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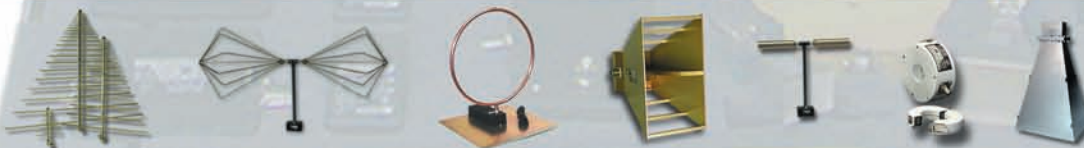




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*You can turn to us as your #1 source for all your compliance news - in our magazine, at events and online.*



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## 22 Designing Automotive Components for Guaranteed Compliance with Electromagnetic Compatibility Requirements

Automobiles typically have dozens of electronic systems operating interactively in a relatively compact space. These systems must operate reliably in a wide range of environments over extended periods of time.

**Todd Hubing**

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**Mary Ann Kahl**





## FCC News

### FCC Touts 4 Year Record on Broadband Deployment

The Federal Communications Commission (FCC) has released a summary of its significant actions and key developments over the past four years in expanding Americans' access to broadband communications.

Released in March 2013, the summary highlights record investments in fixed and mobile broadband infrastructure. According to the Commission, nearly \$250 billion in private capital has been invested in wired and wireless broadband networks in the U.S. since 2009, outstripping private investment in any other sector of the U.S. economy.

Europe, where investments in wireless networks are unchanged. Importantly, the Commission notes that investments in wireless broadband infrastructure have also created more than 1.6 million jobs over the past six years.

In connection with fixed, high-speed broadband access, the Commission estimates that average fixed broadband speeds have nearly doubled since 2009, with more than 80% of U.S. homes now having access to Internet speeds of at least 100 megabits per second (up from just 20% of U.S. homes in 2009). By comparison, the Commission says that networks capable of 30 megabits per second reach only 50% of households in the European Union.

The Commission's summary is available at [incompliancemag.com/news/1305\\_01](http://incompliancemag.com/news/1305_01).

### Commission Proposes Action to Improve 911 Reliability

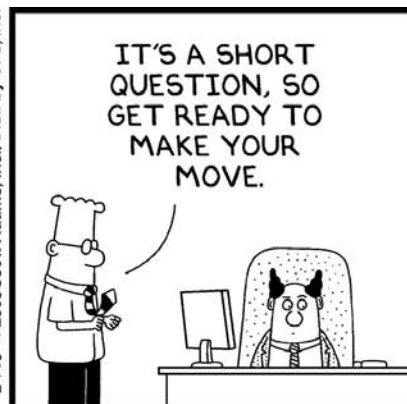
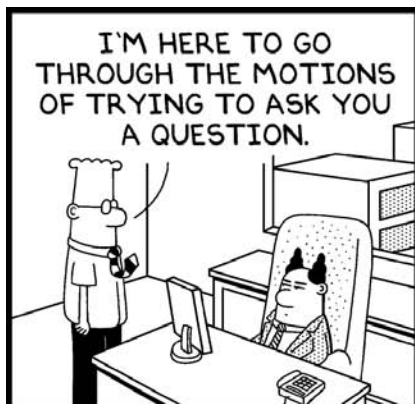
In an effort to ensure the reliability of emergency communications during natural and manmade disasters, the Federal Communications Commission (FCC) has proposed rule changes that would facilitate the identification of network outages and speed service restoration.

In an effort to ensure the reliability of emergency communications during natural and manmade disasters, the FCC has proposed rule changes that would facilitate the identification of network outages and speed service restoration.

This investment includes nearly \$30 billion in U.S. wireless networks in 2012 (a 40% increase since 2009), and a projected investment of \$35 billion in 2013. The growth in U.S. investment rates in mobile broadband far surpass those in Asia, where investment has grown a meager 4% in four years, and in

The release of the Commission's summary of its broadband accomplishments corresponds with the resignation of FCC Chairman Julius Genachowski, who championed expanded broadband access as a key part of the Commission's agenda during his four year term.

In a Notice of Proposed Rulemaking issued in March 2013, the Commission has proposed the adoption of key recommendations for bolstering emergency communications services made by its Public Safety and Homeland Security Bureau. The proposed changes would establish



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## FCC News

emergency communications network reliability requirements, and modify certification and reporting rules to ensure compliance. The FCC would also implement compliance reviews and inspections to ensure that emergency communications service providers are meeting requirements and adhering to prescribed practices.

The Bureau's recommendations were the result of an extensive investigation into emergency communications service failures that occurred following a major storm that hit portions of the U.S. in June 2012. During the so-called "derecho" storm, 77 emergency call centers operating in six states lost some or all communications capabilities, affecting more than 3.6 million people.

The Commission's NPRM on emergency communications networks is available at [incompliancemag.com/news/1305\\_02](http://incompliancemag.com/news/1305_02).

### Company Pays \$1 Million in Connection with Rural Call Completion Failures

Level 3 Communications of Broomfield, CO has agreed to make a "voluntary contribution" of nearly \$1 million to the U.S. Treasury to settle charges that it failed to meet rigorous new call completion standards imposed by the Federal Communications Commission (FCC).

According to the FCC, the higher rate of rural call completion failures is attributable to long-distance carriers who attempt to reduce the intercarrier compensation paid to local telephone companies by using third-party "least-cost routers." Under the provisions of the federal Communications Act, long distance carriers are responsible for correcting any network service-related issues that result in degraded communications service to certain areas.

Under its agreement with the FCC, Level 3 has agreed to cease its use of poor performing least-cost routers and to achieve long-distance call completion rates to rural areas within 5% of completion rates in non-rural areas over a two-year period. Further, the company has agreed to report compliance with this 5% benchmark every quarter beginning in January 2014, and to pay an additional \$1 million voluntary contribution if it fails to achieve the 5% benchmark in any quarter.

As part of its own effort to reduce rural call failure rates, the Commission has proposed new data collection and reporting rules in order to better monitor the performance of long-distance carriers in rural areas. In addition, the Commission is gradually phasing out intercarrier fees, thereby reducing the financial incentives that it says contribute to call completion failures.

## European Union News

### EU Commission Updates Standards List for PPE Directive

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

For the purposes of the Directive, personal protective equipment (or PPE) is defined as "any device or appliance designed to be worn or held by an individual for protection against one or more health and safety hazards." Specifically excluded from the scope

of the Directive is equipment designed specifically for private use (such as seasonal outdoor clothing), equipment for use by armed forces or law enforcement personnel, and equipment intended for the protection or rescue of individuals on vessels or aircraft.

The extensive list of CEN and Cenelec standards was published in March 2013 in the *Official Journal of the European Union*, and replaces all previously published standards lists for the Directive.

The complete updated standards list for the EU's PPE Directive is available at [incompliancemag.com/news/1305\\_03](http://incompliancemag.com/news/1305_03).

### EU Council Makes Electronic OJ Official

The Council of the European Union (EU) has taken action to make the electronic version of the *Official Journal of the European Union* official.

The *Official Journal* is the definitive record of all legislation, regulation and other legal acts implemented within the EU, and is available in all 23 of the official languages of the EU. Until now, the printed version of the *Official Journal* has been the only legally binding version of EU law, despite its long-time availability in electronic form. This has required the printing and distribution of each daily edition in each official



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## European Union News

language, creating immense logistical challenges and perpetuating an outdated and ecologically problematic mode of communication.

In its Regulation issued in March 2013, the EU Council moved to give the electronic version of the *Official Journal* equal legal status with the printed version. Under the Regulation, the electronic version “shall be authentic and shall produce legal effects,” and be available online and free of charge “in a non-obsolete format and for an unlimited period.” The Regulation is expected to take effect as of July 2013.

The complete text of the Council’s regulation regarding the status of the electronic version of EU’s *Official Journal* is available at

[incompliancemag.com/news/1305\\_04](http://incompliancemag.com/news/1305_04). Access to the on-line version of the *Official Journal* is available at [incompliancemag.com/news/1305\\_05](http://incompliancemag.com/news/1305_05).

### EU Amends Energy Efficiency Labeling Regulations

The Parliament and the Council of the European Union (EU) have amended the EU’s energy-efficiency labeling program regulations for office equipment.

The EU originally issued energy-efficiency labeling regulations in 2008 to support its partnership with the U.S. Environmental Protection Agency’s ENERGY STAR program. Since then,

the EU has also established a framework that created ecodesign requirements for a wide range of energy-related products, as well as a 2010 directive addressing labeling and product information requirements. In addition, the EU and the U.S. have recently signed an updated agreement defining the coordination of their respective energy-efficiency labeling programs for office equipment. The amended EU regulations were issued to accurately reflect these and other changes.

The amendments to the EU’s energy-efficiency labeling program were published in the *Official Journal of the European Union* in March 2013. The complete text of the EU’s regulations amendments is available at [incompliancemag.com/news/1305\\_06](http://incompliancemag.com/news/1305_06).

## CPSC News

### Company Recalls Air Purifiers Due to Fire Hazard

The 3M Company of St. Paul, MN has announced the recall of about 10,000 of its Filtrete-brand room air purifiers manufactured in Taiwan.

According to the company, the ion generator in the air purifier unit can overheat, posing a burn and fire hazard to consumers. 3M says that it has received two separate reports in connection with the recalled air purifiers, one in which the unit overheated and another in which the unit caught fire. However, there have been no reports of injuries.

The Filtrete air purifiers were sold at hardware stores and home goods centers nationwide, including Ace Hardware stores True Value Hardware stores, and Lowes, as well as online through Amazon.com. Purifier models

affected by this recall were sold between November 2008 and January 2013 for about \$60.

Additional information about this recall is available at [incompliancemag.com/news/1305\\_07](http://incompliancemag.com/news/1305_07).

### LED Light Bulbs Recalled Due to Fire Hazard

Lighting Science Group of Satellite Beach, FL has recalled more than half a million LED light bulbs manufactured in China.

The company has reported to the U.S. Consumer Product Safety Commission that the light bulbs can overheat, posing a burn and fire hazard to consumers. Lighting Science Group has received 68 separate reports of failures related to the recalled bulbs, including eight reports of bulbs emitting visible smoke or fire. The

failures have resulted in damage to light sockets, melted fixtures, and burned rugs, carpets and floors. There have been no reports of injuries.

The recalled 120-volt LED lighting bulbs were manufactured in 2010 and 2011, and marketed under the brand names Definity, EcoSmart, Sylvania and West-inghouse. They were sold through various retailers nationwide, including hardware, lighting and electrical supply stores.

Further details about this recall are available at [incompliancemag.com/news/1305\\_08](http://incompliancemag.com/news/1305_08).

### Disco Lamps Recalled Due to Electric Shock Hazard

Justice stores have recalled about 19,100 of its “Style my Room by Justice” disco lamps manufactured in China. Justice has reported to the U.S.



## CPSC News

Consumer Product Safety Commission that the electrical wiring in the lamp base is accessible to consumers, and that the lamp can overheat, posing a risk of both burns and electrical shock to consumers. The company says that it has been notified of one incident related to the recalled lamp overheating, as well as one incident in which a consumer received an electric shock from the lamp.

The recall disco lamps were sold in Justice stores nationwide and online at [www.shopjustice.com](http://www.shopjustice.com) from May through November 2012 for about \$24.

For more information about this recall, go to [incompliancemag.com/news/1305\\_09](http://incompliancemag.com/news/1305_09).

### No Wonder They Tasted So Good! (From our "You Can't Make This Stuff Up" file)

The U.S. Food and Drug Administration (FDA) has shut down a New Jersey bakery for unlawfully distributing misbranded "sugar free" and "fat free" food products.

According to the FDA, Butterfly Bakery, Inc. of Clifton, NJ engaged for several years in distributing muffins and snack cakes that contained undisclosed levels of sugar and fat. FDA laboratory tests showed that certain foods labeled as "sugar free" contained sugar, and that other products contained as much as three times the amount of sugar declared on the products' labels. In addition,

some products contained two times the labeled amount of fat or saturated fat.

The FDA's action was affirmed in a consent decree issued in March 2013 by a U.S. federal judge, and the company is barred from producing or distributing bakery products until it complies with FDA regulations. Butterfly Bakery and its president, Brenda Isaac, may be also subject to damages for future violations.

An FDA news release regarding the case is available at [incompliancemag.com/news/1305\\_10](http://incompliancemag.com/news/1305_10).

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## iNARTE Fully Integrated with RABQSA International, Inc.

BY RABQSA STAFF

On May 6, 2012, iNARTE formally merged with RABQSA International. Since that time, the iNARTE staff members, including Mr. and Mrs. Brian and Kathy Lawrence, have worked closely with RABQSA staff members to successfully merge iNARTE operations and exam development into RABQSA.

While the [www.narte.org](http://www.narte.org) website continues to be the main source of information for iNARTE certifications at this time, the operations of iNARTE certifications are fully managed by RABQSA out of the Milwaukee, WI principal office.

