESD STM2.1, there are three categories of ESD garment:

- ESD Category 1 garment; a **static control garment** without being attached to ground. However, without grounding, a charge may accumulate on conductive or dissipative elements of a garment, if present, resulting in a charged source.

- ESD Category 2 garment; a **groundable static control garment,** when connected to ground, provides a higher level of suppression of the affects of an electric field from clothing worn underneath the garment.
- ESD Category 3 garment; a **groundable static control garment system** also bonds the skin of the person to an identified ground path. **The total system resistance including the person, garment and grounding cord shall be less than 35 megohms.**

WORKSTATIONS AND WORKSURFACES

An ESD protective workstation refers to the work area of a single individual that is constructed and equipped with materials and equipment to limit damage to ESD sensitive items. It may be a stand-alone station in a stockroom, warehouse, or assembly area, or in a field location such as a computer bay in commercial aircraft. A workstation also may be located in a controlled area such as a cleanroom. The key ESD control elements comprising most workstations are a static dissipative worksurface, a means of grounding personnel (usually a wrist strap), a common point ground, and appropriate signage and labeling. A typical workstation is shown in Figure 2.

The workstation provides a means for connecting all worksurfaces, fixtures, handling equipment, and grounding devices to a common point ground. In addition, there may be provision for connecting additional personnel grounding devices, equipment, and accessories such as constant or continuous monitors and ionizers.

Static protective worksurfaces with a resistance to ground of 1 megohm to 1 gigohm provide a surface that is at the same electrical potential as other ESD control items at the workstation. They also provide an electrical path to ground for the controlled dissipation of any static charges on materials that contact the surface. The worksurface also helps define a specific work area in which ESDS are to be handled. The worksurface is connected to the common point ground.

CONTINUOUS OR CONSTANT MONITORS

Continuous (or constant) monitors are designed to provide ongoing testing of the wrist strap system. While a number of technologies are utilized, the goal remains consistent: electrical connections are tested between the ground point, ground cord, wristband and person's body while the wearer handles ESDS. Continuous monitors