Mr. Peter Holtmann, CEO of RABQSA, commented that the addition of iNARTE products to the RABQSA offering has provided great value and a broader scope of offering to our global audience. "We see a bright future for the iNARTE product. The experience gained by merging of the non-profit into RABQSA will serve us well for our future pursuits."

iNARTE would not be where it is today without the dedication of Brian

and Kathy Lawrence, ensuring the continuance of the legacy iNARTE certifications and continuing to add value to industry by identifying and developing new certification programs to meet the needs of professionals around the world. RABQSA thanks Brian and Kathy Lawrence for their time and expertise over the last year, ensuring the knowledge and content transfer was a success so that iNARTE will continue to thrive as a product of RABQSA.

To learn more about the iNARTE certification programs, visit [www.narte.org](http://www.narte.org)

To learn more about RABQSA, visit [www.rabqsa.com](http://www.rabqsa.com)

### PRODUCT SAFETY CERTIFICATION PROGRAM: JOB ANALYSIS SURVEY RESULTS ARE IN

The primary purpose of a job analysis survey is to validate the knowledge and performance topics required within a job role that are measured as part of the written examination. The survey results are also used to validate other requirements applicants must meet before certification can be awarded.

To establish the validity of knowledge topics, respondents are asked to provide an importance and frequency rating, based on how the topic applies in their current role. The importance and frequency ratings are used to ensure that the knowledge topics being measured within an examination are appropriate, important, and applied frequently enough within the job role.

The results of the Product Safety Job Analysis survey administered in December 2012 validated the current certification requirements for the iNARTE Product Safety certification program. As reported in the prior issue of InCompliance magazine, 78% of the responders had over 10 years of work experience in product safety and 58% held at least a bachelor's degree, thus confirming the current work experience and education requirements so that these requirements can remain unchanged for the Product Safety program.

The data regarding the knowledge examination validated all examination topics except the topic titled "Military and Civil Electrical Safety Standards". This topic had low importance and frequency ratings, meaning that this topic is neither important nor used frequently enough in the role of Product Safety Engineers and Technicians to be included as part of the examination process. More



importantly, given that most Product Safety Engineers and Technicians are in the United States and Japan, the low ratings were consistent between both countries. As a result, this topic will be removed from all examinations beginning in June 2013.

The results from the survey were used to construct the final structure of the test specifications. A set of test specifications are the knowledge topics and the number of test questions that will appear in each exam in support of a certification program. More information on the final set of test specifications for the Product Safety Engineer and Technician exams can be found at [www.narte.org/h/ps.asp](http://www.narte.org/h/ps.asp)

For more information regarding the Product Safety Job Analysis Survey, please contact Mary Rehm, RABQSA Psychometrician, at [mrehm@rabqsa.com](mailto:mrehm@rabqsa.com) or visit [www.narte.org/h/ps.asp](http://www.narte.org/h/ps.asp)

### **RABQSA IS SEEKING INARTE EMC SUB- COMMITTEE MEMBERS**

RABQSA International, in partnership with the EMC Society, is currently facilitating the review of the certification and examination requirements for the iNARTE EMC Engineer and Technician personnel certification program. The process for this review includes conducting a job analysis survey, developing an updated

version of test specifications, and validating or updating the certification requirements.

The EMC Steering Committee is seeking individuals to participate on several Technical Advisory Groups (TAGs) who will meet in web (online) meetings to accomplish the following activities:

- **Item Writing: writing test questions (items) for the EMC Engineer and Technician exams**

Individuals who may participate on the Item Writing TAG are individuals who

- Are currently certified as an iNARTE EMC Engineer or Technician
- May be current or future instructors

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- **Item Review:** review current test questions (items) and newly written test questions for accuracy and appropriateness
- **Exam Review:** review the pilot exam form for accuracy and appropriateness
- **Cut Score Study:** analyze the content of the pilot exam form to aid in setting an appropriate passing (cut) score

Individuals who may participate on the Item Review, Exam Review and Cut Score Study TAGs are individuals who


- Are currently certified as an iNARTE EMC Engineer or Technician
- May NOT be current or future instructors

All TAG members are required to sign a confidentiality agreement with RABQSA International prior to attending any meetings stating that no confidential information (i.e., the written test items) will be disclosed to third-parties.

If you would like to participate on an iNARTE EMC TAG, please confirm

your interest by sending your resume or CV to Mary Rehm, RABQSA Psychometrician, at [mrehm@rabqsa.com](mailto:mrehm@rabqsa.com).

## RABQSA ONLINE PORTAL

To ensure you receive access to your iNARTE records via the RABQSA Online Portal when it is made available, send your name, certificate number, and current email address to Laura Funk, RABQSA Office Assistant, Certification Services, at [lfunk@rabqsa.com](mailto:lfunk@rabqsa.com). 

*iNARTE is a product of RABQSA International, Inc.*

## QUESTION OF THE MONTH

**Last month's question was from the EMC Design Engineer pool:**

When designing high-speed Printed Wiring Boards, should power and return planes be on adjacent layers, and for what reason?

- A) Yes, to reduce noise on the power plane at high frequencies.
- B) No, because the material that separates the power and return planes will often fail and short the power plane.
- C) Yes, it is industry standard to design the connectors so that they are forced to feed the power and grounds on adjacent layers.
- D) Yes, if the planes are not routed next to each other, the boards may warp during fabrication.

While a case could be made for (A), the generally accepted answer is *D*) Yes, if the planes are not routed next to each other, the boards may warp during fabrication.

**This month's question is from the EMC Engineer pool:**

In Automotive EMC testing according to CISPR 25, what value of series capacitance is in the LISN (Artificial Network) between the power supply and equipment under test (EUT)?

- A) 500  $\mu$ F
- B) 50  $\mu$ F
- C) 5  $\mu$ F
- D) A series capacitor is not used.

See next month's iNARTE Informer for the correct answer to this month's question.

*RABQSA's mission is to provide world-class products and services that add value to professionals in industry through competency-based certification. RABQSA creates value for you and your customers. We design, develop, and deliver personnel and training certification services relevant to your industry. Our certification services are designed to be efficient, consistent and relevant to Industry's needs. We create and maintain value to industry, our certified professionals, and training providers by ensuring that our certification remains relevant and also compliant to international standards. RABQSA International certification delivers the right people, with the right abilities, to achieve the right outcomes.*

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9:00 am - 5:00 pm  
June 13, 2013:  
9:00 am - 12:00 noon

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## Neutralization of Static Charges by Air Ions

### Part II: Experimental Results

BY NIELS JONASSEN, sponsored by the ESD Association

This second installment on charge neutralization demonstrates that a CPM can be used to determine fundamental atmospheric electric quantities.

#### 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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The most commonly used instrument for evaluating the ionization state of an atmosphere is the charged-plate monitor (CPM) shown in Figure 1. In the figure, a metal plate with the area A is placed a distance d from a ground plate in which is inserted a fieldmeter probe. The charged plate can be charged to a selected voltage (usually 1 or 5 kV), and the voltage can be measured on the fieldmeter.

When an atmosphere or ionization system is to be evaluated, the charged plate is exposed to the atmosphere, charged to a selected voltage, and the time,  $t_{10}$ , for the voltage to drop to one-tenth of the starting voltage is measured. This time depends on the geometry of the CPM and the negative resistivity of the air if a positive voltage is chosen.

Consequently, it is not possible to use a CPM measurement to predict directly how fast an arbitrary item will be neutralized, even when both the CPM and the item are exposed to the same atmosphere. However, in many cases, the neutralization time for an item can be deduced indirectly from CPM measurements.

#### THEORY OF A CPM

In Part I of this article, it was shown that the charge on a positively charged body suspended freely in air will be neutralized exponentially with a time constant of

$$\tau_o^+ = \epsilon_o \rho^- \quad (1)$$

where  $\rho^-$  is the resistivity of the air due to negative ions.<sup>1</sup>

The time constant in an exponential decay is the time it takes the decaying quantity to drop to  $1/e$  of the initial value, with e being the base of the natural logarithm ( $\approx 2.72$ ). Consequently, for any system with the time constant  $\tau$ , there is the relationship

$$t_{10} = \tau \cdot \ln 10 \quad (2)$$

The time constant  $\tau_o$  (known as the *fundamental time constant*) given by Equation 1 is the lowest time constant for any system in an atmosphere

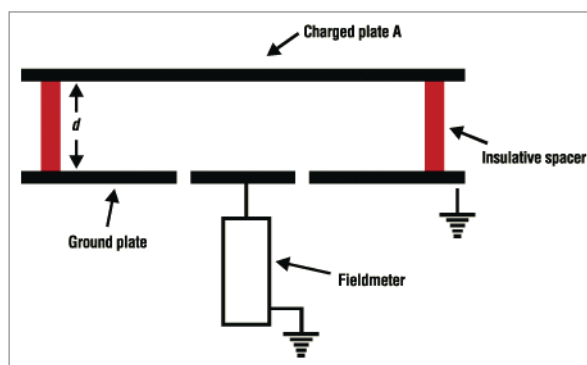


Figure 1: Charged-plate monitor



characterized by the parameters  $\epsilon_o$  and  $\rho$ .

Figure 2 shows a system consisting of a positively charged metal plate with the area  $A$ , separated from ground by a dielectric with the thickness  $d$  and the relative permittivity  $\epsilon_r$ . In Part I, it was suggested that the plate A, when exposed to an atmosphere with the fundamental time constant  $\tau_o^+$ , would have a time constant  $\tau^+$  given by

$$\tau^+ = \frac{C_a + C_d}{C_a} \cdot \tau_o^+ \quad (3)$$

where

$$C_d = \epsilon_o \epsilon_r \frac{A}{d} = \epsilon_o \epsilon_r \frac{\pi r^2}{d} \quad (4)$$

The variable  $r$  is the (equivalent) radius of the metal plate

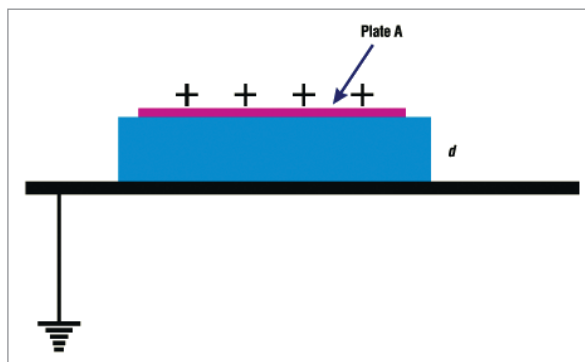


Figure 2: Charged plate near ground

$$r = \sqrt{\frac{A}{\pi}} \text{ or } \frac{O}{2\pi}$$

where  $O$  is the circumference of plate A. The variable  $\epsilon_r$  is the relative permittivity of the dielectric. The capacitance  $C_a$  of the metal plate relative to the air was approximated by

$$C_a = 2\pi\epsilon_o r \quad (5)$$

Introducing Equations 4 and 5 into Equation 3 gives

$$\tau^+ = \left(1 + \frac{\epsilon_r r}{2d}\right) \tau_o^+ \quad (6)$$

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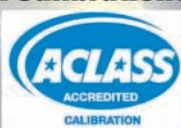


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It should be mentioned that, in some CPMs, the plate voltage is monitored by a noncontacting voltmeter, which may add a stray capacitance  $C_s$  from the support.

When applying Equation 3 on a CPM, as shown in Figure 1, Equation 6 reduces to

$$\tau^+ = \left(1 + \frac{r}{2d}\right) \tau_o^+ \quad (7)$$

because  $\epsilon_r = 1$  for air.

It should be mentioned that, in some CPMs, the plate voltage is monitored by a noncontacting voltmeter, which may add a stray capacitance  $C_s$  from the support. In such cases, the factor

$$1 + \frac{r}{2d}$$

should be replaced by

$$1 + \frac{C_s}{2\pi\epsilon_o r} + \frac{r}{2d}$$

## EXPERIMENTAL RESULTS

To verify experimentally the relationship expressed in Equation 7, it is necessary to be able to establish an atmosphere with a known value for  $\tau_o$ . Although the fundamental time constant,  $\tau_o$ , cannot be measured directly, Equation 1 may be reformulated, writing  $\rho^-$  as

$$\rho^- = \frac{1}{ek^- n^-} \quad (8)$$

where  $e$  is the electronic (and small-ion) charge,  $k^-$  is the mobility of negative ions, and  $n^-$  is the relevant negative-ion concentration.