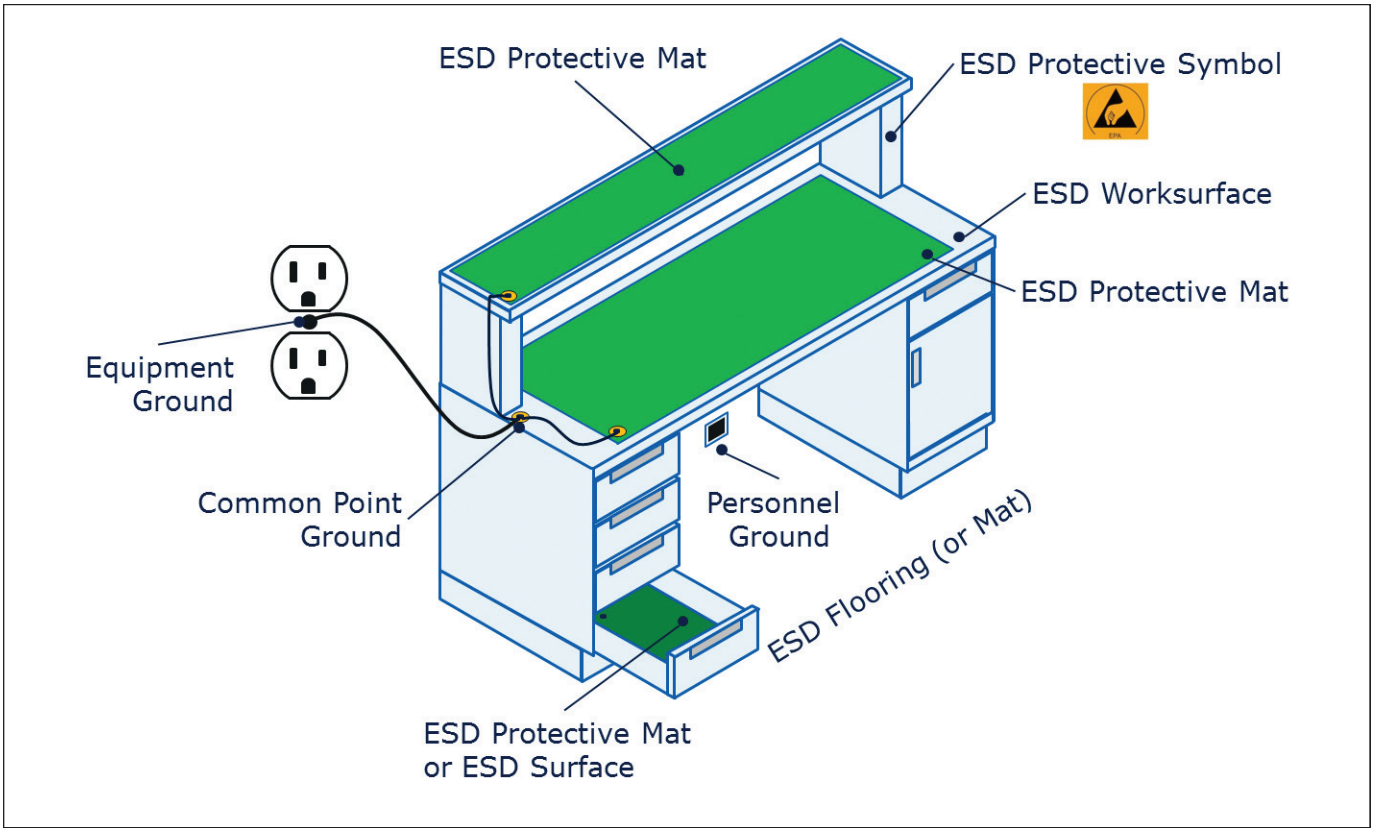


Figure 2: Typical ESD Workstation

may also provide a monitoring circuit for the ESD worksurface or other equipment connection to the ground reference.

Typical test programs recommend that wrist straps that are used daily should be tested daily. However, if the products that are being produced are of such value that knowledge of a continuous, reliable ground is needed, and then continuous monitoring should be considered or even required. Daily wrist strap testing may be omitted if continuous monitoring is used.

PRODUCTION EQUIPMENT AND PRODUCTION AIDS

Although personnel can be the prime generator of electrostatic charge, automated manufacturing and test equipment also can pose an ESD problem. For example, an ESDS device may become charged from sliding down a component part feeder. If the device then contacts the insertion head or another conductive surface, a rapid discharge occurs from the device to the metal object — a Charged Device Model (CDM) event. If charging of the ESDS cannot be avoided – which is quite often the case in modern assembly lines due to the insulative IC packages – charge storage should be reduced by the use of ionizers. In addition, various production aids such as hand tools, tapes, or solvents can also be ESD concerns.

Grounding is the primary means of controlling static charge on equipment and many production aids. Much electrical equipment is required by the National Electrical Code to be connected to the equipment ground (the green wire) in order to carry fault currents. This ground connection also will function for ESD control purposes. All electrical tools and equipment used to process ESD sensitive hardware require the 3 prong grounded type AC plug. Hand tools that are not electrically powered, i.e., pliers, wire cutters, and tweezers, are usually grounded through the ESD worksurface and the grounded person using the conductive/dissipative tools. Holding fixtures should be made of conductive or static dissipative materials when possible. Static dissipative materials are often suggested when very sensitive devices are being handled. A separate ground wire may be required for conductive or dissipative fixtures not in contact with an ESD worksurface or handled by a grounded person. For those items that are composed of insulative materials, the use of ionization or application of topical antistats may be required to control electrostatic charge generation and accumulation of static charges.

GLOVES AND FINGER COTS

Certainly, grounded personnel handling ESDS should not be wearing gloves or finger cots made from insulative material. If gloves or finger cots are used, the material should be dissipative or conductive. Compliance Verification ESD TR53 provides test procedures for measuring the electrical resistance of gloves or finger cots together with personnel in a system.

PACKAGING AND MATERIAL HANDLING

Inside the EPA packaging and material handing containers are to be low charging and be dissipative or conductive. Outside the EPA packaging and material handing containers are to also have a structure that provides electrostatic discharge shielding.

Direct protection of ESDS devices from electrostatic discharge is provided by packaging materials such as shielding bags, corrugated boxes, and rigid or semi-rigid plastic packages. The primary use of these items is to protect the product when it leaves the facility, usually when shipped to a customer. In addition, materials handling products such as tote boxes and other containers primarily provide protection during inter- or intra-facility transport.