Combining Equations 1, 4, and 5 gives the following results:

$$\tau^+ = \left(1 + \frac{r}{2d}\right) \frac{\epsilon_o}{ek^- n^-} \quad (9)$$

and

$$\tau^- = \left(1 + \frac{r}{2d}\right) \frac{\epsilon_o}{ek^+ n^+} \quad (10)$$

The constants in Equations 4, 5, 9, and 10 had the following values:  $r = 9 \cdot 10^{-2}$  m,  $d = 1.5 \cdot 10^{-2}$  m,  $\epsilon_o = 8.85 \cdot 10^{-12}$  F  $\cdot$  m $^{-1}$ ,  $e = 1.6 \cdot 10^{-19}$  C,  $k^- \approx 1.8 \cdot 10^{-4}$  m $^2 \cdot$  V $^{-1} \cdot$  s $^{-1}$ , and  $k^+ \approx 1.4 \cdot 10^{-4}$  m $^2 \cdot$  V $^{-1} \cdot$  s $^{-1}$ . Substituting these values into the relevant equations results in the following capacitance and decay-time values to be recorded on the CPM:  $C_d = 15$  pF,  $C_a = 5$  pF,

$$t_{10}^+ = \ln 10 \cdot \tau^+ = 2.83 \cdot 10^{12} \frac{1}{n^-} \quad (11)$$

and

$$t_{10}^- = \ln 10 \cdot \tau^- = 3.64 \cdot 10^{12} \frac{1}{n^+} \quad (12)$$

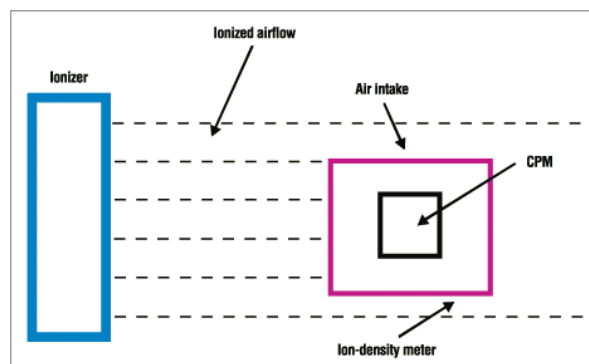


Figure 3: Experimental setup

The setup shown in Figure 3 was used for the experiments. An ionizer was placed at a well-defined distance from an ion-density meter. Because an ion blower was used as the ionizer, the air intake of the ion-density meter was placed perpendicular to the airflow so that the airflow would not be disturbed through the meter. The CPM was placed on top of the ion-density meter. It is important that the field from the charged plate is insignificant at the air intake, and the placement on top of the ion-density meter turned out to be the

Distance $a$ (m)	$n^+$ ( $10^{11}$ ions/m $^3$ )	$n^-$ ( $10^{11}$ ions/m $^3$ )	$t_{10}^+$ (seconds)	$t_{10}^-$ (seconds)
Ion blower				
1	3.2–3.6	2.5–2.9	11.8	12.3
1.5	2.2–2.6	1.8–2.2	16.9	17.7
2	1.0–1.4	0.8–1.2	32.0	34.1
2.5	0.4–0.6	0.2–0.4	105	83.7
Ion bar				
1	0.20–0.24	0.16–0.20	180	190

Table 1: Ion concentrations and CPM decay times.



A series of experiments were performed in which the positive- and negative-ion density and the corresponding decay times ( $t_{10}$  values) were measured.

best because the CPM also needed to be exposed to the ionized airflow.

A series of experiments were performed in which the positive- and negative-ion density and the corresponding decay times ( $t_{10}$  values) were measured. The ion densities were varied by varying the distance  $a$  between the ionizer and the ion-density meter. For each distance, the average ion density and the decay times for positive and negative voltages were measured. The results are shown in Table 1. Each of the decay times is the average of five measurements.

To compare the experimental results with the predictions of Equations 11 and 12, the products

$$n^+ \cdot t_{10}^-$$

and

$$n^- \cdot t_{10}^+$$

were calculated with the following results:

$$t_{10}^- = 4.18 \cdot 10^{12} \cdot \frac{1}{n^+} \quad (13)$$

and

$$t_{10}^+ = 3.23 \cdot 10^{12} \cdot \frac{1}{n^-} \quad (14)$$

It appears that the coefficients in the experimentally determined Equations 13 and 14 are 14–15% greater than the theoretical values of the corresponding Equations 12 and 11, respectively. This discrepancy must be caused by the approximation used in evaluating the

air capacitance  $C_a$  (Equation 5), which overestimated the capacitance by about 19%. Therefore, Equation 5 should read

$$C_a = 1.68\pi\epsilon_0 r \quad (5a)$$

resulting in  $C_a = 4.2$  pF for the CPM investigated. Correspondingly, Equations 6, 7, 9, and 10 become


$$\tau^+ = \left(1 + \frac{\epsilon_r r}{1.68d}\right) \tau_0^+ \quad (6a)$$

$$\tau^+ = \left(1 + \frac{r}{1.68d}\right) \tau_0^+ \quad (7a)$$

$$\tau^+ = \left(1 + \frac{r}{1.68d}\right) \frac{\epsilon_0}{ek^+ n^-} \quad (9a)$$

and

$$\tau^- = \left(1 + \frac{r}{1.68d}\right) \frac{\epsilon_0}{ek^+ n^+} \quad (10a)$$


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It has been demonstrated that it is possible to use a CPM with given dimensions to determine fundamental atmospheric electric quantities such as ion density and resistivity.

## DISCUSSION OF THE RESULTS

The equations developed in this article indicate that, by the use of a CPM with given geometric and dielectric characteristics, it is possible to predict the ion concentrations and resistivities of a given (ionized) atmosphere. However, a more-important implication is that it is, in many cases, also possible to estimate how fast an ordinary charged item (i.e., not just a CPM) will be neutralized in a given atmosphere.

For example, if Equation 7a is applied on the CPM used in this investigation (i.e.,  $r = 9 \cdot 10^{-2}$  m and  $d = 1.5 \cdot 10^{-2}$  m), the result would be

$$\tau_{\text{CPM}}^+ = 4.57 \cdot \tau_o^+ \quad (7b)$$

Equation 7b indicates that, for a given atmosphere, the CPM will measure a time constant that is 4.57 times greater than the fundamental time constant for the atmosphere in question.

Now assume there is an item like that shown in Figure 2, with a charged metal plate A, an effective radius  $r_i = 0.1$  m, a thickness  $d_i = 10^{-2}$  m, and a relative permittivity  $\epsilon_{ri} = 4.0$ . According to Equation 6a, the time constant should be

$$\tau_i^+ = \left(1 + \frac{4 \cdot 0.1}{1.68 \cdot 10^{-2}}\right) \tau_o^+ = 24.8 \cdot \tau_o^+ \quad (6b)$$

Combining Equation 6b with 7b results in

$$\tau_i^+ = 5.43 \cdot \tau_{\text{CPM}}^+ \quad (15)$$

It is therefore possible to use a CPM measurement to predict how fast a charged metal plate, separated from ground by a dielectric, will be neutralized.

Labeling the parameters of the CPM with c and of the item with i, the general equation relating a predicted neutralization time with the corresponding time measured by a CPM will be

$$t_{10,i} = \frac{1 + \frac{\epsilon_{ri} r_i}{1.68 d_i}}{1 + \frac{r_c}{1.68 d_c}} \cdot t_{10,c} \quad (16)$$

Equation 16 is valid for positive as well as negative voltages, corresponding to ions of opposite polarities, and for time constants as well as for  $t_{10}$  times.

## INSULATORS

As was explained in Part I, the neutralization of a charge located on the surface of a dielectric follows the same rules as that of a charge located on the surface of a conductive plate.<sup>1</sup> The equations in this article are therefore valid when  $r_i$  is the radius of the charged area,  $\epsilon_{ri}$  is the relative permittivity, and  $d_i$  is the thickness of the dielectric.

## CONCLUSION

It has been demonstrated that it is possible to use a CPM with given dimensions to determine fundamental atmospheric electric quantities such as ion density and resistivity. Furthermore, it has been shown that the neutralization time for commonly

shaped charged conductors, as well as for insulators, can be deduced from measurements of the neutralization time with a CPM. ■

## ACKNOWLEDGMENT

The cooperation of Ion Systems (Culemborg, The Netherlands) and Simco (Lochem, The Netherlands) for allowing the use of their ion blower and ion bar, respectively, is greatly appreciated.

## REFERENCE

1. Niels Jonassen, "Neutralization of Static Charges by Air Ions: Part 1, Theory" in Mr. Static, *Compliance Engineering* 19, no. 4 (2002): 28–31.

(the author)

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







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# Designing Automotive Components for Guaranteed Compliance with Electromagnetic Compatibility Requirements

BY TODD HUBING

Automobiles typically have dozens of electronic systems operating interactively in a relatively compact space. These systems must operate reliably in a wide range of environments over extended periods of time. As a growing number of these systems play an ever expanding role in protecting the safety of a vehicle's occupants, there is an increasing need to ensure that the integrity of these systems will not be compromised by electromagnetic interference.

**T**he traditional design, build and test approach to automotive EMC compliance will not be sufficient to ensure the safety or reliability of tomorrow's automobiles. A *Design for Guaranteed Compliance* approach promises to ensure that automotive components will meet all EMC requirements the first time they

are tested, and that compatibility will not depend on the specific vehicle or system in which the components are installed. More work needs to be done before this concept reaches its full potential, but electronic system designers can already derive significant benefit by applying this approach to products currently under development.







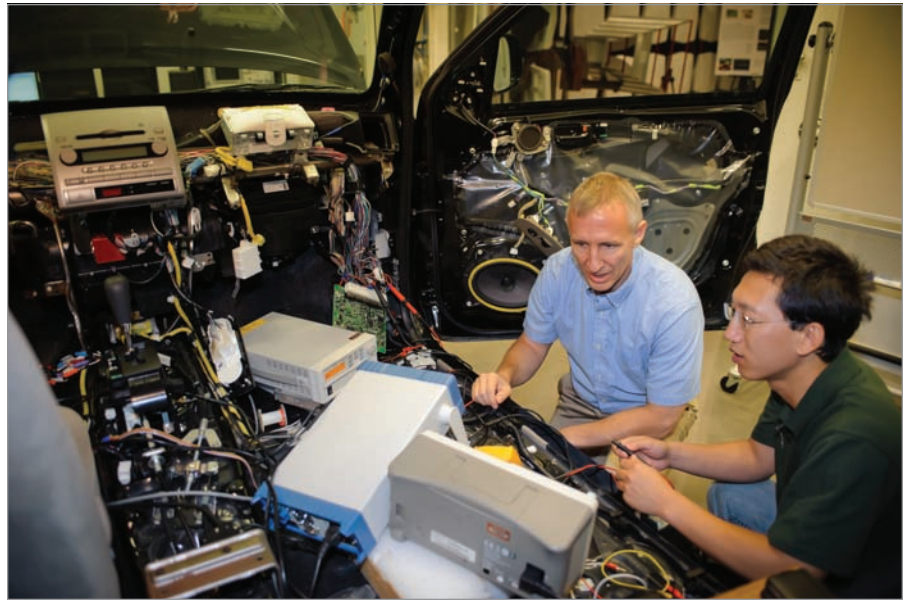


## INTRODUCTION

In a graduate automotive electronics course at Clemson University (AuE 835), electronic systems are defined as systems that are managed or controlled by computers. By that definition, the number of electronic systems in automobiles has been zero for the majority of the automobile's illustrious 120-plus year history. It was only in the 1980s that microprocessors started to see widespread use in automobiles, primarily for engine control. By the 1990s, they were required in automobiles for on-board diagnostics. Today, a typical automobile has dozens of embedded processors managing everything from passenger comfort and entertainment to critical vehicle safety systems. In fact it is no longer possible to build vehicles that meet federal requirements for passenger safety without microprocessors that control systems such as the anti-lock brakes, tire pressure monitoring and electronic stability control.

Cars and trucks are safer than they have ever been [1], due in-part to the implementation of various electronic systems that can compensate for driver error or unexpected obstacles. Examples of some of these systems include electronic stability control, adaptive cruise control, automatic braking, lane departure warning and blind-spot detection. However, as automobiles begin to rely more heavily on electronic systems for passenger safety, it becomes increasingly important to ensure that these systems work reliably, and as intended, 100% of the time.

Less than a decade ago, none of the electronic systems commonly found in production of cars were designed to apply the brakes or turn the steering without explicit driver input. Today, a car may have several systems with these capabilities plus nearly a dozen that can actuate the throttle [2], and the number of systems that control safety-critical actuators increases with every new model year. As electronic systems play a bigger role in automotive



**Prof. Hubing and Clemson graduate student, Dexin Zhang, making measurements on a pickup truck with interior trim removed.**

safety, ensuring the electromagnetic compatibility (EMC) of these systems has never been more important.

The aerospace electronics industry is also concerned with reliability and electromagnetic compatibility. A failure in a critical system can ruin a multi-billion dollar space mission. Likewise a critical failure in a commercial aircraft can jeopardize the lives of its passengers and crew. For these reasons, aerospace systems are generally designed so that the failure of any one component won't compromise a safety-critical (or mission-critical) system. Automobiles have not traditionally been held to the same high reliability standards as aerospace electronics, but this is changing. Unlike aerospace systems, an automotive electronic system that appears in a popular vehicle may experience hundreds of millions of operating hours every year. In a safety-critical system, a failure rate as low as one for every million operating hours, could affect hundreds of people every year.