The main ESD function of these packaging and materials handling products is to limit the possible impact of ESD from triboelectric charge generation, direct discharge, and in some cases electrostatic fields. The initial consideration is to have low charging materials in contact with ESD sensitive items. For example, the low charging property would control triboelectric charge resulting from sliding a board or component into the package or container. A second requirement is that the material can be grounded so that the resistance range must be conductive or dissipative. A third property required outside the EPA is to provide protection from direct electrostatic discharges that is discharge shielding.

Many materials are available that provide all three properties: low charging, resistance, and discharge shielding. The inside of these packaging materials have a low charging layer, but also have an outer layer with a surface resistance conductive or dissipative range. Per the Packaging standard ANSI/ESD S541, a low-charging, conductive or dissipative package is required for packaging or material handling within an EPA. Outside the EPA, the packaging must also have the discharge shielding property. Effectiveness, cost and device vulnerability to the various mechanisms need to be balanced in making packaging decisions (see ANSI/ESD S541, the ESD Handbook ESD TR20.20, and/or CLC/TR 61340-5-2 User guide for more detailed information).

Resistance or resistivity measurements help define the material's ability to provide electrostatic shielding or charge dissipation. Electrostatic shielding attenuates electrostatic fields on the surface of a package in order to prevent a difference in electrical potential from existing inside the package. Discharge shielding is provided by materials that have a surface resistance equal to or less than 1 kilohm when tested according to ANSI/ESD STM11.11 or a volume resistivity of equal to or less than 1×10^3 ohm-cm when tested according to the methods of ANSI/ESD STM11.12. In addition, effective shielding may be provided by packaging materials that provide a sufficiently large air gap between the package and the ESDS contents. Dissipative materials provide charge dissipation characteristics. These materials have a surface resistance greater than 10 kilohms but less than 100 gigohms when tested according to ANSI/ESD STM11.11 or a volume resistivity greater than 1.0×10^5 ohm-cm but less than or equal to 1.0×10^{12} ohm-cm when tested according to the methods of ANSI/ESD STM11.12. The ability of some packages to provide discharge shielding may be evaluated using ANSI/ESD STM11.31 which measures the energy transferred to the package interior. A material's low charging properties are not necessarily predicted by its resistance or resistivity.

IONIZATION

Most static control programs also deal with isolated conductors that are not grounded, or insulating materials (e.g., most common plastics) that cannot be grounded. Topical antistats may provide temporary ability to dissipate static charges under some circumstances.

More frequently, however, air ionization is used to neutralize the static charge on insulated and isolated objects by producing a balanced source of positively and negatively charged ions. Whatever static charge is present on objects in the work environment will be reduced, neutralized by attracting opposite polarity charges from the air. Because it uses only the air that is already present in the work environment, air ionization may be employed even in cleanrooms where chemical sprays and some static dissipative materials are not usable.

Air ionization is one component of a complete ESD control program, and not a substitute for grounding or other methods. Ionizers are used when it is not possible to properly ground everything and as backup to other static control methods. In cleanrooms, air ionization may be one of the few methods of static control available.

See Ionization standard ANSI/ESD STM3.1, ANSI/ESD SP3.3, and ESD TR53 for testing offset voltage (balance) and discharge times of ionizers.

CLEANROOMS

While the basic methods of static control discussed here are applicable in most environments, cleanroom manufacturing processes require special considerations.

Many objects integral to the semiconductor manufacturing process (quartz, glass, plastic, and ceramic) are inherently charge generating. Because these materials are insulators, this charge cannot be removed by grounding. Many static control materials contain carbon particles or surfactant additives that sometimes restrict their use in cleanrooms. The need for personnel mobility and the use of cleanroom garments often make the use of wrist straps difficult. In these circumstances, ionization and flooring/footwear grounding systems become key weapons against static charge.