The new automotive safety standard, ISO 26262, is designed to ensure that vehicle electronics meet certain criteria for reliability and safe operation. The standard employs a risk-based

approach for assigning components to various risk classes and defines procedures for the development, operation and service of components depending on their class. Modeling and testing (including EMC modeling and testing) play a key role in these procedures.

## AUTOMOTIVE EMC

Prior to the widespread use of electronic systems in automobiles, electromagnetic compatibility was a relatively minor concern in the automotive industry. Any EMC problems that arose in prototype vehicles were generally dealt with in an ad hoc fashion. Was the engine spark being picked up by the AM radio? Use resistive spark plug wires. Was relay noise causing spurious transients that burned out ignition components? Apply snubber circuits or employ better isolation.

As electronics began to be used for more automotive systems, individual manufacturers began developing their own EMC tests to ensure that the components or systems from their Tier 1 suppliers would be unlikely to cause interference problems when integrated in a vehicle. Eventually, there was an



**Clemson graduate student, Li Niu, setting up a radiated emissions test in the Clemson Vehicular Electronics Laboratory.**

and vehicle level. These tests give the manufacturer confidence that electromagnetic compatibility problems will not be a significant source of vehicle failures or customer complaints over the life of the product. However, the rate at which EMC standards are written and revised has been slow compared to the exponential growth in the number of automotive electronic systems and their role in ensuring vehicle safety. It is not realistic to expect to test for all possible sources of interference or anticipate all possible interactions between systems that various Tier 1 suppliers develop for a given vehicle. Also, current EMC test procedures are performed on components and systems that are new and in good working order. There is generally very little testing performed on systems that have undetected failures or components that are out of specification (e.g. due to age or excessive heat).

In order to meet the requirements of ISO 26262 and ensure that electronic components and systems do not present an unacceptable risk, we must change the current development paradigm. Rather than designing the best we can and testing to ensure compliance, we need to use design procedures that ensure compliance and test procedures that validate compliance with the design criteria.

## **DESIGN FOR GUARANTEED PERFORMANCE**

Is it possible to design automotive components in a way that ensures compliance with electromagnetic compatibility requirements? Even the simplest electronic control units (ECUs) in an automobile typically have hundreds of circuits. The component designers rarely have complete information regarding the attached wire harness routing or other key parameters that affect EMC performance. In addition, EMC test set-ups can vary depending on who is conducting the test, and results obtained for EMC tests conducted at different test sites can vary significantly [3, 4]. So is it



**Prof. Hubing and Clemson graduate student, Chentian Zhu, measuring the currents in a three-phase motor driver.**

effort to consolidate these tests to make EMC testing more meaningful and cost-effective across the industry. Standards organizations such as SAE and CISPR formed committees of interested parties, such as automobile manufacturers, Tier 1 electronics suppliers and EMC test houses. These committees developed standards and test practices for evaluating conducted

and radiated EM emissions, conducted and radiated EM susceptibility, transient voltages, power bus noise, electrostatic discharge and other forms of electromagnetic interference.

Today, automotive electronic systems are subjected to a wide range of EMC tests, both at the component level (before being installed in a vehicle)



A *Design for Guaranteed Performance* approach requires that an ECU design be reviewed circuit-by-circuit to ensure that the combination of electrical and geometric parameters cannot couple sufficient energy (in or out) to cause an EMC failure under any circumstances.

really possible to guarantee that a particular component design will meet all automotive EMC requirements the first time it is tested? In most cases, the answer is yes.

A *Design for Guaranteed Performance* approach requires that an ECU design be reviewed circuit-by-circuit to ensure that the combination of electrical and geometric parameters cannot couple sufficient energy (in or out) to cause an EMC failure under any circumstances. For example, if a given radiated emissions specification can be exceeded only if an ECU radiates at least 4 nW

of power at a given frequency; then the designer must ensure each circuit on the board is incapable of supplying 4 nW of power at that frequency, either alone or in conjunction with other circuits. In the event that a particular circuit is required to supply more than 4 nW of power at that frequency in order to meet functional criteria, then that signal path must be design in a manner that ensures that all power in excess of 4 nW is accounted for and dissipated within the ECU.

The following section demonstrates how *Design for Guaranteed*

*Performance* can be implemented in order to meet radiated emission requirements. Note that this section deals with actual *radiated* emissions, as opposed to electric- or magnetic-field coupled emissions (i.e. coupling in the near field). Since many automotive “radiated” EMC tests actually measure near-field coupling, a similar procedure must be employed for ensuring near-field coupling in a particular test environment does not exceed the corresponding limit.

## DESIGN TO MEET RADIATED EMISSIONS CRITERIA

### Step 1: Know Your Limits

The first step in the process of designing for guaranteed performance is to know your limits. For example, if your product specification requires that the radiated field strength at a distance of 10 meters is no greater than 30 µV/m at 80 MHz, then the power radiated must be less than:

$$P_{RAD} < \frac{1}{2} \frac{|E|^2}{\eta_0} \frac{4\pi r^2}{D_{max}} \quad (1)$$

$$< \frac{1}{2} \frac{|30 \times 10^{-6} \text{ V/m}|^2}{377 \Omega} \frac{4\pi(10\text{m})^2}{1.6}$$

$$< 1\text{nW}$$

where  $r$  is the distance from the source,  $\eta_0$  is the intrinsic impedance of free space and  $D_{max}$  is the maximum directivity of the radiating structure. (In this case, we’ll assume the radiating structure is not electrically large at 80 MHz, so the directivity should not exceed 1.6.) Equation 1 indicates that a circuit that is incapable of supplying more than 1 nW of power at 80 MHz will not be capable of being the sole



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Figure 1 shows a plot of the radiated emissions compared to an FCC radiated emissions test limit. Note that this component is capable of producing radiated emissions about 15 dB above the limit at 80 MHz.

source of a radiated emissions failure at this frequency. For analog circuits, the maximum power supplied by the source can be readily determined, and is probably already known. For digital circuits, the maximum power at any given frequency is probably not part of any functional specification. Designing for guaranteed performance requires that the maximum power these circuits are capable of generating is known and/or controlled.

## Step 2: Control Risetimes

Any digital circuit source that cannot deliver at least 1 nW of power at 80 MHz cannot be the sole source of radiated emissions that exceed the specification in the example above. This is true no matter how poorly the circuit is routed and no matter what other circuits or structures the signal may be coupled to. A primary objective in designing for guaranteed compliance is to ensure that no source produces power capable of exceeding the specification unless that power is necessary for the circuit to serve its intended function.

For every digital circuit in the system that is operating at clock speeds of 16 MHz or less, the best way to control the emissions at 80 MHz and higher is to control the transition times. Slowing transition times to 20% of the bit width significantly reduces the energy in the signal at frequencies above the fifth harmonic. For example, suppose our signal source is an automotive microcontroller output with a 3.3-volt signal amplitude and a 165-ohm source resistance (i.e. 20 mA max current). If the operating frequency is 100 kHz and we're driving a 5-pF load, the bit width is 10 µsec and the transition time

is 1.8 ns. The signal voltage at each odd  $n^{\text{th}}$  harmonic of the clock frequency (assuming a trapezoidal waveform) would be given by:

$$V_n = \left| \frac{2A}{n\pi} \right| \left| \frac{\sin\left(\frac{n\pi t_r}{T}\right)}{\left(\frac{n\pi t_r}{T}\right)} \right| \leq \left| \frac{2A}{n\pi} \right| \times \text{MIN} \left\{ 1 \text{ OR } \left| \frac{T}{n\pi t_r} \right| \right\} \quad (2)$$

where A is the peak-to-peak signal voltage,  $t_r$  is the signal transition time, and T is the signal period. Now let's assume that all of the power produced by the source is radiated (i.e. the source drives a lossless matched antenna).

$$E_{RAD} \leq \sqrt{\eta_0 \frac{|V_n|^2}{R} \frac{D_{max}}{4\pi r^2}} \quad (3)$$


Figure 1 (page 28) shows a plot of the radiated emissions compared to an FCC radiated emissions test limit. Note that this component is capable of producing radiated emissions about 15 dB above the limit at 80 MHz.

Now suppose we insert a 20-kΩ resistor in series with the output of this controller. For the same 5-pF load, the transition time would now be increased to 220 ns. Since the transition time is

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about 2% of the bit width, the integrity of the digital signal is preserved.

Figure 2 shows the radiated emission that would result if all of the power produced by this source was radiated. Note that this circuit is incapable of producing enough power to exceed the FCC radiated emission specification at any frequency above 30 MHz. From a design standpoint, this means that this signal can be routed anywhere on the board or on any attached wiring harness. No matter how poorly the routing is done, or how many other circuits this signal couples to, it cannot be the source of a radiated emission failure.

For the purposes of meeting a radiated emissions specification, most of the digital circuits in most automotive ECUs can be eliminated from further consideration simply by controlling their transition times. Once the transition time has been slowed to between 10% and 20% of a bit width, only the faster circuits will remain viable sources of radiated emissions. Series resistors are one way to control transition times. The use of controlled slew-rate sources can also be effective.

Faster digital circuits cannot be eliminated as possible sources simply by limiting their transition times, but controlling these times reduces the amount of power available to be radiated. It also reduces the range of frequencies that must be considered. Figure 3 shows the maximum possible radiated emissions from the same automotive controller in the previous example when it is operating at 1 MHz. Note that it is capable of exceeding the limit by about 35 dB at 80 MHz, and is not guaranteed to meet the requirement at any frequency below about 600 MHz. Slowing the transition time down to 90 ns using an 8-k $\Omega$  resistor results in the maximum emissions plotted in Figure 4. Although the circuit is still not guaranteed to be okay at 80 MHz, it is within 5 dB of the limit, and the controlled transition time guarantees that the circuit will not exceed the limit at frequencies above 100 MHz.

### Step 3: Control Current Paths and Coupling

After controlling all transition times, the number of circuits capable of being a radiated emissions source in a typical automotive ECU will be relatively small. It should be noted that circuits capable of radiating a few dB above the limit are unlikely to do so. The

calculations in the previous section assumed that the source was connected to a lossless impedance-matched antenna. This is unlikely to happen in a real device, so the actual emissions will generally be lower than the maximum possible emissions. Nevertheless, each circuit capable of radiating above the specification limit should be examined to ensure that most of the power being

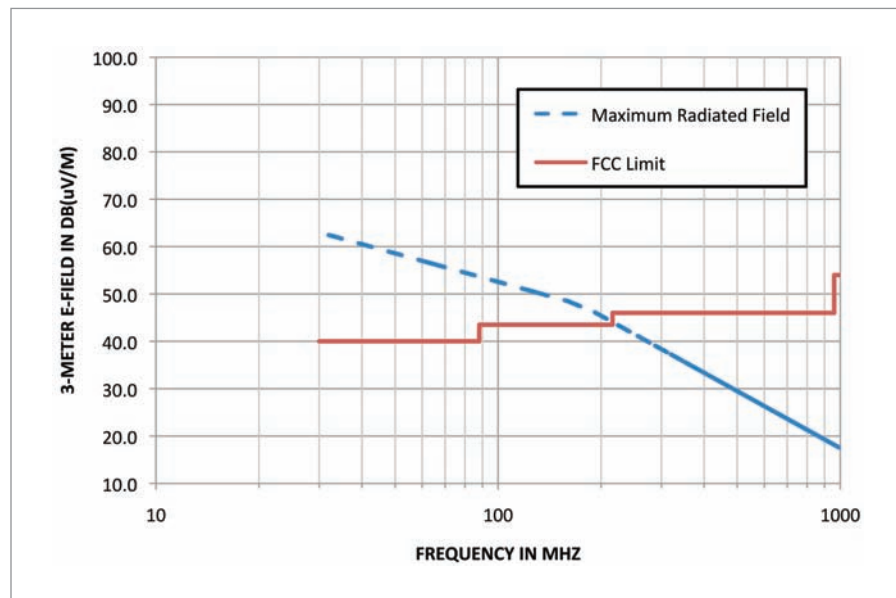


Figure 1: Maximum possible radiated emissions from a 100-kbps, 3.3-volt, 20-mA source with a 1.8-ns transition time

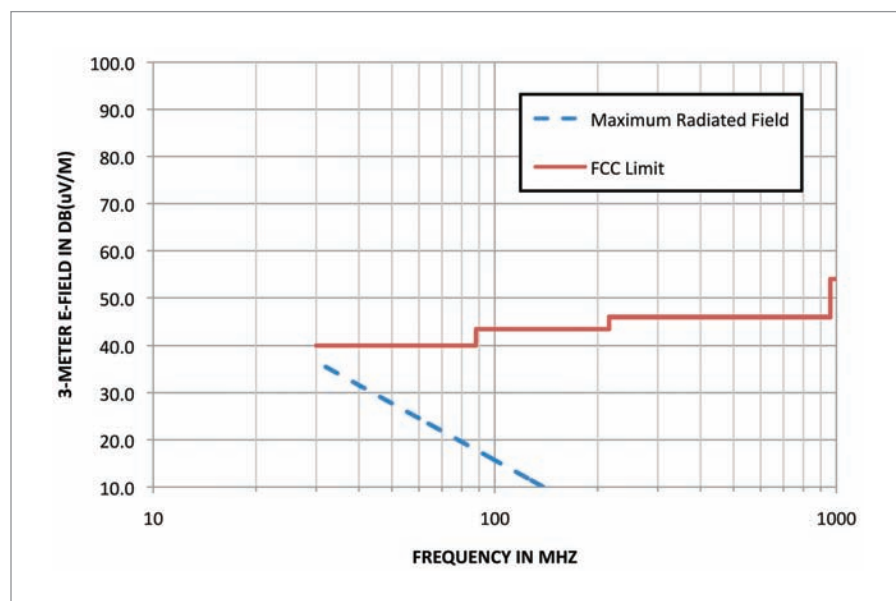


Figure 2: Maximum possible radiated emissions from a 100-kbps, 3.3-volt, 20-mA source with a 220-ns transition time

supplied at the offending frequencies reaches the load. The best way to do this is to trace the signal current paths from the source to the load and back again.

During the design review, it is important to recognize any structures or coupling paths that could steal power from the intended signal path

and direct it elsewhere. Traces over a solid ground plane (microstrip traces) are relatively easy to examine, because they present fewer opportunities for unwanted coupling. Levels of crosstalk between adjacent microstrip traces can easily be kept below -20 dB simply by following general design guidelines for trace routing. If your maximum coupling is -20 dB, then the maximum

radiated power will be 20 dB lower than the maximum available power calculated in the previous section.

## Step 4: Recognize and Control Coupling to Antennas

In many automotive ECUs, applying Steps 1-3 above will eliminate the vast majority of the circuits from consideration as possible sources of a radiated emissions problem. At this point, attention can be focused on the few remaining circuits/signals capable of being a problem source. By recognizing that all radiated emissions problems involve both a source and an antenna, and further recognizing that any antenna that is small relative to a wavelength will not be efficient, it is possible to examine every possible antenna structure in a system and evaluate the maximum possible coupling between every possible source and every possible antenna. Typically, in an automotive ECU the possible antennas are limited to one or more cable harnesses, one or more large heatsinks, and perhaps a metal enclosure or connection to the vehicle chassis. Evaluating 3 to 5 possible antennas against 1 to 10 possible circuit sources is a very manageable task.

While it is possible to gain some insight relative to the maximum possible coupling between a circuit and antenna structure using electromagnetic modeling tools, a more effective approach is to apply closed-form equations designed to calculate the maximum possible emissions from specific source-structure geometries typically found in electronic systems. Examples of these closed-form equations can be found in [5-14]. Several of these are implemented in a web-based calculator on the Clemson Vehicular Electronics Laboratory website [15]. Maximum emissions calculations basically assume that everything not known about a particular source/antenna geometry is worst case. For example, if a source drives a cable of unknown length, the calculator assumes that the cable is a lossless, resonant antenna at every

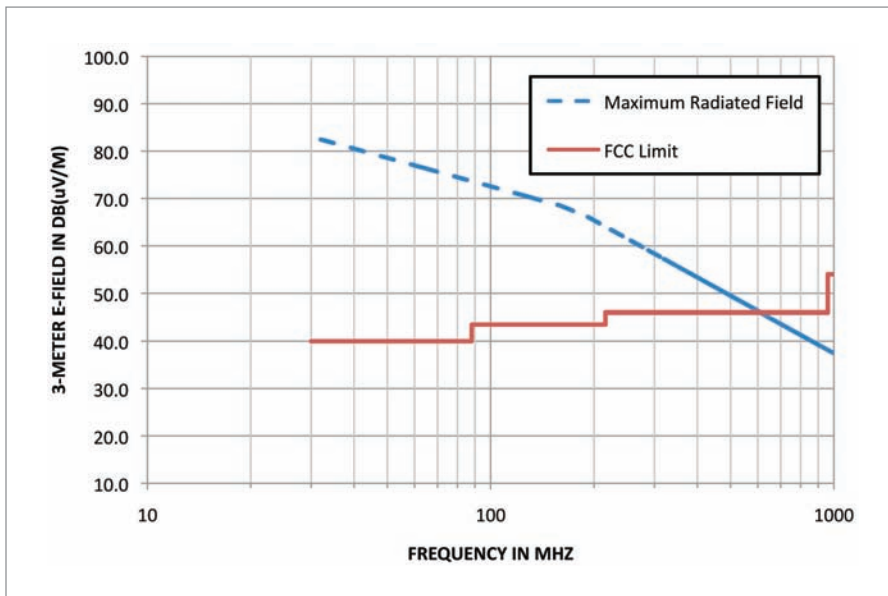


Figure 3: Maximum possible radiated emissions from a 1-Mbps, 3.3-volt, 20-mA source with a 1.8-ns transition time

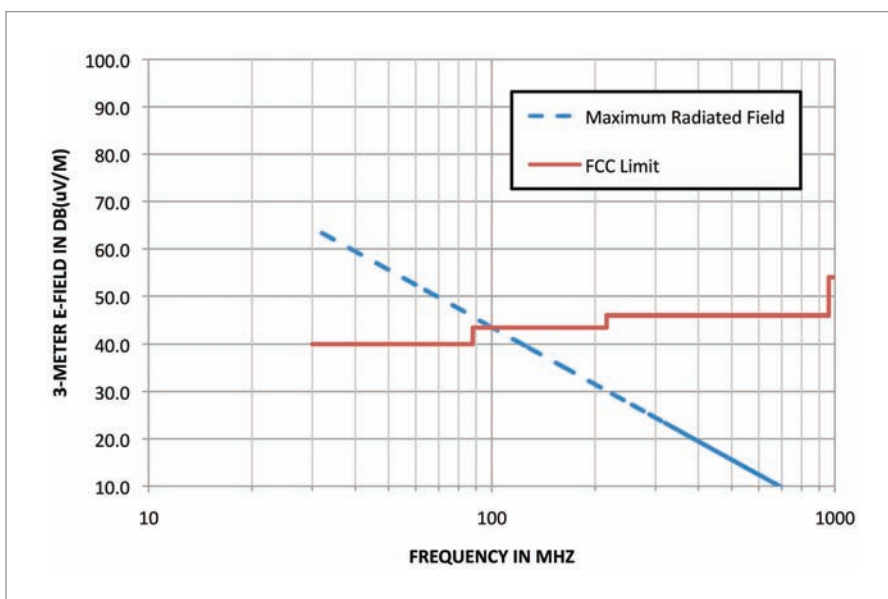


Figure 4: Maximum possible radiated emissions from a 1-Mbps, 3.3-volt, 20-mA source with a 90-ns transition time



frequency of interest. If a transition time is unknown, it is assumed to be zero. While these calculations will generally overestimate the actual measured radiated emissions, they provide an upper bound. For EMC work, an upper bound is generally preferable to an exact calculation of emissions from a specific configuration. Designing a system to be compliant with a radiated emissions specification based on maximum emissions calculations ensures that the specification will be met regardless of where it is tested or what it is connected to.

While the procedure outlined above is relatively time consuming, it is not as difficult as it might first appear. It is true that every circuit on the board must be evaluated, and a board with average complexity might have hundreds of circuits. However with a little experience, a designer will learn to recognize many of the circuits that are incapable of being the source of a problem without explicitly doing a calculation. Also, simple alterations to many types of circuits that change them from being possible sources to negligible contributors will become evident to the designer over time. This will make it easier to adjust the design rather than calculate the possible emissions. Since many of the calculations required for this procedure can be automated, these calculations can eventually be integrated with existing computer-aided design tools. This will further reduce the burden on the design engineer and reduce the level of EMC design experience required to implement the procedure.

It is tempting to think that an electronic system designed for guaranteed compliance will be over-designed and expensive. However, most of the EMC design decisions made early in a product's development cycle have little or no impact on the cost of the product. The costs associated with building a compliant product based on the procedure

outlined above are often limited to a few cents worth of components. On the other hand, the costs associated with fixing an EMC problem in a product that has already been prototyped can be relatively high. Routing and placement options that would have been easy to implement early, may no longer be available. Fixing problems that are discovered when testing a prototype is much more likely to involve relatively expensive filters or shields and can cause delays to the product development schedule.

## CONCLUSION

The previous section describes a design procedure for guaranteeing compliance with radiated emissions requirements. Similar procedures can be followed to ensure compliance with other EMC requirements, although it is important to recognize that "radiated" automotive EMC test procedures are often measuring near-field coupling over much of their designated frequency range. Also "conducted" emissions tests measure both conducted and field-coupled emissions. Procedures for guaranteeing compliance with susceptibility tests can guarantee a maximum coupled signal, but they can't guarantee that every part of the system will tolerate that signal unless that has been previously determined for each component.

There are many advantages to a design for guaranteed compliance approach. Although the technique requires more time and effort than a design-rule based approach, it is much more likely to result in a low-cost, compliant design on the first pass. The design for guaranteed compliance approach also highlights the most vulnerable aspects of a design, making it easier to diagnose any problems that may occur in the field. On the other hand, the rigorous, but arbitrary enforcement of EMC design rules can add cost and complexity to a design without necessarily improving its EMC performance. In fact, the misapplication of a well-intended

design rule can significantly degrade EMC performance [16].

Another advantage of the design for guaranteed compliance approach is that it does not rely on testing to establish the electromagnetic compatibility of the design. Testing alone can never be thorough enough to anticipate all the possible problems/interactions that can arise in modern automotive systems. With the design for guaranteed compliance approach, the compatibility is designed in and the testing simply confirms that the design performs as expected. Although there is much more work to be done before this approach reaches its full potential, it is likely that the design-for-compliance-and-test-for-validation concept will ultimately define the methods used to ensure that increasingly complex automotive electronic systems meet all EMC performance requirements. ■

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# Heading to the EU? Get Your EMC Compliance Passport Ready!

BY OZGUR OZTURK

When a manufacturer is thinking of the European Union (EU) as the next market for its electronic equipment, EMC compliance is one of the must-haves on the list of approvals.

Unless a company has dedicated quality personnel to ensure testing and certification is done to the letter, the approval process can be quite complicated for engineers – from identifying the correct standards and models for testing to writing the declaration of conformity and preparing the product for testing. This article will explain what engineers need to do to demonstrate compliance.

## WHAT THE EMC DIRECTIVE IS AND ... IS NOT

Most electronic equipment that will be sold in the EU needs to comply with the EMC Directive 2004/108/EC. While the directive sets rather tough requirements to regulate the product's electromagnetic disturbances, it is not a safety directive because it only covers

equipment's EMC concept. Compliance with the EMC Directive alone does not enable CE marking, a mandatory conformity mark for products placed on the market in the European Economic Area; the product must comply with all applicable directives to earn the mark.

## THERE IS A STANDARD FOR YOU...

Out of hundreds of standards featured in the EMC Directive, the manufacturer must pick the right standard for the product and bears responsibility for the choice. This is often a point of confusion for the US engineers, who, if they work with a third-party testing and certification body, believe that the registrar should be responsible for testing to the

correct standard. While most testing laboratories will help identify standards applicable to a particular piece of equipment, the responsibility remains with the manufacturer. It is a good idea to get acquainted with the standards to be able to choose the right one.

## TOO MANY CHOICES?

Each standard in Directive 2004/108/EC governs a particular type of equipment, such as laboratory, IT, industrial or household. The standards determine the strength and the limits for every test used to evaluate the product; this means that if equipment is used in ITE applications, it will be tested to requirements different from those used for industrial equipment. Included below is the hierarchy of the standards and where to find them.

The conformity assessment procedure sets out steps to follow to demonstrate the product's EMC compliance. Engineers should begin by reviewing harmonized standards to determine the one applicable to the product.

**Top level generic and product family standards** describe the overall EMC requirements for the product. Engineers should use generic standards only when there is no family standard covering the product.

Many organizations sell the standards, including ANSI and Global Standards. For CE marking, these standards are listed on the EU website as the harmonized standards list or are featured in *The Official Journal of the European Union (OJ)*, the only periodical published every working day in all official languages of the EU.

**Basic standards** are one step down the hierarchy. They explain the individual

procedures used to test products for EMC compliance. The basic standards are listed in the Normative References section of the product family and generic standards. They are not listed in *OJ*.

Testing the product to the latest version of harmonized standards is the main method of compliance with the EMC Directive. However, if a product had been tested to the version of the standard that since then expired, manufacturers can perform a gap analysis to identify only new requirements to which the product needs to be re-tested. If requirements of the new version do not affect the product, the manufacturer can

prepare documentation proof with justifications, explaining why re-testing is not necessary.