IDENTIFICATION

A final element in our ESD control program is the use of appropriate symbols to identify ESD sensitive items, as well as specialty products intended to control ESD. The two most widely accepted symbols for identifying ESDS parts or ESD control protective materials are defined in ESD Association Standard ANSI/ESD

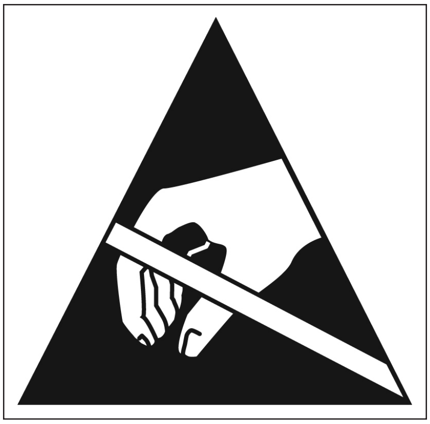


Figure 3: ESD Susceptibility Symbol

Figure 4: ESD Protective Symbol

S8.1 — ESD Awareness Symbols. The ESD Susceptibility Symbol (Figure 3) consists of a triangle, a reaching hand, and a slash through the reaching hand. The triangle means "caution" and the slash through the reaching hand means "Don't touch." Because of its broad usage, the hand in the triangle has become associated with ESD and the symbol literally translates to "ESD sensitive stuff, don't touch."

The ESD Susceptibility Symbol is applied directly to integrated circuits, boards, and assemblies that are ESD sensitive. It indicates that handling or use of this item may result in damage from ESD if proper precautions are not taken. Operators should be grounded prior to handling. If desired, the sensitivity level of the item may be added to the label.

The ESD Protective Symbol (Figure 4) consists of the reaching hand in the triangle. An arc around the triangle replaces the slash. This "umbrella" means protection. The symbol indicates ESD protective material. It is applied to mats, chairs, wrist straps, garments, packaging, and other items that provide ESD protection. It also may be used on equipment such as hand tools, conveyor belts, or automated handlers that is especially designed or modified to provide ESD control properties (low charging, conductive/dissipative resistance, and/or discharge shielding).

SUMMARY

Effective ESD control programs require a variety of procedures and materials. The ESD coordinator should release and control regularly a list of the specific EPA ESD control products permitted to be used in the program. We have provided a brief overview of the most commonly used products. Additional in-depth discussion of individual materials and procedures can be found in publications such as the ESD Handbook (ESD TR20.20) published by the ESD Association or the CLC/TR 61340-5-2 User guide.

Your program is up and running. How do you determine whether it is effective? How do you make sure your employees follow it? In Part Four, we will cover the topics of Auditing and Training. IN

FOR ADDITIONAL INFORMATION

ESD Association Standards

- *ANSI/ESD S1.1: Wrist Straps*, ESD Association, Rome, NY 13440
- *ANSI/ESD STM2.1: Garments-Characterization*, ESD Association, Rome, NY 13440
- *ANSI/ESD STM3.1: Ionization*, ESD Association, Rome, NY 13440
- *ANSI/ESD SP3.3: Periodic Verification of Air Ionizers*, ESD Association, Rome, NY 13440
- *ANSI/ESD S4.1: Worksurfaces-Resistance Measurements*, ESD Association, Rome, NY 13440
- *ANSI/ESD STM4.2: ESD Protective Worksurfaces - Charge Dissipation Characteristics*, ESD Association, Rome, NY 13440
- *ANSI/ESD S6.1: Grounding*, ESD Association, Rome, NY 13440
- *ANSI/ESD S7.1: Resistive Characterization of Materials-Floor Materials*, ESD Association, Rome, NY 13440
- *ANSI/ESD S8.1: Symbols-ESD Awareness*, ESD Association, Rome, NY 13440
- *ANSI/ESD STM9.1: Footwear-Resistive Characterization*, ESD Association, Rome, NY 13440
- *ESD SP9.2: Footwear-Foot Grounders Resistive Characterization*, ESD Association, Rome, NY 13440
- *ANSI/ESD SP10.1: Automated Handling Equipment*, ESD Association, Rome, NY 13440
- *ANSI/ESD STM11.11: Surface Resistance Measurement of Static Dissipative Planar Materials*, ESD Association, Rome, NY 13440
- *ANSI/ESD STM11.12: Volume Resistance Measurement of Static Dissipative Planar Materials*, ESD Association, Rome, NY 13440
- *ANSI/ESD STM11.13: Two-Point Resistance Measurement*, ESD Association, Rome, NY 13440
- *ANSI/ESD STM11.31: Evaluating the Performance of Electrostatic Discharge Shielding Bags*, ESD Association, Rome, NY 13440
- *ANSI/ESD STM12.1: Seating-Resistive Measurement*, ESD Association, Rome, NY 13440
- *ESD STM13.1: Electrical Soldering/Desoldering Hand Tools*, ESD Association, Rome, NY 13440
- *ANSI/ESD SP15.1: In-Use Resistance Testing of Gloves and Finger Cots, ESD Association, Rome, NY 13440*
- *ANSI/ESD S20.20: Standard for the Development of an ESD Control Program*, ESD Association, Rome, NY 13440
- *ANSI/ESD STM97.1: Floor Materials and Footwear - Resistance in Combination with a Person*, ESD Association, Rome, NY 13440
- *ANSI/ESD STM97.2: Floor Materials and Footwear - Voltage Measurement in Combination with a Person*, ESD Association, Rome, NY 13440
- *ANSI/ESD S541: Packaging Materials for ESD Sensitive Devices, ESD Association, Rome, NY 13440*
- *ESD ADV1.0: Glossary of Terms, ESD Association, Rome, NY 13440*
- *ESD ADV11.2: Triboelectric Charge Accumulation Testing*, ESD Association, Rome, NY 13440
- *ESD ADV53.1: ESD Protective Workstations*, ESD Association, Rome, NY 13440
- *ESD TR20.20: ESD Handbook*, ESD Association, Rome, NY 13440
- *ESD TR53: Compliance Verification of ESD Protective Equipment and Materials*, ESD Association, Rome, NY 13440