## COMPLIANCE STEPS

The conformity assessment procedure sets out steps to follow to demonstrate the product's EMC compliance. Engineers should begin by reviewing harmonized standards to determine the one applicable to the product. They need to decide how to actually test the product – themselves or with the help of a third-party laboratory. Because of the procedure's complexity, most companies choose the latter and must find the right partner to work with. When looking for laboratories,

engineers need to ensure that prospective registrars devote the time to educate them on what EMC testing involves, how long it takes and what is required because open communication is crucial to the success of the endeavor.

Some engineers may not be aware that they must review all the models, or versions, of the product to determine which ones need to be tested. The directive requires all possible product configurations be included in the EMC assessment. If there are five models, and each differs from the others in terms of design and has different electrical components, all five need to be tested. If the difference is not design-related, such as a color scheme or shape, this model can be excluded from the list.



If an electronic product is intended for export to the EU, EMC compliance is one of the must-haves on the list of approvals. (photo courtesy of TÜV Rheinland)

Determining in advance what models need testing will help a testing provider give an accurate quote from the start. If a laboratory discovers that other models need testing after the initial quote was issued, it will need to issue another quote and schedule time to test additional models.

To select models for testing, many companies take the so-called “worst case” representative(s) approach. They select one or more of the most advanced versions of the product and apply the results of their tests to models simpler in design. Engineers should keep in mind that “the worst case” model for immunity testing may be different from the “the worst case” candidate for emissions testing. The company may need to test more than one variation or use different configurations for emissions and immunity testing. As with the standard selection, the manufacturer is responsible for identifying the “worst case(s)” and possible configurations for testing, but a laboratory can assist with making the decision.

Determining in advance what models need testing will help a testing provider give an accurate quote from the start. If a laboratory discovers that other models need testing after the initial quote was issued, it will need to issue another quote and schedule time to test additional models, adding time to the process.

Once the company determined which product versions to test, it needs to prepare technical documentation in accordance with Annex IV. The documentation file should contain necessary information to easily identify the product, such as general description, environments where it can be used, warnings and manuals.

After the testing is done, test reports will go into the file to provide evidence of compliance with harmonized standards. If the company did not have every variation of the product tested, the file should explain why certain models were excluded and

how it selected the “worst case” representative.

Manufacturers must always keep their technical files up-to-date. If a design change is made to the product, the equipment might need to be re-tested – fully or partially – and the technical file needs to be updated accordingly.

Annex IV of the directive instructs manufacturers to prepare the EMC declaration of conformity (DoC) for the EU as part of technical documentation. According to Part 2 of the Annex, DoC must include the following:

- Dated reference to the Directive 2004/108/EC
- Identification of the product
- Name and address of the manufacturer
- Name and address of the authorized representative in the country of distribution
- Dated reference to the specifications (A manufacturer must include the date of the standard to which the product was tested. As new versions of standards are issued, old versions become invalid and the product may need to be tested again to the new specifications.)
- Date of declaration of conformity
- Identity and signature of the responsible party

Engineers do not need to list the basic standards in the DoC, only harmonized product family or generic standards. They should remember that for a product to be CE marked, it must comply with all the applicable directives and related harmonized standards and these directives and standards must be listed in the DoC.

The directive does not specify a format for the DoC and documentation file as long as they include the minimum required information. If any of the minimum required content is missing, the DoC is considered incomplete and invalid, which might lead to an appropriate action from the competent authorities of a member state. The following standards are a good reference on how to prepare a DoC: EN ISO/IEC 17050-1:2005 and EN ISO/IEC 17050-2:2005. CENELEC has also published a specific guide for the DoC: “CENELEC Guide 16 on the implementation of New Approach directives and the Low Voltage directive with respect to the EC declaration of conformity.” A testing laboratory may also provide engineers with a DoC template to streamline the process.

The directive requires manufacturers or their authorized representatives to hold the technical documentation in the country of distribution for at least 10 years after the last manufacturing date. If the company does not have a local representative, whoever places the product on the market is responsible for providing the technical documentation and DoC to competent authorities upon request within a reasonable timeframe.

Of course, manufacturing products according to the technical documentation is paramount. This way, the products are consistent in quality and performance per EMC phenomena.

## WORKING WITH A NOTIFIED BODY

Occasionally, manufacturers might want to go the extra mile to ensure that products are tested to the correct



standards and are in full compliance. In this case, the company has an option to send the technical file and EMC report to a Notified Body (NB) for review. Specifically, a NB does the following:

- Reviews the technical file to ensure the essential requirements of the Directive are met;
  - Reviews the technical file to ensure that it clearly demonstrates that all the Directive requirements are met;
- and
- If everything is in order and complete, issues a statement of opinion to be included in the technical file.



In certain instances, a mobile EMC laboratory will come to the manufacturer's site to test the equipment. (photo courtesy of TÜV Rheinland)

## MAINTAINING COMPLIANCE

Harmonized standards are occasionally updated, with the revisions listed in *OJ* well before they become mandatory. When an existing version of a standard expires, manufacturers must use the new standard on the DoC as the old one no longer shows compliance with the directive. Often, this means re-testing the product to the new standard.

Revisions to basic standards are more challenging to keep up with; there is no publication comparable to *OJ* for the basic standards. If engineers use a product family or generic standard that has undated basic standard references, they must take into account changes or updates to basic standards.

## DON'T TEMPT FATE

If a manufacturer tries to place a non-compliant product on the EU market, it could face penalties. Penalties differ by the country and range from removing the product from the market and prohibition or restriction of the free

movement of the product to liability for a fine and/or imprisonment. Typically, a relevant enforcement authority will give a manufacturer a chance to fix the problem and ensure the product is correctly CE-marked; the measures are much stricter when consumer safety is at risk.

## GETTING READY FOR THE TEST

To make the testing process go smoothly, engineers are well advised to prepare for testing in advance. They will need to get ready all of the product information, including the product's description, function and intended environments, product variations, as well as electrical specifications, including clock speeds of all microprocessors.

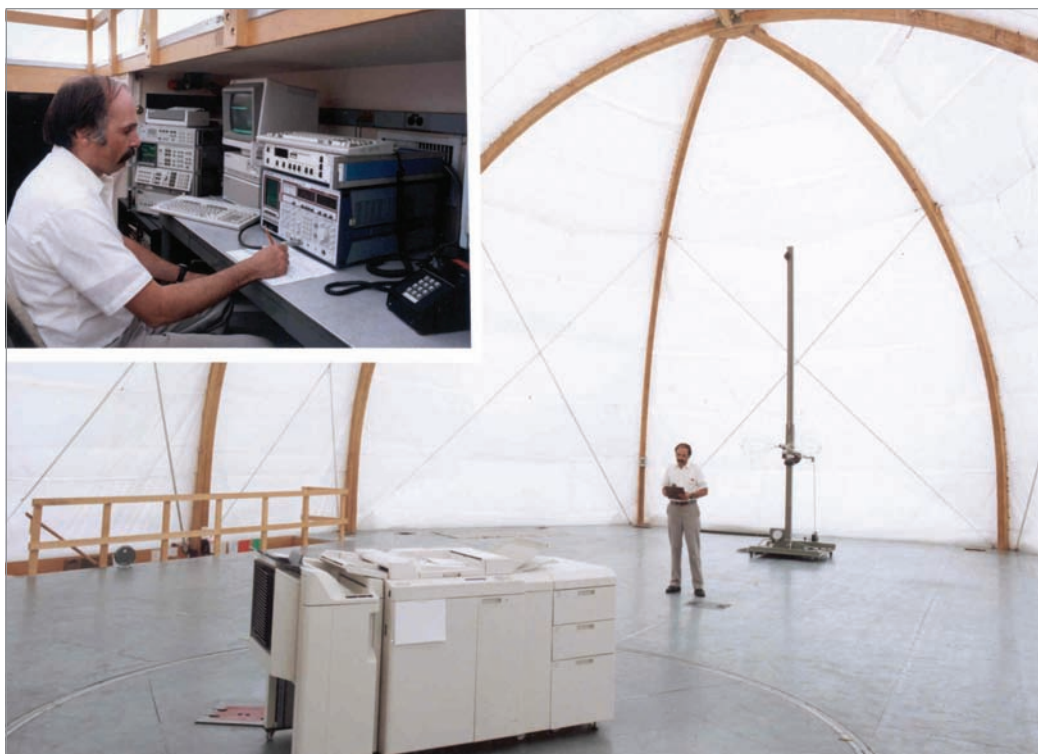
Engineers sometimes forget to factor into their schedules various lead times involved in a testing procedure. In addition to the lead time to issue a quote, the testing provider may not

be able to test the product right away if other products are in the queue. After the tests are done, there is a lead time for the laboratory to issue a report. If a product fails part of the test, the manufacturer will need to make changes to it and have it re-tested in that area, which will add more time to the process. Engineers should ask their testing partners about lead times before committing to working together as lead times vary between laboratories.

When preparing to ship the product to the laboratory for testing, engineers need to include everything that is needed to operate the tested product, including step-by-step operating instructions so that test personnel know how to properly operate the equipment. When necessary, supporting equipment that is not subject to the test also needs to be shipped. For example, if a printer is tested, a manufacturer needs to include a computer, a USB cord, and power cords for the computer and printer.

## HOSTING THE EMC TEST CREW

EMC evaluations typically take place in a specially equipped laboratory; however, there are three instances when a testing provider will travel to the manufacturer's site to conduct tests. First, if a product is very large, such as a built-in-place industrial system, which cannot be fitted into the laboratory space. Second, if a product requires substantially more power than can be provided in the laboratory. Third, if a product requires special auxiliary equipment that cannot be shipped to the laboratory.



EMC testing done in the open area test site (OATS). (photo courtesy of TÜV Rheinland)

There are some differences between the EMC testing performed in the laboratory and at the manufacturer's site. When done in a laboratory, radiated immunity testing takes place in an EMC chamber that is completely isolated from its surroundings and allows a full range of tests to be performed. When testing is done onsite, only limited frequencies are permitted. The deviations in testing are allowed when at least one of the three above-mentioned conditions are satisfied. The decision to test at the manufacturer's site should be documented and justified in the technical file.

Before the testing crew arrives at the manufacturer's site, the company personnel needs to prepare the tested product and supporting equipment, clear the space around the tested equipment and ensure that it runs in a continuous operating mode. If more than one product variation needs to be tested, all models should be ready for evaluation in advance, whenever possible. Reconfiguring equipment while the laboratory team is waiting on site will add time and cost to the testing process.

## ACHIEVING COMPLIANCE

After the testing is completed, the laboratory will provide the customer with a report stating the test results. If the product falls short in some area, the report will identify the problem. The customer can adjust the design or troubleshoot the problem and then send the modified version back to the laboratory to re-test it in the area where it failed. While implementing changes to the product, engineers need to be aware that the modifications might affect the EMC phenomena in more ways than intended. Depending on a modification, they may consider testing the product in more areas than only where it previously failed. Once the product demonstrates full compliance, the laboratory issues a final report to be included in the technical documentation file.

In addition to the EMC testing, a product exported to the EU needs to comply with a great number of other regulations. To save time and money,

engineers are advised to inquire if their test laboratories can assist with other necessary approvals. Consolidating all of the testing needs with one laboratory eliminates the inconvenience of managing multiple laboratories, streamlines logistics, simplifies documentation and results in a faster, more efficient and cost-effective compliance strategy. ■

### (the author)

**OZGUR OZTURK** serves as Senior Business Manager, EMC and Telecommunication Services, at TÜV Rheinland of North America, Inc. He has more than 12 years of experience in regulatory compliance in testing and certification. Ozturk graduated from University of Missouri-Rolla with a degree in Electrical Engineering, with an emphasis in EMC. He can be reached at [OOzturk@us.tuv.com](mailto:OOzturk@us.tuv.com).



# Engineering Our Future: A View of Changes Facing Engineers

BY GREGG KERVILL

*Editor's Note: Over the past months we've explored one engineer's view of historical patterns and events that have set the landscape for today's economic challenges. In this final installment, Mr. Kervill brings us into the present and concludes the series by summarizing his predictions for the future.*

## FACTORS EFFECTING INNOVATION

### Communication

Communication is so fast that it is not a factor in restricting today's technology. Not only is the world flat, as described by Thomas Friedman<sup>1</sup>, but it has only one time zone.

This has the drastic effect of eliminating communication as the prime factor that limits growth of new ideas.

Thanks to the Internet and television we no longer rely on explorers like Marco Polo to bring back knowledge of gunpowder, how to grow rice, or the latest phone application!

### The cost of employment

Few of us would turn down a windfall of \$3.5 million (Kubasik-Lockheed)<sup>2</sup>,

but there is a huge difference between *need* and *want*. Need is a key factor. It is the lower limit of payments that a workforce can accept. Less than this limit and we will have a transitory workforce incapable of great innovation because it will be constantly changing.