Other Resources

- System Reliability Center, 201 Mill Street, Rome, NY 13440
- *ANSI/IEEE STD142, IEEE Green Book*, Institute of Electrical and Electronics Engineers
- *ANSI/NFPA 70, National Electrical Code*, National Fire Protection Association, Quincy, MA
- *CLC/TR 61340-5-2 User guide,* European Committee for Electrotechnical Standardization, Brussels

EVENTS in Compliance

May 2014

19-22
8th Annual International Electrostatic Discharge Workshop (IEW)
ESD Association
Villard de Lans, France
www.incompliancemag.com/events/140519

20-22
Fundamentals of Random Vibration and Shock Testing, HALT, ESS, HASS
National Technical Systems
Santa Clarita, CA
www.incompliancemag.com/events/140520

21-22
CST STUDIO SUITE® EMC/EMI Training
CST of America
San Mateo, CA
www.incompliancemag.com/events/140521

June 2014

1-6
IMS2014 - 2014 International Microwave Symposium
IEEE Microwave Theory and Techniques Society (MTT-S)
Tampa Bay, FL
www.incompliancemag.com/events/140601

3-5
Advanced EMC & Signal Integrity Seminar
Archambeault EMI/EMC Enterprises and In Compliance
Peachtree City, GA
www.incompliancemag.com/events/140603_1

3-5
Fundamentals of Random Vibration and Shock Testing
Equipment Reliability Institute
Boxborough, MA
www.incompliancemag.com/events/140603_1

4
The CE Marking: Strategies for European Compliance
UL Knowledge Solutions
Chicago, IL
www.incompliancemag.com/events/140604

10
Understanding Ground Resistance Testing Training Seminar
AEMC Instruments
Denver, CO
www.incompliancemag.com/events/140610_1

10-11
Electronic Systems Design for EMC Compliance
LearnEMC
Detroit, MI
www.incompliancemag.com/events/140610_2

12
Computer Modeling Tools for Electromagnetic Compatibility
LearnEMC
Detroit, MI
www.incompliancemag.com/events/140612

16-19
Understanding, Planning and Performing Climatic and Dynamic Tests to MIL-STD-810G
Equipment Reliability Institute
Leuven, Belgium
www.incompliancemag.com/events/140616

17
Safety of Household and Similar Electrical Appliances; General Requirements, IEC 60335-1, 5th Ed
UL Knowledge Solutions
Chicago, IL
www.incompliancemag.com/events/140617_1

17-18
Industrial Control Panels UL 508A and Short-Circuit Current Ratings
UL Knowledge Solutions
Denver, CO
www.incompliancemag.com/events/140617_2

17-19
China 2014 / China MW 2014
Beijing International Convention Center
Beijing, China
www.incompliancemag.com/events/140617_3

24-26
Using Warnings and Instructions to Increase Safety and Reduce Liability
University of Wisconsin-Madison
Department of Engineering Professional Development
Madison, WI
www.incompliancemag.com/events/140624

PRODUCT Showcase

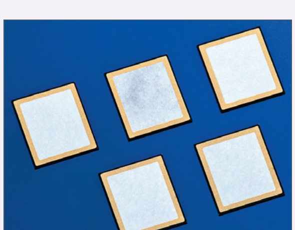
BUSINESS News

Advanced Test Equipment Rentals Now Carries Two New EMI Analyzers for CISPR 16-1-1 Compliance for Rent

Advanced Test Equipment Rentals (ATEC) has announced they now carries the latest EMI receiver and analyzers from top manufacturers Agilent and Rohde & Schwarz, from 20 Hz to 40 GHz, fully compliant to CISPR 16-1-1 with A2LA ISO 17025 calibration certification. The receivers that are now available for rental include the Agilent N9038A MXE with option 526 and the ESU40 from Rohde & Schwarz. Advanced Test Equipment Rentals supplies these essential tools for customers in need of conducted and radiated emissions testing to meet CISPR 16-1-1 standard and many other standards, and continues to provide the equipment the industry uses for their compliance testing needs. Visit www.atecorp.com for more information.

Cree Introduces the Industry's Most Powerful SiC Schottky Diodes

Cree, Inc. has introduced the new CPW5 Z-RecR high-power silicon-carbide (SiC) Schottky diodes, the industry's first commercially available family of 50 Amp SiC rectifiers. Designed to deliver the cost reduction, high efficiency, system simplicity and improved reliability of SiC technology to high power systems from 50kW to over 1MW, these new diodes can address demanding applications that include solar / PV inverters, industrial power supplies, induction heating, battery charging stations, wind turbine converters and traction inverters. Visit www.cree.com/power for more information.

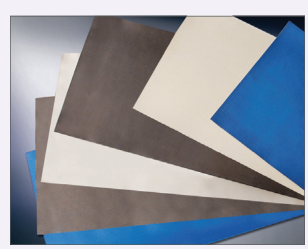


HAEFELY HIPOTRONICS Launches FP-COMB 32, Three-Phase CDN

HAEFELY HIPOTRONICS has introduced the FP-COMB 32 combined automatic three-phase Coupling/ Decoupling Network (CDN) for Surge Combination Wave, Ring Wave and EFT/Burst. It is fully compliant with the standard requirements of IEC/EN 61000-4-4, IEC/EN 61000-4-5 and IEC/EN 61000-4- 12. It is designed to allow users to efficiently set up and perform tests together with the AXOS series expandable immunity test systems. For more information, visit www.hipotronics.com

Conductive Elastomer Sheets

Leader Tech now offers its complete line of conductive elastomers in sheet form, giving manufac-turers the ability to cost-effectively create limitless shapes and custom die-cut gaskets for virtually any application requirement. TECHSIL conductive elastomer sheets are offered in 16 different formulations and several standard sizes including 10" x 10", 10" x 15" and 10 x 20". Multiple thicknesses can also be specified between .020" and .125". Additionally, Leader Tech's onsite formulation, testing and manufacturing capabilities allow customers to create a completely custom product with few restrictions on size, thickness or performance parameters. To learn more, download the complete product line catalog: www.leadertechinc.com/elastomercatalog.



Pasternack Introduces All New Line of X Band Amplifiers

Pasternack Enterprises, Inc., has introduces a new family of coaxial X band high gain power amplifiers. The new X band high gain power amplifiers from Pasternack are perfectly suited for high linearity applications with frequencies ranging from 8 to 12 GHz. These X-band amplifiers offer 30 to 41 dB small signal gain over a temperature range of -30°C and +70°C. The excellent gain flatness of these high gain amplifiers ranges from 0.50 dB to 1.0 dB and the IP3 output performs up to 44 dBm. View the entire line of these new products at www.pasternack.com/pages/Featured_Products/x-band-high-gain-power-amplifiers.htm.

Rohde & Schwarz Releases New Edition of CISPR News

Rohde & Schwarz has released the latest version of their CISPR News informs clients about new developments in CISPR product standards, arising from changes to EMI and EMS compliance measurements. For each standard, it describes the currently valid edition, new amendments, potential maintenance items, and more. To download the latest version, visit www.rohde-schwarz-usa.com/rs/rohdeschwarz/images/CISPR_March2014.pdf.