If pay is much higher than the basic level of *need*, then business risks being unprofitable. Employee pay is a second factor which can limit or restrict new products being capitalized and turned into revenue. Consider this:

A college student graduating with \$60,000 worth of debt must repay \$5 for each working day for the rest of her life. If she is to be downsized at the age of 55 then the amount increases to \$8 a day.

By age 30 most engineers will have added a mortgage to this financial commitment.







This means that if we are to create US jobs they need to be high tech, well-paid jobs – which leads us to the next requirement.

## LITERACY AND EDUCATION

The third factor to consider is the technical, financial and global literacy of our workforce. These qualities are essential as never before because, as our businesses become more global the potential for insulting or alienating fellow workers, partners or even customers increases exponentially.

In terms of literacy the US ranks poorly with Asia. Results from a 2002 survey reveal that only 3% of Americans have sufficient literacy to work at the highest level of engineering.

According to the 1992 National Adult Literacy Survey the average U.S. adult reads between the 8<sup>th</sup> and 9<sup>th</sup> grade level. USA Today quoted a study showing that 1 in 7 Americans (or 14%) could read its stories. This could have a serious impact on future employment opportunities for 80% of the U.S. population. (Note: It is possible that this is not indicative of declining literacy but because such information is increasingly available we are more informed than in the past.)

## THE LEAP REPORT<sup>3</sup>

In 2011 the Association of American Colleges and Universities published the LEAP Report

The leap study was created as a way forward.

### Agree or not – this is coming down the pike

Teagle Foundation President Richard Morrill wrote a blog post for the *Huffington Post* titled “What is the Value of Liberal Education?” (November 6, 2012). Mr. Morrill notes that “The key to seeing the enduring power of liberal learning is to trace how knowledge and its processes take

up residence in students as they move toward becoming independent thinkers and agents of their own lives. A liberal education provides students with a broad set of capabilities such as critical thinking, effective communication, quantitative reasoning, creative thinking, problem-solving, integrative thinking, and personal and social responsibility. While not monetarily quantifiable at graduation, there is no question of the value of these capabilities for all individuals in the workforce of the future, as citizens and as human beings.”

### A warning for engineers

It does not matter if you agree – this is the force that will drive the syllabi of universities and colleges– and future graduates will not only be looking to take your job but (thanks to the new syllabi) may be better qualified than you are now!

New learning should not only include familiarity with new technology but the place of America in the Global Village – so add foreign newspapers and *The Economist* to your weekly reading list.

It may well take 10+ years before the majority of colleges are on-stream but we should see the first graduates arriving in less than 5 years.

### Do we have enough engineers?

The short answer is – unequivocally no! And we knew there was a problem in 2005<sup>4</sup>.

According to Russell Harrison in the first quarter of 2005, electrical engineers (EE) faced an unemployment rate that fell to 2.1%, just about its historic average. The rate had been declining since 2003 when electrical engineers faced an unemployment rate of 6.3% — the highest ever recorded for EEs.

Between 2000 and 2003, electrical engineers faced a typical, if bad, job market: unemployment went up as total employment fell.

## Can universities and colleges provide enough engineering graduates?



But in 2003, the situation changed. Between 2003 and the first quarter of 2005, unemployment fell along with total employment, which declined from 363,000 in 2003 to 335,000 in March of 2005, almost 8 %. The only way the number of unemployed engineers and the number of employed engineers can both fall at the same time is if a large number of engineers are simply leaving the profession.

Harrison makes an excellent point – “Declining employment can be as worrisome as increasing unemployment. The economy can still benefit from an unemployed engineer who has taken a non-engineering job. But when an engineer leaves the profession, *those high-value skills may be lost for good.*”

## Can universities and colleges provide enough engineering graduates?

The short answer is again – unequivocally no!

*Excerpt from The Economist on the Future of Jobs*

*“In 2008, one in four workers in America with a degree in science, technology, engineering, or mathematics was 50 or over. Lockheed Martin, an aerospace firm, expects nearly half its science and engineering workforce to retire*

by 2019 and will have to hire a total of 142,000 engineers. Currently only 60,000 engineers a year graduate from American universities.<sup>5</sup>"

So how are the other 100,000 engineers needed by Lockheed being trained? And what about other large companies that employ older workers and those about to retire?

Clearly there are not enough engineers. Perhaps now is the time for senior managers to consider taking on more interns, giving engineers an apprentice who would assist engineers and in doing so, learn what engineering is all about while they are still in school?

## **JOBS, START-UPS AND FUNDING**

Until recently, most entrepreneurs started their companies with their own money or some form of 'angel'. Taking on the whole financial risk means full control and remuneration. If significant capital was needed the entrepreneur sought either a partner or an investor.

Now we have Crowd Funding – which is a huge benefit for getting start-up capital. *Please note that in 2013 the legislation around Crowd/Cloud funding will change.*

Technology has advanced. Computing power is cheap – 3-D printing can eliminate the need for machinists and many start-up and fully-fledged businesses can operate from a couple of laptop computers. Bricks and mortar have been replaced by the internet – so the original investment associated with setting up business is a fraction of the cost 10-20 years ago.

### **Sunset and sunrise**

If a business is established, has been around for ages, will always be there, and where there is little change of technology it is considered a sunset industry, water, sewage, coal power generation, nuclear power generation, hospitals, teaching and insurance. The financial returns of sunset

industries are well known and from the perspective of investing money they are assumed to give low risk and low return rewards.

Then there are sunrise industries – these industries weren't here yesterday and some won't be here tomorrow. And some sunrise industries will grow and become new entities that will shape our environment. Google, Facebook, and solar power generation are new and continue to spawn new infant industries.

### **So what is the future?**

We can expect many engineers leaving the workplace to be older engineers retiring within the next 5 to 10 years and thus removing themselves from the market.

As this happens we can expect to see an acute shortage of experienced engineers who will work at an artificially low rate created by downsizing. Companies will be forced to pay higher rates until we return to previous (realistic) hourly rates.

Given that there will be a shortage of engineers and that full-time employment of a specialist is always inefficient then a logical natural solution is for more engineers to become contractors.

### **The Dilbert effect and the consultant**

From another perspective, the only route to higher pay was for an engineer to transfer into management – which led to the loss of some very good engineers and an even worse consequence of more than a few dreadful managers: a double loss to the industry. (Dilbert is, indeed, alive and well!)

For many years the only way that an engineer could make good money (as an engineer) was to become a consultant. Hiring a consultant is the logical model to reduce the impact of our impending engineer shortage by making better use of scarce resources.

It will, however require industry to be prepared to pay a much higher price for the convenience of employing a consultant on a daily or even hourly rate on an as-needed basis.

## **The fire-fighter, the engineer and the plant<sup>7</sup>**

Large corporations have a range of options available, including those available to the SMEs (Small and Medium size Enterprises).

The classic solution has been to create a small team of 'firefighters' (engineers placed into a project that needs help). When the problems are found and solutions identified then the team moves on to the next project. This is a smart way for large employers to maximize their scarce engineering resources. It also helps to create a team with a greater chance of a successful outcome (see footnote – The Plant).

Small businesses have often employed a consultant engineer to perform specialist engineering tasks and then release them to work for another company – this is a logical way forward for industries that cannot afford to employ experts in all fields.

## **WORK HAS CHANGED FOREVER**

Remember the massive layoffs between 1996 – 2010? Well some of those jobs have gone forever and will never come back. Let me repeat, some of those jobs have gone forever and will never come back!

It has happened before and will happen again. The word processor brought an end to the massive typing pools we saw in 1950s movies. So what became of all those typists? Did they starve; did they sit about for the rest of their lives waiting for another typist job to land on their lap? No! Some retired – others retrained – others took new careers.

When will the next transition in employment happen? Look around you: it is happening now!



## All change is positive – it just depends on your perspective

The modern capability to create new products has just reached a new height. One designer with a PC and a 3-D printer can now replace several design draughtsmen, a buyer, a goods inwards inspector, someone to run the stores and an inventory controller, plus all the bookkeepers needed to track the time of all those individuals. This is a good thing, and a good time for entrepreneurs.

## The rise of small business

Now is the time for small business. The right ten people can outpace a 1990s company of 100 or more in terms of design capability, throughput and ability to build a product. Computing power is cheap. Laptops capable of more than 50,000 MIPS are now common and off-the-shelf. The need for a big centralized computer center is relegated to specialist companies. Adobe and other software providers have made their software Cloud based (or similar) and available for rent on a monthly basis.

These are major milestones and will lift restrictions from small design companies that will be able to pay as they go and never need worry about updates, software or hardware compatibility issues again.

Individuals are now empowered to take an idea, build a company and take ownership. (It can be stressful but is infinitely preferable to pleading to spend \$100 of the company's money in order to save \$1,000, or to spend hours of your own time, writing proposals to your employer justifying why the company should patent your idea and pay its shareholders millions.

## Large versus small

Whereas large businesses gain headlines in the press whenever they layoff a couple thousand people, small businesses seldom receive accolades for employing more than half the workers in the US.


According to SEPH data<sup>7</sup>, in 2011 small businesses employed between 58% to 68% of professional service staff. Small businesses are smaller, less bureaucratic than large businesses and can respond to changes and needs much quicker.

It is small businesses that will change the face of industry, leading large companies in employing surplus labor. It is small business that will stimulate and sell into new markets. It is small business that will lead the way into a successful future.

## Now is a good time to be an entrepreneur

Those of you who have read my books on regulatory compliance and product safety may remember this quotation from Krishnamurti *"In oneself lies the whole world and if you know how to look and learn, the door is there and the key is in your hand. Nobody on earth can give you either the key or the door to open, except yourself."*

Well, the key is in your hand. here is much help<sup>8</sup> for start-up businesses – there is even Crowd Funding (also called Cloud Funding). So, do you have the courage to open the door before you?

**Just remember: "If you get up one more time than you fall you will make it through." - Chinese proverb** 

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### (the author)

#### GREGG KERVILL

Kervill started out as a physicist but has spent all of his career in electronics because, as he puts it, it was more fun. Gregg career as an electronics design engineer began in the industrial controls, consumer electronics, space and military markets. He completed a Diploma in Industrial Management (the forerunner of the MBA) in the 1980s with a thesis on the application of Kan Ban and JIT to highly variable product lines. Also in the 1980s, he became involved with product safety for military products, and became a CSA design verification engineer for Digital Corporation. In 1993, he formed GK Consultants Ltd, with whom he has maintained a web presence.



A registered consultant to the European Union (advising on Slovenia's entry to the EU), Gregg has contracted to NIST and the US-Consumer Electronics Association, and has advised the UK, Northern Ireland, Slovenia and Hong Kong governments. He has also provided pro bono support to Virginia Governor Mark Warner's VALET export program, as well as the planning and strategy committee of the City of Austin, Texas. Since 1995, he has lectured and consulted on three continents, published three engineering books, and created the first multi-media training software for electrical product safety. Currently he is developing web-based training material from world-class subject matter experts (SMEs) for the Phoenix Technical Group, an internet-based company with a presence in the US, UK, and Brazil.

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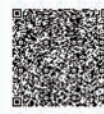
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# A Sunny Day in Tennessee

The new Volkswagen plant at Chattanooga

BY MARY ANN KAHL

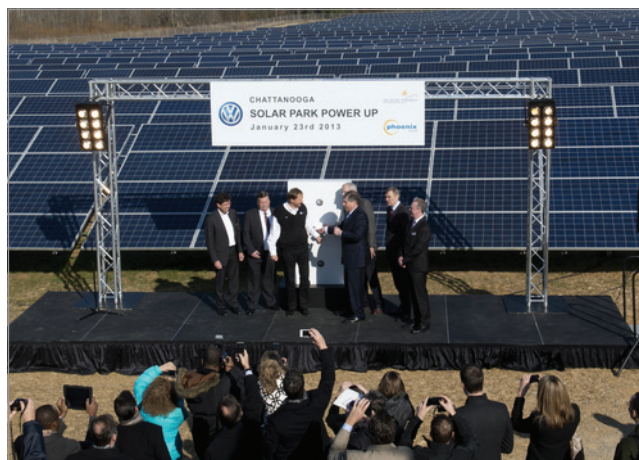
The lack of conversation around the environment, climate change, and our energy economy during the 2012 election season, while widely noted, still seemed to attract little attention.

Certainly health, financial and national security issues were more immediate concern for many voters. Yet, the lack of initiative at the federal level has not kept technical innovators, astute business people and local governments from moving forward with new ideas for addressing our environmental and energy concerns.

On these fronts, there are plenty of encouraging news items that don't necessarily make the headlines or feature familiar political faces. These

are the less glamorous corporate press releases, web article links and third-page news stories most of us only stumble upon. One such example of environmental innovation being put

into practice with too little fanfare was the inauguration, two days after the President's own this past January, of the Volkswagen Assembly Plant in Chattanooga, Tennessee (Picture 1).