Saelig Debuts Air-Inflated EMI Shelters

Saelig Company, Inc. has introduced inflatable AirBeam Enclosures for quick set-up Electromagnetic Interference (EMI) shielded, Radio

Frequency Interference (RFI) shielded, or Chemical Biological Containment (CBC) enclosures, configured to rapidly deploy and provide an instant and uncomplicated state-of-the-art environment. These inflatables can be as small as 7x7-feet or as big as an aircraft hangar. Applications may include many types of EMI-RFI compliance testing, embassy or field military security, RF or radar interference shielding, EMI-RFI tolerance testing including HERO testing, secure TEMPEST communications, and field hospital or CBC uses with internal anti-microbial or other specialized fabric in place of the EMI-RFI shielded material. AirBeam enclosures are available now from Saelig Company Inc. Fairport, NY. For detailed specifications, visit www.saelig.com.

SCHURTER's New High Performance Compact Fuse for 3-phase Systems

SCHURTER announced the new series SHF 6.3x32 compact fuse. The series provides overcurrent protection up to 500 VAC. The high breaking capacity of 1500A at rated voltage safeguards electronic systems and operators in the event of a catastrophic short circuit incident. The compact size of the fuse, combined with its high ratings and performance, makes it suitable for a much broader range of applications than a typical 6.3x32 mm fuse. The SHF 6.3x32 series is offered in 10 current ratings ranging from 1 to 8 A. The fuse has a quick-acting characteristic according to UL 248-14. Visit www.SCHURTERinc.com/new_fuses for detailed specifications.

Slaughter Company, Inc. Announces Release of Electrical Safety Compliance Test Systems That Performs the Four Most Common Safety Tests

Slaughter Company, Inc. has announced the release of their new line of electrical safety test systems that will perform the four most common safety tests, AC Hipot, DC Hipot, Insulation Resistance and Ground Bond. The test systems include a 2900 Series Hipot tester and 2600 Series Ground Bond tester. The all new electrical safety test system series is a convenient and easy way to expand test functionality and maintain a single point of control. Learn more about the test systems by visiting Slaughter online at www.hipot.com/products/Systems.aspx.

TDK Offers New EPCOS Ferrite Data Book

TDK Corporation offers design engineers the newly-published EPCOS Data Book Ferrites and Accessories. The new data book covers RM cores, PQ cores, PM cores, EP, EPX and EPO cores, P cores and P core halves for proximity switches, E cores, ELP cores, EQ cores, ER cores, ETD cores, EFD cores, EV cores, U and UI cores, toroids, double-aperture cores, and ferrite polymer composites. The 621-page EPCOS Data Book Ferrites and Accessories from TDK can be downloaded free of charge at www.epcos.com/ferrites_databook.

Test Equipment Plus Announces the Signal Hound BB60A Real-time Spectrum Analyzer

Test Equipment Plus announced the Signal Hound BB60A, a real-time spectrum analyzer and RF recorder designed to capture and display RF events as short as 1 μs. The BB60A is a small, light-weight, and affordable USB-based real-time RF spectrum analyzer that operates from 9 kHz to 6 GHz and can go anywhere. It can also be customized to perform complex, remote, and/or automated functions. For more information, contact sales@signalhound.com or call 1-800-260-TEST.

York EMC Services Introduces a Combination Kit for their Popular YRS Line

York EMC Services (YES), of York England, with over 25 years of experience providing regulatory and compliance services and products introduces their new YRS (York Reference Source) Combination Kit. This new YRS includes both the YRS02 and the YRS03 reference sources for full 5 kHz to 6 GHz coverage in both Comb and Noise signals. This combination kit provides a 20% reduction in cost versus purchasing the two YRS units separately. This and other York EMC Services products are provided by Reliant EMC LLC as the exclusive distributor of York EMC Services products to the Americas. For more information, visit reliantemc.com/York-EMC-Services-YRS-Combination-Kit.html.

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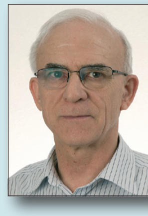

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We wish to thank our community of knowledgeable authors, indeed, experts in their field - who come together to bring you each issue of *In Compliance*. Their contributions of informative articles continue to move technology forward.

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