**Picture 1: Power-up ceremony at Volkswagen Chattanooga Plant on January 23, 2013**

The plant is nestled on 1,400 acres between the Appalachians and the Mississippi Embankment near the borders of Georgia and Alabama. Currently employing over 3,200 and growing, it is the first and only LEED Platinum Certified auto plant in the world today. Plant components include a body shop, paint shop, assembly line, technical center, training academy, and supplier park (expected to include eight suppliers and indirectly employ another 9,500 people). Bringing both



Picture 2: Aerial view of Chattanooga solar park

*The fixed-angle array system at Chattanooga is made up of 33,600 solar panels having a generating capacity of slightly more than 9.5 megawatts. The 3 x 6 polycrystalline silicon modules were made in China and Mexico for the JA Solar Company.*



Picture 3: Inverter strings

good jobs and increased tax revenue, the plant is a welcome boost to the regional economy. But even more exciting is the wide-ranging environmental sensitivity exercised by business leaders and local government in engineering this great example of combining economic growth with sound environmental solutions.

Beginning in the paint shop, an advanced painting process has been implemented which eliminates one step of the painting procedure, thus reducing CO<sub>2</sub> emissions by 20% while also bringing down cost and energy use. Furthermore, in this improved painting system, a new Eco Dry Scrubber System avoids the consumption of 20,000 gallons of water each day.

Also in the interest of water conservation is the use of collected rainwater for cooling and in the restrooms, saving up to 350,000 gallons per month. Meanwhile, the use of low-nitrogen oxide gas burners in the plant's boilers reduce nitrogen oxide emissions into the atmosphere, and heat exchangers capture and recycle heat from the building.

Other features incorporated into the design of the building itself are six-inch mineral rock wool insulation panels that reduce building energy consumption by 35 percent, a T5 lighting system that reduces energy consumption by 20 percent (over conventional lighting), and a specially designed white roof that reduces the heat island effect of the plant by reflecting the heat from the sun. The entire site is being operated under certified environmental management systems (ISO 14001 and ISO 50001).

Around the building, LED street lighting saves about 100,000 kilowatt hours per year and greatly reduces light pollution at night. During construction, two creeks on the site were restored to enhance the wildlife habitat and provide a wildlife corridor around the

site, while wetlands and habitats of native vegetation have been identified and protected. Even the impact of shipping finished product has been considered, as 85% of vehicles are sent to dealers via rail to reduce diesel emissions and road traffic.

But possibly the most ambitious and high-profile aspect of the Chattanooga plant's environmental commitment is a 66 acre solar park, the largest in the state of Tennessee (Picture 2). The park was designed and installed by Phoenix Solar Inc., the US subsidiary of Phoenix Solar AG headquartered in San Ramon, CA. Phoenix Solar is an industry leader in designing, building and operating large commercial and utility-scale solar power plants. The park is owned and managed by the Silicon Ranch Corporation, a Nashville-based developer and operator of solar facilities whose other projects include a 1.4 megawatt solar energy campus in Pulaski, Tennessee, a rooftop installation for Second Harvest in Nashville, Memphis Bioworks, and Simon Solar Farm in southeast Tennessee.

The fixed-angle array system at Chattanooga is made up of 33,600 solar panels having a generating capacity of slightly more than 9.5 megawatts. The 3 x 6 poly-crystalline silicon modules (model JAP6-72-285) were made in China and Mexico for the JA

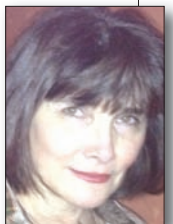
Solar Company. Each panel is rated at 285 watts. The field is designed as 10 inverters of 3,360 panels each. The panels of each inverter are arranged in 168 strings with 20 modules per string (Picture 3). The inverters are connected to 5 transformers, which convert the 9.58 megawatts of DC power generated by the field to 7.6 megawatts of AC power at the plant substation. The Volkswagen plant consumes 100% of the power generated by the park for car manufacturing. This covers 12.5% of the plant's need during peak production times. During non-production times (weekends), the solar park is able to provide 100% of the plant's power needs.

If the growing use of large-scale solar power plants in Tennessee is an indication, and we hope it is, the field of renewable energy is ready for a growth spurt. This is great news for all of us as citizens, as well as a great opportunity for electrical engineering in general and compliance engineering in particular. As more of the general population becomes aware of our joined opportunities for immediately accessible alternative energy, the engineering community will need to step forward with solutions for generating more efficient, low-cost options in delivering that energy. The ability to respond to this need will offer both individuals and companies a chance for industry leadership. ■

#### (the author)

##### MARY ANN KAHL

While her educational background is in architecture and English, Mary Ann's professional editing experience began in the early 80s as a research assistant in the Epidemiology and Genetics Section at the National Cancer Institute (NCI). Leaving the office environment to be at home with her two sons, Mary Ann continued editing for NCI as an independent contractor. On moving to New England, she began looking for new clients (these were the nascent days of the internet, so local was better). Stumbling upon an electrical engineer who wanted help with a pocketguide to Taguchi and Robust Design, Mary Ann abandoned the doctors for the technical guys ... and has spent the next 25 years helping bright and creative people articulate their ideas and inventions. The bulk of this work has been for QFD and TRIZ articles, books and seminars. Mary Ann is very happy to have spent the past two years dotting "I"s, crossing "t"s, and adding or removing countless commas for In Compliance Magazine.





## The View from the Chalkboard

BY MARK STEFFKA

One of the questions I get asked frequently is “What software exists that can be used to assist in the teaching of EMC?” This is a good question! For this month’s column I would like to ask you that same thing – with the hope that either (a) Others can learn from what you are using, or (b) This serves as a “thought starter” as to the type of software is needed or could be used in EMC education.

**I**t has been my experience that although some people have had success with adapting various circuit analysis programs (such as SPICE) for EMC analysis purposes, it required significant up-front work

to fully define the problem (such as identification of parasitic components) which was then input to the circuit analysis. At the other end of the spectrum, many of us are familiar (and/or have used) some of the highly

capable electromagnetics modeling and simulation packages that also exist. While both these methods have their value, it seems like there is a gap in the needs of students and EMC educators to have software that can be used as a first introduction to EMC analysis using computer analysis methods.

The feedback that I have received when I have also asked this question of my colleagues is that what EMC



### Software Name

“ABC”

“XYZ”

educators are looking for is a way to be able to illustrate various concepts in EMC without the students getting lost in the details of the analysis program itself. Ideally, the software should be able to demonstrate the basic concepts of EMC, such as determination of emissions levels for a certain hardware design (conducted and radiated), effects of various electric and magnetic fields upon basic circuits and systems (conditions of radiated susceptibility/immunity) and methods to provide insight into shielding effectiveness for various conditions such as near and far fields, electric or magnetic field shielding, perhaps with identification of the dominant shielding mechanism for a specific conditions (such as reflection or absorption). These programs would ideally run on the most common systems in use today, and possibly some of them even be made available in the “app” format for smartphone/tablet usage.


So – what do you think? Is it possible to utilize computer packages to illustrate various EMC concepts in an effective manner in the university classroom? What features or capabilities would you like to see in order for this to be useful to you? Should this software be restricted to “on campus” use or be made available for students via the internet? Where best this software would be used – in a classroom lecture or in a lab class? These are just some of the initial questions that I see as

important ones to address when incorporating software packages as a part of an EMC curriculum (or course).

As I have done before on other topics that we’ve discussed in this column – I’d like to have your feedback, comments, and questions that we can explore in the upcoming months. To get started, perhaps it would be useful to provide readers of this column an overview of

what is currently being done and/or desired. I am proposing a simple matrix that can help answer some of these questions.

If you have information that you would like to share, please contact me, I look forward to helping us all in this important aspect of EMC education.

Thank you in advance! 

#### (the author)

**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.

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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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is the Michelin Professor of Vehicle Electronic Systems Integration at Clemson University and Director of the Clemson Vehicular Electronics Laboratory (CVEL). His research focuses on the design of electronic components and systems that work safely and reliably in automotive environments. For his full bio, please visit page 31.



**NIELS JONASSEN, MSC, DSC**, worked for 40 years at the Technical University of Denmark, where he conducted classes in electromagnetism, static and atmospheric electricity, airborne radioactivity, and indoor climate. Mr. Jonassen passed away in 2006. For Mr. Jonassen's full bio, please visit page 20.

**MARY ANN KAHL**

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started out as a physicist but has spent all of his career in electronics because, as he puts it, it was more fun. Gregg's career as an electronics design engineer began in the industrial controls, consumer electronics, space and military markets. He completed a Diploma in Industrial Management (the forerunner of the MBA) in the 1980s with a thesis on the application of Kan Ban and JIT to highly variable product lines. For Gregg's full bio, please visit page 42.

**OZGUR OZTURK**

serves as Senior Business Manager, EMC and Telecommunication Services, at TUV Rheinland of North America, Inc. He has more than 12 years of experience in regulatory compliance in testing and certification. Ozturk graduated from University of Missouri-Rolla with a degree in Electrical Engineering, with an emphasis in EMC. For Ozgur's full bio, please visit page 37.

**MARK STEFFKA**

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. For Mark's full bio, please visit page 49.



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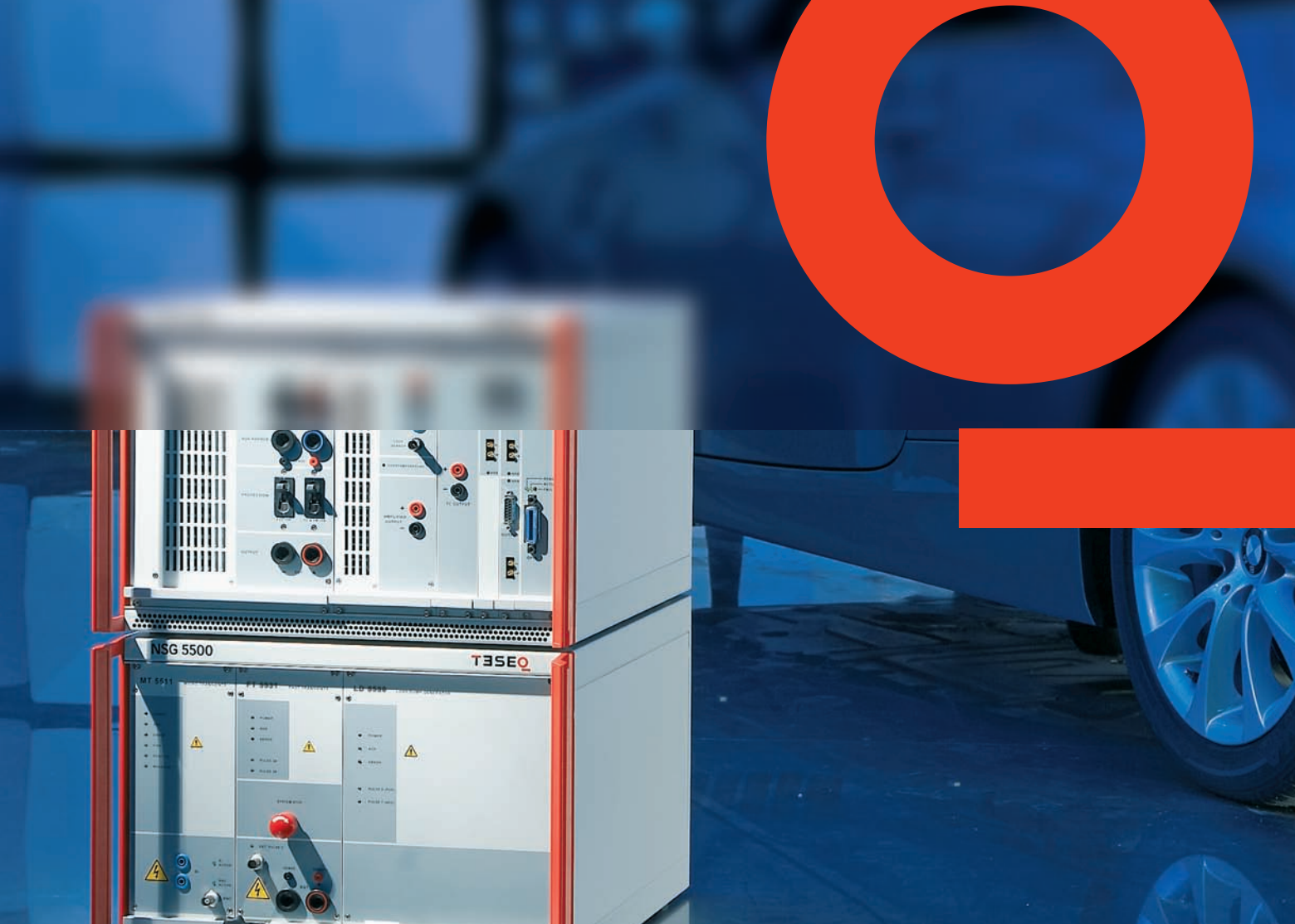
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